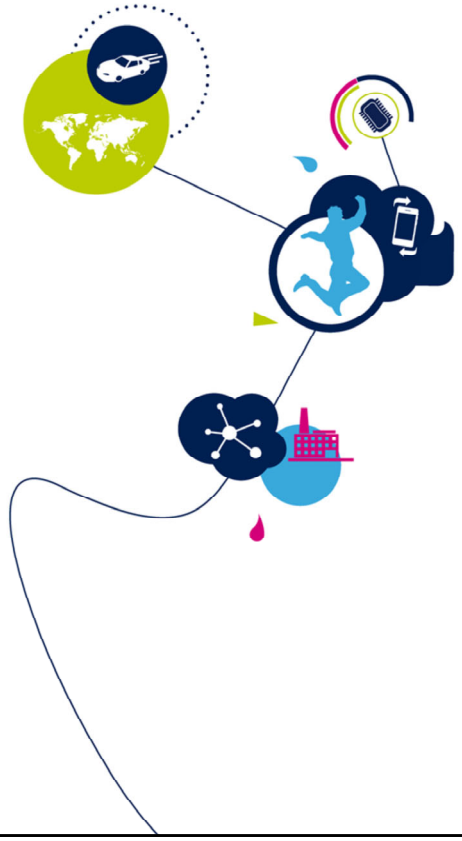
STM32MP1 - DTS

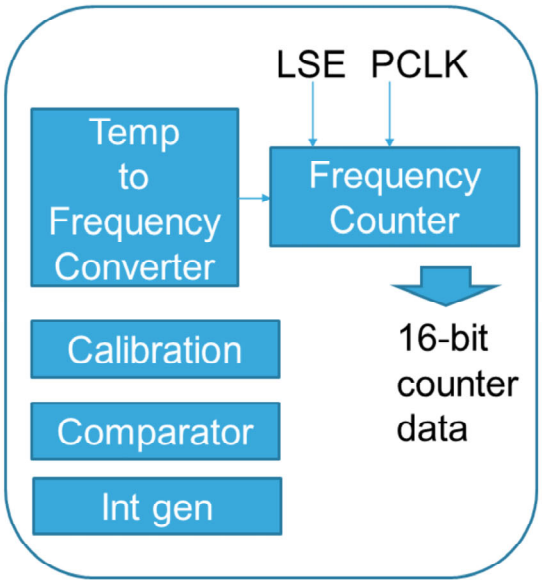
Digital Temperature Sensor
Revision 1.0



life.augmented

Hello and welcome to this presentation of the STM32MP1 Digital Temperature Sensor module. It covers the main features of this block, which is used to convert the die temperature to digital values for further processing in the digital domain.

Overview



- Provides digital readable temperature data
  - Low power temperature measurement
  - Interrupt generation by temperature watchdog
  - Wakeup signal generation by temperature watchdog

Application benefits

- Low power temperature measurement
- No need to enable ADC, totally digital interface

life.augmented

This digital temperature sensor allows the microcontroller to measure the die temperature without using other analog resources. The temperature sensor itself only consumes 20 µA. The temperature is converted into a frequency, so that a counter based on LSE or PCLK clock can measure it. Output data is 16-bit data. It also integrates a window comparator for threshold detection. This comparator triggers an interrupt when the temperature exceeds a predefined level.

Key features

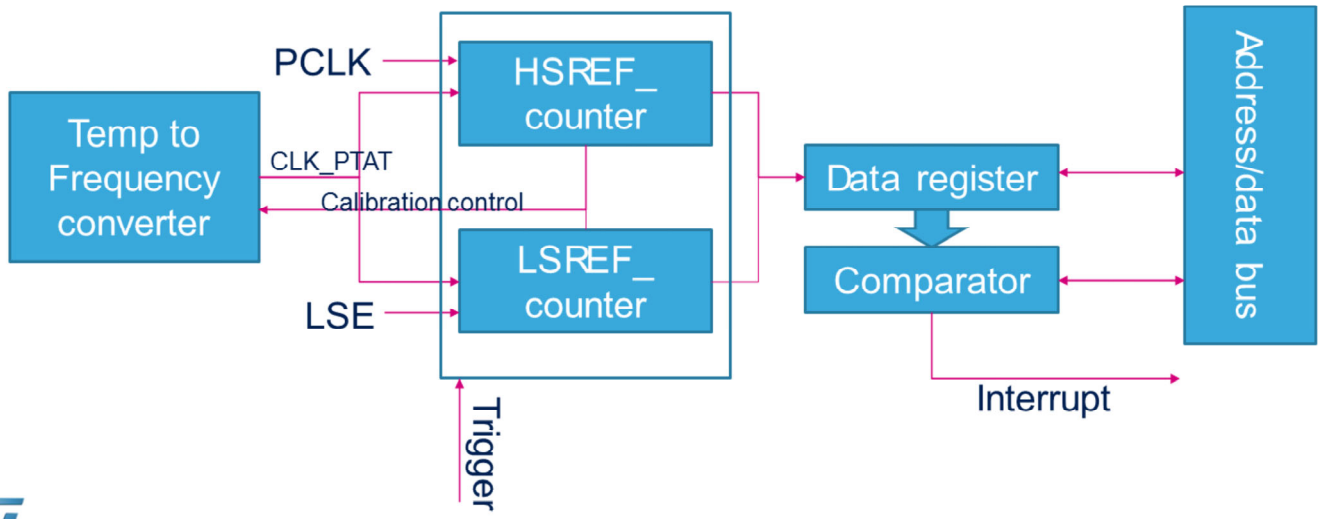
3

Parameters	Description
Temperature range	-40 to 125 °C
Linearity	± 1 °C (TBD)
Max error	± 5 °C (TBD)
Counter operation	Operated by LSE or PCLK clock
Temperature data	Read by 16-bit counter data through APB interface
Triggers	Software or external trigger (for Timers & IOs)
Special functions	Asynchronous wakeup signal generation (LSE mode)
Interrupt generation	Threshold detection, end of measurement
Consumption	20µ A
Measurement time	~1.5µ s w/out calibration, ~2 ms with calibration

life.augmented

The STM32MP1 device integrates a digital temperature sensor which can measure the die temperature from -40 to 125 °C. It can operate either using the LSE clock or PCLK clock. There are also several different methods to trigger the measurement. The temperature watchdog function can generate interrupts or wakeup signals.

Block diagram



This is the general block diagram for the digital temperature sensor embedded in the STM32MP1 device.

Operating modes

Different clock configuration

- PCLK only
  - Temperature measurement done with PCLK clock
  - APB register can be fully accessible
- PCLK and LSE
  - Temperature measurement done with LSE clock
  - APB register can be fully accessible
- LSE only
  - Temperature measurement done with LSE clock
  - APB register cannot be accessible

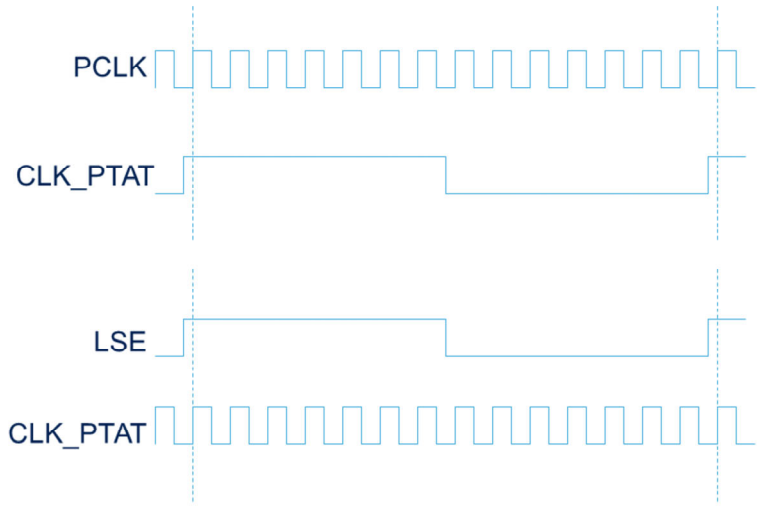
life.augmented

The digital temperature sensor has three operating modes depending on the clock source selected to operate the temperature measurement. Note that the PCLK clock is mandatory to access the APB registers.

Temperature measurement (1/2)

Frequency counter to measure the temperature

- CLK_PTAT is typical 641 kHz.
  - When PCLK is selected
    - CLK_PTAT cycle measured by PCLK counter
  - When LSE is selected
    - LSE (32 kHz) cycle is measured by CLK_PTAT counter
  - The counter result is available at TS1_MFREQ register



life.augmented

The digital temperature sensor block generates a clock output frequency proportional to the temperature.
This frequency can be measured by the PCLK clock or when LSE mode is selected; LSE clock frequency is measured by CLK_PTAT.
The counter data is available in the TS1_MFREQ register.

Temperature measurement (2/2)

Frequency counter to measure the temperature

- Temperature calculation
  - T = T0 + (FRQ(T) – FRQ(T0)) x (TS1_RAMP_COEFF))

    Where T0 is the factory calibration temperature and

    TS1_RAMP_COEFF is the temperature coefficient measured in factory stored in option byte

    FRQ(T) is frequency measured by counter : (F(PCLK)/TS1_MFREQ)*TS1_SMP_TIME

    FRQ(T0) is frequency measured in factory stored in option byte : 100*TS1_MPT0
- Sampling time
  - To increase the measurement accuracy, frequency counter can measure up to 15 cycles

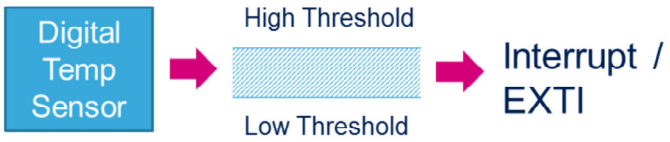
life.augmented

The temperature is calculated using a factory-measured calibration frequency and temperature coefficient information.
To increase the measurement accuracy, it is possible to measure the temperature over several cycles.

Temperature watchdog

Window comparator

- Temperature sensor has a window comparator
  - When temperature measurement result exceeds a threshold, it can create an interrupt or wakeup signal.
  - When PCLK is available, it can generate an interrupt to NVIC
  - When PCLK is not available, it can generate a wakeup signal for the system



life.augmented

The digital temperature sensor integrates a watchdog with high and low threshold settings. The measured temperature is compared to this window threshold. If the result exceeds the threshold, an interrupt or an external signal can be generated.

Interrupts

Interrupt event	Description
ITEF	End of measurement
ITLF	Low threshold detection
ITHF	High threshold detection

life.augmented

The temperature sensor can generate 3 different interrupts: end of measurement, low threshold detection and high threshold detection.

Low-power modes

Mode	Description
CRun	**Active**.
CSleep	**Active**.
Stop + LP Stop	**Active**. DTS can run from LSE. It can be used as wakeup source.
LPLV Stop	**Active**. DTS can run from LSE. It can be used as wakeup source.
Standby	**Powered-down**. The peripheral must be reinitialized after exiting Standby mode.

life.augmented

The digital-to-analog converter is active in the following low-power modes: CRun, Csleep, Stop, LP Stop and LPLV Stop.
In Standby mode, the DAC is powered-down and it must be reinitialized afterwards.

Related peripherals

- Refer to these trainings linked to this peripheral, if needed:
  - Interrupts
  - TIM – Timers for triggering interrupts and events

life.augmented

This is a list of peripherals related to the temperature sensor. Please refer to these peripheral trainings for more information.