**STM32F401RE: Relay Control on PA5**

**Overview**

This project toggles **PA5** on the **STM32F401RE** (e.g., a Nucleo-F401RE board) every 500 ms, effectively controlling a relay (if connected through a transistor driver) or blinking the on-board LED.

**Features**

1. **PA5 Output** toggles high/low every 500 ms.
2. **Simple software delay** for timing.
3. **Can drive a relay coil (through driver) or blink LED** if connected.

**Hardware Setup**

**Pin Usage**

| **Function** | **Pin** | **Notes** |
| --- | --- | --- |
| **Relay/LED** | **PA5** | If the Nucleo on-board LED is connected here, you'll see it blink. For a relay, connect PA5 to a transistor + relay coil at 3.3 V. |

**Connection Notes**

* **PA5** is also the user LED pin on many Nucleo boards, so you may see an LED blink if no external relay is attached.
* **Relay** typically requires a transistor driver or MOSFET for the coil, as microcontroller pins can’t directly drive high current.

**Software Explanation**

**Toggling PA5**

* **GPIOA** clock is enabled.
* **PA5** is configured as **output**.
* In the main loop, we set PA5 high, wait 500 ms, then set it low, wait 500 ms again.

**Delay**

* A **blocking delay** is used:
* void delayMs(int n)
* {
* volatile int i;
* for (; n > 0; n--)
* for (i = 0; i < 3195; i++)
* \_\_NOP();
* }
* Each iteration ~1 ms at **16 MHz**.

**Project Structure**

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├── Inc/

│ └── stm32f4xx.h

├── Src/

│ └── main.c // Toggling PA5 every 500ms

└── README.md

**Building & Uploading**

**Using Keil uVision / STM32CubeIDE**

1. **Open** your IDE.
2. **Create** a new project for **STM32F401RE**.
3. **Copy** main.c to Src/.
4. **Compile** & **Flash** the board.

**Usage**

1. **Flash** the code.
2. **Observe** PA5 toggling:
   * If an LED is on PA5, it blinks every half-second.
   * If a relay driver is used, the relay toggles on/off every half-second.

**Troubleshooting**

* **No blinking?** Ensure system clock is indeed 16 MHz. Check that PA5 is not set for another function.
* **Relay not activating?** Confirm transistor driver, coil voltage, and coil current requirements.

**License**

This project is provided under the **MIT License**.

**References**

* [STM32F401RE Datasheet](https://www.st.com/en/microcontrollers-microprocessors/stm32f401re.html)
* [Nucleo-F401RE Pinout Reference](https://www.st.com/resource/en/user_manual/dm00105823.pdf)

**🚀 Summary**

* **PA5** toggles every 500 ms.
* **Use** an external driver to drive a relay, or rely on the built-in LED.

**Have fun controlling your relay on STM32F401RE!**