Project Integration
Research Applied Computer Science

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Group 1

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Contents

Abbreviations

ACS	Applied Computer Science.
AIoT	Artificial Intelligence of Things.
HTTP	Hypertext Transfer Protocol.
SDK	Software Development Kit.

Glossary

Bluetooth A short-range wireless interconnection of mobile phones, computers, and other electronic devices.

WiFi A wireless networking technology that uses radio waves to provide high-speed Internet access.

References

Espressif. (n.d.). *About Espressif.* https://www.espressif.com/en/company/about-espressif.

1 Introduction

As part of Project Integration, Applied Computer Science (ACS) students need to conduct research about the ESP32 microcontroller. Upon completion of this research, a set of assignments have to be completed. First, some introductory assignments in order to familiarize ourselves with concepts that are important for the project, followed by a final assignment that goes more in depth into specific topics that are of value for our final product.

2 The ESP32

The ESP32 is a microcontroller developed by Espressif. The ESP32 has integrated WiFi and Bluetooth modules.

3 Espressif

Espressif Systems is a multinational semiconductor company that focusses among other things on developing wireless communication and Artificial Intelligence of Things (AIoT) (Espressif, n.d.). Popular products Espressif created, are the ESP32 series of chips, development boards, and modules (Espressif, n.d.). Espressif supports various open-source software projects such as Software Development Kits (SDKs), libraries, and tools.

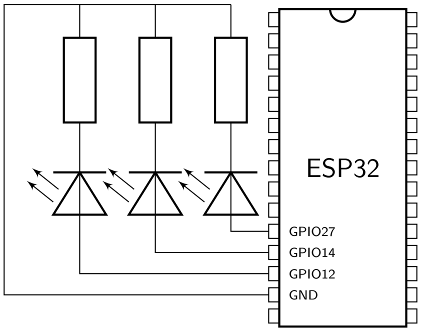
4 Lilygo

5 Assignment 1

Show that the ESP32 can turn three different LEDs on and off seperately using an internal loop with delays.

5.1 Circuit

For this assignment, the circuit used is quite straightforward. Connect three LEDs to the ESP32, put these LEDs in series with a resistor, and connect them to a common ground. For all subsequent assignments, it can be assumed that the same circuit is used unless explicitly stated otherwise.



5.2 Toolchain

For this assignment, I have used the ESP-IDF toolchain. This assignment was done using the ESP-IDF toolchain.

5.3 Software

```
#include <array>
#include <chrono>
#include <ranges>
#include <thread>

#include "driver/gpio.h"
#include "rom/gpio.h"

extern "C" void app_main() {
    const std::array<gpio_num_t, 3> led_pins{
        GPIO_NUM_12,
        GPIO_NUM_14,
        GPIO_NUM_27,
    };

    // configure the pins for output
    for (auto pin : led_pins) {
        gpio_pad_select_gpio(pin);
        gpio_reset_pin(pin);
        gpio_set_direction(pin, GPIO_MODE_OUTPUT);
    }

    // blink individual LEDs indefinitely
    for (auto pin : std::views::join(std::views::repeat(led_pins))) {
        gpio_set_level(pin, 1);
        std::this_thread::sleep_for(std::chrono::seconds{1});
        gpio_set_level(pin, 0);
    }
}
```

6 Assignment 2

Show that the ESP32 can turn three different LEDs on and off separately by sending commands over the serial interface.

6.1 Toolchain

Just like the previous one, for this assignment I have used the ESP-IDF toolchain. The ESP-IDF toolchain provides good C++ support. From the UART can be read using `std::cin`, but to get the usual behaviour, our program needs to initialize the UART driver first.

6.2 Software

```cpp
#include <iostream>
#include <map>
#include <ranges>

#include "driver/gpio.h"
#include "driver/uart.h"
#include "esp_vfs_dev.h"
#include "rom/gpio.h"

void toggle(gpio_num_t pin) {
    int level = gpio_get_level(pin) ^ 1;
    gpio_set_level(pin, level);
}

extern "C" void app_main() {
    // configure stdin to use blocking mode
    setvbuf(stdin, nullptr, _IONBF, 0);
    constexpr auto uart_num = CONFIG_ESP_CONSOLE_UART_NUM;
    uart_driver_install(static_cast<uart_port_t>(uart_num), 256, 0, 0, nullptr, 0);
    esp_vfs_dev_uart_use_driver(uart_num);

    const std::map<char, gpio_num_t> led_pins{
        {'0', GPIO_NUM_12},
        {'1', GPIO_NUM_14},
        {'2', GPIO_NUM_27},
    };

    // configure the pins for input and output
    for (auto pin : led_pins | std::views::values) {
        gpio_pad_select_gpio(pin);
        gpio_reset_pin(pin);
        gpio_set_direction(pin, GPIO_MODE_INPUT_OUTPUT);
    }

    for (char ch : std::views::istream<char>(std::cin)) {
        if (auto it = led_pins.find(ch); it != led_pins.end()) {
            toggle(it->second);
        }
    }
}
```

7 Assignment 4

Show that the ESP32 can turn three different LEDs on and off separately. Connect the ESP32 to a WiFi access point and host a webserver on the ESP32 to control the LEDs.

7.1 Toolchain

7.2 Software

https://github.com/jochemarends/project-integration/tree/main/leds-wifi

8 Final Assignment

For the final assignment, I'm managing a database using SQL and will insert data using an ESP32. I chose this assignment because there's a high chance the ESP32 has to communicate with a database in the final product.

8.1 Software Architecture

The software exists of three major components, The ESP32 which acts as an Hypertext Transfer Protocol (HTTP) client, a HTTP server, and a database, of which the HTTP server and the database are hosted a Raspberry Pi.