Esp32 energy Saving

IoT Low Power

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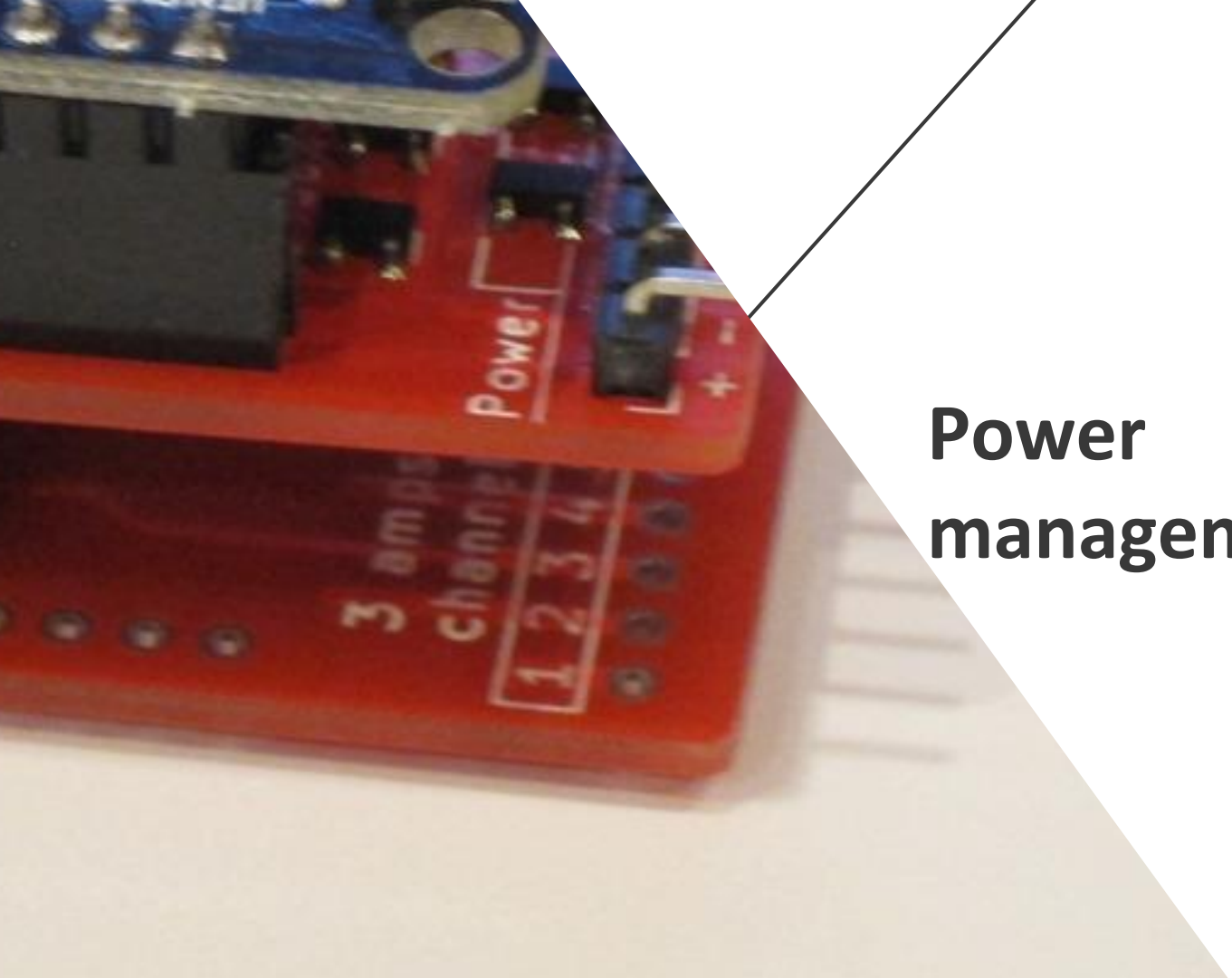
System Baterai

Goal

- Memahami low power management pada system IoT
- Mendesain dan implementasi low power IoT
- Membuat battery management dan deep sleep



01

Power management

Pengenalan

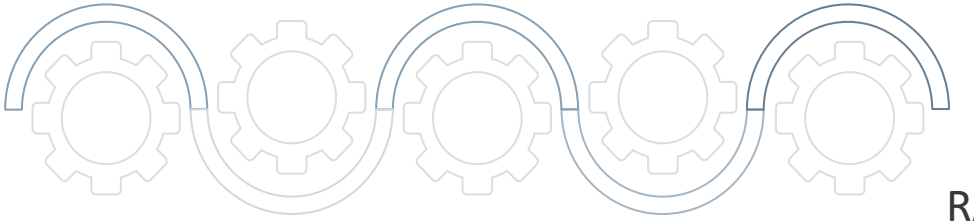
Metric design

POWER MANAGEMENT

Supply Daya menggunakan baterai, energy harvesting.

COMPLEXITY

Kemudahan desain dan development



CONNECTIVITY

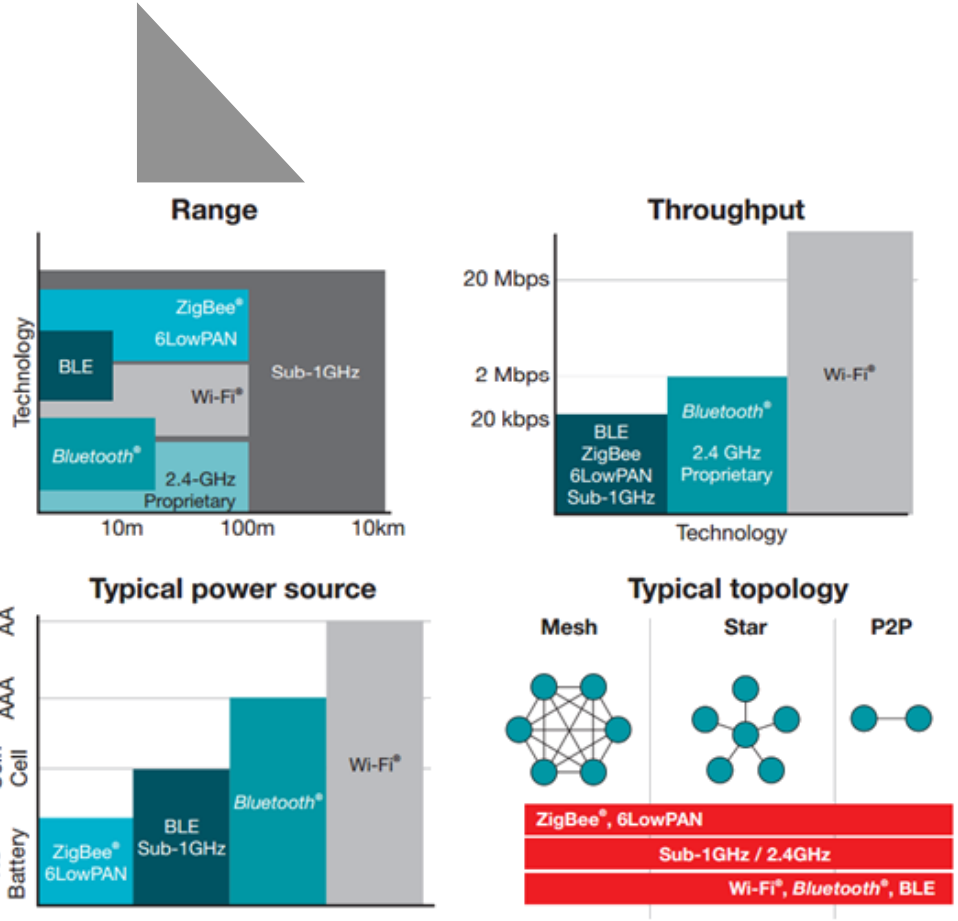
Banyak standar koneksi yang biasa digunakan tergantung dari kebutuhan

SECURITY

Hardware security dan protokol yang aman/secure.

RAPID EVOLUTION

Flexibilitas bisa digunakan di berbagai aplikasi



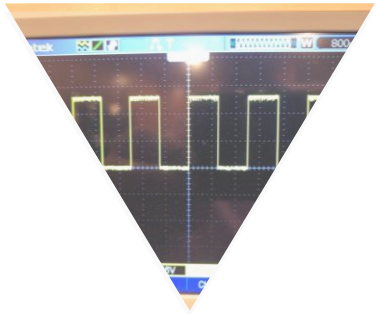
PARAMETER CONNECTIVITY

Range
Throughput
Power source
Topology

Trick for esp32

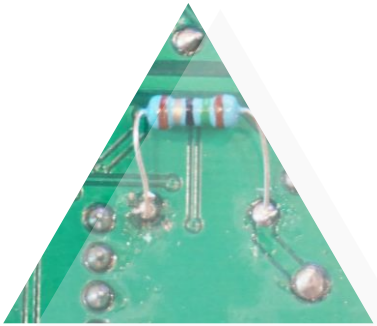
clock

Decrease clock rate



Sleep mode

Sleep mode ketika tidak ada process data



Hardware modification

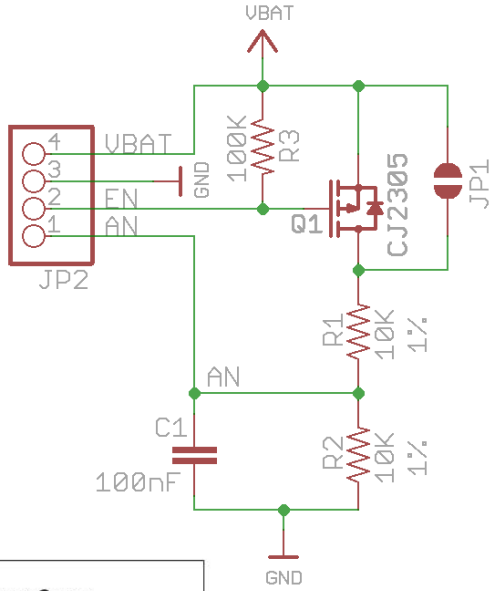
Komponen low power
Clock gatling
Energy harvesting

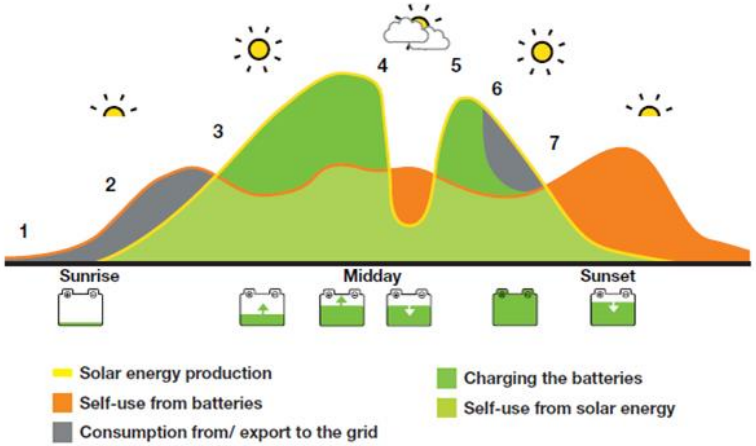
Software

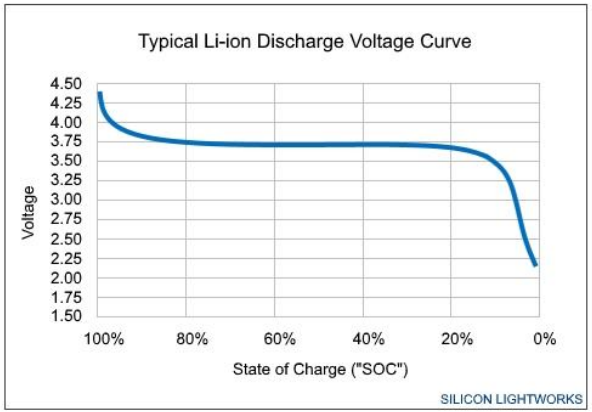
- Reduce the CPU frequence to minimum.
- Shut down second CPU core.
- Minimum code execution, max sleep time

Hardware

- Control Sensor (Clock gating), subsystem, ULP coprocessor
- Block power (LDO) – remove regulator (direct 3V)
- Energy harvester
- Brownout detection (Capacitor)
- Supercapacitor + battery



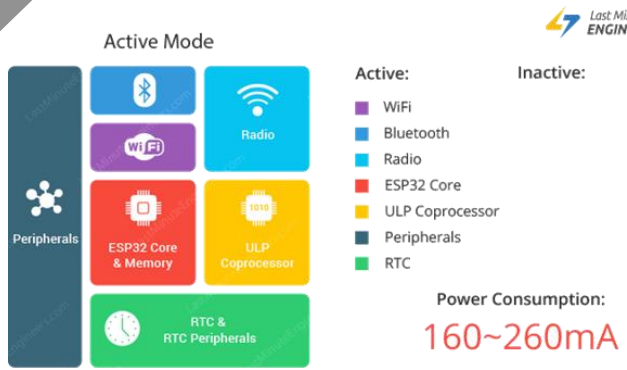




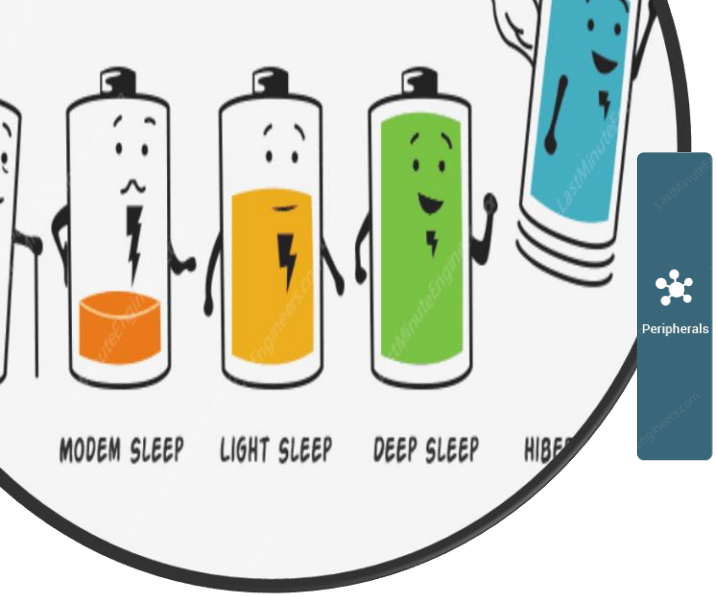
Deep sleep esp32

ESP32 sleep method

ESP32 Power Modes



- Active Mode
- Modem Sleep Mode
- Light Sleep Mode
- Deep Sleep Mode
- Hibernation Mode



Active Mode

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Modem Sleep

Active:
- WiFi
- Bluetooth
- Radio
- ESP32 Core
- ULP Coprocessor
- Peripherals
- RTC

Inactive:

Power Consumption:
160~260mA

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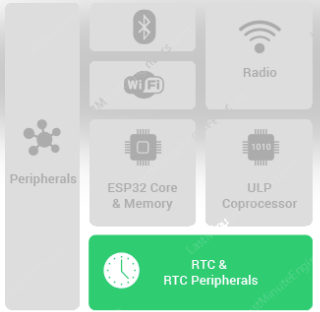
Active:
- ESP32 Core
- ULP Coprocessor
- RTC

Inactive:
- WiFi
- Bluetooth
- Radio
- Peripherals

Power Consumption:
3~20mA

Hibernation



Active:
- RTC

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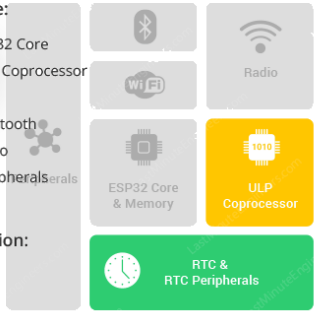
Deep Sleeep

Inactive:
- ESP32 Core
- ULP Coprocessor
- WiFi
- Bluetooth
- Radio
- Peripherals

Power Consumption:
2.5µA



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Light Sleep

Active:
- ULP Coprocessor
- RTC

Inactive:
- ESP32 Core
- WiFi
- Bluetooth
- Radio
- Peripherals

Power Consumption:
10µA

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Active:
- ULP Coprocessor
- RTC

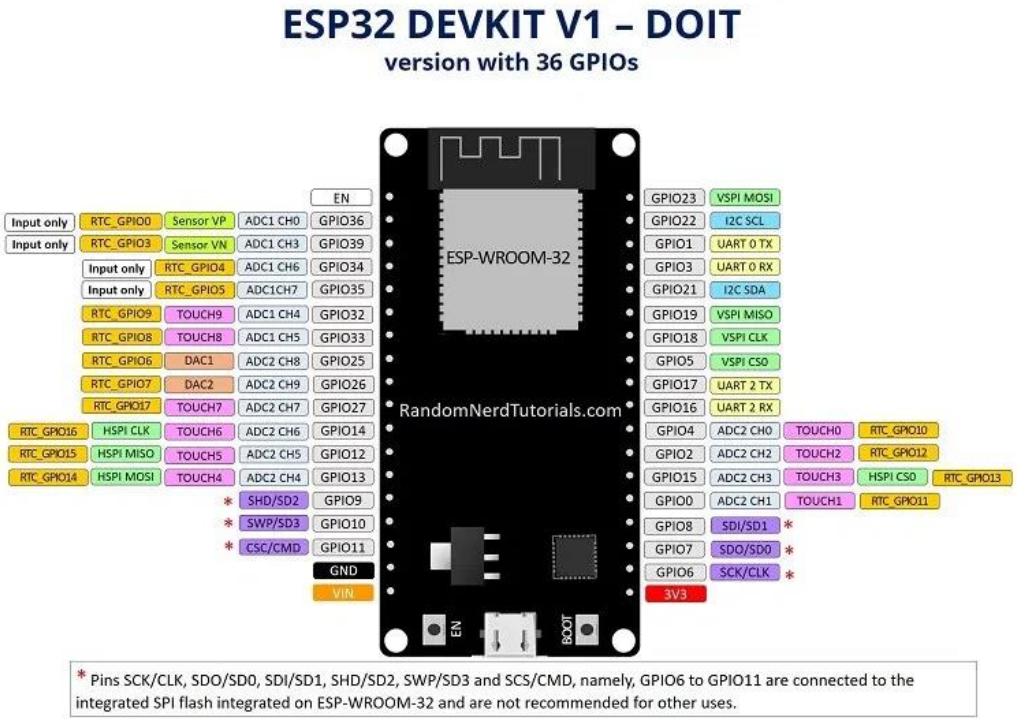
Paused:
- ESP32 Core

Inactive:
- WiFi
- Bluetooth
- Radio
- Peripherals

Power Consumption:
0.8mA

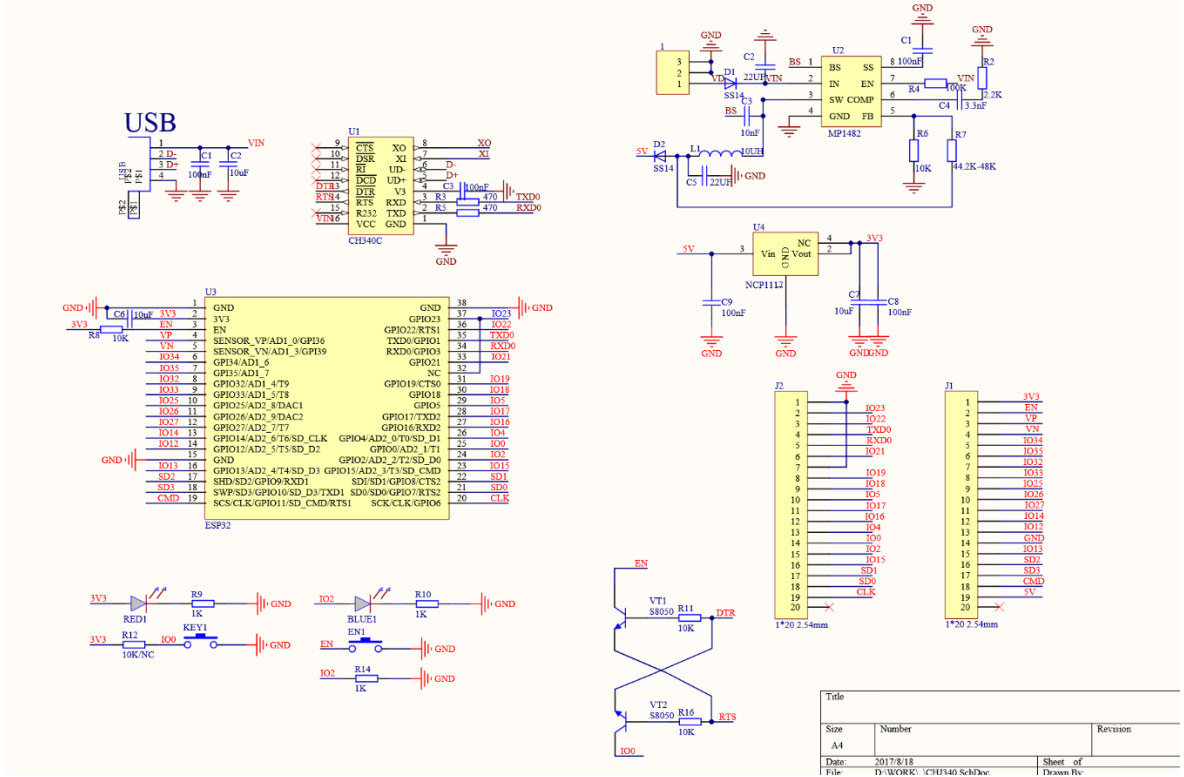
Wake Up Sources

Timer
Touch pins
External wake up
ULP co-processor



Hardware modification

Hardware Modification



Design ESP low power

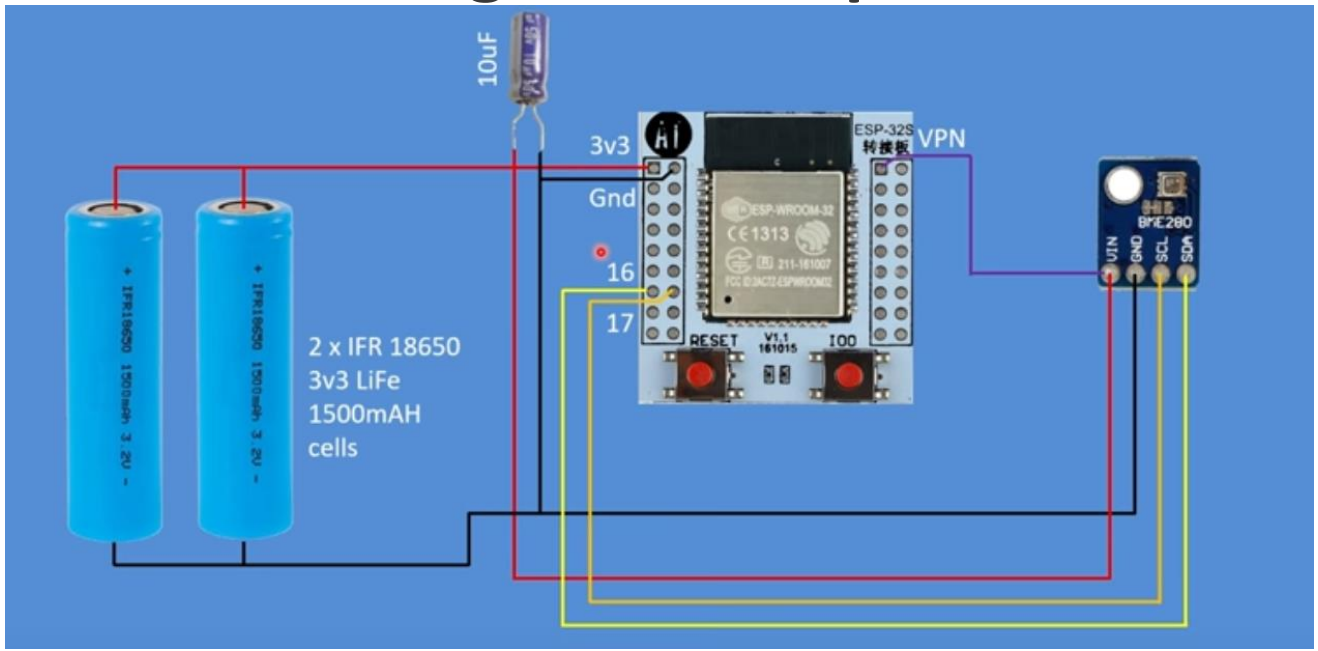
Software

Scale the **single** core frequency down to 80 MHz
Switch off with DPORT register directly
Minimum flash memory usage
Skip flash checking for every wakeup
Turn off/sleep peripheral (OLED, flash, SRAM)
ULP programming

Hardware

Redesign antenna (matching network)
Min hardware solution (no uart), no Regulator, no LED

Design ESP low power

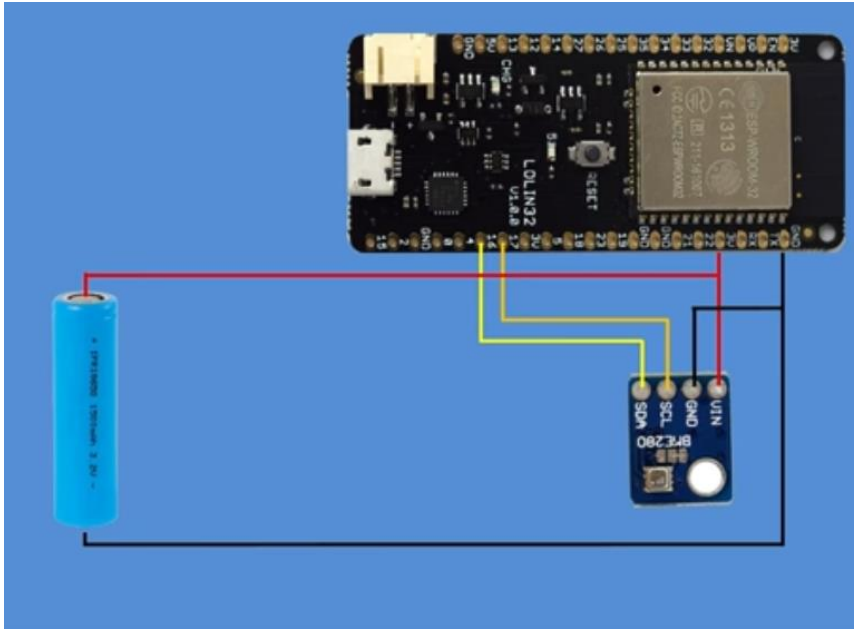


Hardware

Redesign antenna (matching network)

Min hardware solution (no uart), no Regulator, no LED

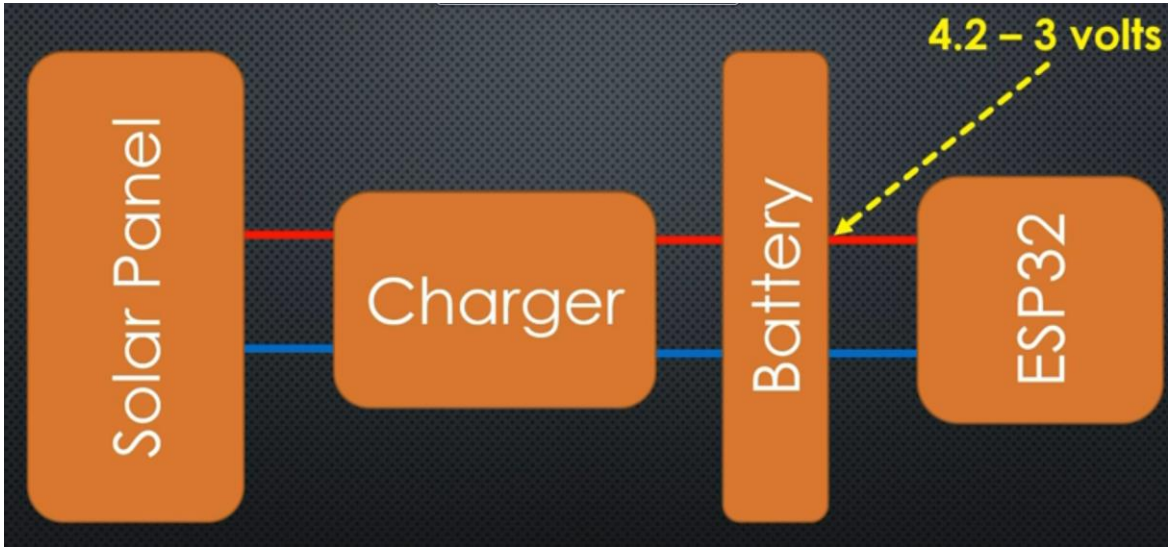
Wemos Lolin32 (Best Available board ESP32)



Condition	Wemos lolin32	General ESP32
DeepSleep 5v	0.235mA	11mA
DeepSleep 3.3v (unregulated)	0.235mA	11mA
Deepsleep 3.7V battery input terminal	128uA	

Battery system

Diagram block



Node Espnow Without sleep

Your results:

Your device will probably run for 12 hours or around less than a day

Its estimated, average power consumption per hour 130 mAh

Software

duration of code execution: 1 sec

sleep time: 0 sec

Hardware

consumption during code execution: 130 mA

consumption in sleep mode*: 0 µA

Battery

power of battery: 2000 mAh

discharge safety: 20 %

Code Diff using sleep timer

- RTC store data
- Init sleep timer (waker)
- Function to print cause of wake up
- Sleep command in main program

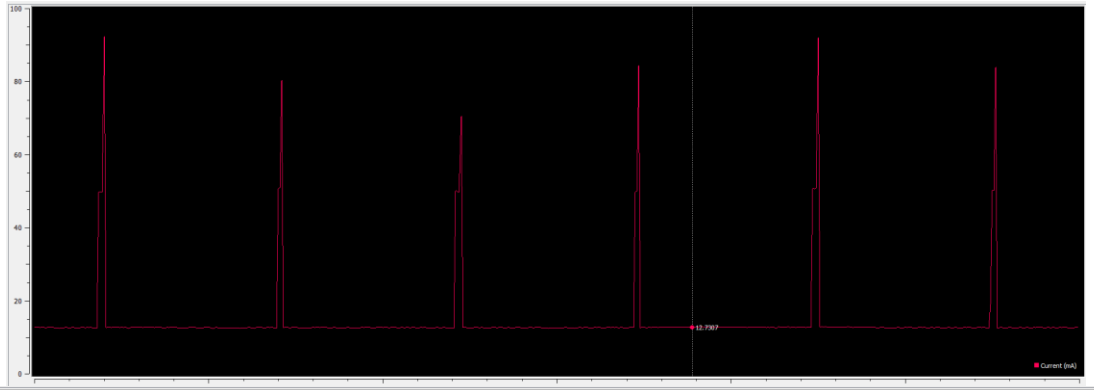
```
RTC_DATA_ATTR int bootCount = 0;
```

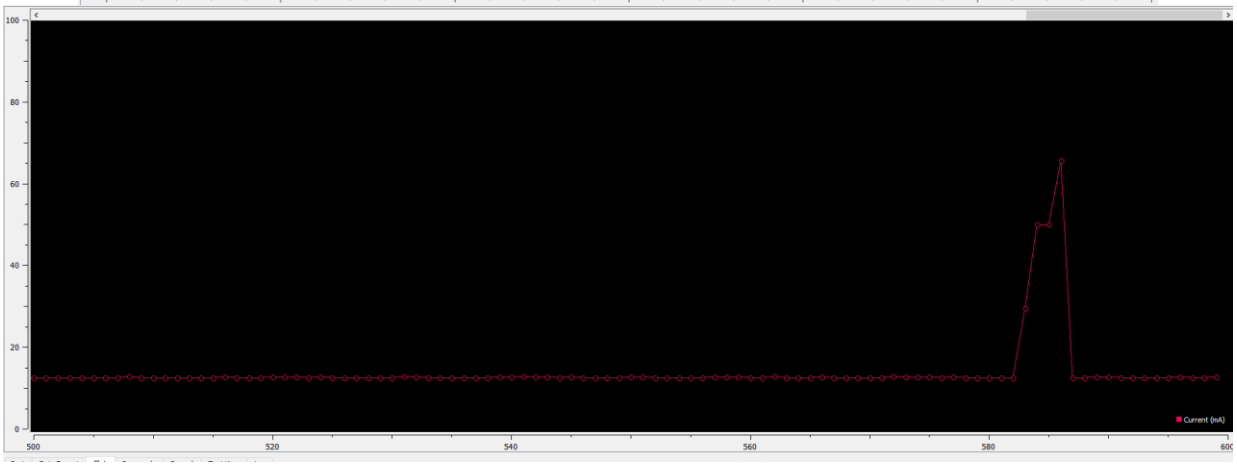
```
esp_sleep_enable_timer_wakeup(time_in_us)
```

```
void print_wakeup_reason()
```

```
esp_deep_sleep_start()
```

Node espnow With sleep





Node espnow With sleep

Your results:

Your device will probably run for 108 hours or around 4 days and 12 hours

Its estimated, average power consumption per hour 14.76 mAh

Software

duration of code execution: 0.5 sec

sleep time: 10 sec

Hardware

consumption during code execution: 60 mA

consumption in sleep mode*: 12.5 mA

Battery

power of battery: 2000 mAh

discharge safety: 20 %

Node espnow With sleep

Sleep time (second)	Power/hour (mAh)	Time run
No sleep	130	12 hours
10	14.76	4 days and 12 hours
60 (1 min)	12.89	5 days and 4 hours
300 (5 min)	12.58	5 days and 7 hours
3600 (1 hour)	12.51	5 days and 7 hours

Code Diff using touch wake up

- RTC store data
- Init touchpin and threshold sensitivuty (waker
- Function to print cause of wake up
- Sleep command in main program

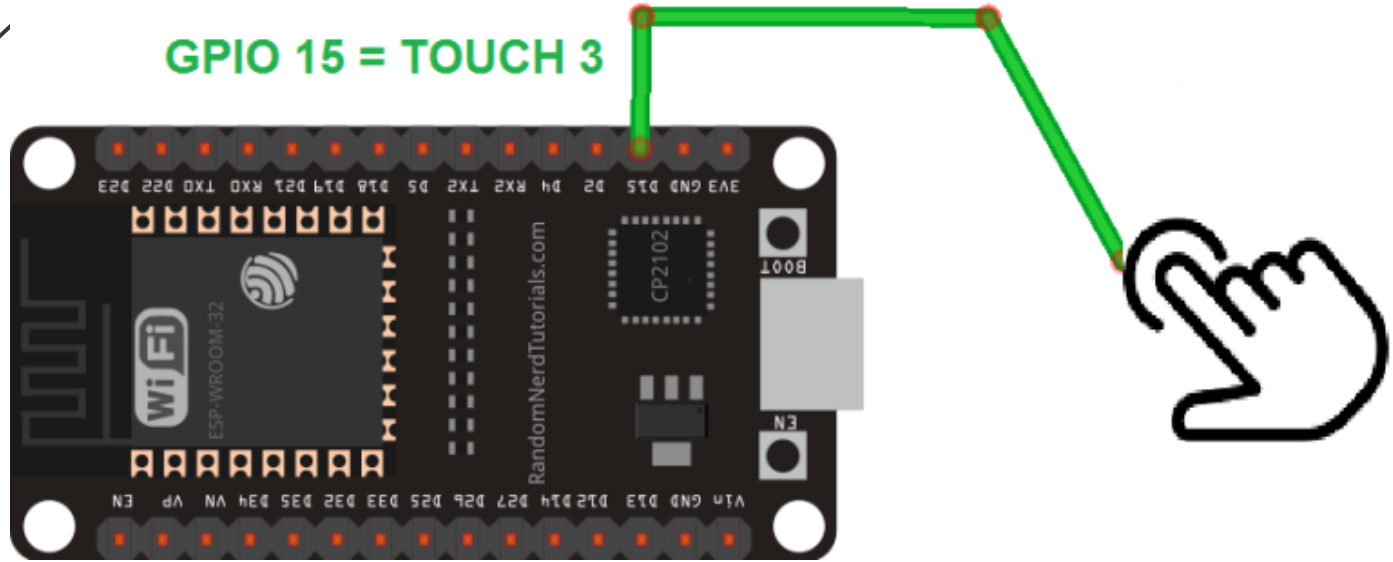
```
RTC_DATA_ATTR int bootCount = 0;
```

```
#define Threshold 40
```

```
touchAttachInterrupt(T3, callback, Threshold);
```

```
void print_wakeup_reason()
```

```
esp_sleep_enable_touchpad_wakeup()
```


GPIO 15 = TOUCH 3
3V3 GND D15 D2 D4 RX2 TX2 D5 D18 D19 D21 RX0 TX0 D22 D23
EN VP VN D34 D35 D32 D33 D25 D26 D27 D14 D12 D13 GND Vin
BOOT
EN
CP2102
RandomNerdTutorials.com
ESP-WROOM-32
Wi Fi

Thanks

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- Mid shot woman at laptop
- Worried woman looking at phone
- Woman jumping and holding a camera
- African american man high view
- Girls dancing
- Front view guy with headphones holding a cup of coffee
- African american man reading his notes close-up
- Adorable model holding glasses

Resources

- Man with black jacket talking on a phone and drinking
- Woman jumping and using her camera photo
- Alluring woman posing in yellow top
- African american man copy space
- Man posing with arms crossed
- Woman holding a camera photo
- Side view of male photographer
- African american man writing
- Man with black jacket talking on the phone
- African american man front view
- Young girl speaking on the phone in the office
- Young man wearing eyeglasses using laptop on kitchen counter
- Mid shot woman talking on phone at table

Resources

- Front view of older woman working with pen
- Stylish model pointing at phone
- Studio shot of woman posing
- Guy sitting on a chair and holding a digital tablet
- Portrait freelance woman working from home
- Front view of businesswoman working with laptop and notebook

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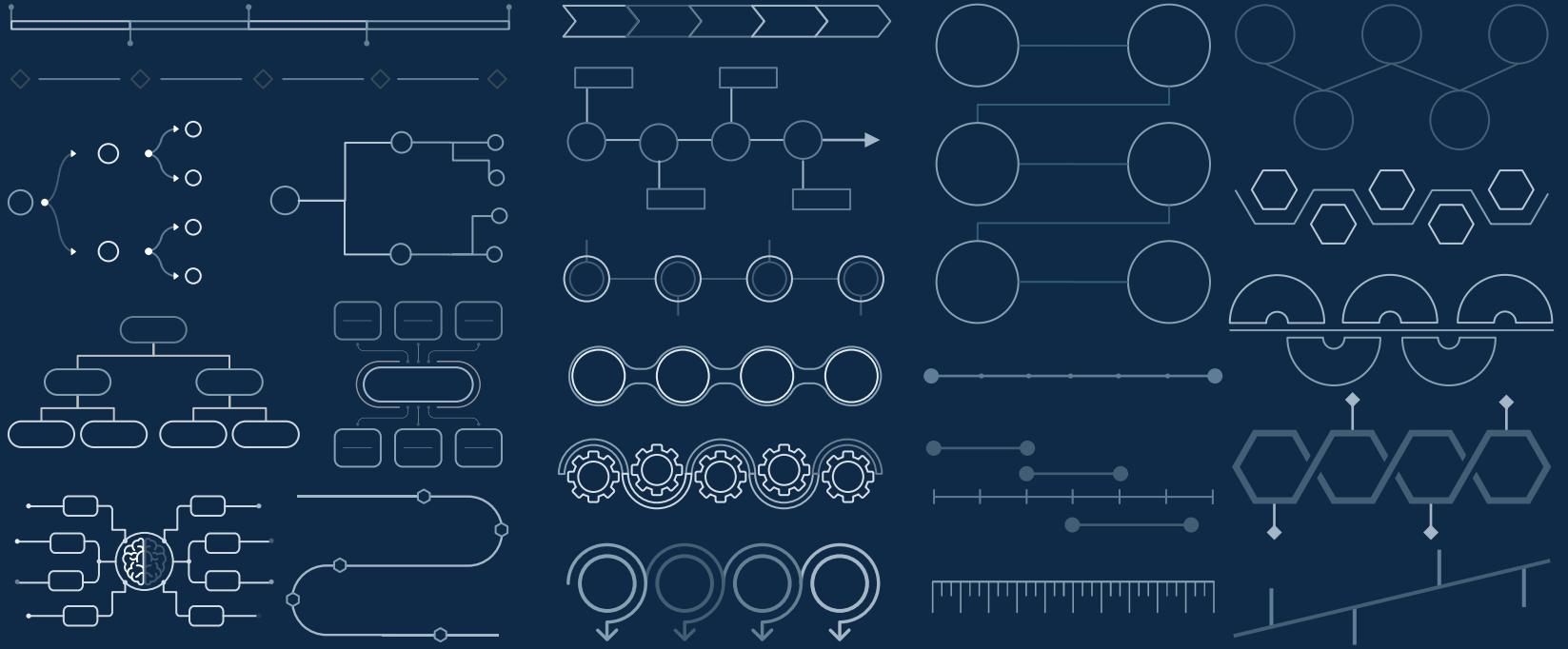

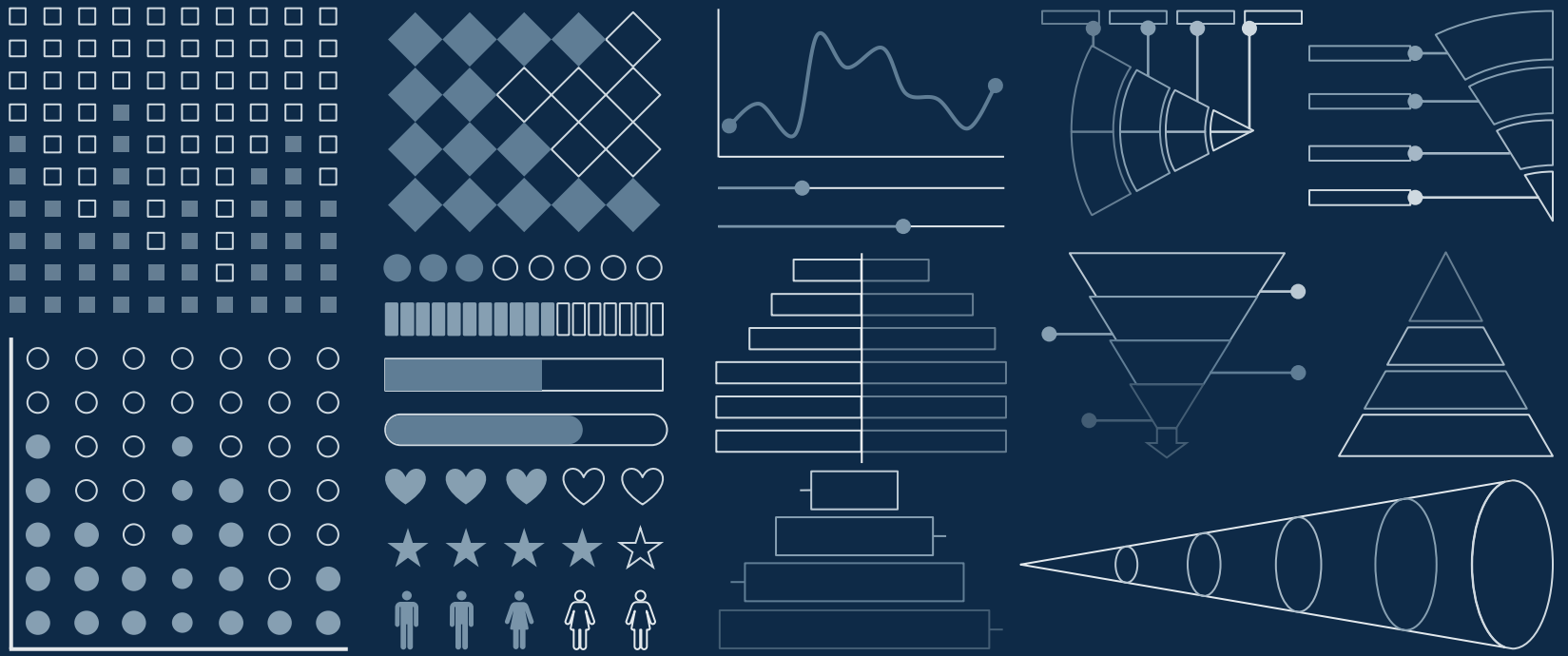

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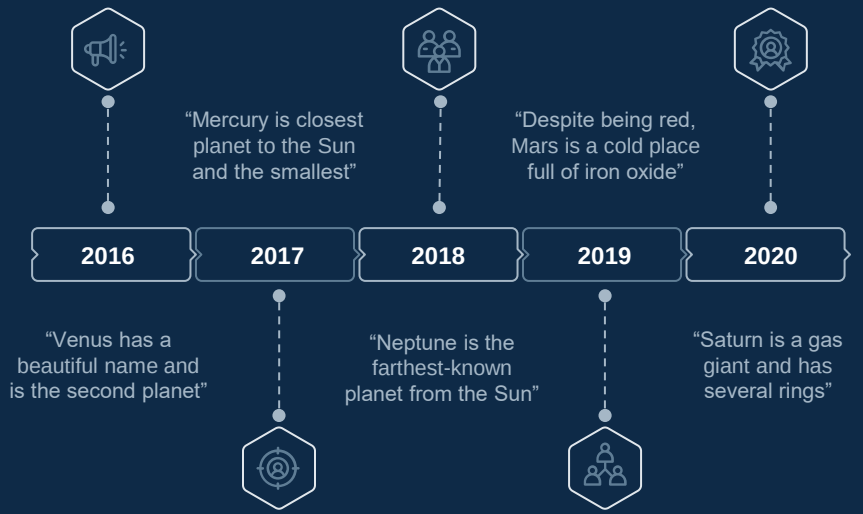

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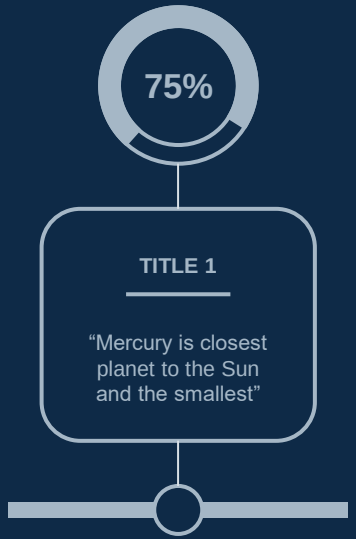

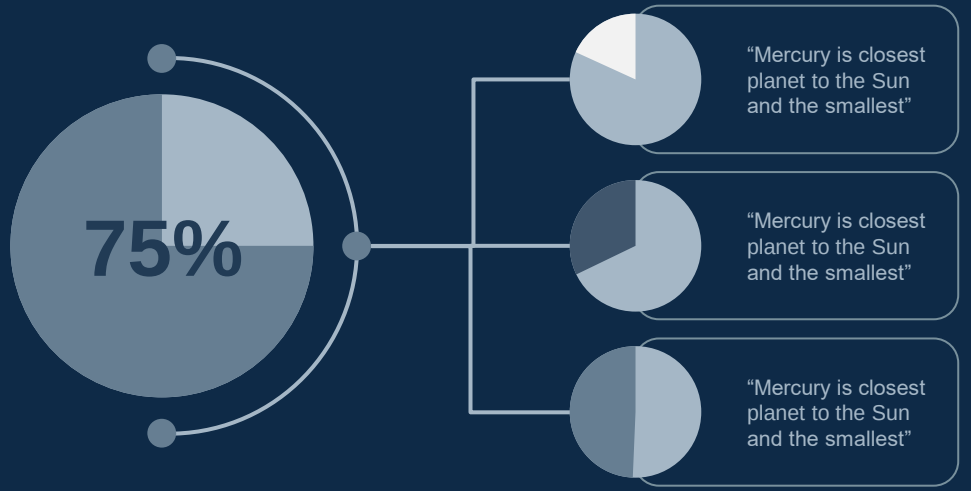

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