Hello, and welcome to this presentation of the STM32G4 analog comparators. It covers the main features of the ultra-low-power comparators and gives some application examples.
Up to seven analog comparators inside STM32 microcontrollers provide a binary output which indicates if the analog voltage on the plus input is larger than the voltage on the negative input. It allows the MCU to react when the analog signal crosses a predefined threshold.

The comparator continuously monitors voltage in contrast to an analog-to-digital converter which operates in sampled mode.

The comparator can be used to wake up devices from Sleep and Stop modes.

Motor control loop is simplified by enabling a cooperation between the following units: comparators, timers, DACs and VREFINT.

Applications can benefit from the flexible configuration of comparator properties which can be locked for safety reasons.
Another safety feature of the comparator is its ability to generate a break signal for timers allowing to safely stop the generation of PWM driving signals. Delay between analog threshold crossing and digital output assertion is less than 15 ns.
STM32G4 microcontrollers implement up to 7 comparators. The comparator includes a programmable hysteresis to avoid spurious output transitions with noisy input signals. It offers flexible inter-connections of inputs and outputs allowing the selection of thresholds for several external and internal inputs such as DAC outputs or internal reference voltage outputs. The comparator output can be connected to I/Os using the alternate function channels or internally redirected to a variety of timer inputs, enabling the break event for fast PWM shutdown. It is also possible to create cycle-by-cycle current control or input captures for timing measurements. The COMPx control registers can be locked until the next microcontroller reset.

Key features

- Up to 7 independent comparators
- Programmable hysteresis
- Configurable plus and negative inputs
  - Multiplexed I/O pins, DAC channels 1 and 2, internal reference voltage and its three submultiple values
- Output redirection
  - Configurable I/Os
  - Timer – break event for fast PWM shutdown, cycle-by-cycle current control, and input capture for timing measurements
  - Output blanking source
- The comparator control and status registers can be write-protected
The number of comparators depends on the exact reference of the STM32G4 microcontroller. STM32G43x and STM32G44x series implement 4 comparators while STM32G47x and STM32G48x series implement 7 comparators.

The figure shows the general block diagram of the comparator integrated in STM32G4 microcontrollers. The multiplexors on the left select the voltage sources to be compared: GPIOs, DAC outputs, VREFINT with four divide ratios.

The output of the comparator can be inverted. The state of the comparator can be connected to:
- GPIOs
- EXTI module to generate a wakeup request or an event to the CPU
- Timer inputs.

It is possible to have the comparator output
simultaneously redirected internally and externally.
Each comparator has a non-inverting input and an inverting input.
The INMSEL field in the COMP1_CSR and COMP2_CSR registers is used to select the inverting input.
Note that VREFINT possibly divided can be selected as the INM input of any comparator.
The INPSEL field in the COMP1_CSR and COMP2_CSR registers is used to select the non-inverting input.
Note that the output of any comparator can be connected to timers and EXTI units.
The blanking function aims to mask the output of the comparator during period of times indicated by a timer. This is typically used in the PFC technique (Predictive Functional Control). The output of the comparator called VALUE is ignored when the timer TIMx_OCy signal is asserted.
The comparator can be used in the cycle-by-cycle regulation loop for monitoring the peak value of the current flowing into the load. The purpose of the blanking function is to prevent incorrect current regulation tripping due to short duration current spikes at the beginning of the PWM period. Short current spikes caused by activating the power switches can produce false pulses on the comparator output – marked by the blue color on the diagram. These pulses need to be masked by a blanking window to avoid false fault detection. The blanking window waveform can be generated by one of the timer output channels.
The comparator’s output can be masked during a blanking time defined by the timer output compare value selected in the BLANKSEL field.

For each comparator, this table indicates which timer output signal is used to control the blanking.

<table>
<thead>
<tr>
<th>BLANKSEL</th>
<th>COMP1</th>
<th>COMP2</th>
<th>COMP3</th>
<th>COMP4</th>
<th>COMP5</th>
<th>COMP6</th>
<th>COMP7</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000</td>
<td>TIM1_OC5</td>
<td>TIM1_OC5</td>
<td>TIM1_OC5</td>
<td>TIM2_OC4</td>
<td>TIM2_OC3</td>
<td>TIM2_OC5</td>
<td>TIM1_OC5</td>
</tr>
<tr>
<td>0001</td>
<td>TIM2_OC3</td>
<td>TIM2_OC3</td>
<td>TIM3_OC3</td>
<td>TIM8_OC5</td>
<td>TIM8_OC5</td>
<td>TIM2_OC4</td>
<td>TIM8_OC5</td>
</tr>
<tr>
<td>0010</td>
<td>TIM3_OC3</td>
<td>TIM3_OC3</td>
<td>TIM2_OC4</td>
<td>TIM6_OC1</td>
<td>TIM3_OC3</td>
<td>TIM6_OC7</td>
<td>TIM3_OC3</td>
</tr>
<tr>
<td>0011</td>
<td>TIM8_OC5</td>
<td>TIM8_OC5</td>
<td>TIM8_OC5</td>
<td>TIM1_OC5</td>
<td>TIM1_OC5</td>
<td>TIM1_OC5</td>
<td>TIM5_OC2</td>
</tr>
<tr>
<td>0100</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
<td>TIM20_OC5</td>
</tr>
<tr>
<td>0101</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
<td>TIM6_OC1</td>
</tr>
<tr>
<td>0111</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
<td>TIM4_OC3</td>
</tr>
</tbody>
</table>
The comparator includes a programmable hysteresis to avoid spurious output transitions with noisy input signals. It is non-symmetrical and only acting to falling edge of the comparator output.

The internal hysteresis function can be disabled so as to set the amount of hysteresis with external components, which can be useful for example when exiting a low-power mode.
Comparator links with timers

- The 2 comparators’ outputs are interconnected with the timers input for versatile configuration:
  - On Inputs 1 and 2 (for capturing external timings or external counter reset)
  - On break input (for PWM permanent shut-down or cycle-by-cycle limit)
  - On ETR input (for cycle-by-cycle limit or external counter reset)

The comparators have internal connections with the timer units.
The output can be internally redirected to a wide range of timer inputs for the following purposes:
- Emergency shut-down of PWM signals, using BKin and BKin2 inputs
- Cycle-by-cycle current control, using Electronic Timing Relay (ETR) inputs
- Input capture for timing measures.
The connection between the comparators and the timer is generally used for two purposes:
• Cycle-by-cycle current limitation based on the blanking mechanism
• External counter reset when the voltage drops below a threshold: zero-crossing detection.

When both are needed simultaneously, the current limitation is based on the ETR timer input and a counter reset is signaled through a timer channel input.
The figure represents an example of direct connection between Timer and COMP units. Over-current limitation uses the ETR input and external reset uses the CH1 input.
The comparator can trigger an interrupt on the rising, falling or both edges of the comparator output through the EXTI line. This is required to exit the Stop modes. The output can also be connected to the CPU's nested vectored interrupt controller (NVIC).
The on-chip comparator remains active in the following modes: Run, Sleep, and Stop modes. In Standby and Shutdown modes, it is powered-down and must be reinitialized for use if returning to one of the higher powered modes. The comparator supports interrupt generation with wake-up from Sleep and Stop modes, through the EXTI unit.
Related peripherals

- Refer to these peripherals trainings linked to this peripheral:
  - IMX - Interconnect matrix
  - TIM - Timers
  - HRTIM – High Resolution Timer
  - EXTI – Extended interrupts and events controller
  - GPIO – General-purpose inputs and outputs
  - DAC – Digital to Analog Converters

This is a list of peripherals related to the COMP unit. Please refer to these peripheral trainings for more information if needed.