Node System Documentation

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June 8, 2021

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1 Introduction

As part of the Engineers without Borders challenge we were tasked with coming up with a solution to a problem that the people of Lobitos and Periditas in Peru, face. Among those described within the document we chose to focus on their water supply; which they have problems with water tapping and sanitisation. Our team's application works in conjuncture with a network of nodes that log data about their respective areas, allowing workers to locate the areas with problems more effectively and reducing the man hours needed to find and fix regularly occurring problems

2 Device

The nodes within the network can work on a plethora of IoT devices all with their benefits and draw backs, a few will be mentioned here however, the key requirements will be network capabilities and data storage connectivity such as an SD card. Systems such as these are designed to be as cost effective as possible however, this will largely be beyond the scope of this project as the development and documentation will be on development versions of the ESP32 and ESP8266 which provide a much simpler and easier interface but with elements unnecessary to this project.

2.1 Boards — Found here

The are a wide range of network orientated boards available all with different benefits, features and costs. The ESP series of boards is among the most popular and as the project was developed on two of these boards (ESP32 and ESP2866) this report will also look at others from the same family. Both boards used in this project were already sourced and were not chosen specifically for it, as such the ESP32 was chosen to be the bridge node due to it's dual core processor and the ESP8266 was chosen to be the logging node for its lower cost.

When deciding for the data logging node the main features we are looking for is enough RAM to handle a single request at a time. As an we are going to take the formatting of a response and assume that all measurements are floats or longs (4 bytes on a 32-bit machine), with the formatting $''''ticket'' :' [ticket - num] : [r_1, r_2, r_3, r_4, r_5, r_6], \ldots''$ — the ticket system is explained later in this document

Starting the request with ''`{''ticket''`: requires 11 characters.

Ending the request with `}`'' requires 2 characters.

The unix timestamp ''`[timestamp]:`'' requires a total of 13 characters.

Each log is comprised of 6 longs/floats with brackets and commas although these will be captured as longs or floats the precision needed can be changed and each sensor reading has max realistic values. The expected readings are described further later in this document but a minimum total of 19 characters are expected to be used.

Readings In total this system requires $45 + 32(n - 1)$ characters, where n is the number of readings.

With the ESP8266 used in this project this would allow for ~1124 logs to be sent at one time, now this of course ignores the board using RAM for other uses and assumes — with a 1 minute logging interval — that the user waits over 18 hours to record and store the devices readings. If the user reguarly polls each node on the network then using this board will not be a problem however, it will produce more network traffic which could slow down the network. Two solutions to this problem are as follows

- Using a board with higher RAM

  - The main issue with this is allowing for larger requests that then have to be dealt with through the bridge node, if this isn't handled properly then the bridge node may crash and reboot — losing all other current requests.

- Sending requests in chunks

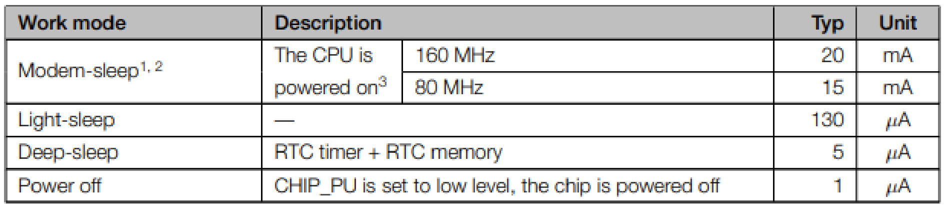
  - The bridge node currently store requests in RAM however, the if the number of requests is too much for the boards RAM then they can be stored and read on an SD card instead, this will reduce response time but will help to prevent memory overflows along with proper checks in place. This allows allows for the logging nodes to have smaller RAM sizes and potentially be less costly.

Table 1: Comparison of key features between ESP models

	ESP32-C3	ESP32-S2	ESP32	ESP8285	ESP8266
CPU	Single core, 160MHz	Single core, 240MHz	Dual core, 160 or 240 MHz	Single core, 80MHz (up to 160MHz)	Single core, 80MHz (up to 160MHz)
RAM	400KB	320KB	520KB	160KB	160KB (36KB user)
ESP-MESH	Yes	Yes	Yes	Yes	Yes
WiFi	802.11b/g/n	802.11b/g/n	802.11b/g/n	802.11b/g/n (up to 65Mbps)	802.11b/g/n (up to 65Mbps)
SPI	3	4	4	2	2
Security	secure boot, flash encryption	secure boot, flash encryption	secure boot	x	x

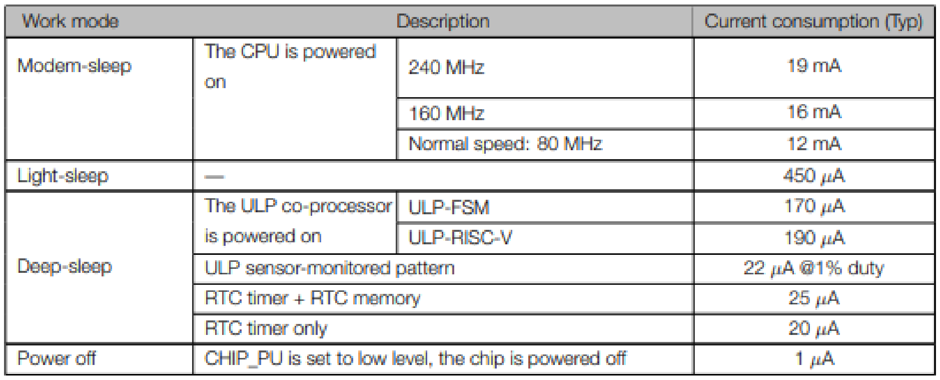
Power Consumption ::

- ESP32-C3



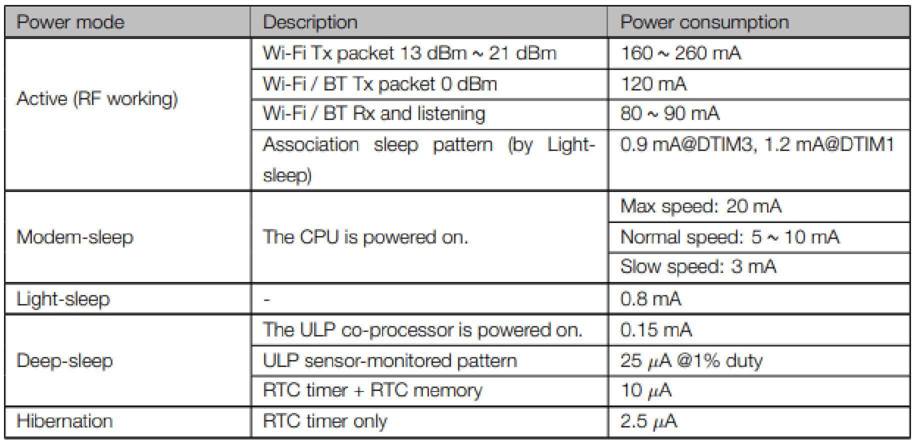
Work mode	Description		Typ	Unit
Modem-sleep[1, 2]	The CPU is powered on[3]	160 MHz	20	mA
		80 MHz	15	mA
Light-sleep	—		130	μA
Deep-sleep	RTC timer + RTC memory		5	μA
Power off	CHIP_PU is set to low level, the chip is powered off		1	μA

- ESP32-S3



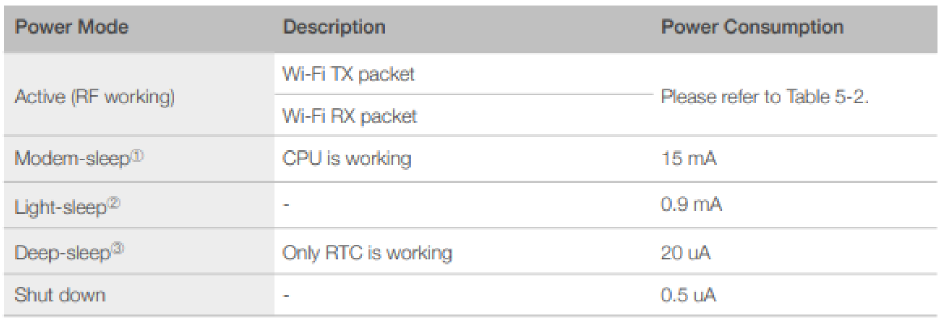
Work mode	Description		Current consumption (Typ)
Modem-sleep	The CPU is powered on	240 MHz	19 mA
		160 MHz	16 mA
		Normal speed: 80 MHz	12 mA
Light-sleep	—		450 μA
Deep-sleep	The ULP co-processor is powered on	ULP-FSM	170 μA
		ULP-RISC-V	190 μA
	ULP sensor-monitored pattern		22 μA @1% duty
	RTC timer + RTC memory		25 μA
	RTC timer only		20 μA
Power off	CHIP_PU is set to low level, the chip is powered off		1 μA

- ESP32



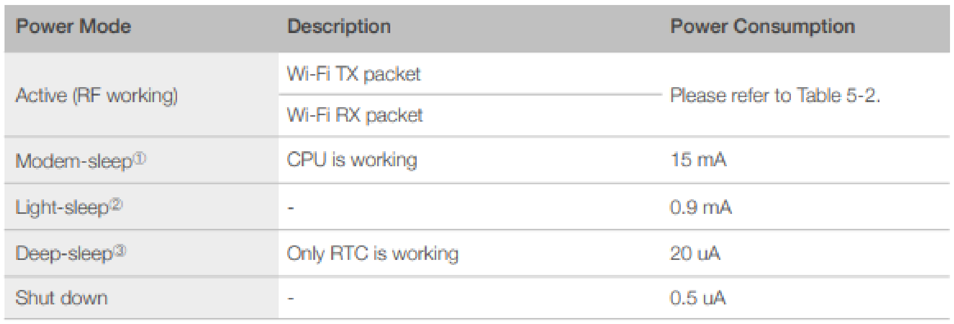
Power mode	Description	Power consumption
Active (RF working)	Wi-Fi Tx packet 13 dBm ~ 21 dBm	160 ~ 260 mA
	Wi-Fi / BT Tx packet 0 dBm	120 mA
	Wi-Fi / BT Rx and listening	80 ~ 90 mA
	Association sleep pattern (by Light-sleep)	0.9 mA@DTIM3, 1.2 mA@DTIM1
Modem-sleep	The CPU is powered on.	Max speed: 20 mA
		Normal speed: 5 ~ 10 mA
		Slow speed: 3 mA
Light-sleep	-	0.8 mA
Deep-sleep	The ULP co-processor is powered on.	0.15 mA
	ULP sensor-monitored pattern	25 μA @1% duty
	RTC timer + RTC memory	10 μA
Hibernation	RTC timer only	2.5 μA

- ESP8285



Power Mode	Description	Power Consumption
Active (RF working)	Wi-Fi TX packet	Please refer to Table 5-2.
	Wi-Fi RX packet	
Modem-sleep[1]	CPU is working	15 mA
Light-sleep[2]	-	0.9 mA
Deep-sleep[3]	Only RTC is working	20 uA
Shut down	-	0.5 uA

- ESP8266



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Shut down	-	0.5 uA

2.1.1 ESP32

2.1.2 ESP8266

2.2 Sensors

- Turbidity
- Total Dissolved Solids (TDS)
- Pressure
- Flow rate
- pH
- Temperature

3 Network

3.1 Documenation

3.2 HTTP vs MQTT

3.3 LoRa