

# HOW TO DESIGN A SMART CAR MODEL

From Requirements to Implementation

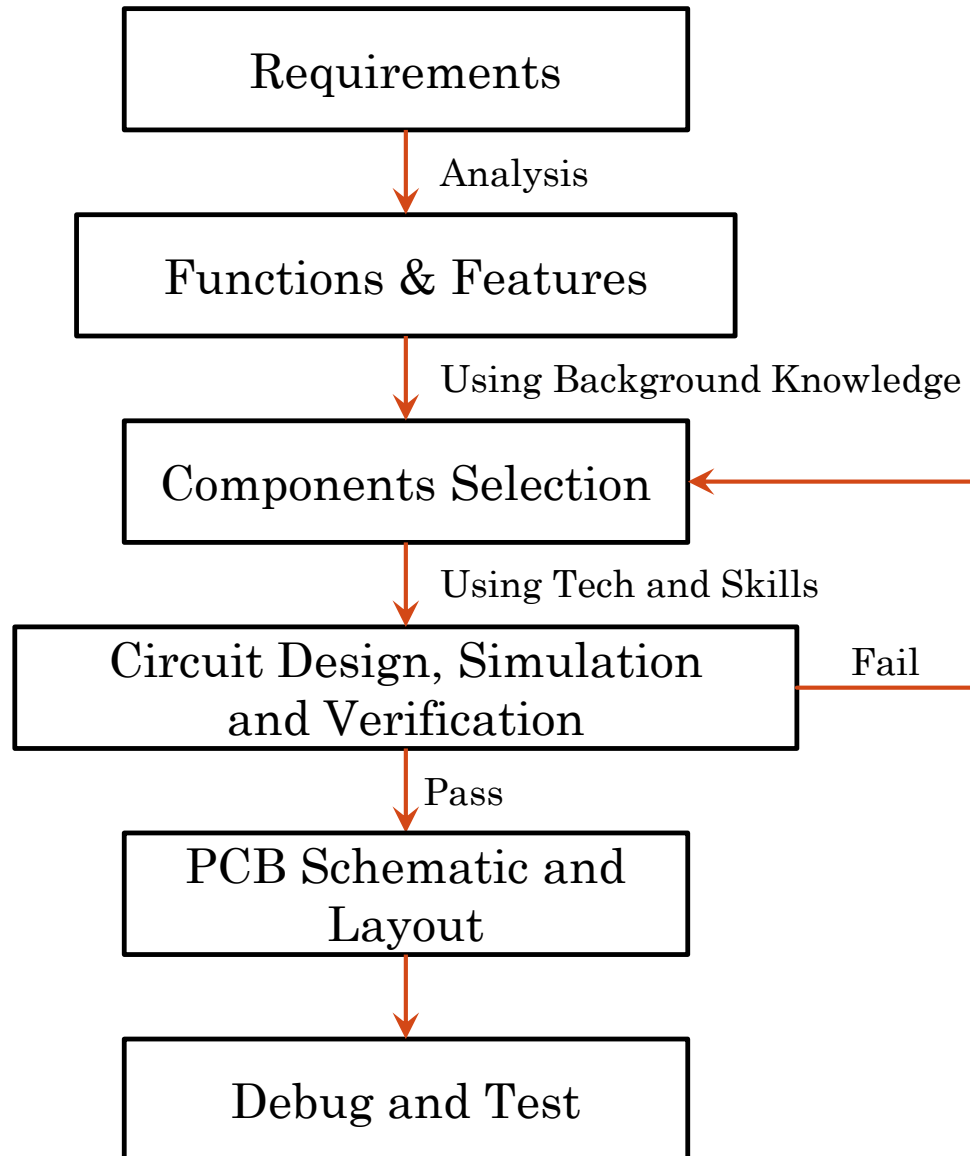
Speaker: Fei Cheng

# Latex XJTLU Template



<http://www.treee.com.cn/doku.php?id=os:treee>

# Design Flow



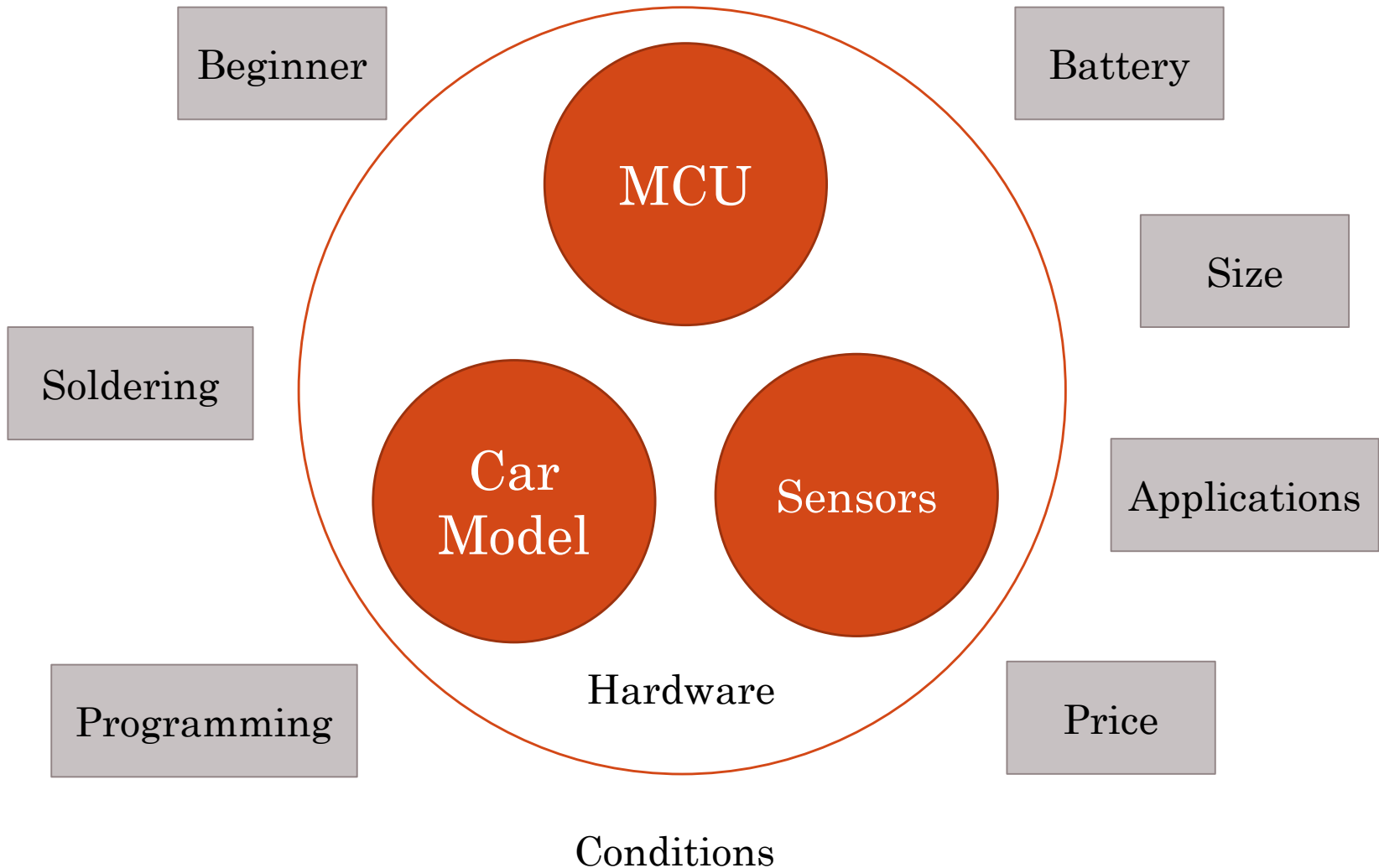


# Requirements

- A smart car model with sensors
- Multiple applications
- Powered by battery
- For beginners
- Soldering practice
- Programming practice
- Not expensive
- .....



# Functions and Features





# Functions and Features

- **MCU**
  - Functions?
  - Difficulty?
- **Car model:**
  - Steering mechanism?
  - Motor?
  - Motor Driver?
- **Sensors**
  - Types?
  - How to obtain data from sensors?



# Components Selection



# MCU

- ARM Cortex M Family (32 bits)
- Digital Signal Processor (DSP, 32 bits)
- Simple MCU (16 bits, 8 bits)

Beginner

Price





# MCU

- ~~ARM Cortex M Family (32 bits)~~
- ~~Digital Signal Processor (DSP, 32 bits)~~
- **Simple MCU (16 bits, 8 bits)**

Beginner

Price

# Simple MCU

- TI MSP 430
- STM 8
- Atmel AVR
- Arduino

Beginner

Applications





# Simple MCU

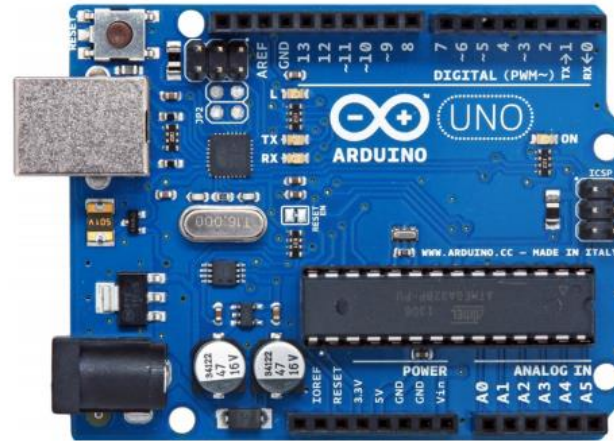
- ~~TI MSP 430~~
- ~~STM 8~~
- ~~Atmel AVR~~
- **Arduino**

Beginner

Applications

# Arduino

- Arduino Uno



- Arduino Nano



Size



# MCU

- Arduino Nano





# Car Model

- PCB used as the chassis (底盘)
- Special chassis

Beginner

Price

Size



# Car Model

- PCB used as the chassis (底盘)
- ~~Special chassis~~

Beginner

Price

Size

# Motor

- DC brush motor
- DC brushless motor

Beginner

Applications





# Motor

- **DC brush motor**
- ~~DC brushless motor~~



Beginner

Applications

# Motor



Size



# Motor Driver

- IC based driver
- Transistor or Power MOSFET based driver

Beginner

Price



# Motor Driver

- IC based driver
- ~~Transistor of Power MOSFET based driver~~

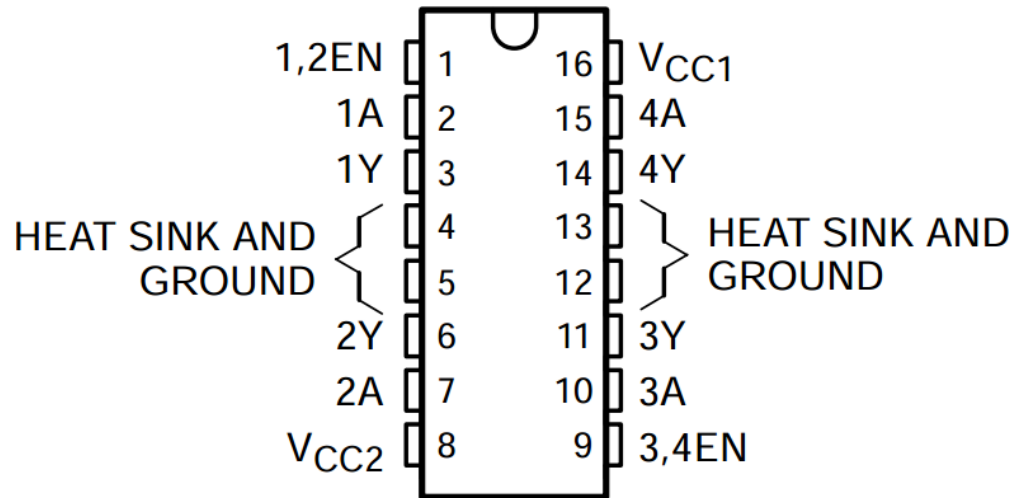
Beginner

Price

# Motor Driver



- L293



Size

Price



# Sensors

- Applications:
  - Auto driving following black line
  - Collision avoidance and falling prevention

- **Black line tracking**

- Optics method
- Camera based method

Beginner

- **Falling prevention**

- Optics method

Price

- **For collision avoidance**

- Mechanical method
- Optics method

Multiple



# Sensors

- Applications:
  - Auto driving following black line
  - Collision avoidance and falling prevention

- Black line tracking

- **Optics method**
- ~~Camera based method~~

Beginner

- Falling prevention

- **Optics method**

Price

- For collision avoidance

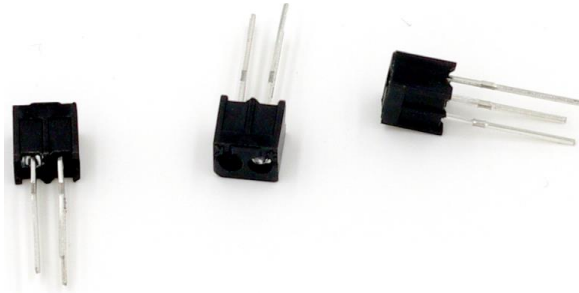
- **Mechanical method**
- ~~Optics method~~

Multiple

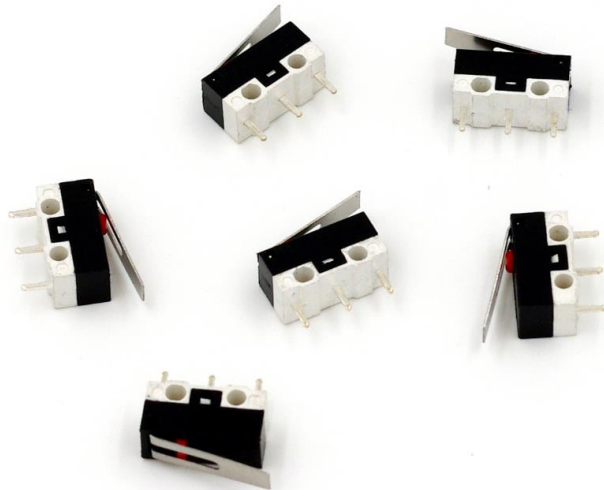


# Sensors

- IR sensors
  - ITR20001



- Collision Switches



Beginner

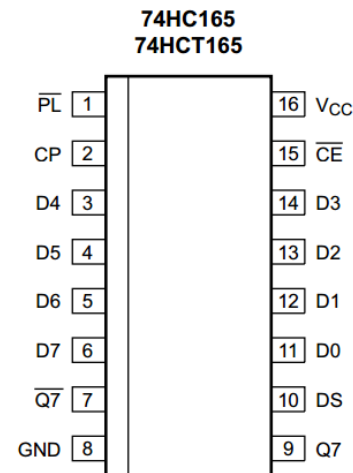
Price





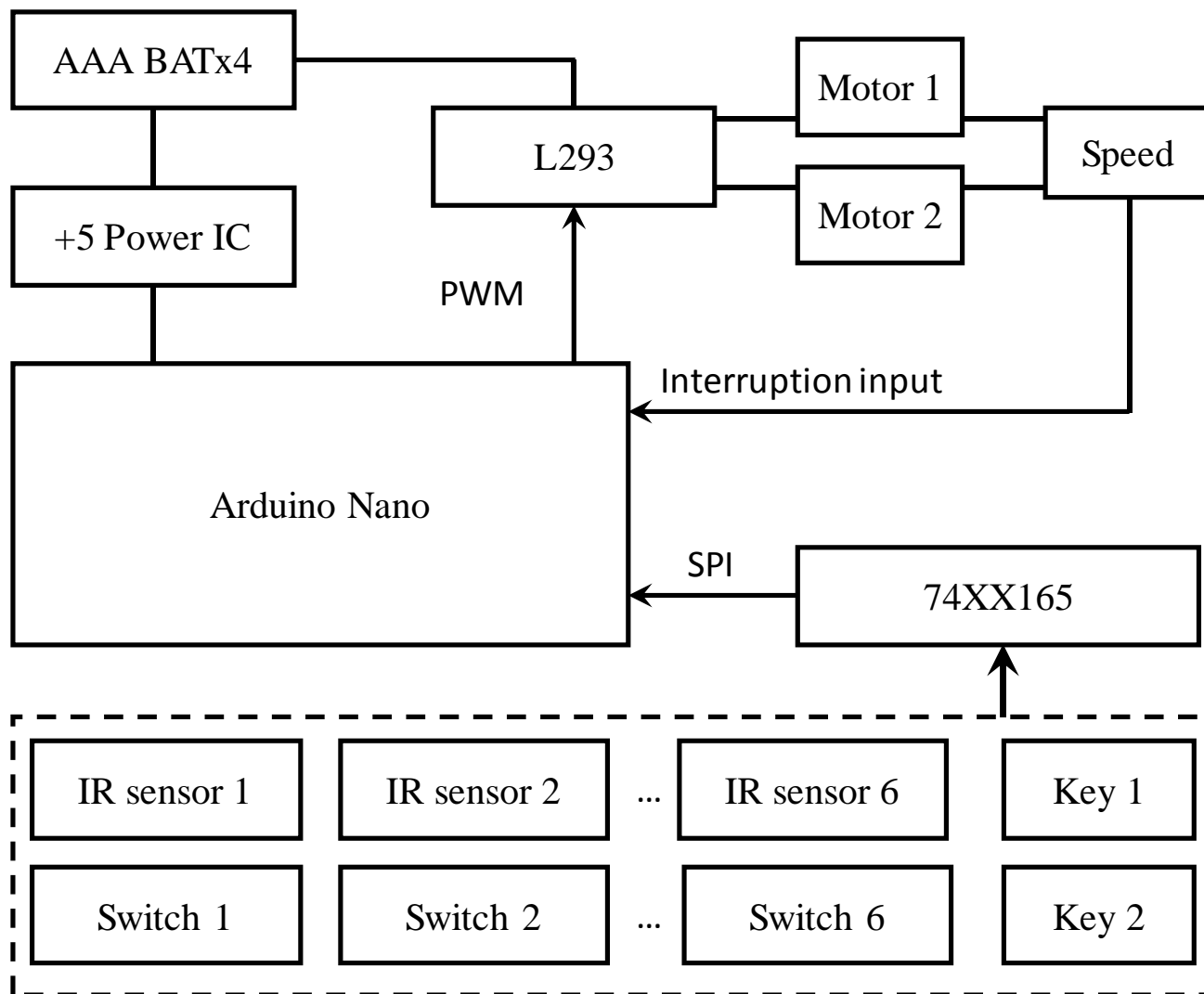
# Sensor Data

- All the sensor signals are digital switch signals
- Problem: there are 14 switch signals, but Arduino Nano only has 11 digital input pins.
- Parallel in serial out shift register
  - 2 x 74XX165
  - Only 4 Pins





# Block Diagram



# Circuit Design



- **Follow the knowledge from your modules**
  - **EEE103**
  - **EEE104**
  - **EEE109**
- **Follow the datasheet of ICs**
  - **How to connect?**
  - **Examples**
  - **Electrical characteristics**
  - **.....**
- **Follow your experience**

# How to become an engineer?



- Initially motivation – interested in EEE
- Basic knowledge – 103,104,109,116,203,204...

# How to become an engineer?



- Do not try to remember all the knowledge and information
- Just remember the index of them:
  - Key words
  - Webpages
  - Our own database
- Search:
  - IC companies' website
  - IC datasheets
  - Shops (Taobao, Digikey .....



# IC Companies

- TI: MSP430, DSP, Analog IC, Low power, expensive
- ST: STM8/32, cheap
- Atmel: AVR, fast
- Freescale: Automobile Electronic
- Linear: Analog, Power
- Infineon: Power IC, MOSFET
- Altera: FPGA
- Nordic: Wireless IC
- .....



# IC Companies

- TI
- ST
- Atmel
- Freescale
- Linear
- Infineon
- Altera
- Nordic
- .....

# IC Companies

- TI





# IC Companies' Website

- Products
- Applications & designs**
- Tools & software
- Support & training
- Sample & buy
- About TI

### Browse products

- Amplifiers & Linear
- Audio
- Broadband RF/IF
- Clock & Timing
- Data Converters
- Die/Wafer Solutions
- DLP® Products & MEMS
- High-Reliability
- Interface
- Isolation
- Logic
- Motor Drivers
- Power Management
- Embedded Processors
- Sitara™ Processors
- Digital Signal Processors (DSP)
- Microcontrollers (MCU)
- Sensor Products
- Space Products
- Storage Products
- Switches & Multiplexers
- Wireless Connectivity

- Calculators & Education Technology
- New products >
- Competitor cross reference search >

**Parametric selection tool >**  
Find the right part fast!

**WEBENCH® Design Center >**  
Use powerful WEBENCH design tools to create custom circuits.  
These easy-to-use tools deliver customized power, lighting, filtering, clocking and sensing designs in seconds.



## Implement cost effective, low power motor control for pumps and fans in major home appliances

- Reduce audible noise
- Increase energy efficiency
- Meet EMC/EMI and safety requirements with reduced cost
- **View reference design**



# IC Companies' Website



IR Products ▾

Applications ▾

Design Resources ▾

Technical Library ▾

## MOSFETs

Automotive MOSFET 20V-600V  
 20V-300V N-Channel MOSFET  
 500V-900V CoolMOS™  
 P-Channel & Small Signal MOSFET  
 Power MOSFET Bare Die

## IGBTs

Automotive IGBTs  
 IGBT with Anti-Parallel Diode  
 IGBT without Anti-Parallel Diode  
 IGBT Modules  
 IGBT Stacks  
 IGBT Bare Die

## Motor Control and Gate Drivers

Automotive Embedded Power ICs  
 Digital Motor Controller  
 Intelligent Motor Control ICs  
 Intelligent Power Modules  
 Isolated Gate Driver ICs  
 Non-Isolated Driver and Control ICs  
 Automotive Gate Driver

## HiRel Products

Rad-Hard and Hermetic MOSFETs  
 DC-DC Converters  
 EMI Filters  
 Voltage Regulators  
 Solid State Relays  
 Schottkys and Rectifiers  
 ICs  
 IGBTs

## DC-DC Converters

Digital Multiphase Controllers  
 PowIRstage®  
 Gate Drivers  
 Integrated POL Converters  
 DC/DC-Converter (Automotive)  
 DC/DC-Converter (Industrial)

## Smart Low-Side and High-Side Switches

High Side Switch  
 Low Side Switch  
 Multichannel Serial Power Switch Controllers

## AC-DC Supply

AC-DC Integrated Power Stage - CoolSET™  
 AC-DC PWM-PFC Controller

## Lighting & Audio Driver ICs

Class D Audio Solutions  
 LED Driver | Lighting ICs

## Solid State Relays

Photovoltaic Isolators  
 Photovoltaic Relays

## Linear Voltage Regulators

## High Power Thyristors & Diodes

## GaN Devices

## SiCarbide (SiC)

International Rectifier Corporation and Infineon Technologies North America Corp. have combined into one unified team: Infineon Technologies Americas Corp.

[Learn More](#)

configuration

[Learn More](#)

GaN ▸

# IC Companies' Website



The screenshot shows the STMicroelectronics website. At the top left is the ST logo with the tagline "life.augmented". To the right of the logo is a search bar with a dropdown arrow and the letter "S". Below the logo is a dark blue navigation menu with the following items: Products, Applications, Tools & Software, Support & Community, Sample & Buy, About ST, and Contacts. The main content area displays a list of products under the heading "Sensors, Analog, Power and Automotive Products". The products are listed in two columns:

- Aerospace and Defense Products
- Amplifiers and Comparators
- Audio ICs
- Automotive Analog & Power ICs
- Automotive Infotainment and Telematics
- Automotive Logic ICs
- Automotive Microcontrollers
- Clocks and Timers
- Data Converters
- Diodes and Rectifiers
- EMI Filtering and Signal Conditioning
- Interfaces and Transceivers
- MEMS and Sensors
- Power Management
- Power Modules
- Power Transistors
- Protection Devices
- Radio Frequency Transistors
- Reset and Supervisor ICs
- Switches and Multiplexers
- Thyristors (SCR) and AC Switches
- Wireless Connectivity

Below this list is another heading: "Microcontrollers, Memories, Imaging and Digital ICs". The products listed under this heading are:

- Digital Set-Top Box ICs
- Display Controllers
- Imaging and Photonics Solutions
- Memories
- Microcontrollers
- SPEAr Embedded Microprocessors
- Secure MCUs

At the bottom of the page, there is a footer with the text "ST25TA conn" on the right and "ent Environment" on the left. Below the footer is a dark blue bar with the text "ST25TA Series" in the center.

# Brainstorming



An idea

Search

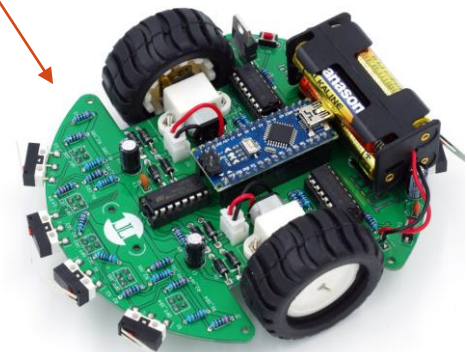
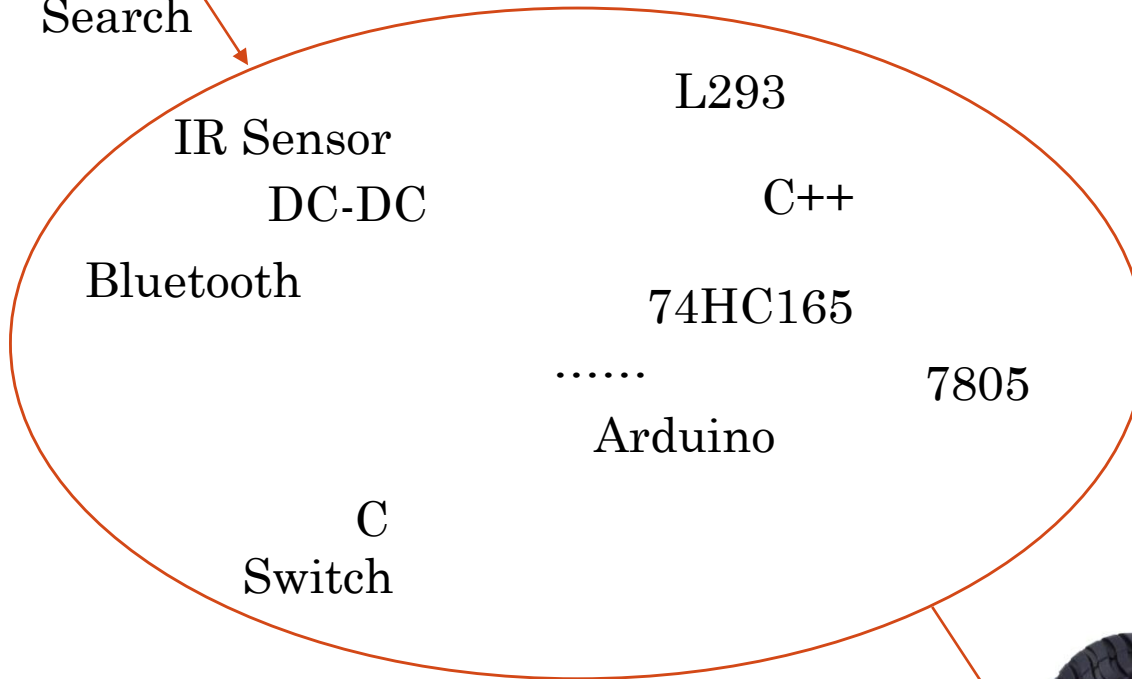
STM32 L293  
IR Sensor  
DC-DC MSP430 C++ DC-AC  
3D Print  
Bluetooth 74HC595 74HC165 IRF9530  
24L01 ST ..... Java 7805  
ESP8266 Arduino  
DSP C TCP/IP TI  
Switch IRF530 STM8

# Brainstorming



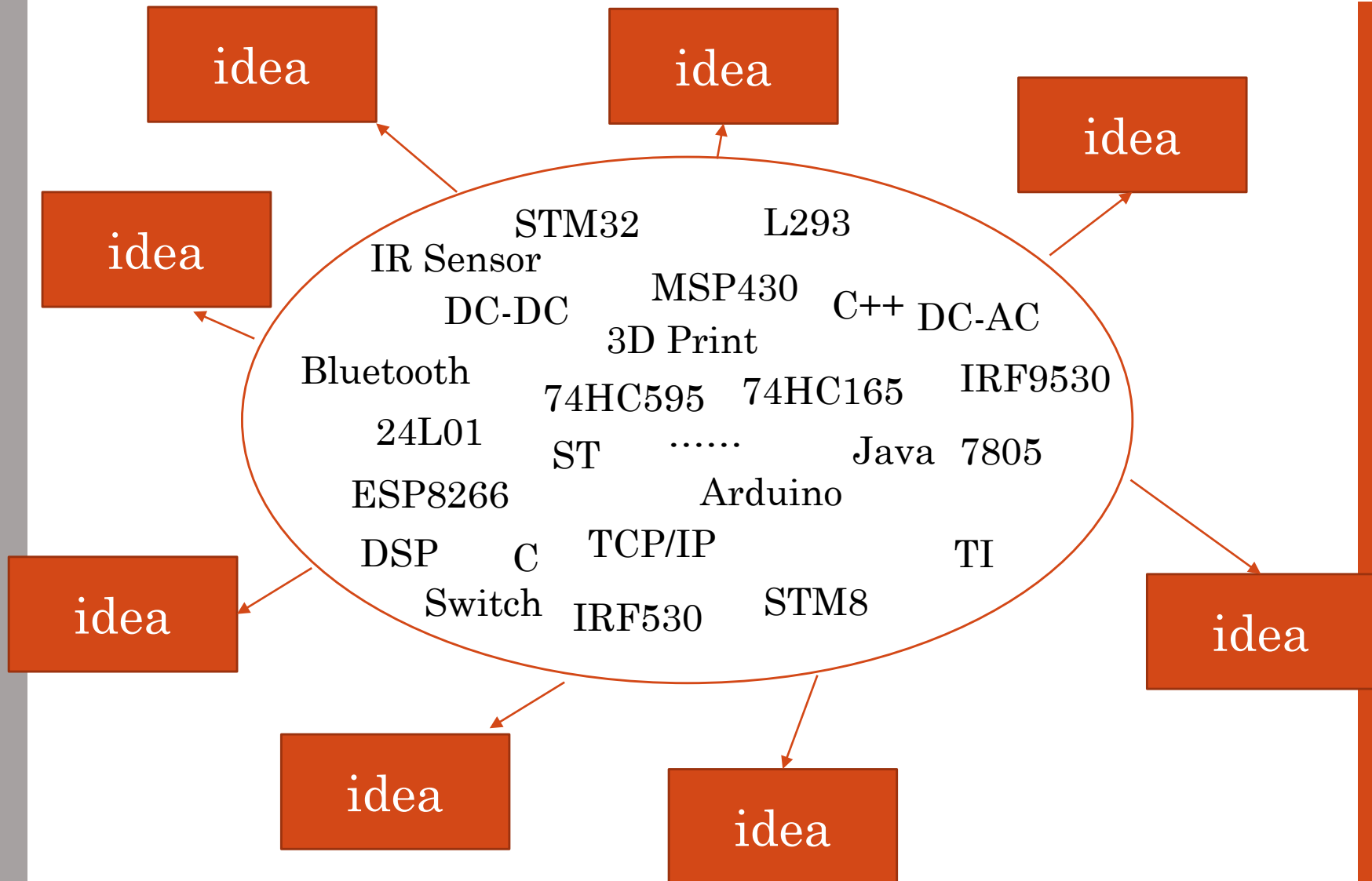
An idea

Search

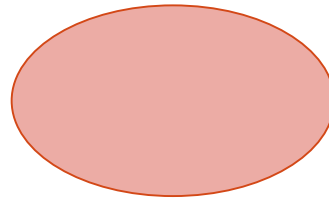




# Brainstorming



# Brainstorming





# Simulation and Verification

- **Simulation Software**
  - Multisim
  - Pspice
  - Proteus
- **Breadboard Verification**
  - Try each part
  - Find problems
  - Redesign



# PCB Schematic



- **Software:**
  - Altium designer
  - Cadsoft Eagle PCB
  - KiCad

# PCB Layout



- **Footprint**
  - Inline elements
  - Surface mount



# Test and Debug

- Write codes to test each function
- Debug codes
- Find problems of circuit
- Improve circuit and PCB board

# Thanks



- Email: [c@treee.com.cn](mailto:c@treee.com.cn)

TREEE Wechat



[www.treee.com.cn](http://www.treee.com.cn)

My Wechat



[www.feieee.com](http://www.feieee.com)