Introduction

Holtek HT8 MCUs normally provide four oscillator types as sources for their system clocks and peripherals to use. These are the HIRC, HXT, LIRC and LXT oscillators, each one with their own special characteristics. This text introduces the various oscillator characteristics and differences, the ways to switch between the different oscillators, the situations in which the MCU enters the SLOW, SLEEP or IDLE modes and behavioral differences between the different oscillators.

Functional Description

System Clock Source Selections and Differences

HT8 MCU Oscillator Overview

In addition to being the source of the main system clock the HT8 oscillators also provide clock sources for the Watchdog Timer and peripheral circuits. There are four oscillator sources, the external high speed crystal oscillator, HXT, the external low speed crystal oscillator, LXT, the internal high speed RC oscillator, HIRC, and the internal low speed RC oscillator, LIRC. External oscillators require some external components, while fully integrated internal oscillators require no external components. All oscillator options are selected through configuration options or registers. The higher frequency oscillators provide higher performance but carry with it the disadvantage of higher power requirements, while the opposite is of course true for the lower frequency oscillators. With the capability of dynamically switching between a fast and slow system clock, the device has the flexibility to optimise the performance/power ratio, a feature especially important in power sensitive portable applications.
The HT8 MCU oscillator and system frequency general structure is as follows:

![HT8 MCU Four Oscillator and System Frequency Structure](image)

Note that the above diagram depicts the general case but as the exact structure may have some variations the actual MCU datasheet should be consulted.

### System Clock Source Differences

There are four clock sources for the HT8 MCUs, the features of each are as follows.

- **External Crystal/Ceramic Oscillator – HXT**
  
The External Crystal/Ceramic System Oscillator is one of the high frequency oscillator choices, which is selected via a configuration option. For most crystal oscillator configurations, the simple connection of a crystal across OSC1 and OSC2 will create the necessary phase shift and feedback for oscillation, without requiring external capacitors. However, for some crystal types and frequencies, to ensure oscillation, it may be necessary to add two small value capacitors, C1 and C2. Using a ceramic resonator will usually require two small value capacitors, C1 and C2, to be connected as shown for oscillation to occur. The values of C1 and C2 should be selected in consultation with the crystal or resonator manufacturer's specification.
For oscillator stability and to minimise the effects of noise and crosstalk, it is important to ensure that the crystal and any associated resistors and capacitors along with interconnecting lines are all located as close to the MCU as possible.

![Oscillator Circuit Diagram](image)

Note: 1. In the low frequency situation it is necessary to connect two capacitors, C1 and C2.

2. It is important to ensure that the crystal and any associated resistors and capacitors along with interconnecting lines are all located as close to the MCU as possible.

### Crystal/Resonator Oscillator – HXT

<table>
<thead>
<tr>
<th>Crystal Frequency</th>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>20MHz</td>
<td>0pF</td>
<td>0pF</td>
</tr>
<tr>
<td>10MHz</td>
<td>0pF</td>
<td>0pF</td>
</tr>
<tr>
<td>8MHz</td>
<td>0pF</td>
<td>0pF</td>
</tr>
<tr>
<td>4MHz</td>
<td>0pF</td>
<td>0pF</td>
</tr>
<tr>
<td>1MHz</td>
<td>100pF</td>
<td>100pF</td>
</tr>
</tbody>
</table>

Note: C1 and C2 values are for guidance only. Consult the crystal oscillator manufacturer for the exact values.

### Crystal Recommended Capacitor Values

- **Internal High Speed RC Oscillator – HIRC**
  
The internal RC oscillator is a fully integrated system oscillator requiring no external components. Device trimming during the manufacturing process and the inclusion of internal frequency compensation circuits are used to ensure that the influence of the power supply voltage, temperature and process variations on the oscillation frequency are minimised. As a result, at a power supply of either 3V or 5V and at a temperature of 25˚C degrees, the oscillation frequency will have a tolerance within 2%. Note that if this internal system clock option is selected, as it requires no external pins for its operation, the external oscillator pins are free for use for other shared functions.

The internal RC oscillator frequency varies with the HT8 MCU device chosen.

Note: Users should check with the MCU datasheet before use.
Internal 32kHz Oscillator – LIRC

The Internal 32kHz System Oscillator is one of the low frequency oscillator choices, which is selected via configuration option. It is a fully integrated RC oscillator with a typical frequency of 32kHz at 5V, requiring no external components for its implementation. Device trimming during the manufacturing process and the inclusion of internal frequency compensation circuits are used to ensure that the influence of the power supply voltage, temperature and process variations on the oscillation frequency are minimised.

External 32.768kHz Crystal Oscillator – LXT

- LXT Basic Performance

The External 32.768kHz Crystal System Oscillator is one of the low frequency oscillator choices, which is selected via configuration option. This clock source has a fixed frequency of 32.768kHz and requires a 32.768kHz crystal to be connected between pins XT1 and XT2. The external resistor and capacitor components connected to the 32.768kHz crystal are necessary to provide oscillation. For applications where precise frequencies are essential, these components may be required to provide frequency compensation due to different crystal manufacturing tolerances. During power-up there is a time delay associated with the LXT oscillator waiting for it to start-up.

When the microcontroller enters the SLEEP or IDLE Mode, the system clock is switched off to stop microcontroller activity and to conserve power. However, in many microcontroller applications it may be necessary to keep the internal timers operational even when the microcontroller is in the SLEEP or IDLE Mode. To do this, another clock, independent of the system clock, must be provided. However, for some crystals, to ensure oscillation and accurate frequency generation, it is necessary to add two small value external capacitors, C1 and C2. The exact values of C1 and C2 should be selected in consultation with the crystal or resonator manufacturer specification. The external parallel feedback resistor, Rf, is required. Some configuration options determine if the XT1/XT2 pins are used for the LXT oscillator or as I/O pins.

- If the LXT oscillator is not used for any clock source, the XT1/XT2 pins can be used for other functions.
- If the LXT oscillator is used for any clock source, the 32.768kHz crystal should be connected to the XT1/XT2 pins.
For oscillator stability and to minimise the effects of noise and crosstalk, it is important to ensure that the crystal and any associated resistors and capacitors along with interconnecting lines are all located as close to the MCU as possible.

![External LXT Oscillator](image)

**External LXT Oscillator**

<table>
<thead>
<tr>
<th>Crystal Frequency</th>
<th>C1</th>
<th>C2</th>
</tr>
</thead>
<tbody>
<tr>
<td>32768kHz</td>
<td>10pF</td>
<td>10pF</td>
</tr>
</tbody>
</table>

Note: 1. C1 and C2 values are for guidance only. Consult the crystal oscillator manufacturer for the exact values. 2. R = 5MΩ~10MΩ is recommended.

**32.768kHz Crystal Recommended Capacitor Values**

◆ LXT Oscillator Low Power Function

The LXT oscillator can function in one of two modes, the Quick Start Mode and the Low Power Mode. The mode selection is executed using the LXTLP bit in the TBC register.

<table>
<thead>
<tr>
<th>LXTLP Bit</th>
<th>LXT Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Quick Start</td>
</tr>
<tr>
<td>1</td>
<td>Low-power</td>
</tr>
</tbody>
</table>

**LXT Oscillator Quick Start**

After power on, the LXTLP bit will be automatically cleared to zero ensuring that the LXT oscillator is in the Quick Start operating mode. In the Quick Start Mode the LXT oscillator will power up and stabilise quickly. However, after the LXT oscillator has fully powered up it can be placed into the Low-power mode by setting the LXTLP bit high. The oscillator will continue to run but with reduced current consumption, as the higher current consumption is only required during the LXT oscillator start-up. In power sensitive applications, such as battery applications, where power consumption must be kept to a minimum, it is therefore recommended that the application program sets the LXTLP bit high about 2 seconds after power-on. It should be noted that, no matter what condition the LXTLP bit is set to, the LXT oscillator will always function normally, the only difference is that it will take more time to start up if in the Low-power mode.
System Clock Source Selections

- Clock Source Selection Methods
The HT8 MCUs have two high speed clock sources and two low speed clock sources. The internal HIRC oscillator, which is one of the high speed clock sources, has several frequencies. Depending upon which MCU is chosen, the clock source and clock frequency are chosen using either:
  1. Selected via configuration options
  2. Selected via registers
Note: Users should consult the corresponding MCU datasheet before use.

- System Clock Selection Methods
Selecting whether the low or high speed oscillator is used as the system oscillator is implemented using the HLCLK bit and the CKS2~CKS0 bits in the SMOD register. Using this bit the system clock can be dynamically selected. The frequency of the slow speed or high speed system clock is also determined using the HLCLK bit and CKS2~CKS0 bits in the SMOD register. Note that two oscillator selections must be made namely one high speed and one low speed system oscillators. It is not possible to choose a no-oscillator selection for either the high or low speed oscillator.

- Bit 0 of the SMOD register, HLCLK, is the system clock selection bit.
  - When this bit is high, the $f_H$ clock will be selected as the system clock.
  - When this bit is low, the $f_H/2$~$f_H/64$ or $f_{SUB}$ clock will be selected as the system clock.
  - When system clock switches from the $f_H$ clock to the $f_{SUB}$ clock and the $f_H$ clock will be automatically switched off to conserve power.

- Bit 7~5 of the SMOD register, CKS2~CKS0, are used to select the system clock source.
  - In addition to the system clock source, which can be either the LXT or LIRC, a divided version of the high speed system oscillator can also be chosen as the system clock source.
  - When HLCLK is “0”, the clock sources selected by the CKS2~CKS0 bits are shown as follows:
    - 000: $f_{SUB}$ (fLXT or fLIRC)
    - 001: $f_{SUB}$ (fLXT or fLIRC)
    - 010: $f_H/64$
    - 011: $f_H/32$
    - 100: $f_H/16$
    - 101: $f_H/8$
    - 110: $f_H/4$
    - 111: $f_H/2$
System Clock Switching (Including High and Low Clock Frequency & Clock Source Switching) Considerations

There are six different modes of operation for the microcontroller, each one with its own special characteristics and which can be chosen according to the specific performance and power requirements of the application. There are two modes allowing normal operation of the microcontroller, the NORMAL Mode and SLOW Mode. The remaining four modes, the SLEEP0, SLEEP1, IDLE0 and IDLE1 Mode are used when the microcontroller CPU is switched off to conserve power.

In the NORMAL Mode the system uses the high speed system oscillator while in the SLOW Mode the system uses the low speed system oscillator. Therefore, switching between the NORMAL Mode and SLOW Mode is switching between the high and low frequency oscillators.

The device can switch between operating modes dynamically allowing the user to select the best performance/power ratio for the present task in hand. In this way microcontroller operations that do not require high performance can be executed using slower clocks thus requiring less operating current and prolonging battery life in portable applications. In simple terms, Mode Switching between the NORMAL Mode and SLOW Mode is executed using the HLCLK bit and CKS2~CKS0 bits in the SMOD register.

**NORMAL Mode**

This is one of the main operating modes where the microcontroller has all of its functions operational and where the system clock is provided by one of the high speed oscillators. This mode operates allowing the microcontroller to operate normally with a clock source will come from one of the high speed oscillators, either the HXT or HIRC oscillators. The high speed oscillator will however first be divided by a ratio ranging from 1 to 64, the actual ratio being selected by the CKS2~CKS0 and HLCLK bits in the SMOD register. Although a high speed oscillator is used, running the microcontroller at a divided clock ratio reduces the operating current.

**SLOW Mode**

This is also a mode where the microcontroller operates normally although now with a slower speed clock source. The clock source used will be from one of the low speed oscillators, either the LXT or the LIRC. Running the microcontroller in this mode allows it to run with much lower operating currents. In the SLOW Mode, the fH is off.

**NORMAL Mode to SLOW Mode Switching**

When running in the NORMAL Mode, which uses the high speed system oscillator, and therefore consumes more power, the system clock can switch to run in the SLOW Mode by set the HLCLK bit to "0" and set the CKS2~CKS0 bits to "000" or "001" in the SMOD register. This will then use the low speed system oscillator which will consume less power.

Users may decide to do this for certain operations which do not require high performance
and can subsequently reduce power consumption. The SLOW Mode is sourced from the LXT or the LIRC oscillators and therefore requires these oscillators to be stable before full mode switching occurs. This is monitored using the LTO bit in the SMOD register.

**SLOW Mode to NORMAL Mode Switching**

In the SLOW Mode the system uses either the LXT or LIRC low speed system oscillator. To switch back to the NORMAL Mode, where the high speed system oscillator is used, the HLCLK bit should be set high or HLCLK bit is “0”, but CKS2~CKS0 is set to “010”, “011”, “100”, “101”, “110” or “111”. As a certain amount of time will be required for the high frequency clock to stabilise, the status of the HTO bit is checked. The amount of time required for high speed system oscillator stabilization depends upon which high speed system oscillator type is used.

**HIRC, HXT, LIRC and LXT Oscillator Characteristics (V, T)**

This section mainly introduces the four oscillator voltage and temperature characteristics. For the crystal oscillators, whether the high speed or low speed oscillator, the oscillation frequency varies little with voltage and temperature. Here the RC oscillator voltage and temperature characteristics are mainly analysed.

**The Reason for RC Oscillator Varying with Temperature**

An active RC oscillator mainly uses a constant current to charge the capacitor. The voltage across the capacitor has a linear relationship with charging time. The oscillator obtains a relatively constant charging time via a voltage comparator and feedback control, and converts it into a fixed frequency clock signal. In the process, the delay time of the voltage comparator and feedback control is the most important factor influencing the clock frequency accuracy.

Because the internal resistance of integrated circuits exhibit a high interdependency on temperature, and because the comparator delay time is also affected by temperature, these will in turn create variations in the clock frequency. This is the reason for the internal RC oscillator frequency varying with temperature.

**HT8 MCU HIRC/HXT/LIRC/LXT Oscillator Voltage and Temperature Characteristics**

- **HT8 MCU Internal HIRC Oscillator Voltage and Temperature Characteristics**

  The internal HIRC oscillator voltage and temperature characteristics include the following parameters:

  1. \( V_{DD}=3V/5V, Ta=25^\circ C \).
  2. \( V_{DD}=3V/5V, Ta=0^\circ C~70^\circ C \).
  3. \( V_{DD}=2.2V~5.5V, Ta=0^\circ C~70^\circ C \).
  4. \( V_{DD}=2.2V~5.5V, Ta=-40^\circ C~85^\circ C \).
The frequency characteristics according to the four conditions are shown below:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( V_{DD} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_{HIRC} )</td>
<td>System Clock (HIRC)</td>
<td>3V/5V</td>
<td>Ta = 25°C</td>
<td>-2%</td>
<td>8</td>
<td>-2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3V/5V</td>
<td>Ta = 0°C~70°C</td>
<td>-5%</td>
<td>8</td>
<td>-5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2V~5.5V</td>
<td>Ta = 0°C~70°C</td>
<td>-8%</td>
<td>8</td>
<td>-8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2V~5.5V</td>
<td>Ta = -40°C~85°C</td>
<td>-12%</td>
<td>8</td>
<td>-12%</td>
</tr>
</tbody>
</table>

**HIRC Oscillator Voltage and Temperature Characteristics**

Refer to the HT66F002/HT66F0025/HT66F003/HT66F004 datasheet named “Cost-Effective A/D Flash 8-Bit MCU with EEPROM” for the data.

**HT8 MCU Internal LIRC Oscillator Voltage and Temperature Characteristics**

The Internal 32kHz System Oscillator is one of the low frequency oscillator choices, which is selected via configuration option. It is a fully integrated RC oscillator with a typical frequency of 32kHz at 5V, requiring no external components for its implementation.

Device trimming during the manufacturing process and the inclusion of internal frequency compensation circuits are used to ensure that the influence of the power supply voltage, temperature and process variations on the oscillation frequency are minimised.

As a result, at a power supply of 5V and at a temperature of 25°C degrees, the fixed oscillation frequency of 32kHz will have a tolerance within ±10%.

Under full temperature and full voltage conditions, the frequency varies as follows.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Test Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( V_{DD} )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_{LIRC} )</td>
<td>System Clock (LIRC)</td>
<td>5V</td>
<td>Ta = 25°C</td>
<td>-10%</td>
<td>32</td>
<td>+10%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2V~5.5V</td>
<td>Ta = -40°C~85°C</td>
<td>-50%</td>
<td>32</td>
<td>+60%</td>
</tr>
</tbody>
</table>

**LIRC Oscillator Voltage and Temperature Characteristics**

Refer to the HT66F002/HT66F0025/HT66F003/HT66F004 datasheet named “Cost-Effective A/D Flash 8-Bit MCU with EEPROM” for the data.

Note: The HT8 MCU operating frequency is dependent upon voltage. Therefore users must take care to ensure that the MCU operating voltage is selected correctly.

**HALT & Wake-up Clock Source Behavioral Differences for Different Modes**

There are six different modes of operation for the HT8 microcontrollers, each one with its own special characteristics and which can be chosen according to the specific performance and power requirements of the application. There are two modes allowing normal operation of the microcontroller, the NORMAL Mode and SLOW Mode. The remaining four modes, the SLEEP0, SLEEP1, IDLE0 and IDLE1 Mode are used when the microcontroller CPU is switched off to conserve power.

The devices can switch between operating modes dynamically allowing the selection of the best performance/power ratio for the present task in hand.
Mode Switching from the NORMAL/SLOW Modes to the SLEEP/IDLE Modes is implemented by executing the HALT instruction. When a HALT instruction is executed, whether the device enters the IDLE Mode or the SLEEP Mode is determined by the condition of the IDLEN bit in the SMOD register and FSYSON in the CTRL register. When the HLCLK bit switches to a low level, which implies that clock source is switched from the high speed clock source, fH, to the clock source, fH/2~fH/64 or fSUB. If the clock is sourced from fSUB, the high speed clock source will stop running to conserve power. When this happens it must be noted that the fH/16 and fH/64 internal clock sources will also stop running, which may affect the operation of other internal functions such as the TMs.

**SLEEP0 Mode**

- **Entering the SLEEP0 Mode**
  The SLEEP0 Mode is entered when a HALT instruction is executed and when the IDLEN bit in the SMOD register is low. The HT8 series of devices have different peripherals, so in the SLEEP0 Mode the peripheral configurations are different.
  The user should consult the corresponding HT8 series datasheet to ensure that the related peripherals are switched off before the system enters the SLEEP0 Mode.

- **SLEEP0 Mode features**
  - The system clock and the fSUB clock will be stopped and the application program will stop at the "HALT" instruction.
  - The Data Memory contents and registers will maintain their present condition.
  - The WDT will be cleared and stopped whether the WDT clock source originates from the fSUB clock or from the system clock.
  - The I/O ports will maintain their present conditions.
  - In the status register, the Power Down flag, PDF, will be set and the Watchdog time-out flag, TO, will be cleared.

**SLEEP1 Mode**

- **Entering the SLEEP1 Mode**
  The SLEEP1 Mode is entered when a HALT instruction is executed and when the IDLEN bit in the SMOD register is low. In the SLEEP1 mode the CPU will be stopped. However whether the fSUB clock will continue to operate is dependent upon the peripheral configurations.

- **SLEEP1 Mode features**
  - The system clock will be stopped and the application program will stop at the "HALT" instruction but the WDT or LVD will remain active with the clock source coming from the fSUB clock.
  - The Data Memory contents and registers will maintain their present condition.
The WDT will be cleared and resume counting if the WDT clock source is selected to come from the fSUB clock as the WDT is enabled.

The I/O ports will maintain their present conditions.

In the status register, the Power Down flag, PDF, will be set and the Watchdog time-out flag, TO, will be cleared.

**IDLE0 Mode**

- **Entering the IDLE0 Mode**

  The IDLE0 Mode is entered when a HALT instruction is executed and when the IDLEN bit in the SMOD register is high and the FSYSON bit in the CTRL register is low. In the IDLE0 Mode the system oscillator will be inhibited from driving the CPU but some peripheral functions will remain operational.

- **IDLE0 Mode features**

  - The system clock will be stopped and the application program will stop at the "HALT" instruction, but the fSUB clock will be on.
  - The Data Memory contents and registers will maintain their present condition.
  - The WDT will be cleared and resume counting if the WDT clock source is selected to come from the fSUB clock and the WDT is enabled. The WDT will stop if its clock source originates from the system clock.
  - The I/O ports will maintain their present conditions.
  - In the status register, the Power Down flag, PDF, will be set and the Watchdog time-out flag, TO, will be cleared.

**IDLE1 Mode**

- **Entering the IDLE1 Mode**

  The IDLE1 Mode is entered when a HALT instruction is executed and when the IDLEN bit in the SMOD register is high and the FSYSON bit in the CTRL register is high. In the IDLE1 Mode the system oscillator will be inhibited from driving the CPU but may continue to provide a clock source to keep some peripheral functions operational. In the IDLE1 Mode, the system oscillator will continue to run, and this system oscillator may be the high speed or low speed system oscillator. For different MCUs the peripheral functions are different.

- **IDLE1 Mode features**

  - The system clock and the fSUB clock will be on and the application program will stop at the "HALT" instruction.
  - The Data Memory contents and registers will maintain their present condition.
  - The WDT will be cleared and resume counting if the WDT is enabled regardless of the WDT clock source which originates from the fSUB clock or from the system clock.
  - The I/O ports will maintain their present conditions.
  - In the status register, the Power Down flag, PDF, will be set and the Watchdog time-out flag, TO, will be cleared.
Standby Current Considerations

As the main reason for entering the SLEEP or IDLE Mode is to keep the current consumption of the device to as low a value as possible, perhaps only in the order of several micro-amps except in the IDLE1 Mode, there are other considerations which must also be taken into account by the circuit designer if the power consumption is to be minimised. Special attention must be made to the I/O pins on the device. All high-impedance input pins must be connected to either a fixed high or low level as any floating input pins could create internal oscillations and result in increased current consumption. This also applies to the device which has different package types, as there may be unbonded pins. These must either be setup as outputs or if setup as inputs must have pull-high resistors connected. Care must also be taken with any loads which are connected to I/O pins and which are setup as outputs. These should be placed in a condition in which minimum current is drawn or connected only to external circuits that do not draw current, such as other CMOS inputs. Also note that additional standby current will also be required if the configuration options have enabled the LXT or LIRC oscillator.

In the IDLE1 Mode where the system oscillator is on, if the system oscillator is from the high speed system oscillator, the additional standby current could be in the order of several hundred micro-amps.

Fast Wake-up

To minimise power consumption the device can enter the SLEEP or IDLE0 Mode, where the system clock source to the device will be stopped. However when the device is woken up again, it can take a considerable time for the original system oscillator to restart, stabilise and allow normal operation to resume. To ensure the device is up and running as fast as possible a Fast Wake-up function is provided, which allows \( f_{\text{SUB}} \), namely either the LXT or LIRC oscillator, to act as a temporary clock to first drive the system until the original system oscillator has stabilised. As the clock source for the Fast Wake-up function is \( f_{\text{SUB}} \), the Fast Wake-up function is only available in the SLEEP1 and IDLE0 modes. When the device is woken up from the SLEEP0 mode, the Fast Wake-up function has no effect because the \( f_{\text{SUB}} \) clock is stopped. The Fast Wake-up enable/disable function is controlled using the FSTEN bit in the SMOD register. If the HXT oscillator is selected as the NORMAL Mode system clock, and if the Fast Wake-up function is enabled, then it will take one to two \( f_{\text{SUB}} \) clock cycles of the LIRC or LXT oscillator for the system to wake-up. The system will then initially run under the \( f_{\text{SUB}} \) clock source until 1024 HXT clock cycles have elapsed, at which point the HTO flag will switch high and the system will switch over to operating from the HXT oscillator. If the HIRC oscillator or LIRC oscillator is used as the system oscillator then it will take \( 15\sim16 \) clock cycles of the HIRC or 1~2 cycles of the LIRC to wake up the system from the SLEEP or IDLE0 Mode. The Fast Wake-up bit, FSTEN will have no effect in these cases.
System Oscillator | FSTEN Bit | Wake-up Time (SLEEP0 Mode) | Wake-up Time (SLEEP1 Mode) | Wake-up Time (IDLE0 Mode) | Wake-up Time (IDLE1 Mode)
---|---|---|---|---|---
HXT | 0 | 1024 HXT cycles | 1024 HXT cycles | 1~2 HXT cycles | 1~2 HXT cycles
| 1 | 1024 HXT cycles | 1~2 $f_{sub}$ cycles (System runs with $f_{sub}$ first for 1024 HXT cycles and then switches over to run with the HXT clock) | 1~2 HXT cycles | 1~2 HXT cycles
HIRC | – | 15~16 HIRC cycles | 15~16 HIRC cycles | 1~2 HIRC cycles | 1~2 HIRC cycles
LIRC | – | 1~2 LIRC cycles | 1~2 LIRC cycles | 1~2 LIRC cycles | 1~2 LIRC cycles
LXT | – | 1024 LXT cycles | 1024 LXT cycles | 1~2 LXT cycles | 1~2 LXT cycles

**Oscillator Wake-Up Time**

**Wake-up**

After the system enters the SLEEP or IDLE Mode, it can be woken up from one of various sources listed as follows:

- **An external falling edge on Port A**

  Each pin on Port A can be setup using the PAWU register to permit a negative transition on the pin to wake-up the system. When a Port A pin wake-up occurs, the program will resume execution at the instruction following the "HALT" instruction.

- **A system interrupt**

  If the system is woken up by an interrupt, then two possible situations may occur. The first is where the related interrupt is disabled or the interrupt is enabled but the stack is full, in which case the program will resume execution at the instruction following the "HALT" instruction. In this situation, the interrupt which woke-up the device will not be immediately serviced, but will rather be serviced later when the related interrupt is finally enabled or when a stack level becomes free. The other situation is where the related interrupt is enabled and the stack is not full, in which case the regular interrupt response takes place. If an interrupt request flag is set high before entering the SLEEP or IDLE Mode, the wake-up function of the related interrupt will be disabled.

- **A WDT overflow**

  If the device is woken up by a WDT overflow, a Watchdog Timer reset will be initiated. The PDF flag is cleared by a system power-up or executing the clear Watchdog Timer instructions and is set when executing the "HALT" instruction. The TO flag is set if a WDT time-out occurs, and causes a wake-up that only resets the Program Counter and Stack Pointer, the other flags remain in their original status.
Programming Considerations

The HXT and LXT oscillators both need a certain amount of time to start up. Therefore HT8 MCUs provide a SST counter for them. After the HXT oscillator is stable, the HTO bit in the SMOD register will be set high by the MCU, and hence users can check this bit to determine whether the HXT oscillator is stable.

The LXT oscillator has a quick start function in the start-up process. When the LXTLP bit in the TBC register is cleared to zero by users, the LXT oscillator will power up quickly. After the LXT oscillator is stable, the LXTLP bit can be set high to conserve power.

Conclusion

This text has described the HT8 series system clock, to ensure users have a deeper understanding of various oscillator characteristics, switching between the high speed and low speed oscillators and switching between different modes. Users can optimise the operation of their microcontroller to achieve the best performance/power ratio.

Versions and Modification Information

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<th>Date</th>
<th>Author</th>
<th>Issue Release and Modification</th>
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<tr>
<td>2016.05.26</td>
<td>王赞臣 (Jasen Wang)</td>
<td>First Version</td>
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References


For more information, refer to the Holtek’s official website

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