PCB DESIGN
UNIVERSITY OF TRIPOLI

MUHARREM DREBI

2024 ربيع

OUTLINE

- Printed Circuit Boards definition
- PCB types
- PCB design cycle
- Example PCBs designed in UOT and manufactured in China from Spring 2023 EC580 class
- Conclusion

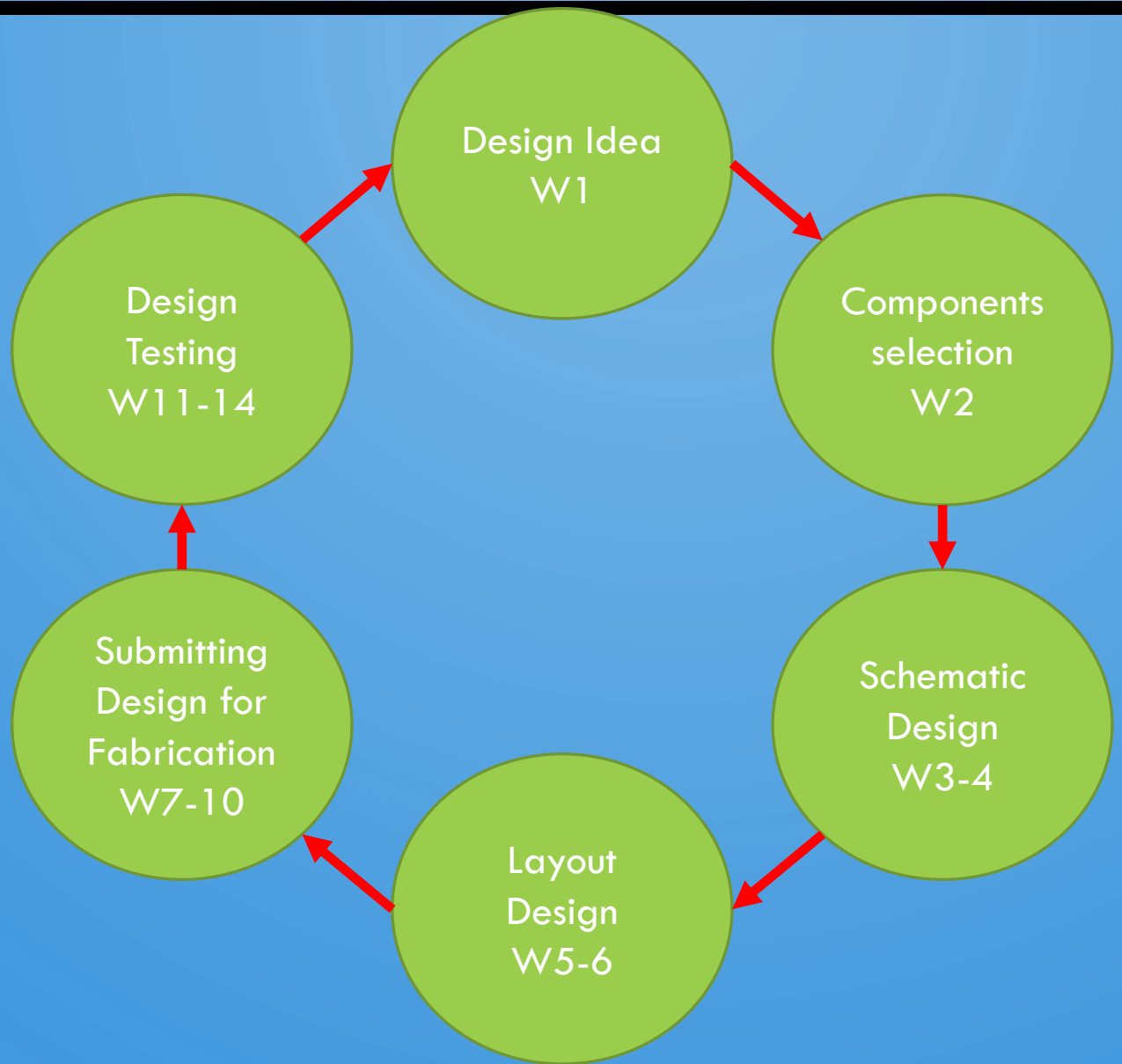
Printed Circuit Boards PCBs

- PCB serves as a medium used to connect electronic components together in a circuit.
- Consists of alternating conductive and insulated layers stacked on top of each other.
- PCBs can take different forms
  - Single-sided PCBs: These have one copper layer.
  - Double-sided PCBs: These have two copper layers on both sides of one substrate layer.
  - Multi-layer PCBs: These have alternating layers of copper and substrate.

Printed Circuit Boards PCBs

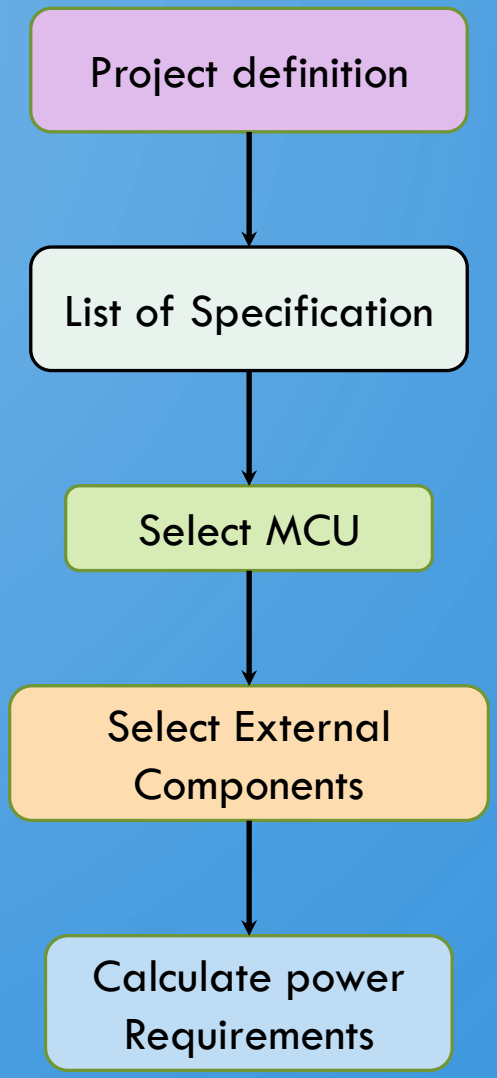
- Types: Stability vs Bendability
  - Rigid normally found in consumer electronics and computers.
  - Flex normally used in wearable devices, medical and aerospace applications
  - Rigid-Flex used in medical implants, defense, and telecommunication industries.
- Other PCB types
  - HDI High Density Interconnect, for complex circuit designs: with densely packed circuits.
    - Thin Traces, Microvias, Blind and Buried Vias
  - Metal Core PCB or MCPCB used in automotive industry.
- Types: Material
  - FR4 Flame Retardant 4, for frequencies <10
  - Rogers, Low dielectric constant used for high frequency applications
  - PTFE for high frequency and high temperature

PCB DESIGN CYCLE



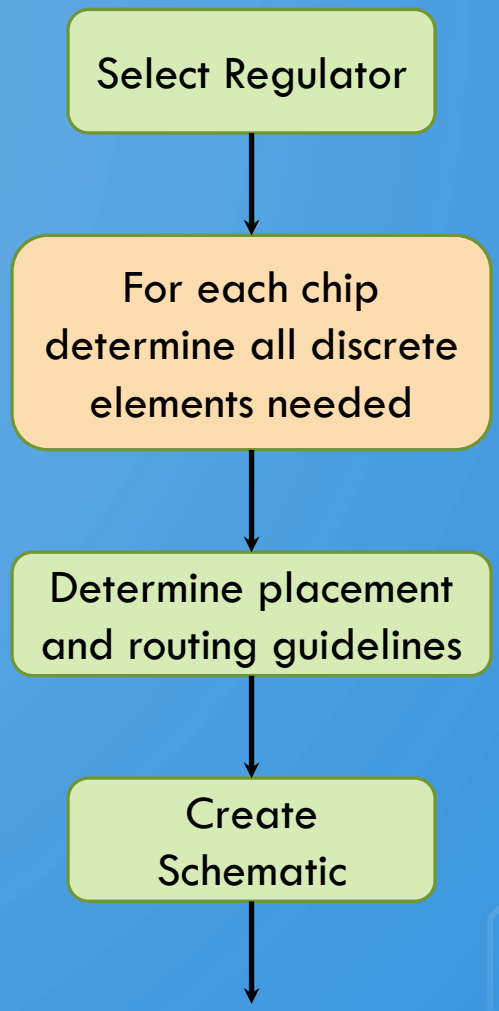
PCB DESIGN STEPS

- Starting from project definition and the task(s) to achieve, we create a list of specification
- From the list of specification we come up with an appropriate Microcontroller/Processor.
- We then select external chipsets or components needed to complement the selected microcontroller to accomplish the given task.
- From data sheet of each major IC we extract maximum power ratings and then we calculate total power requirement for each power domain.



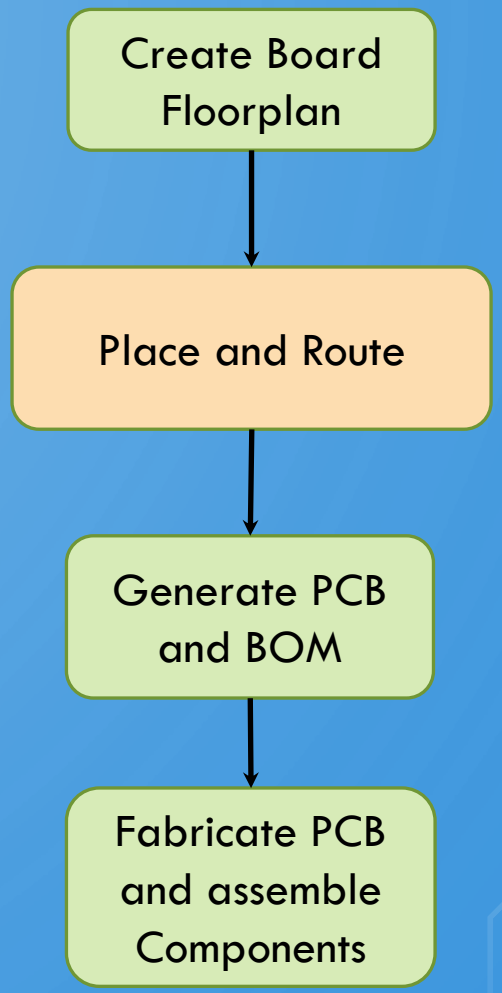
PCB DESIGN STEPS…

- Select appropriate power regulator(s) either linear (LDO) or switched (SMPS) regulator (Buck converter).
- From data sheets of MCU and selected components, determine all discrete elements that must be connected externally for the component to work.
- From datasheet of each components determine all guidelines related to PCB design like special routing or placement of component and its discrete elements.
- Create schematic of the MCU and connected components along with all discrete elements.



PCB DESIGN STEPS…

- Create PCB floorplan of the board and determine best location of the major components and determine board IO ports.
- Place components in the PCB board and then route the design following all guidelines.
- Generate PCB Gerber file and BOM or Bill Of Material.
- Fabricate or send Gerber file and BOM to fabrication facility to make PCB and assemble components on PCB.



SIGNAL INTEGRITY

Signal integrity refers to the ability of a digital or analog signal to propagate accurately from the transmitter to the receiver without distortion, noise, or interference.

Goal of design engineers is to ensure that data and control signals arrive at their destinations reliably and without corruption.

Sources of SI issues include Ringing, Crosstalk, Ground Bounce, Distortion due to impedance mismatches, parasitic effects, power supply noise and EMI.

SOURCE OF SIGNAL INTEGRITY ISSUES

Ringing: When a signal transitions from high to low or vice versa, it can cause unwanted oscillations due to reflections. Ringing can lead to false triggering or data corruption.

Crosstalk: This occurs when signals interfere with each other due to electromagnetic coupling. Crosstalk can distort adjacent signals, affecting their integrity.

Ground Bounce: Rapid switching of digital signals can cause voltage fluctuations in the ground plane. Ground bounce affects signal levels and can lead to errors.

Distortion: Various factors, such as impedance mismatches, transmission line reflections, and parasitic effects, can distort signals during propagation.

POWER INTEGRITY?

Power integrity focuses on maintaining stable power distribution within a circuit or system.

Goal of design engineers is to design power delivery network or PDN so that power supply voltages remain consistent and noise-free, preventing disruptions to digital logic, analog components, and sensitive devices.

Sources of PI issues include voltage ripple (due to rapid current changes), ground bounce (voltage fluctuations in the ground plane), radiated emissions (caused by weak decoupling), and excessive power dissipation (leading to thermal issues).

EXAMPLE: MICROCONTROLLER BOARD DESIGN

Design problem definition

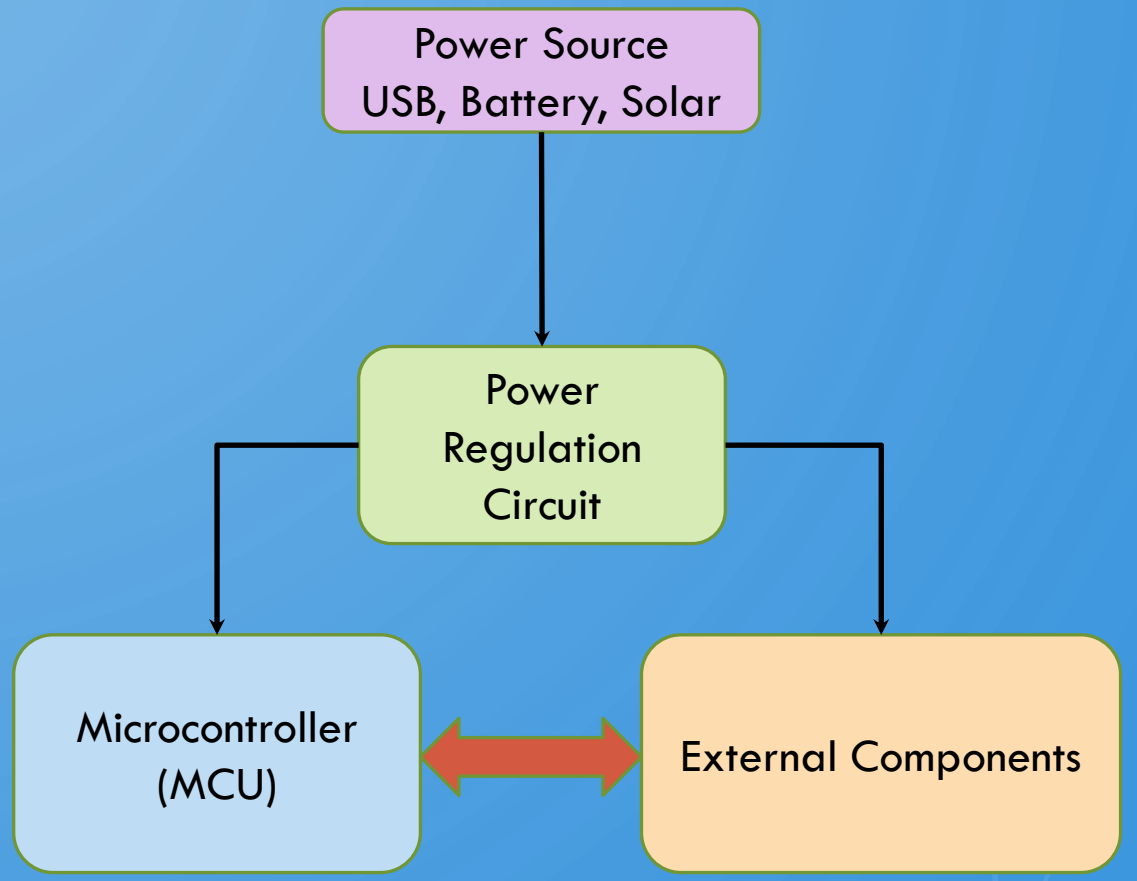
Lets assume the following specifications are required

Design a microcontroller board that has the following features:

Minimum of 48Mhz processor with no less than 32KB RAM, the board should have 14bit ADC, a 10Bit DAC, a 9 DOF Accelerometer/Gyroscope/Magnetometer IMU Sensors, a USB type C power connection, at least 30 GPIO pins, RTC clock, at least 2 channels PWM. The board should contain LEDs for power indication for each power source of different color.

EXAMPLE: MICROCONTROLLER BOARD DESIGN

- Generally when we design a Microcontroller board, we typically need at least the following four main components
  - Power Source
  - Power Regulator (SMPS, LDO)
  - Microcontroller
  - Microcontroller peripherals (Memory, DACs, ADCs, H-bridges, sensors like IMUs, 9 DOF etc.
- We start by looking into a microcontroller database with features selection as for example www.mouser.com or www.lcsc.com

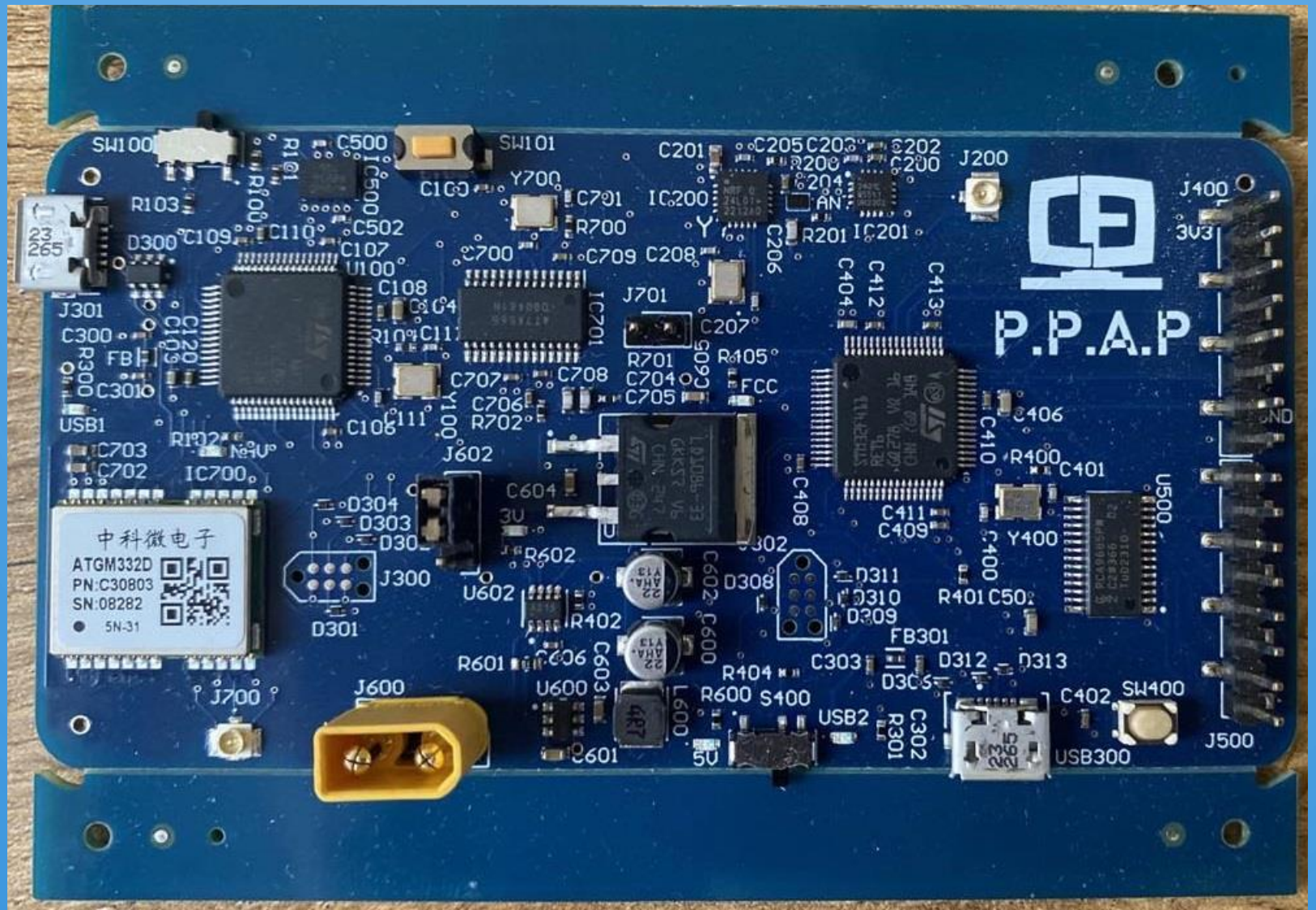


Example PCBs Designed In University Of Tripoli

All boards are designed during Spring 2023 EC580 class and manufactured in China

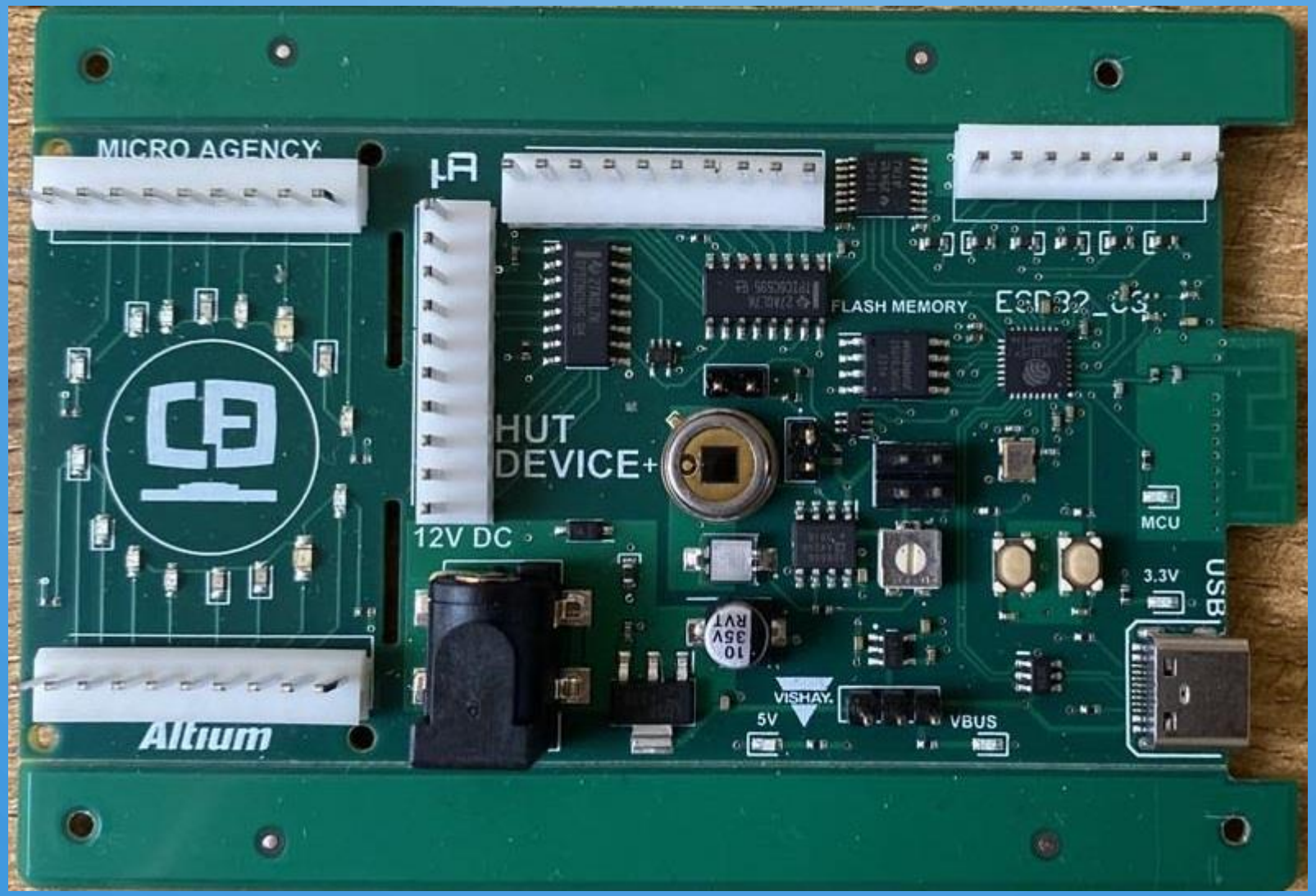
Example PCBs Designed In University Of Tripoli

All boards are designed during Spring 2023 EC580 class and manufactured in China



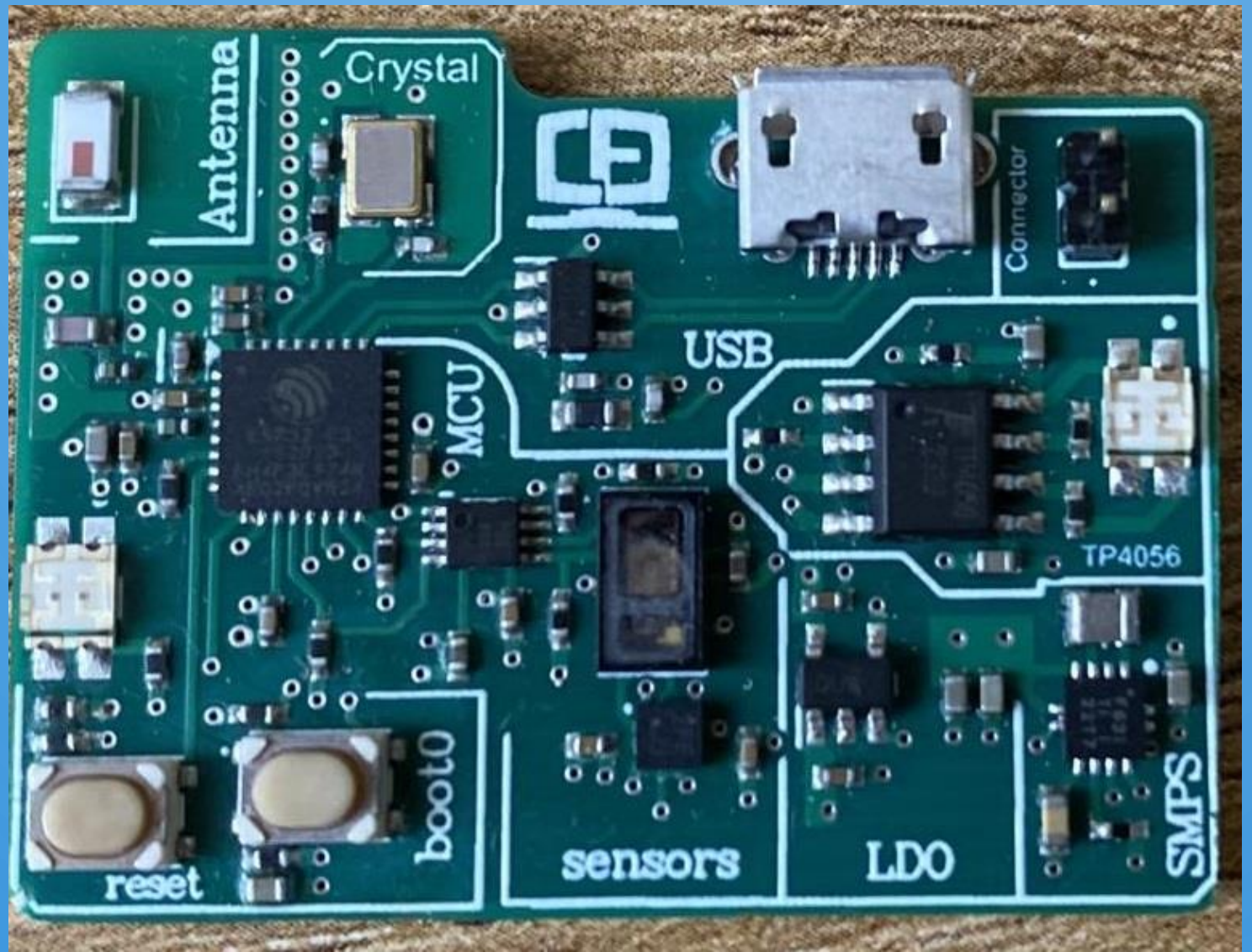
Example PCBs Designed In University Of Tripoli

All boards are designed during Spring 2023 EC580 class and manufactured in China



Example PCBs Designed In University Of Tripoli

All boards are designed during Spring 2023 EC580 class and manufactured in China

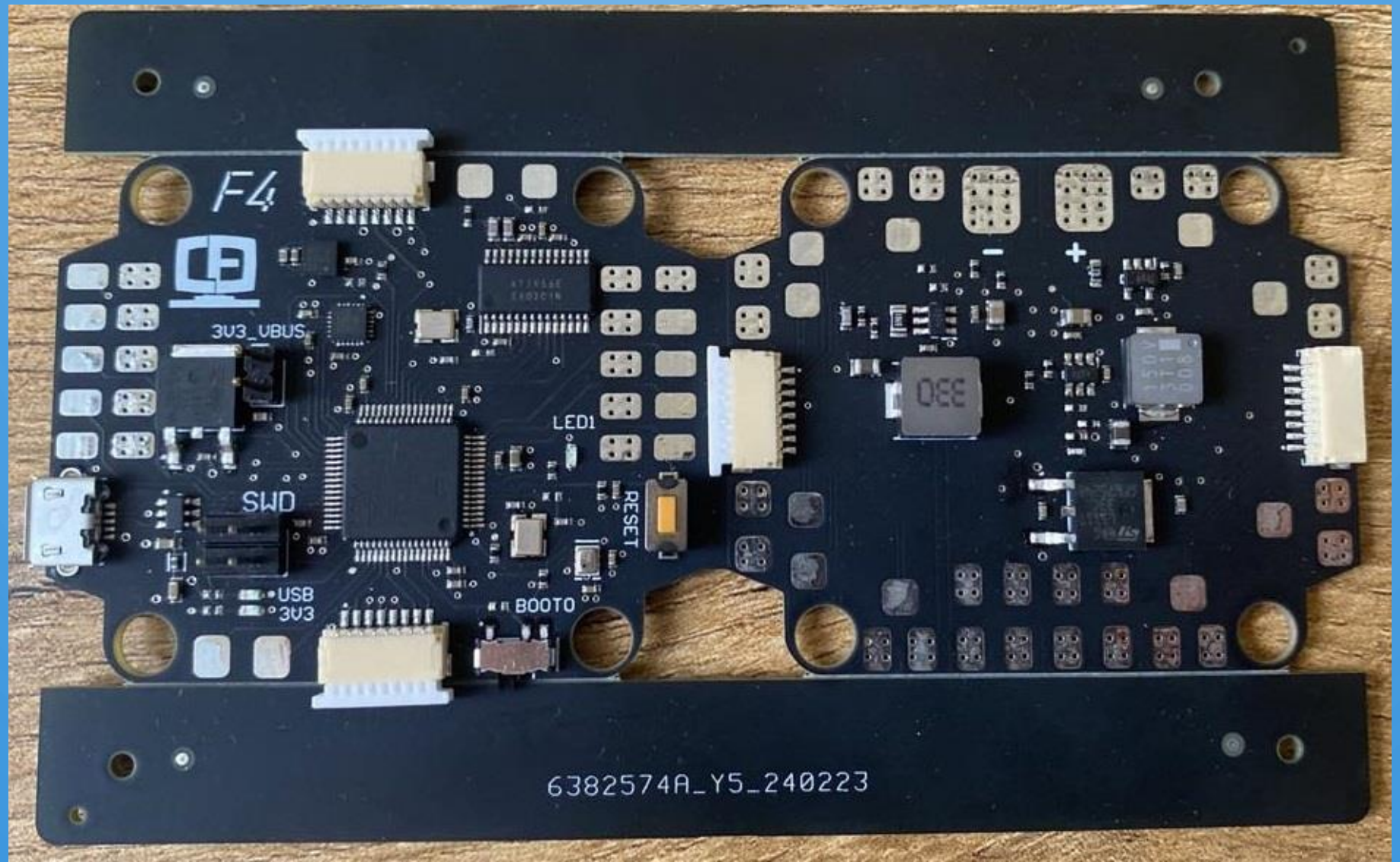


Example PCBs Designed In University Of Tripoli

All boards are designed during Spring 2023 EC580 class and manufactured in China

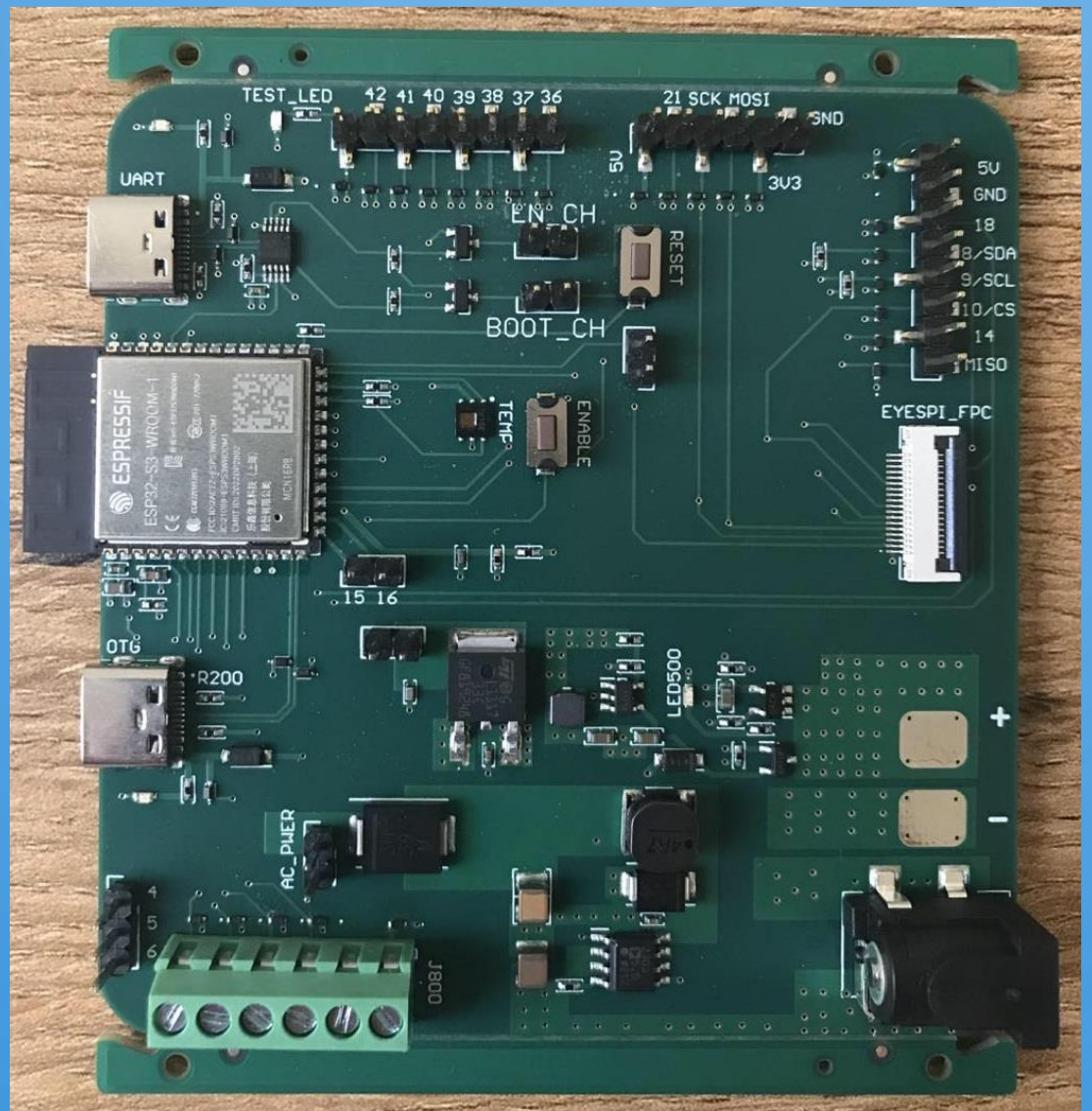
Example PCBs Designed In University Of Tripoli

B.Sc. Projects boards designed Fall 2023 and manufactured in China



Example PCBs Designed In University Of Tripoli

B.Sc. Projects boards designed Fall 2023 and manufactured in China



CONCLUSION

- Printed circuit board design is a challenging and very interesting design journey.
- Engineers not only need to exercise engineering skills to develop a working PCB board but also must have attention to details skill and lots of patience.
- Failures are expected from the first prototype, do not relapse from the first try!
- There are no limits, so use AI, use all sources even learn from reverse engineering!