

Introduction

This document is intended for application designers who require a hardware implementation overview of low power modes in the STM8L and STM8AL product families (see [Table 1](#) for applicable products). It shows how to use the STM8L and STM8AL devices in these modes, explains differences between different modes and gives several examples of how to select the best mode for your application needs.

This document is not intended to replace the STM8L and STM8AL datasheets. All values given in this document are for guidance only. Please refer to the related datasheets to get guaranteed values.

Table 1. Applicable products

Product family	Part numbers
Microcontroller	<ul style="list-style-type: none">– STM8L05xxx– STM8L101xx– STM8L151C2/K2/G2/F2 and STM8L151C3/K3/G3/F3– STM8L151x4, STM8L151x6, STM8L152x4, STM8L152x6– STM8L151x8, STM8L152x8, STM8L151R6, STM8L152R6, STM8L162R8, STM8L162M8– STM8AL313x, STM8AL314x, STM8AL316x, STM8AL3L4x, STM8AL3L6x

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1 Power consumption factors

The STM8L and STM8AL microcontrollers are digital logic devices using the complementary metal oxide semiconductor (CMOS) technology. In these type of devices, power consumption is a sum of:

- Static power (mainly caused by transistor polarization and leakage)
- Dynamic power which depends on the supply voltage and the clock frequency. It is calculated from the formula: Dynamic power = $C \times V^2 \times f$, where:
 - C is the CMOS load capacitance
 - V is the supply voltage
 - f is the clock frequency.

Static consumption is negligible compared to dynamic consumption when the clock is running. In some low power modes, when no clock is running, static consumption is the main consumption source.

- Total consumption is a sum of static and dynamic consumption

$$I_{DD} = f \times I_{\text{DynamicRun}}[\mu\text{A} / \text{MHz}] + I_{\text{Static}}[\mu\text{A}]$$

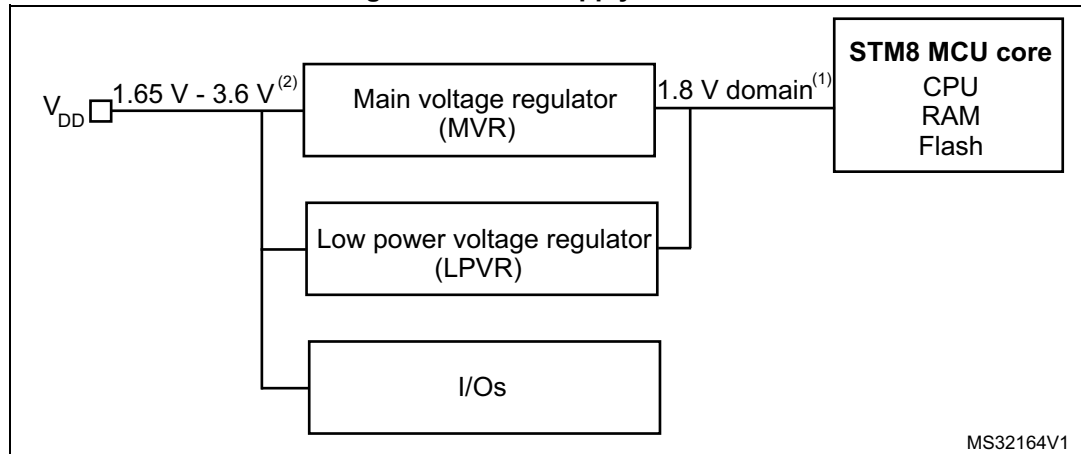
Consequently, power consumption depends on:

- **The microcontroller unit (MCU) chip size:** technology used, number of transistors, analog features/peripherals embedded and used in the application.
- **The MCU supply voltage:** the amount of current used in CMOS logic is directly proportional to the squared power supply voltage (V^2). Thus, power consumption may be reduced by lowering the MCU supply voltage. This is less critical for STM8L and STM8AL devices than for other microcontrollers, as an internal voltage regulator is used but this could have an influence for the remaining components on the board.
- **The clock frequency:** Power consumption may be reduced by decreasing the clock frequency when fast processing is not required by the application.
- **The number of active peripherals or used MCU features** (CSS, BOR, PVD,...): the greater the number of active peripherals or features, the greater the amount of consumed power.
- **The operating mode:** Power consumption depends on which mode a particular application is running (CPU on/off, oscillator on/off,...). For an application powered by a battery, the consumption is very important. Usually, the average consumption should be below a certain target value to ensure an optimum battery lifetime. This means that an application can consume more for short periods of time and keep its average current consumption below the target value.

2 Power supply

The STM8L/STM8AL families embed two regulators which provide a supply voltage (V_{CORE}) for the core and internal peripherals.

Figure 1. Power supply overview



1. If V_{DD} is lower than 1.8 V, the 1.8 V domain is supplied by the voltage on the V_{DD} input. For low power modes where the LPVR is used, this domain is supplied by a 1.55 V voltage.
2. V_{DD} between 1.8 V to 3.6 V for STM8L05xxx.

The main voltage regulator (MVR) provides a 1.8 V supply voltage. It has a high current capability, as it can deliver up to 25 mA. However, the consumption of this regulator is higher than the consumption of the low power regulator (LPVR). Consequently, the MVR is used during a standard operation only.

The consumption of the LPVR is very low, as required for low power modes. The LPVR can deliver up to 200 μ A, providing 1.55 V to the digital part of the MCU.

After reset, the MVR provides a supply voltage (V_{CORE}) to the internal digital parts of the microcontroller. Depending on the functional mode, the MVR can be switched off. In this case, the LPVR continues to provide the V_{CORE} voltage.

The power supply is monitored by the POR/PDR (power-on reset/power-down reset) and BOR (brown-out reset) system. This system ensures a proper startup and reset of the MCU, while V_{DD} is rising above the POR/BOR threshold. It resets the MCU when V_{DD} is falling below the PDR/BOR threshold. Correct device reset during power-on sequence is guaranteed when $t_{VDD[max]}$ is respected. Use of internal BOR is recommended to ensure correct device reset during power-down, when $V_{PDR} < V_{DD} < V_{DD[min]}$.

Note: *Analog peripherals require a power supply voltage above the PDR threshold ($V_{DD} > 1.8$ V, while $V_{PDR} = 1.5$ V). In this case, it is recommended to use the BOR (Brownout reset) to guarantee a proper functionality.*

The BOR is not available in STM8L101xx devices. If needed, external circuitry shall be used instead.

For better power monitoring, the STM8L15xxx, STM8L162xx, STM8AL31xx, and STM8AL3Lxx provide a brown-out reset (BOR) and programmable power voltage detection (PVD) for an earlier detection of voltage drop.

2.1 Internal supply structure for STM8L101xx devices

The STM8L101xx devices are able to operate from 1.65 V up to 3.6 V, connected to one pair of supply pins.

There are no dedicated supply pins for the analog voltage domain. It is recommended to use a decoupling ceramic capacitor placed close to the supply pins.

- In Run and Wait modes, both MVR and LPVR provide the V_{CORE} .
- In Halt/Active-halt modes, the LPVR is automatically used while the MVR is switched off by the system in order to reduce current consumption.

2.2 Internal supply structure for STM8L05xxx, STM8L15xxx, STM8L16xxx, STM8AL31xx and STM8AL3Lxx devices

Internal supply structure for STM8L05xxx, STM8L15xxx, STM8L16xxx, STM8AL31xx and STM8AL3Lxx devices require a supply voltage of 1.8 V to 3.6 V. Once the supply voltage reaches 1.8 V, the MCU can work down to 1.65 V with a limitation in the functionality of analog peripherals (except STM8L05xxx).

These devices have several supply pins, depending on the package pincount. In addition to the main supply pair V_{SS}/V_{DD} , another supply pin (V_{DDA}) can be present on the package.

It is recommended to use a decoupling ceramic capacitor, placed close to the supply pins.

- In Run and Wait modes, both MVR and LPVR provide the V_{CORE} .
- In Low power run mode and Low power wait mode, the MVR has to be switched off. Only the LPVR provides the V_{CORE} .
- In Active-halt mode, during the Halt phase, either the MVR or the LPVR can provide the V_{CORE} . The user can select the regulator to be used.
- In Halt mode, the LPVR is automatically used, once MVR is switched off.

2.2.1 Brownout detector (BOR)

The brownout detector is used to guarantee a proper functionality of all peripherals, mainly analog ones. By default, this detector is enabled but the user can disable it through option byte to decrease the MCU consumption by $\sim 2.8 \mu A$.

The BOR is mandatory to ensure a proper functionality of the product at power-down, to cover a supply voltage area between $V_{DD \text{ min.}}$ and V_{PDR} .

Note: The BOR is not available in STM8L101xx devices.

3 Clock management

3.1 STM8L101xx clock system overview

The 16 MHz high speed internal RC oscillator (HSI) is the only clock source that can be used to drive the system clock.

The 38 kHz low speed internal RC oscillator (LSI) is only used to supply the auto-wakeup unit (AWU) and watchdog.

Each peripheral clock can be switched on or off independently, in order to optimize power consumption when the peripheral is not used. This is done by using the peripheral clock gating (PCG) feature. See the “Clock control” section of the STM8L101xx reference manual (RM0013) for more details.

3.2 STM8L05xxx, STM8L15xxx, STM8L16xxx, STM8AL31xx and STM8AL3Lxx clock system overview

Several different clock sources can be used to drive the system clock, depending on the product and package you use:

- 1-16 MHz high speed external clock from the crystal oscillator (HSE crystal)
- Up to 16 MHz high speed external clock provided by the user (HSE bypass)
- 16 MHz high speed internal RC oscillator (HSI)
- 32.768 kHz low speed external crystal oscillator (LSE)
- 38 kHz low speed internal RC oscillator (LSI)

Each clock source can be switched on or off, depending on the actual needs of the application. Each peripheral clock can be switched on or off independently, in order to optimize power consumption when it is not used. This is done by using the peripheral clock gating (PCG) feature. See the ‘Clock control’ section in the STM8L05xx, STM8L15xx, STM8L162x, STM8AL31xx and STM8AL3Lxx microcontroller family reference manual (RM0031) for more details.

Several clock sources can be enabled in one time. The following table shows the main features of each clock source. STM8L and STM8AL devices offer a complete range of clock sources to meet customer application requirements in terms of cost, accuracy and consumption.

Table 2. Clock sources

	HSE oscillator	external HSE	HSI	external LSE	LSE crystal	LSI
Cost	Low to medium	Low to high	Free	Low to medium	Low to medium	Free
Accuracy	~ ppm / %	depending on external clock	~ %	depending on external clock	~ ppm	~ %
Consumption	0.7 mA max	High/medium	100 µA		1.4 µA max	100 - 400 nA
Start-up time	1 ms	depending on external clock	4 µs	depending on external clock	1 s	200 µs max
Other information	Crystal or ceramic resonator	Clock already existing in the system	-	Clock already existing in the system	Watch crystal	-

The default clock source after reset is HSI/8. The user can then switch the clock to different frequencies and sources by using the following procedure:

- On the STM8L101xx devices:
 - Choose the prescaler (/1, /2, /4 or /8) for an internal RC 16 MHz (HSI) clock through the HSIDIV[1:0] bits in the CLK_CKDIVR register.
- On the STM8L05xxx, STM8L15xxx, STM8L162xx, STM8AL31xx and STM8AL3Lxx devices:
 - Choose the prescaler (/1, /2 ... /128) for an internal RC 16 MHz (HSI) clock through the CKM[2:0] bits in the CLK_CKDIVR register.
 - Or, change the system clock (to HSE, LSE or LSI). Refer to the STM8L05xx, STM8L15xx, STM8L162x, STM8AL31xx and STM8AL3Lxx microcontroller family reference manual (RM0031) for more details about the clock switching mechanism.

Before switching off a previous clock source when using automatic switching mode, the user must ensure that the core is no longer running on the current clock. This means that the previous clock must be turned off after the SWIF flag has been set. If the user tries to switch off the clock and the SWIF flag has not been set by hardware, the current clock is not switched off as the microcontroller is still running using this clock source.

Such clock switching can be combined with Wait mode (for example, if the HSE crystal is the new clock) as clock switch execution interrupt can wake up the MCU from wait mode. This enables the synchronization of the MCU wakeup with the new clock availability. The clock switching feature can also be used at the beginning and the end of a regular or interrupt routine to speed it up (for instance, if the clock master is LSI RC, but some parts of the code have to be executed quickly with HSI RC).

3.3 Clock configuration and power management

In addition to the flexibility of the clock sources, different complementary clock configurations and features are available to optimize the power consumption of the device:

- Each peripheral clock can be switched on/off through the CLK_PCKENRx registers.
- System clock divider from 1 to 8 (HSIDIV[1:0] bits in the CLK_CKDIVR register) is available on STM8L101xx devices.
- System clock divider from 1 to 128 (CKM[2:0] bits in the CLK_CKDIVR register) is available on STM8L05xxx, STM8L15xxx, STM8L162xx, STM8AL31xx and STM8AL3Lxx devices.

Note: System clocks are used to supply both CPU and peripherals.

The STM8L and STM8AL devices are focused on low consumption. This is why all peripheral clocks are gated by default. Before accessing any peripheral register, it is mandatory to enable the clock for the given peripheral.

3.4 Clock selection vs. power consumption

The selected clock type and speed is one of the major factors influencing power consumption of the MCU. In general, there are two parts in consumptions:

- A static part, depending on the number of enabled peripherals (mainly analog ones)
- A dynamic part, directly proportional to clock speed (increasing with higher clock speed)

$$I_{DD} = f \times I_{DynamicRun}[\mu A/MHz] + I_{Static}[\mu A]$$

$$I_{DD(STM8L101xx)} = f \times 150[mA/MHz] + 215[mA]$$

Note: The values given above are measured with all peripherals disabled.

Slowing down the clock decreases the immediate consumption but this is not the ideal solution in many cases. By slowing down the clock, the CPU performance is also reduced. Therefore, a longer time is required to perform an action or computation. If we consider the average consumption, it might be better to use the highest available clock speed to perform the required operation, and force the MCU to one of the low power modes (like Active-halt mode) for the remaining time frame. This should be taken into account during the design of application flowcharts.

4 Run and low power modes

By default, after a reset, the microcontroller is in Run mode. The default CPU clock is 2 MHz (HSI / 8). Several low power modes are available to save power when the CPU is not used for a standard operation (for instance: waiting for an external event). It is up to the user to select the mode that gives the best compromise between low power consumption, short startup time, good peripheral functionality, and availability of wakeup sources. Those power modes are listed in [Section 4.2.1](#) and [Section 4.2.2](#).

Power consumption in Run and Wait modes can also be reduced by one of the following means:

- Slowing down the system clocks
- Executing code from RAM
- Gating the clocks to the peripherals when they are not used.

4.1 Flash memory

On STM8L and STM8AL devices, the Flash memory supports a low power mode called I_{DDQ}. In this mode, the Flash is switched off. It enters power-down mode (I_{DDQ}) automatically when Halt, Active-halt, Low power wait or Low power run mode is entered.

By enabling the EEPM bit (available on STM8L05xxx, STM8L15xxx, STM8L162xx, STM8AL31xx and STM8AL3Lxx devices only) in the FLASH_CR1 register, the Flash program memory automatically enters I_{DDQ} mode when the code is executed from RAM or when the device is in Wait mode. When the Flash program memory is in I_{DDQ} mode, the recovery / wakeup time is longer (up to 2.8 μs) and depends on the supply voltage and temperature.

4.2 Overview of low power modes

The following table lists the STM8L and STM8AL low power modes and shows a basic behavior of STM8L and STM8AL devices and the influence of different low power modes on CPU, peripherals and consumption.

A detailed description of each mode is given in the following chapters.

In all low power modes, the general purpose I/Os continue to drive actively outputs (both digital and analog - DAC).

The MCU can be woken up from these low power modes by specific interrupts, including through comparators and incoming communications on SPI, I2C and/or USART. Refer to the interrupt mapping table in the device datasheet.

Table 3. Low power mode summary

Low power modes	Entry	Functions							Low power modes names and consumptions	
		CPU	Peripherals	High speed osc.	RTC calendar	LSI LSE	Flash	RAM	STM8L & STM8AL typical values @ 3V/25°C	STM8L & STM8AL typical values @ 3V/85°C
Low power run	Software sequence	ON	Can be enabled	OFF	ON	ON	OFF	ON	5.4 μ A	6.8 μ A
Low power wait	Software sequence + WFE	OFF	Can be enabled	OFF	ON	ON	OFF	ON	3.3 μ A	4.4 μ A
Active-halt w/ full RTC	HALT	OFF			ON	ON	OFF	ON	1.0 μ A ⁽¹⁾	1.4 μ A
Active-halt w/ RTC on LSI					OFF	ON	OFF	ON	0.8 μ A ⁽¹⁾	1.2 μ A
Halt					OFF	OFF	OFF	ON	0.4 μ A ⁽¹⁾	1 μ A

1. Internal reference voltage and BOR off.

4.2.1 STM8L101xx low power modes

The STM8L101xx devices feature the following main low power modes:

- Wait mode: CPU stopped and peripherals kept running
- Active-halt mode: CPU stopped, AWU (auto-wakeup) and IWDG (independent watchdog) kept running if enabled.
- Halt mode: CPU and peripheral clocks stopped

4.2.2 STM8L05xxx, STM8L15xxx, STM8L162xx, STM8AL31xx and STM8AL3Lxx low power modes

STM8L05xxx, STM8L15xxx, STM8L162xx, STM8AL31xx and STM8AL3Lxx devices feature the following main low power modes:

- Wait mode: CPU clock stopped, peripherals kept running
- Low power run mode: executing code is done from RAM with a low speed oscillator (LSI or LSE); selected peripherals remain active
- Low power wait mode: CPU clock stopped; selected peripherals remain active
- Active-halt mode: CPU clock stopped, AWU/RTC (auto wakeup/real-time clock) and IWDG (independent watchdog) kept running if enabled
- Halt mode: everything is stopped.

4.3 Slowing down the clock frequency

In Run mode, choosing the clock frequency is very important to ensure the best compromise between performance and consumption. The selection is done by programming the prescaler registers. These prescalers can also be used to slow down peripherals before entering low power modes.

Note: Keep in mind the recommendations given in [Section 3.4](#) about performance and ratio between Run mode and Halt mode operation.

4.4 Peripheral clock gating (PCG)

You can use peripheral clock gating (PCG) for additional power saving. This can be done at any time by selectively enabling or disabling the clock connection to individual peripherals through the CLK_PCKENRx registers. These settings are effective both in Run and Wait modes.

Note: As all peripheral clocks are gated on STM8L and STM8AL devices after reset, it is mandatory to enable the clock for a given peripheral before accessing any peripheral register.

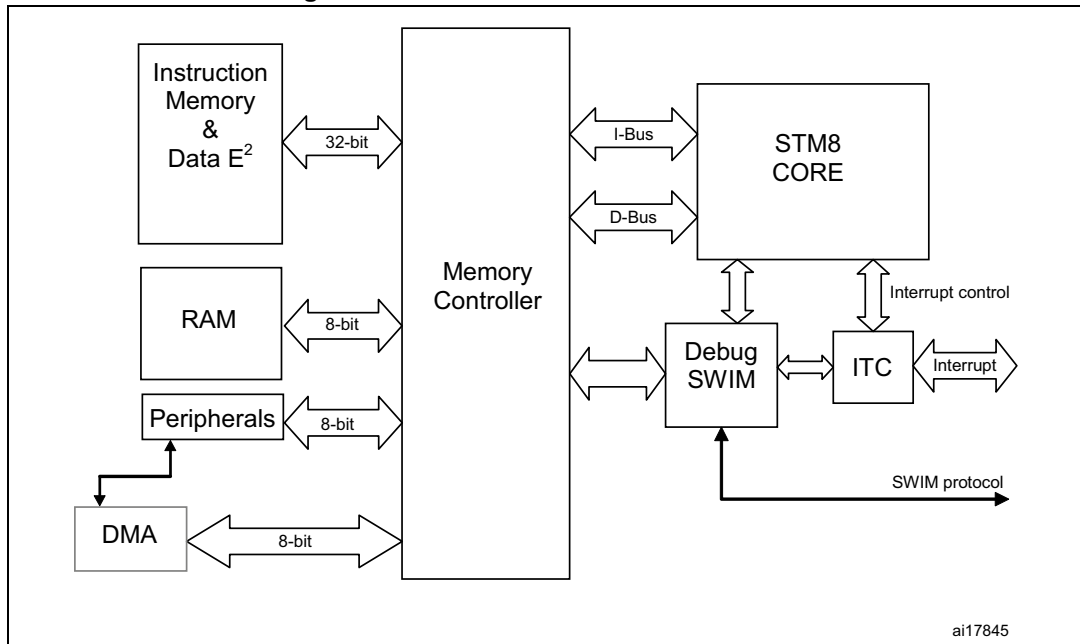
4.5 Execution from RAM

The code can be executed from RAM in order to save power consumption. However, due to the difference between size of data & instruction bus from Flash (32-bit) and RAM (8-bit), the performance is degraded when the execution is done from RAM. This is important to take into account the performance and the ratio between Run/Halt operations.

In this mode, the Flash memory can be forced to I_{DDQ} mode.

The following figure shows the different bus widths for Flash and RAM memories.

Figure 2. STM8L and STM8AL architecture



4.6 Wait mode

The STM8L and STM8AL devices support two different Wait modes: WFI (Wait for interrupt) and WFE (Wait for event). Both modes are designed to reduce STM8L and STM8AL device power consumption by switching off the core when it is not used. Wait mode is mainly used when the STM8L/STM8AL is waiting for an external or internal event so that the program execution can continue.

The device can be switched to Wait mode instead of waiting for an Event in Run mode with:

```
While( ! Event );
```

This mode can be used with PCG and with a low speed clock source to further reduce the power consumption of the device.

This mode offers the lowest wakeup time.

4.6.1 Entering Wait mode

Wait mode is entered by executing the WFI or WFE assembly instruction. This stops the CPU, but other peripherals and the interrupt controller can continue to run. When entering Wait mode, the global interrupts are automatically enabled.

- Before entering WFI mode, at least one interrupt must be enabled.
- Before entering WFE mode, at least one event source must be enabled.

4.6.2 Exiting Wait for interrupt mode

When an internal or external interrupt request occurs, the CPU wakes up from Wait mode and resumes processing.

The following list gives examples of peripherals or features with interrupts having exit-from-wait capability:

- I2C
- USART
- SPI
- ADC
- Comparator
- AWU/RTC
- External interrupt
- Timers
- Clock controller (clock switch execution)

Refer to the STM8L/STM8AL reference manuals for more details. Refer to the STM8L/STM8AL datasheets for the availability of the above peripherals and features on your devices.

4.6.3 Exiting Wait for event mode

When an internal or external event request occurs, the CPU wakes up from Wait mode and resumes processing.

The following list gives examples of peripherals or features with events having exit-from-wait capability:

- I2C
- USART
- SPI
- ADC
- Comparator
- External interrupt
- Timers

If an interrupt occurs during Wait for event mode, the related interrupt service routine is executed. After this routine, the MCU goes back to Wait for event mode.

Refer to the STM8L/STM8AL reference manuals for more details. Refer to the STM8L/STM8AL datasheets for the availability of the above peripherals and features on your devices.

4.7 Low power run mode

This mode is based on code execution from RAM, using a low speed clock source. The main voltage regulator (MVR) is switched off and the low power voltage regulator (LPVR) is used to supply the voltage to internal structures. The Flash memory is configured by software in I_{DDQ} mode.

The ADC is not supported in this mode, as its clock source must have a minimum frequency of 1 MHz.

No interrupt is allowed in this mode as the interrupt vectors are located in the Flash (which is switched off). Consequently, all interrupts must be masked.

While using this mode, you have to switch from high speed clock sources to low speed clock sources.

Note: This mode is not available on the STM8L101xx devices.

4.7.1 Entering Low power run mode

This mode is entered by executing the following software sequence:

1. Switch off all unused peripherals, oscillators (except LSI or LSE) and analog blocks
2. Mask all interrupts
3. Jump to RAM
4. Switch system clock to LSI or LSE clock sources
5. Configure the Flash memory in I_{DDQ} mode by setting the EEPM bit in the FLASH_CR1 register
6. Add a software delay loop to make sure the Flash/Data EEPROM are off
7. Configure the ultralow power mode for the regulator by setting the REGOFF bit in the CLK_REGCSR register (do not confuse with the ULP bit in the PWR_CSR2 which configures the behavior of the internal reference voltage).

Steps 1 to 4 can be performed in any order.

4.7.2 Exiting Low power run mode

The only way to exit this mode is to follow these steps:

1. Switch on the main regulator by resetting the REGOFF bit in the CLK_REGCSR register. The REGREADY flag in the CLK_REGCSR register is set when the regulator is ready.
2. Switch on the Flash/Data EEPROM by resetting the EEPM bit in the FLASH_CR1 register. The EEREADY flag in the CLK_REGCSR register is set when the Flash/Data EEPROM is ready.
3. Switch the clock to HSI (or HSE).
4. Reset interrupt mask.
5. Switch on what is necessary and jump to Flash/Data EEPROM if needed.

4.8 Low power wait mode

This mode is entered by executing a WFE instruction, while the MCU is in Low power run mode. It can be exited only by means of an external or internal event, in this case the MCU returns to Low power run mode. WFI instruction cannot be used, because interrupts have to be disabled in Low power run mode.

4.9 Halt mode

In this mode the system clock is stopped. This means that the CPU and all the peripherals requiring clocks are disabled, except for the following cases:

- The HSI clock is not stopped if used by the SWIM
- The system clock source is not stopped if a Flash/Data EEPROM write operation is in progress.
- The LSI clock is not stopped if used by the SWIM, by the IWDG or if the “IWDG_HALT” option bit is disabled.

In Halt mode, none of the peripherals is clocked and the digital part of the MCU consumes almost no power.

4.9.1 Entering Halt mode

The MCU enters Halt mode when a HALT instruction is executed. Before executing a HALT instruction, the application must clear any pending peripheral interrupt by clearing the interrupt pending bit in the corresponding peripheral configuration register. Otherwise, the HALT instruction is executed but the MCU wakes up immediately and the program execution continues.

However, the Halt procedure can be delayed if one of the following flags is set:

- SWBSY flag in the CLK_SWCR register
- EEBUSY flag in the CLK_REGCSR register
- RTCWBSY flag in the CLK_CRTCR register
- BEEPSWBSY flag in the CLK_CBEEPR register when the Beep is enabled in Active-halt mode.

If the SAHALT bit is set in the CLK_ICKCR register, the main regulator (MVR) is switched off without taking into account that some high speed clocks may be used by the system.

4.9.2 Exiting Halt mode

Wakeup from Halt mode is triggered by an external interrupt, sourced by a general purpose I/O port configured as interrupt input or by an alternate function pin capable of triggering a peripheral interrupt.

The system clock is then restarted at a frequency depending on the FHW bit in the CLK_IKCR register. If the FHW bit is set, HSI/8 is the system clock. Otherwise, the system clock is the last selected clock source before the system enters Halt mode.

Note: When the STM8L101xx microcontroller is woken up from Halt mode, the same clock source as that used before entering this mode is always selected.

In an interrupt-based application, where most of the processing is done through the interrupt routines, the main program may be suspended by setting the activation level bit (AL) in the CFG_GCR register. Refer to [Section 4.10: Activation level control on page 19](#).

4.9.3 Active-halt mode

In Active-halt mode, the main oscillator, the CPU and almost all peripherals are stopped. Only the LSI RC oscillator or the LSE crystal is running to drive the SWIM, beep, IWDG, RTC and LCD, if enabled. The user can enter this mode by a HALT instruction, once some of the peripherals above have been enabled.

4.10 Activation level control

The STM8L/STM8AL devices support an automatic activation level control feature. Consequently, the user can configure the MCU so that it directly returns to a low power mode after it has been woken up from such a mode through interrupts.

In an interrupt-based application, where most of the processing is done through the interrupt routines, the main program may be suspended by setting the activation level bit (AL) in the CFG_GCR register. Setting this bit causes the CPU to return to low power mode after exiting an interrupt service routine without restoring the main execution context when the IRET instruction is executed. This saves power by removing both the save/restore context activity and the need for a main software loop execution for power management (in order to return to low power mode).

To return to the main loop, the AL bit has to be cleared by software. This must be done at least two clock cycles before the IRET instruction is executed.

5 Power management tips

5.1 Choosing the optimal low-power mode for your application

Different low power modes can be selected depending on your application:

- Application powered by a battery where the MCU is in sleep mode most of the time:
 - If the MCU is woken up due to external events, no time tracking is necessary and power consumption has to be as low as possible. Then, Halt mode is advised to extend battery life as much as possible.
 - Active-halt mode with AWU/RTC clocked by the LSI is advised if the application does not only depend on external events, but needs a non accurate periodic wakeup. The LSE can be used to achieve a high timing precision.
- Application powered by a battery where the MCU is awake most of the time:
 - Active-halt mode is advised if the MCU has to perform a few periodic actions during which no peripheral has to remain enabled.
 - Wait mode is advised if at least one peripheral has to remain enabled all the time and an interrupt or event can wake up the MCU.
- Application supplied by mains but where consumption is critical:
 - Run mode, with a clock prescaler adapted to the application requirement, is advised if the MCU has to run all the time and low power modes cannot be used.

5.2 GPIO initialization

By default, the I/Os are configured as floating input.

It is important to change the configuration of all I/Os that are not connected to defined logic signals so as to obtain one of the following configurations:

- input configuration with pull-up
- or, output configuration with a low (or high) logic level

Otherwise, an increased consumption is generated by noise, as the internal Schmitt triggers detecting this noise are toggling.

Floating I/Os could generate additional consumption in the range of a few 10 μ A.

There are also parts with some unbonded I/Os (typically different packages of the same product). Those I/Os are connected to a defined level by factory option configuration, unless otherwise specified in the datasheet.

5.3 Dynamic control of pull-up resistor

Many applications have buttons which are used as a user interface. Those buttons are connected to I/Os that are connected to V_{SS} once the buttons are pressed. An internal pull-up is used in order to have a defined logic level on these I/Os when the button is off.

Once the button is pressed, the I/O is grounded and it generates an additional current of $\sim 40 - 70 \mu A$, drawn from the power supply. This current is negligible if the application is in Run mode, but becomes very important for applications mainly running in low power modes.

For this type of applications, you can control the pull-up dynamically. Once a button is pressed, the related service routine is executed. This routine disables the pull-up and the interrupt, in order to save consumption while the button is pressed.

As the application has to check the button status regularly, this pull-up is enabled again before this check. If the button is still pressed, this process is repeated. Once a button release is detected, the pull-up remains on.

For this task, an I/O can be left floating for a short time frame, given by a check period, generating an extra consumption in the range of $\sim 10 \mu A$. Therefore, the total current consumption for a button press operation is lower than without this dynamic control.

5.4 Waiting loops / delays

In some cases, the application has to wait for an input from the user, slow peripheral (ADC), or another external unit.

If there is no useful code to execute in the meantime, instead of using:

- a typical delay loop:

```
(delay = 0; delay < 0xFFFF; delay++)
_asm ("nop");
```

- or a polling loop like:

```
ADC_CR1 |= ADC_START; // start conversion
while (!(ADC_SR & ADC_SR_EOC)); // wait for EOC bit set
```

it is recommended to use a more advanced solution, using a Wait for event mode:

1. Configure the ADC as a source of event
2. Enable an event by allowing the related interrupt:

```
WFE_CR2 |= ADC_COMP_EV; // enable ADC as a source of event
ADC_CR1 = ADC_EOCIE; // enable interrupt for end of conversion
```

An event is then generated after each conversion. The conversion starts as follows:

```
ADC_CR1 = ADC_START; // start conversion
_asm ("wfe");
```

The sequence described above uses WFE mode to wait for an end of conversion. This can also be used for other sources like communication lines, etc. In case of external sources (like interrupt from an I/O port), you can also consider using Halt mode.

5.5 Minimizing power consumption

The following recommendations can help you choose the right configurations to minimize the power consumption of your device in your application:

- Switch off all unused peripherals (peripherals are switched off by default) and use the PCG feature (through the CLK_PCKENRx registers) to disable the clock provided to the unused peripherals (these clocks are disabled by default).
- All unused pins must be connected to a defined logic level. One of the option is to configure them as output low level. Make sure there are no unused I/O pins configured as a floating input. This needlessly leads to a high consumption.
- Use Wait mode if you need external wakeup capability in low power mode and if some peripherals have to remain active.
- Use the appropriate V_{DD} value for your application. The higher the V_{DD} value, the more consumed power.

Thanks to the internal regulator, which supplies internal structures of the MCU, there is no major difference in the MCU consumption but the difference could be visible on an application level, e.g. due to the current flowing through pull-up resistors out of the MCU.

- Use Low power run mode and Halt modes as much as possible. To achieve this, you need to shorten the time spent in the Run mode, for example by using the highest clock speed in Run mode.
- When a low power mode cannot be used, use the minimum possible frequency for your application. You can select the frequency value that meets your requirements.
- Use the dynamic control of pull-up configuration if possible. See [Section 5.2: GPIO initialization on page 20](#) for a the detailed description.

6 Conclusion

The STM8L/STM8AL families offer many possibilities for the development of low consumption applications. The user can take advantage of various low power modes like Wait, Low power Run/Wait, or Halt and Active-halt modes. He can also reduce consumption by switching off peripherals when they are not being used. Another important point is the optimization of the ratio between Run and Halt modes due to the good performance of the CPU itself.

The main important principles are described in this application note, including a few hints on how and when to use it. Much more examples exist, depending on your exact needs. You can find them on www.st.com.

7 Revision history

Table 4. Document revision history

Date	Revision	Changes
31-Mar-2010	1	Initial release
06-Nov-2012	2	Document updated to include the STM8AL products. Added Table 1: Applicable products . Updated Table 2: Clock sources .
01-Aug-2013	3	Updated POR/PDR description in Section 2: Power supply .

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