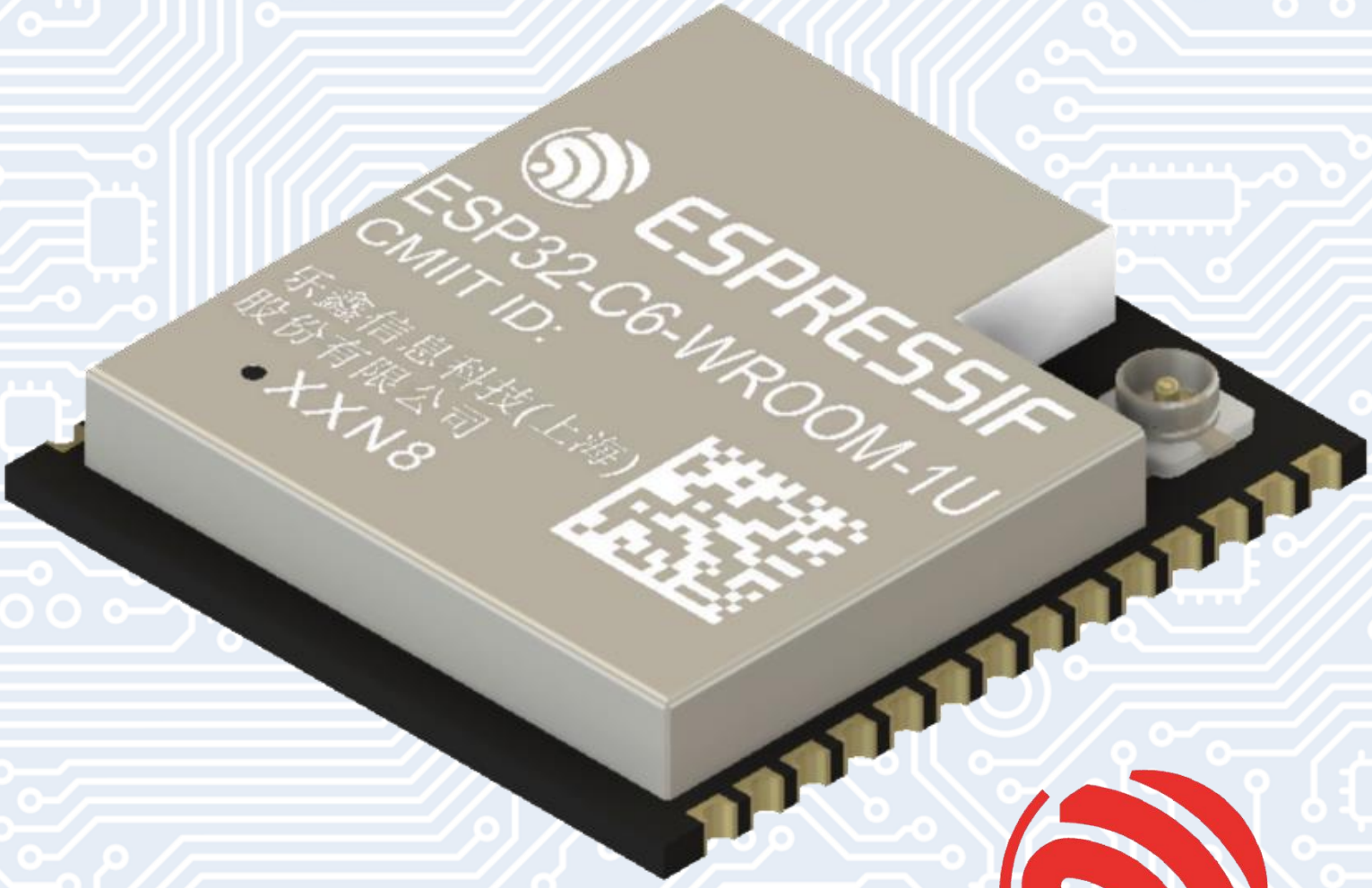
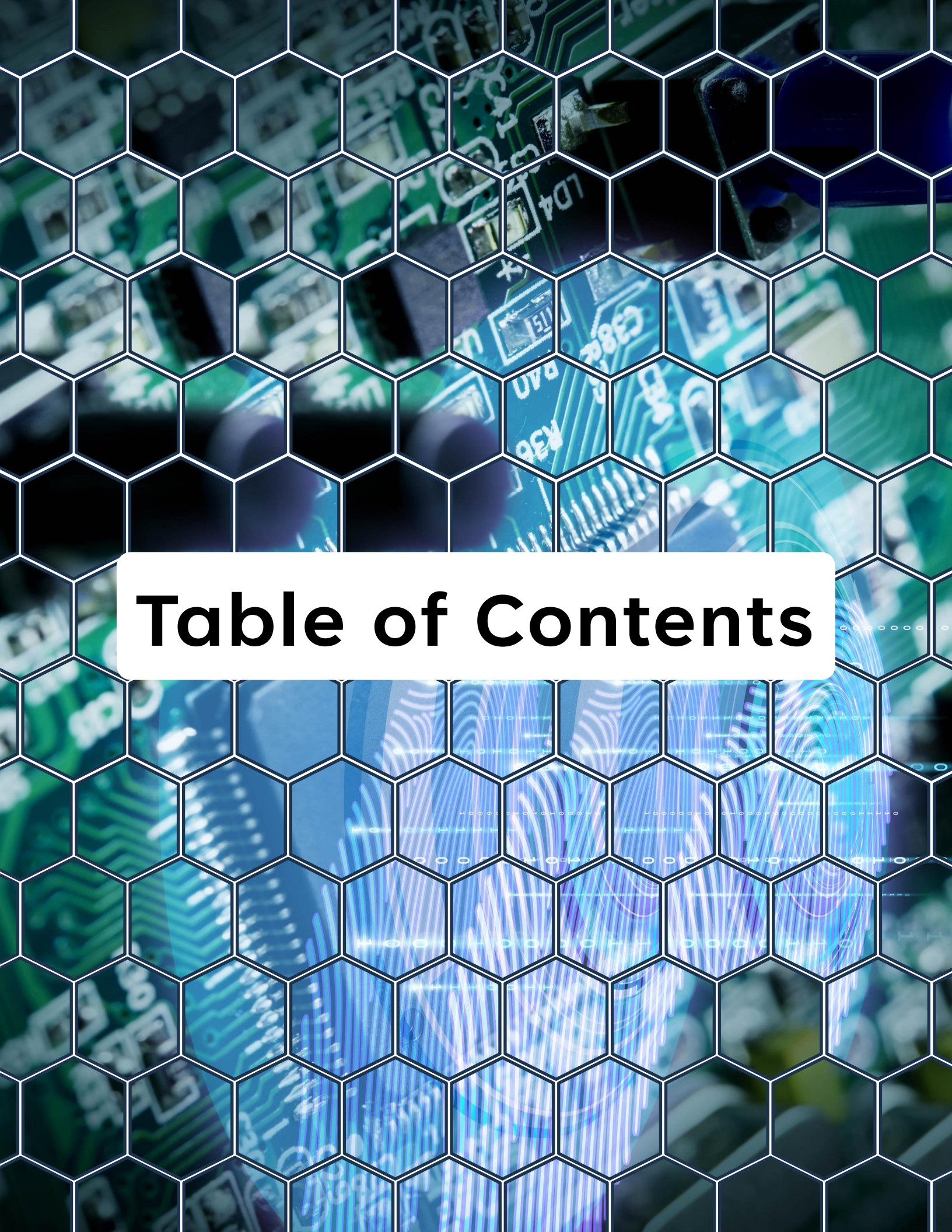
How to Create and Use a Software Timer with ESP32 and ESP-IDF Framework



freeRTOS

ESP-IDF



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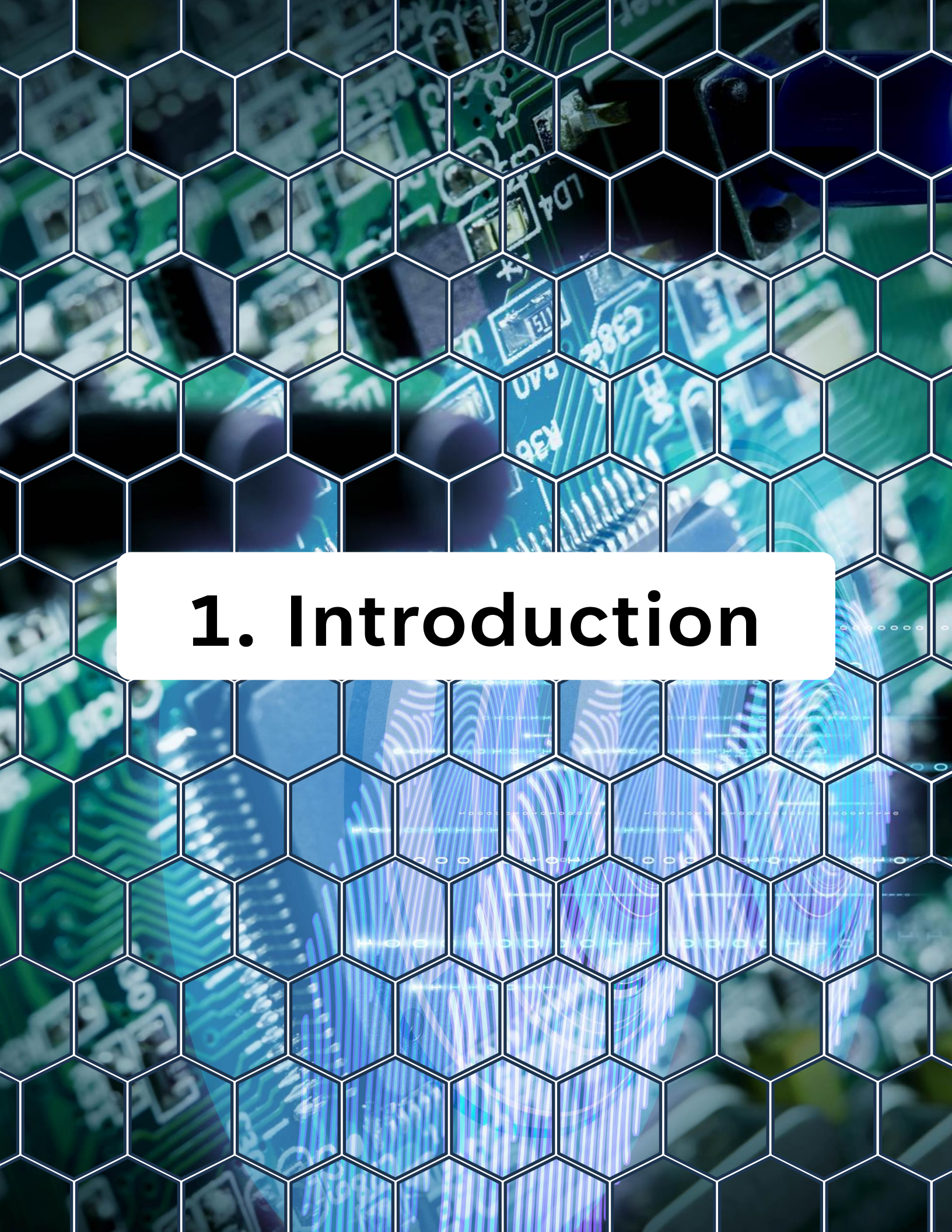

1. Introduction

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In modern IoT applications, timing is everything. Whether it's blinking LEDs, reading sensors periodically, or managing communication timeouts, software timers are a critical building block.

In this article, we will explore how to create and use software timers in the **ESP-IDF** framework on the **ESP32** microcontroller — a platform renowned for its versatility and robustness in IoT development.

2. What is a Software Timer?

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A **Software Timer** is a timer managed by the **FreeRTOS kernel** rather than by hardware peripherals. Instead of using a dedicated hardware timer, software timers allow you to schedule the execution of a callback function after a specified period — either once or periodically — without consuming critical hardware resources.

In ESP-IDF, FreeRTOS software timers are extensively used to implement non-blocking periodic or delayed tasks.

3. Why Use Software Timers in IoT Applications?

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Software timers provide:

- **Resource efficiency**: Save precious hardware timers for time-critical operations.
- **Flexibility**: Easy to create, start, stop, and manage dynamically.
- **Simplicity**: No need to handle interrupts manually.
- **Portability**: Code written with software timers is easier to migrate across platforms.

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Typical use cases include:

- Periodic sensor data reading
- Triggering watchdog resets
- Managing communication timeouts
- Delaying execution of non-critical operations

4. Steps to Create and Use a Software Timer

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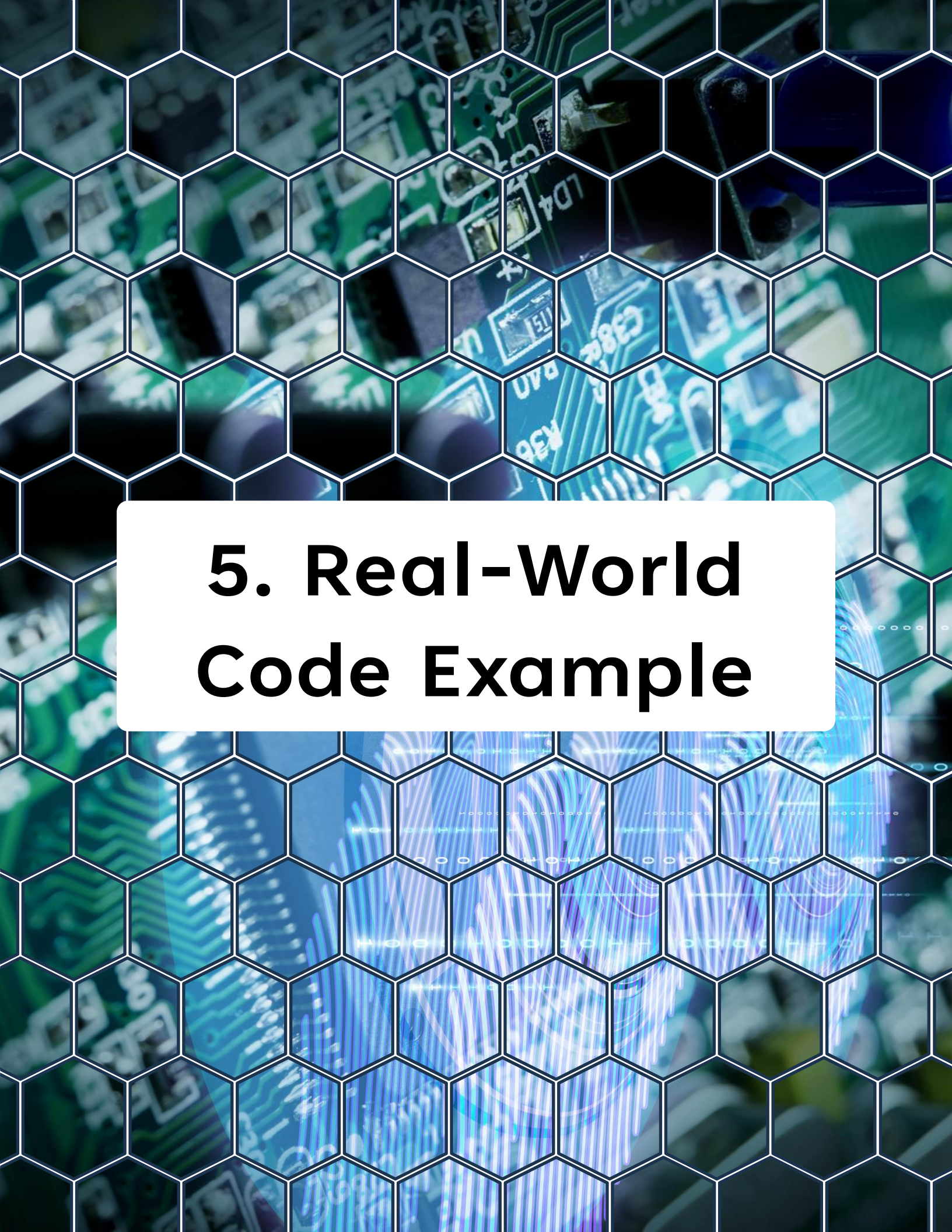
Here’s the basic process when working with software timers in ESP-IDF:

- **Define the timer callback function**: The function to execute when the timer expires.
- **Create the timer**: Using `xTimerCreate()`.
- **Start the timer**: Using `xTimerStart()`, optionally with a timeout.
- **Optionally stop/reset/change period**: Using corresponding FreeRTOS timer APIs like `xTimerStop()`, `xTimerReset()`, etc.



5. Real-World Code Example

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Let’s implement a software timer that toggles an LED every 2 seconds.

```c
#include <stdio.h>
#include "freertos/FreeRTOS.h"
#include "freertos/task.h"
#include "freertos/timers.h"
#include "driver/gpio.h"
#include "esp_log.h"

// Define LED GPIO
#define LED_GPIO GPIO_NUM_2

// Global variable declaration
TimerHandle_t blink_timer;  // Timer Handle
static const char *TAG = "Software Timer Example";

// Timer Callback Function
void blink_timer_callback(TimerHandle_t xTimer) {
    // Toggle the LED
    static bool led_on = false;
    gpio_set_level(LED_GPIO, led_on);
    led_on = !led_on;
    ESP_LOGI(TAG, "LED is now %s", led_on ? "ON" : "OFF");
}

// Program entry point
void app_main(void) {
    // Initialize the LED GPIO
    gpio_config_t io_conf = {
        .pin_bit_mask = (1ULL << LED_GPIO),
        .mode = GPIO_MODE_OUTPUT,
        .pull_up_en = 0,
        .pull_down_en = 0,
```

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```
// Program entry point
void app_main(void) {
    // Initialize the LED GPIO
    gpio_config_t io_conf = {
        .pin_bit_mask = (1ULL << LED_GPIO),
        .mode = GPIO_MODE_OUTPUT,
        .pull_up_en = 0,
        .pull_down_en = 0,
        .intr_type = GPIO_INTR_DISABLE,
    };
    gpio_config(&io_conf);

    // Create the software timer
    // The minimum software timer granularity is 1 ms
    blink_timer = xTimerCreate(
        "BlinkTimer",               // Name of timer
        pdMS_TO_TICKS(2000),        // Timer period in ticks (2000ms)
        pdTRUE,                     // Auto-reload (pdTRUE means periodic)
        (void *)0,                  // Timer ID (not used here)
        blink_timer_callback        // Callback function
    );

    if (blink_timer == NULL) {
        printf("Failed to create timer\n");
        return;
    }

    // Start the timer
    if (xTimerStart(blink_timer, 0) != pdPASS) {
        printf("Failed to start timer\n");
    }
}
```

5. Real-World Code Example

Code Breakdown:

- **GPIO Setup**: Configures the LED pin as an output.
- **Timer Creation**: xTimerCreate sets up a 2-second periodic timer linked to a callback function.
- **Timer Start**: xTimerStart starts the timer immediately.
- **Callback Function**: blink_timer_callback toggles the LED state every time the timer fires.

6. Best Practices

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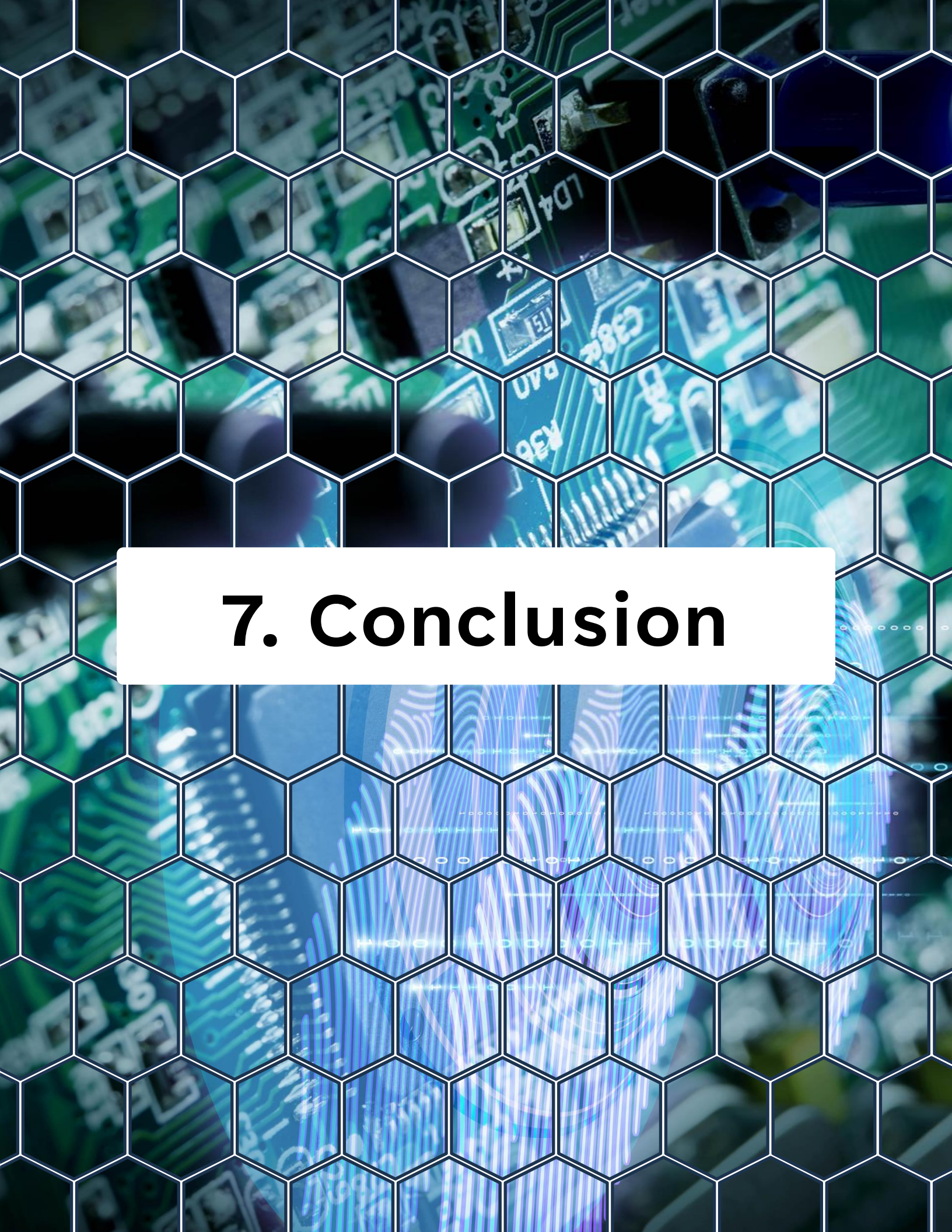
When using software timers in ESP32 projects:

- **Keep callbacks short**: Timer callbacks should execute quickly to avoid delaying other timers.
- **Use proper synchronization**: If the callback touches shared resources, protect them with mutexes or other synchronization primitives.
- **Always check return values**: Functions like `xTimerCreate()` and `xTimerStart()` can fail — never assume success.
- **Use meaningful timer names**: Helps in debugging using the ESP-IDF tracing tools.
- Free resources if needed: Use `xTimerDelete()` if you dynamically create timers that will no longer be used.



7. Conclusion

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Software timers are an indispensable feature for managing time-driven events in IoT applications with ESP32 and ESP-IDF. By integrating them properly, developers can design efficient, non-blocking, and scalable systems without consuming scarce hardware resources. Whether it's blinking LEDs, reading sensors, or triggering maintenance tasks, software timers provide a lightweight and flexible solution that fits perfectly into FreeRTOS-based projects.

In the dynamic world of IoT development, mastering tools like software timers separates a good design from an outstanding one.