

STM32U5: Clock Configuration and Power Consumption Analysis

Nianhang Hu

May 13, 2025

1 Background

The STM32U5 series microcontrollers offer a variety of flexible clock source options, including external crystal oscillators(HSE), internal high-speed oscillators(HSI), multi-speed oscillators(MSIS) and their kernel output(MSIK),low-speed internal oscillators(LSI), and low-speed external crystal oscillators(LSE). In low-power designs, the choice of clock source directly impacts the system's overall energy efficiency. Therefore, selecting the most suitable clock source becomes a critical consideration. This article analyzes the characteristics and typical application scenarios of each clock source from multiple dimensions such as power consumption, accuracy, and startup time, aiming to assist developers in making optimal configuration choices in low-power scenarios.

2 Common Types of Clock Sources

Clock Source	Frequency Range	Power Consumption	Accuracy	Startup Time	Typical Use Case	Notes
HSI	16MHz	Medium	Medium	Fast	Medium-speed task	Internal high-speed oscillator
MSIS	100KHz-48MHz	Ultra-low	Medium-Low	Ultra-fast	Low-power frequency-tuning	Supports low-power modes
MSIK	100KHz-48MHz	Ultra-low	Medium-Low	Ultra-fast	Used with low-power peripherals	MSI kernel output branch
HSE	1MHz - 25MHz	High	High	Slow	High-precision Speed scenarios	External crystal oscillator, high power consumption
LSI	~32KHz	Ultra-low	Low	Slow	RTC/low-power clocks	Internal low-speed oscillator
LSE	32.768KHz	Low to Medium	High	Relatively Slow	RTC/low-frequency Communication	External crystal oscillator
PLL	N/A	Very High	High	Slow	USB / high-performance application	Highest power consumption, not suitable for low-power scenarios

Figure 1: Clock Source Types

3 Recommended Clock Source Order from Power Consumption Perspective

From lowest to highest power consumption:

- MSIS - Optimal choice(supports frequency tuning and STOP/low-power modes)
- MSIK - Suitable for low-power peripherals (e.g., LPUART,LPTIM,SPI3)
- LSI/LSE - Used fro low-frequency applications such as RTC and watchdog.
- HSI - General-purpose, medium power consumption, no external crystal required.

- HSE + PLL - For high-precision or high-performance requirements

4 MSI, MSIS and MSIK

Let us first distinguish between the three related terms: MSI, MSIS, and MSIK.

- MSI(Multi-Speed Internal Oscillator) is a multi-frequency internal RC oscillator available on the STM32U5 series. It can operate at frequencies ranging from 100KHz to 48MHz. It serves as a general term referring to the internal oscillator's overall functionality.
- MSIS(MSI System Clock) is the system clock branch of MSI. It is primarily used to supply the main system clock(SYSCLK) or as an input source for the PLL.
- MSIK(MSI Kernel Clock) is the kernel clock branch of MSI. It is specifically designed to provide clock signals to low-power peripherals(such as LPUART, LPTIM, and I2C) during low-power modes.

5 Extension: How to Choose an Application Clock Configuration

Application Scenario	Recommended Clock Source	Description
Ultra-low power with	MSIK + LSE	MSIK Provides clock for UART, LSE provides clock for RTC.
High-precision timing or peripheral synchronization	HSE + PLL	Requires external crystal; higher power consumption
General-purpose MCU control tasks	HSI / MSIS	Balanced power and performance with moderate precision
Watchdog or simple periodic wake-up tasks	LSI / MSIS	Fast startup and low power consumption

Figure 2: Application Section

6 Conclusion

- If the goal is ultra-low power consumption or battery-powered devices, prioritize using MSIS/MSIK + LSE.
- If the goal is high-speed data processing or external communication, consider using HSE + PLL.
- If you need a balance between startup time, power consumption, and accuracy, HSI or MSIS are suitable choices.

References