Microprocessor Systems

Homework 1 (GPIO, RTC, RCC)

Faculty of Electrical Engineering

Course: Microprocessor Systems

Assignment No. 1

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Question 1 – Clock Management in STM32 Microcontrollers

a) What modes exist for configuring the internal clock in STM32 microcontrollers? Briefly explain each.
b) In STM32F1 series microcontrollers, how many input clock paths are available? Why are multiple paths provided?
c) If we want the system clock frequency to be higher than the input frequency, which unit should we use? Explain.
d) What is the function of the 'Enable CSS' option in the microcontroller clock configuration?
e) Research the AHB and APB buses. Briefly explain their features and typical applications (which peripheral units use them?).

Question 2 – Smart Irrigation System

We intend to design an intelligent irrigation system. The system activates an electric water valve twice a day (at 9:00 a.m. and 9:00 p.m.) for 10 minutes to water plants. Assume the electric valve is connected to a relay controlled by pin PA0 of the ARM microcontroller. The microcontroller uses its internal RTC to track time, which is already accurately set. There is also a button connected to EXTI0 that allows enabling or disabling the entire system by pressing it. Write a program that can implement this system.

Question 3 – Time-Window Controlled Relay Lock System

Design a system to control a relay-based lock that only accepts access requests during authorized daily time windows (for example, 07:45–12:00 and 13:00–17:30). When the user presses the request button (a GPIO input with interrupt), if the current time is within the valid window, the lock should open for exactly 8 seconds. If pressed again within that 8-second interval, the open duration should restart. A separate Supervisor button disables the entire system, ignoring all access requests while disabled. Two LEDs (green and red) should display distinct patterns for normal operation, door open, and disabled states. The green LED should blink normally in active mode, remain ON when the door is open, and turn OFF when disabled. The red LED should remain ON when the system is disabled and blink if the RTC is invalid.

After startup, the system must check the validity of the RTC. If invalid (not previously set), the system must remain in an inactive state until the RTC time is configured. RTC alarms or second-level comparisons should be used to determine window timing and the end of the 8-second duration. The RCC should keep only the necessary clocks active. The logic must ensure that the lock never remains unintentionally open and that rapid button presses are ignored using RTC timing or software filtering.

Question 4 – Three-Level Lighting System

Three outputs (for example PA0, PA1, PA2) define the brightness level for a three-level lighting system. In High mode, all three outputs are ON; in Medium mode, two are ON (PA0 and PA1); in Low mode, only PA0 is ON; and in Off mode, all outputs are OFF. In AUTO mode, the lighting level changes based on RTC time:

- 06:00–17:00 → High
- 17:00–23:00 → Medium
- 23:00–06:00 → Low

A button (connected to PC13 via EXTI) cycles through the modes in sequence: Manual (Off → Low → Medium → High → Auto). In Manual mode, time is ignored. In AUTO mode, a green LED indicates that AUTO is active. If the RTC time is invalid (flag not set), the system enters ERROR mode and a red LED blinks periodically (e.g., 300 ms ON, 700 ms OFF) until the RTC is configured. After time configuration or initial setup, the system switches to AUTO mode, applying the level based on the current time immediately. Sudden RTC time changes in AUTO mode must be handled immediately to correct output levels. The RTC should use a stable clock (LSE) and the minimum necessary system clocks should remain active during idle periods to save power.

Question 5 – Power Modes and Clock Sources in STM32

Summarize the power modes (Run, Sleep, Stop, Standby) for a low-power family such as STM32L4 and a general-purpose family such as STM32F1. Describe the clock sources (HSE, HSI/MSI, LSE, LSI, and PLL) and their effects on accuracy and power consumption. Explain why combining a low-power internal clock with the LSE is suitable for precise timing during long inactive periods. Discuss the concept of disabling unused peripheral clocks via RCC and the importance of proper GPIO configuration (to prevent floating inputs). Explain the role of DMA or autonomous peripheral operation (e.g., timer trigger → ADC → automatic transfer to RAM) in reducing CPU wake time and increasing Sleep/Stop duration.