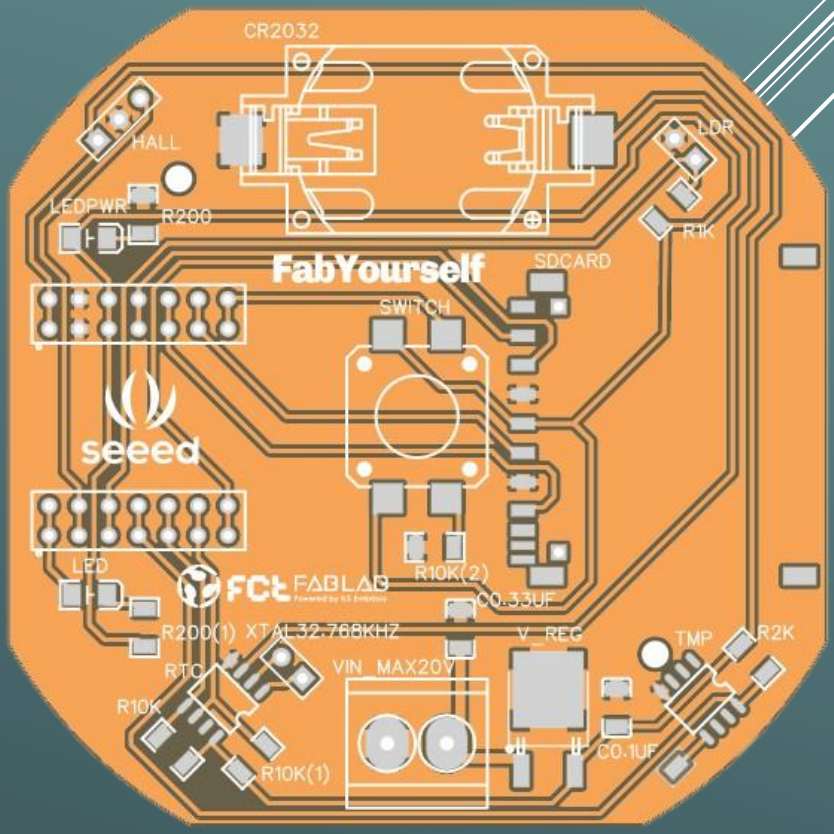

FABYOURSELF COURSE

LabBox as Laboratory Box

FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

FCT FABLAB Powered by U.S. Embassy

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Introduction

FCT FabLab developed FabYourself course to gather vast techniques and share the knowledge of digital fabrication. This course is made by three online sessions, and one extra session for custom implementation, to teach the students tools and techniques of fabrication.

In this course we will develop a Laboratory Box, or LabBox for short, to provide us a reading of implemented digital and analog sensor. The aim of this project is record different types of data along time to build and analyze the various behaviors of the sensors in Microsoft Excel charts of environment or in a specific system implementation.

So, to construct the LabBox project our first session will be PCB Design workshop using EasyEDA software. We will develop a schematic diagram of electrical connections of sensors and components for physical mounts on PCB.

Second session is all about the enclosure. We will use the power of 3D printer to print our box to protect the electronics of the environment. The 3D model of the enclosure will be developed on 3D modeling software OnShape.

For last we will program the behavior of our system using Arduino IDE, in our Arduino session workshop.

This document has you covered. Enjoy!

1 Project Overview

1.1 LabBox Description

The goal of LabBox device is to record data sensors and save to SD card. Next the SD card can be plugged in to computer to analyze the behavior among time in form of Microsoft Excel charts for different environments and systems studies. It also possible to download the file to PC after the readings.

The portable Laboratory Box is an electronic device that is incorporated with sensors for data record. The printed circuit board (PCB) is incorporated with following integrated circuits (IC) and sensors:

- Magnetic Hall Sensor
- Light Sensor
- Temperature Sensor
- Pressure push button Sensor
- Real Time Clock IC
- Incorporated LED light
- SD card

The FabYourself course include a physical project that will be provided by post mail at your address. The package includes the following items:

- Seeeduino XIAO Microcontroller.
- USB-A to USB-C cable.
- 3V Coin Battery.
- LabBox soldered PCB Project.
- LabBox 3D printed enclosure with laser cut cover.
- 32Gb micro-SD card with expansion SD card.

1.1.1 Power

The microcontroller unit (MCU) Seeeduino XIAO operates in a 3.3 volt architecture and includes voltage regulator to provide that voltage when powered through USB port (USB ports provide 5V).

To power the project, you will be able to do so through an USB connection with provided USB cable connected to a PC or a power supply like a cell phone charger.

The LabBox include a terminal block for external power source connection like 12V battery car or 9V external battery can be plugged in. The terminal block is connected to a LM78M05A voltage regulator with maximum input voltage range is 7V to 20V. Upper input voltages origins higher power dissipation on voltage regulator IC. See the LM78M05A datasheet for more information.

The integrated 3V battery coin does not power the board! The battery power only the RTC module to keep track of time even when the board is not powered.

2 Printed Circuit Board Design

2.1 PCB Designing Software

There are many types of PCB designing software's capable provide with us enough capabilities for our needs in making circuits. There is list of some designing PCB software's:

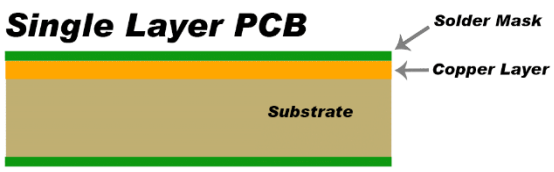
- Autodesk Eagle (free)
- EasyEDA (free)
- Altium Designer
- KiCad (free)
- CircuitMaker (free)
- Proteus

In our course we will be using EasyEDA software.

2.2 Types of PCBs

There are different types of PCB constructions that provide us of interesting characteristics for our design. We can see the following types of PCB:

- Single-layer or single-sided boards, have components on one side of the board and a conductor pattern on the opposite side. They have just one layer of conductive material, typically copper. A single-layer board is comprised of a substrate layer, a conductive metal layer and then a protective solder mask and silk-screen. You will find single-layer boards in many simpler electronic devices.

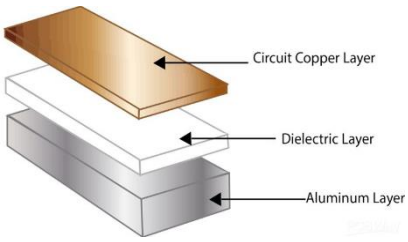


- Double-layer or double-sided board, which has more layers than a single-layer board but fewer than a multi-layer. Double-sided PCBs, like the single-sided variation, have one substrate layer. The difference is that they have a layer of conductive metal on both sides of the substrate.

- Multi-layer PCB has one or multiple conductor patterns inside the board, this increases the area available for wiring. multilayer PCB, such as 4 layer, 6 layer and 8 layer PCBs are usually used for more complicated devices. For example, smart phones use 12 layers due to the various demands of the circuit. The largest one ever made was 129 layers thick.

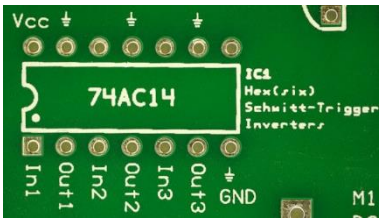
- Flexible also known as FPC (Flexible Printed Circuit) are characterized by a distinctly patterned printed circuitry and component arrangement highlighted by a malleable base material.

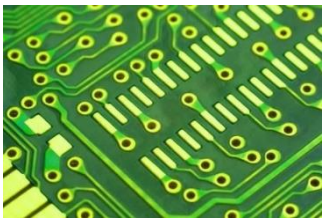
- Aluminum backed consists of aluminum core base material consists. It features a highly efficient heat dissipation in an efficient manner of cooling components and increasing the overall performance of the devices.

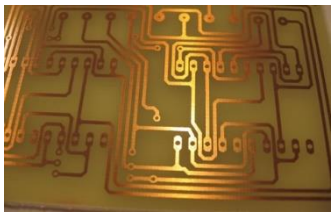


- Flex-rigid printed circuit boards are boards using a combination of flexible and rigid board technologies in an application.

2.3 Layers of PCB





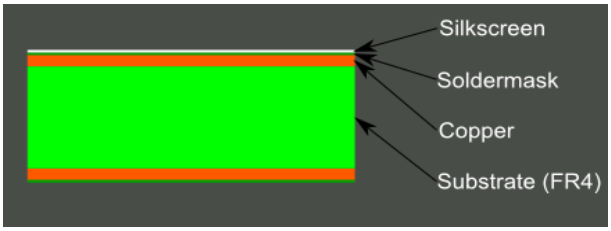


Slikscreen is the legend that is usually printed on one or both sides of the PCB. This layer contains the technical information about the components and helps the user to better understand the plate in the process of assembly, testing and welding.

Soldermask is a thin layer like polymer lacquer that is usually applied over the copper layer of the PCB to protect against oxidation and to prevent the formation of solder bridges between tracks.

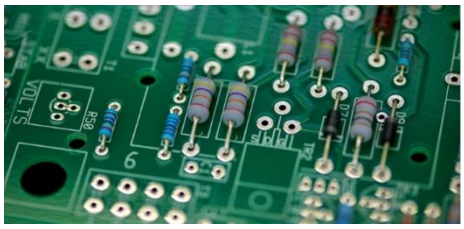
Copper is the very thin copper layer (35µm) that makes the electrical connections between the components.

FR-4 Substrate gives rigidity to PCB and is composed of a mixture of fiberglass with an epoxy resin. It has low water absorption (up to about 0.15%), good insulation and resistance properties. Normally rated to 130 °C.



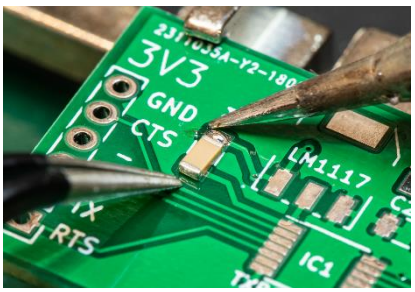
2.4 THT Components

Through Hole Technology (THT) is a technology that allows the insertion of components in the holes of the pcb. The terminals of the components go completely through the pcb where it is then possible to weld them to the pads. They are components that are easier to handle.



2.5 SMD or SMT Components

Surface Mount Device (SMD) or Surface Mount Technology (SMT), is an electronic component that is mounted on the surface of a PCB board. SMD components are typically smaller than traditional THT components.



2.5.1 Standard sizes of SMD Components

The standard sizes of capacitors, resistance diodes and LEDs

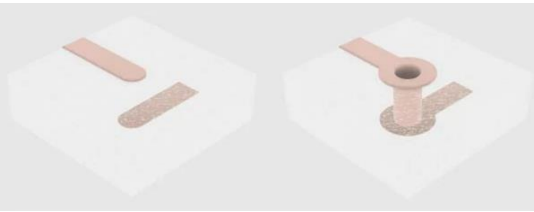
Imperial				Size	Metric			
Resistor Case Code	Approx. Length (in)	Approx. Width (in)	Power (W)		Resistor Case Code	Approx. Length (mm)	Approx. Width (mm)	Power (W)
01005	0.016	0.008	0.031		**0402**	0.4	0.2	0.031
0201	0.02	0.01	1 / 20 (0.05)		**0603**	0.6	0.3	1 / 20 (0.05)
0402	0.04	0.02	1 / 16 (0.062)		**1005**	1.0	0.5	1 / 16 (0.062)
0603	0.06	0.03	1 / 10 (0.10)		**1608**	1.6	0.8	1 / 10 (0.10)
0805	0.08	0.05	1 / 8 (0.125)		**2012**	2.0	1.25	1 / 8 (0.125)
1206	0.125	0.06	1 / 4 (0.25)		**3216**	3.2	1.6	1 / 4 (0.25)
1210	0.125	0.10	1 / 2 (0.5)		**3225**	3.2	2.5	1 / 2 (0.5)
1812	0.18	0.125	3 / 4 (0.75)		**4532**	4.5	3.2	3 / 4 (0.75)
2010	0.20	0.10	3 / 4 (0.75)		**5025**	5.0	2.5	3 / 4 (0.75)
2512	0.25	0.125	1		**6332**	6.3	3.2	1

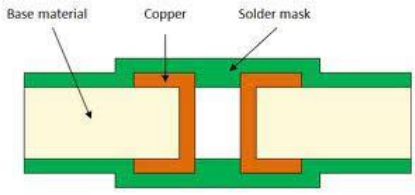
2.6 SMD vs THT

THT		SMD	
Easier for prototyping	Higher PCB cost due to perforation	Smaller size logo denser PCBs	Weaker physical connections to the PCB
Strong physical connections	Components take up more space on the board	Lower electrical noise therefore more reliable communication at high speeds	Lower heat tolerance
Heat tolerance	The PCB assembly process is more involved	Faster and cheaper assembly	Lower energy handling capacity
Energy handling capacity	Slower speeds	Without perforation, therefore, the manufacture of the plate is more economical	

2.7 Vias

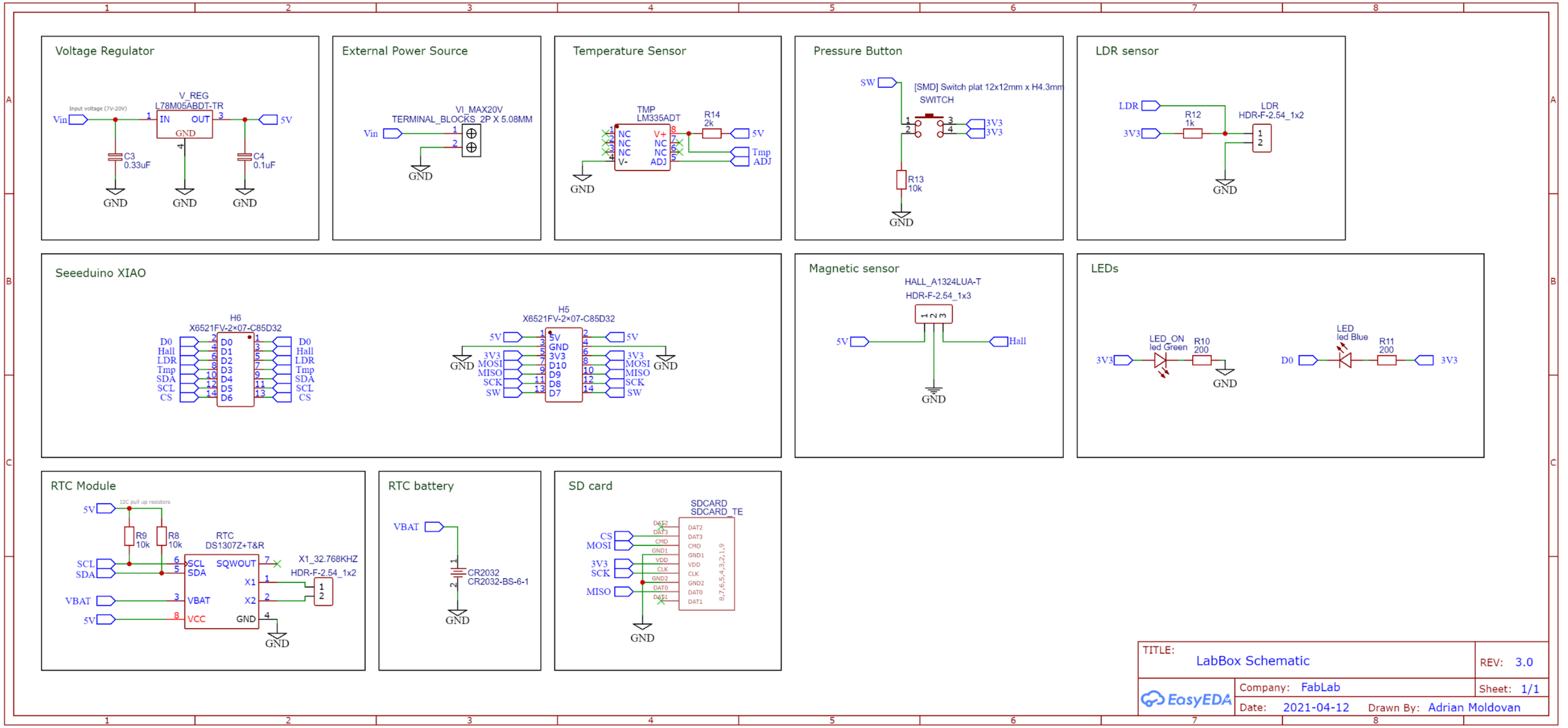
Vias are used to electrically join two tracks of the various layers of a PCB. This vias are copper cylinders placed or formed in the drilled holes in the PCB to make electrical connection between two or more layers





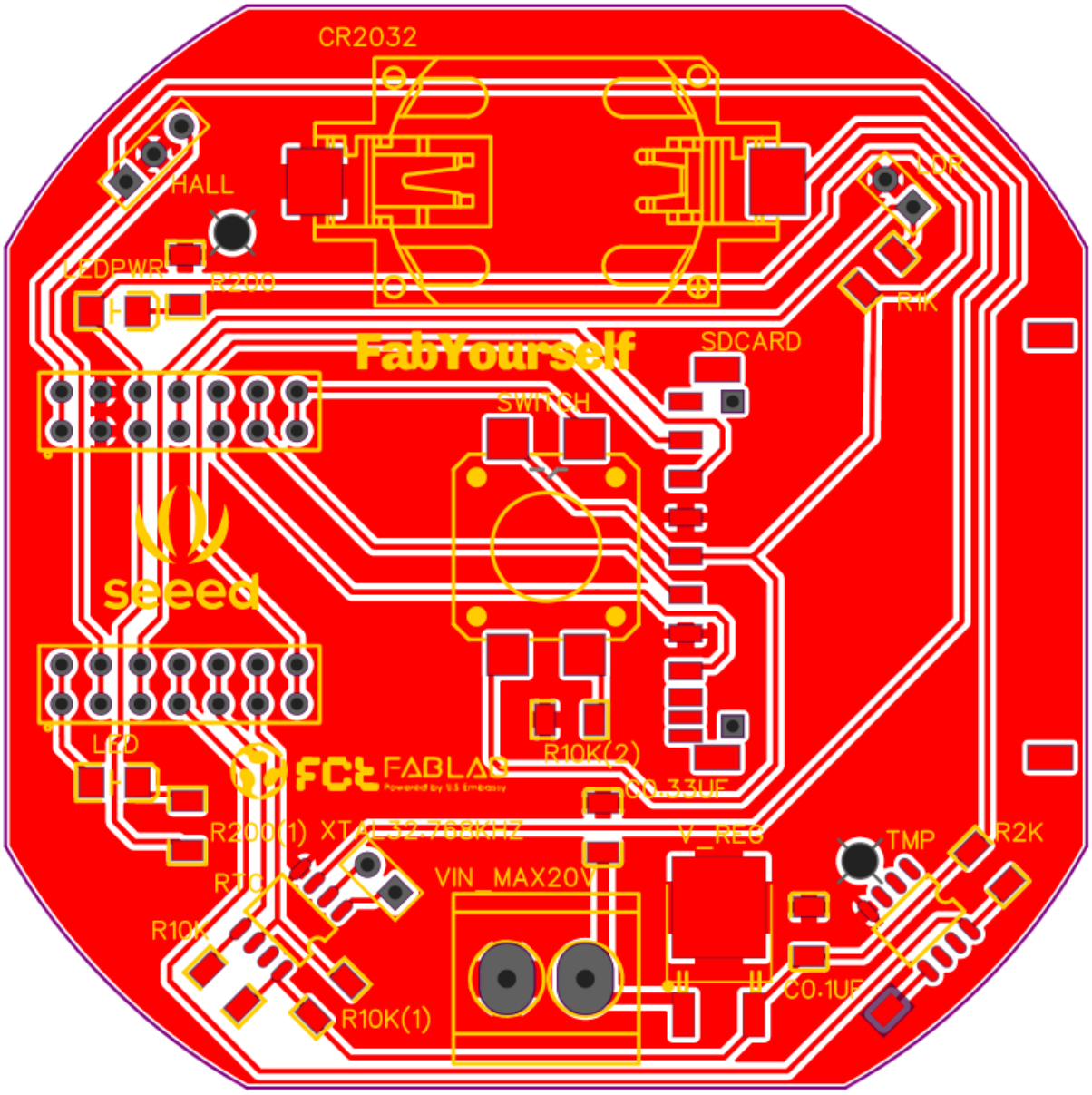
2.8 LabBox PCB

2.8.1 Schematic



LabBox Electric Circuit Diagram

2.8.2 PCB Layout



LABBOX PCB LAYOUT

2.8.3 BOM

Name	Designator	Footprint	Quantity
0.33uF	C3	C1206	1
0.1uF	C4	C1206	1
CR2032-BS-6-1	CR2032	BAT-TH_CR2032-BS-6-1	1
X6521FV-2×07-C85D32	H5,H6	HDR-TH_14P-P2.54-V-F-R2-C7-S2.54	2
HDR-F-2.54_1x3	HALL_A1324LUA-T	HDR-F-2.54_1X3	1
HDR-F-2.54_1x2	LDR,X1_32.768KHZ	HDR-F-2.54_1X2	2
led Blue	LED	LED1206-RD	1
led Green	LED_ON	LED1206-RD	1
200	R10,R11	R1206	2
1k	R12	R1206	1
10k	R8,R9,R13	R1206	3
2k	R14	R1206	1
DS1307Z+T&R	RTC	SOIC-8_L5.0-W4.0-P1.27-LS6.0-BL	1
SDCARD_TE	SDCARD	SDCARD_TE	1
[SMD] Switch plat 12x12mm x H4.3mm	SWITCH	TACTILE-SMD-12MM	1
LM335ADT	TMP	SOIC-8_L5.0-W4.0-P1.27-LS6.0-BL	1
TERMINAL_BLOCKS_2P X 5.08MM	VI_MAX20V	TERMONAL BLOCKS 2P_5,08MM	1
L78M05ABDT-TR	V_REG	TO-252-2_L6.5-W6.1-P4.58-LS10.0-TL	1

2.8.4 Seeeduino connections

Seeeduino Pin	Flag Name	Sensor
D0	D0	LED light
D1	Hall	Magnetic sensor
D2	LDR	Light sensor
D3	Tmp	Temeprature sensor
D4	SDA	I2C - SDA pin
D5	SCL	I2C - SCL pin
D6	CS	SPI - Chip select pin
D7	SW	Pressure button
D8	SCK	SPI - Clock pin
D9	MISO	SPI - MISO pin
D10	MOSI	SPI - MOSI pin
3V3	3V3	POWER
GND	GND	POWER
5V	5V	POWER