Below is a **README** for your **STM32F401RE SysTick LED Toggle** project. You can copy and save it as **README.md** (for GitHub) or **README.docx** (for Word).

**SysTick LED Toggle on STM32F401RE (16 MHz)**

This project toggles the **on-board green LED (LD2, PA5)** every **500 ms** using the **SysTick timer** on an **STM32F401RE (Nucleo-F401RE)** running at **16 MHz**.

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**1. Overview**

* **MCU**: STM32F401RE (running at **16 MHz**)
* **LED Pin**: **PA5 (LD2 on Nucleo-F401RE)**
* **SysTick Timer**:
  + Configured to count down from **7,999,999** (to give a **500 ms** delay).
  + Uses **polling** (COUNTFLAG) to toggle the LED.
  + No interrupts, keeping the implementation simple.

**Behavior**

* **LD2 blinks every 500 ms**.
* The **SysTick timer counts down**, and when it reaches zero, it toggles PA5 (the LED pin).
* This continues indefinitely inside while(1).

**2. Hardware Setup**

**Board Connections**

| **Component** | **STM32F401RE Pin** | **Notes** |
| --- | --- | --- |
| **LD2 (Green LED)** | **PA5** | On-board LED |
| **SysTick Timer** | Internal | Configured for **500 ms delay** |

**Powering the Board**

* **Via USB** (micro-USB to the PC).
* No extra wiring is needed since **LD2 (PA5)** is **on-board**.

**3. Software Explanation**

**SysTick Configuration**

* **SysTick->LOAD = 8,000,000 - 1;** (500 ms at 16 MHz).
* **SysTick->CTRL = 5;** (Enable timer, No interrupts, Use System Clock).
* **Polling COUNTFLAG** (bit 16) to check when **500 ms elapsed**.

**LED Blinking Logic**

1. **SysTick starts counting** from 7,999,999 down to 0.
2. **When COUNTFLAG is set**, PA5 (LED) toggles.
3. **Repeat forever** inside the while(1) loop.

**4. Project Structure**

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├── Inc/

│ └── stm32f4xx.h // CMSIS/Device headers

├── Src/

│ └── main.c // Contains SysTick LED toggle code

└── README.md // This file

* If using **Keil uVision** or **STM32CubeIDE**, place main.c in Src/.

**5. Building and Uploading**

**Steps**

1. **Open** the project in **Keil uVision** or **STM32CubeIDE**.
2. **Check the clock configuration**:
   * System clock **must be set to 16 MHz** (using **HSI** or custom PLL settings).
3. **Compile the code**.
4. **Flash** the binary to the **Nucleo-F401RE** board.
5. **Observe LED (LD2) blinking every 500 ms**.

**6. Usage**

1. **Power the Nucleo-F401RE board** via USB.
2. **Observe** that **LD2 blinks every 500 ms**.
3. No further interaction is required—it runs automatically.

**7. Troubleshooting**

**No LED blinking?**

✅ **Check System Clock**

* Ensure that **16 MHz** is the actual clock frequency.
* If your board is running at **84 MHz** (default Nucleo-F401RE setting), you need to change **SysTick->LOAD** accordingly (42,000,000 - 1 for 500 ms at 84 MHz).

✅ **Check GPIOA Configuration**

* PA5 **must be set as output** (GPIOA->MODER |= (1 << 10);).
* Ensure **GPIOA clock is enabled** (RCC->AHB1ENR |= (1 << 0);).

✅ **Use Debugging**

* Add a breakpoint inside while(1) to see if execution is reaching the toggle statement.

**Want an interrupt-based version?**

* Modify SysTick->CTRL to enable an **interrupt** and use an **ISR handler** instead of polling.

**8. License**

This project is licensed under the [MIT License](https://opensource.org/licenses/MIT).  
You are free to **modify, distribute, and use** the code.

**9. References**

* [STM32F401RE Datasheet](https://www.st.com/en/microcontrollers-microprocessors/stm32f401re.html)
* [SysTick Timer - ST Reference Manual (RM0368)](https://www.st.com/resource/en/reference_manual/dm00096844.pdf)
* [Nucleo-F401RE User Manual](https://www.st.com/resource/en/user_manual/dm00105823.pdf)

**🎯 Summary**

✅ **SysTick toggles LED every 500 ms** using **16 MHz system clock**.  
✅ **Uses polling (COUNTFLAG) instead of interrupts** for simplicity.  
✅ **Works on Nucleo-F401RE with no extra wiring**.

**🚀 Enjoy your SysTick-based LED toggle project on STM32F401RE! 🎉**