**Input Capture Unit**

The Timer/Counter1 incorporates an Input Capture unit that can capture external events and give them a time-stamp indicating time of occurrence. The external signal indicating an event, or multiple events, can be applied via the ICP1 pin or alternatively, via the analog-comparator unit. The time-stamps can then be used to calculate frequency, duty-cycle, and other features of the signal applied. Alternatively the time-stamps can be used for creating a log of the events.

The Input Capture unit is illustrated by the block diagram below. The elements of the block diagram that are not directly a part of the Input Capture unit are gray shaded. The lower case “n” in register and bit names indicates the Timer/Counter number.

Figure 1. Input Capture Unit Block Diagram for TC1 

Note: The “n” in the register and bit names indicates the device number (n = 1 for Timer/Counter 1), and the “x” indicates Output Compare unit (A/B).

When a change of the logic level (an event) occurs on the Input Capture pin (ICP1), or alternatively on the Analog Comparator output (ACO), and this change confirms to the setting of the edge detector, a capture will be triggered: the 16-bit value of the counter (TCNT1) is written to the Input Capture Register (ICR1). The Input Capture Flag (ICF) is set at the same system clock cycle as the TCNT1 value is copied into the ICR1 Register. If enabled (TIMSK1.ICIE=1), the Input Capture Flag generates an Input Capture interrupt. The ICF1 Flag is automatically cleared when the interrupt is executed. Alternatively the ICF Flag can be cleared by software by writing '1' to its I/O bit location.

Reading the 16-bit value in the Input Capture Register (ICR1) is done by first reading the low byte (ICR1L) and then the high byte (ICR1H). When the low byte is read form ICR1L, the high byte is copied into the high byte temporary register (TEMP). When the CPU reads the ICR1H I/O location it will access the TEMP Register.

The ICR1 Register can only be written when using a Waveform Generation mode that utilizes the ICR1 Register for defining the counter’s TOP value. In these cases the Waveform Generation mode bits (WGM1[3:0]) must be set before the TOP value can be written to the ICR1 Register. When writing the ICR1 Register, the high byte must be written to the ICR1H I/O location before the low byte is written to ICR1L.

See also [Accessing 16-bit Timer/Counter Registers](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-A7CE312E-676A-4DC2-B0C1-0A78575A1F85.html#GUID-A7CE312E-676A-4DC2-B0C1-0A78575A1F85).

* [**Input Capture Trigger Source**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-DA78F340-3559-45B9-9D4F-4A1E2EA2685F.html)
* [**Noise Canceler**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-E0E98BE5-664A-473E-8A94-99289E64CFC2.html)
* [**Using the Input Capture Unit**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-A55E12E2-5F05-4C0F-A588-BF0347326DEE.html)

**Parent topic:** [16-bit Timer/Counter1 with PWM](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-8734BE98-9BE4-403E-BDEF-9EFEDAB3E227.html)

**Input Capture Trigger Source**

The main trigger source for the Input Capture unit is the Input Capture pin (ICP1). Timer/Counter1 can alternatively use the Analog Comparator output as trigger source for the Input Capture unit. The Analog Comparator is selected as trigger source by setting the Analog Comparator Input Capture (ACIC) bit in the Analog Comparator Control and Status Register (ACSR). Be aware that changing trigger source can trigger a capture. The Input Capture Flag must therefore be cleared after the change.

Both the Input Capture pin (ICP1) and the Analog Comparator output (ACO) inputs are sampled using the same technique as for the T1 pin. The edge detector is also identical. However, when the noise canceler is enabled, additional logic is inserted before the edge detector, which increases the delay by four system clock cycles. The input of the noise canceler and edge detector is always enabled unless the Timer/Counter is set in a Waveform Generation mode that uses ICR1 to define TOP.

An Input Capture can be triggered by software by controlling the port of the ICP1 pin.

**Parent topic:** [Input Capture Unit](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-D7891C64-41BB-410A-B974-8439BBF393E9.html)

**Noise Canceler**

The noise canceler improves noise immunity by using a simple digital filtering scheme. The noise canceler input is monitored over four samples, and all four must be equal for changing the output that in turn is used by the edge detector.

The noise canceler is enabled by setting the Input Capture Noise Canceler bit in the Timer/Counter Control Register B (TCCR1B.ICNC). When enabled, the noise canceler introduces an additional delay of four system clock cycles between a change applied to the input and the update of the ICR1 Register. The noise canceler uses the system clock and is therefore not affected by the prescaler.

**Parent topic:** [Input Capture Unit](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-D7891C64-41BB-410A-B974-8439BBF393E9.html)

**Using the Input Capture Unit**

The main challenge when using the Input Capture unit is to assign enough processor capacity for handling the incoming events. The time between two events is critical. If the processor has not read the captured value in the ICR1 Register before the next event occurs, the ICR1 will be overwritten with a new value. In this case the result of the capture will be incorrect.

When using the Input Capture interrupt, the ICR1 Register should be read as early in the interrupt handler routine as possible. Even though the Input Capture interrupt has relatively high priority, the maximum interrupt response time is dependent on the maximum number of clock cycles it takes to handle any of the other interrupt requests.

Using the Input Capture unit in any mode of operation when the TOP value (resolution) is actively changed during operation, is not recommended.

Measurement of an external signal’s duty cycle requires that the trigger edge is changed after each capture. Changing the edge sensing must be done as early as possible after the ICR1 Register has been read. After a change of the edge, the Input Capture Flag (ICF) must be cleared by software (writing a logical one to the I/O bit location). For measuring frequency only, the clearing of the ICF Flag is not required (if an interrupt handler is used).

**Parent topic:** [Input Capture Unit](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-D7891C64-41BB-410A-B974-8439BBF393E9.html)

**AC - Analog Comparator**

* [**Overview**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-B9CE65F1-A479-4345-92EF-F32400BAB216.html)
* [**Analog Comparator Multiplexed Input**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-D42A1B6F-EE17-4BC5-B544-A086200B73FA.html)
* [**Register Description**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-DC2D66FE-6245-4BC8-8486-7528AB1A3538.html)

**Overview**

The Analog Comparator compares the input values on the positive pin AIN0 and negative pin AIN1. When the voltage on the positive pin AIN0 is higher than the voltage on the negative pin AIN1, the Analog Comparator output, ACO, is set. The comparator’s output can be set to trigger the Timer/Counter1 Input Capture function. In addition, the comparator can trigger a separate interrupt, exclusive to the Analog Comparator. The user can select Interrupt triggering on comparator output rise, fall or toggle. A block diagram of the comparator and its surrounding logic is shown below.

The Power Reduction ADC bit in the Power Reduction Register (PRR.PRADC) must be written to '0' in order to be able to use the ADC input MUX.

Figure 1. Analog Comparator Block Diagram 

Note: Refer to the *Pin Configuration* and the I/O Ports description for Analog Comparator pin placement

**Parent topic:** [Analog Comparator](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-2C6D5553-9283-4192-B127-5E20BB847330.html)

**Related Links**

* [I/O-Ports](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-17CFE490-9407-4B66-86B0-F62B6E0B469D.html)
* [PM - Power Management and Sleep Modes](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-B9279CDD-5742-4610-8FE1-BCF5C953081A.html)
* [Pin Configurations](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-4BA67711-B7C2-4345-B579-16840EF9E6ED.html)

# Analog Comparator Multiplexed Input

* It is possible to select any of the ADC[7:0] pins to replace the negative input to the Analog Comparator. The ADC multiplexer is used to select this input, and consequently, the ADC must be switched off to utilize this feature. If the Analog Comparator Multiplexer Enable bit in the ADC Control and Status Register B (ADCSRB.ACME) is '1' and the ADC is switched off (ADCSRA.ADEN=0), the three least significant Analog Channel Selection bits in the ADC Multiplexer Selection register (ADMUX.MUX[2:0]) select the input pin to replace the negative input to the Analog Comparator, as shown in the table below. When ADCSRB.ACME=0 or ADCSRA.ADEN=1, AIN1 is applied to the negative input of the Analog Comparator.

| Table 1. Analog Comparator Multiplexed Input |
| --- |
| **ACME** | **ADEN** | **MUX[2:0]** | **Analog Comparator Negative Input** |
| 0 | x | xxx | AIN1 |
| 1 | 1 | xxx | AIN1 |
| 1 | 0 | 000 | ADC0 |
| 1 | 0 | 001 | ADC1 |
| 1 | 0 | 010 | ADC2 |
| 1 | 0 | 011 | ADC3 |
| 1 | 0 | 100 | ADC4 |
| 1 | 0 | 101 | ADC5 |
| 1 | 0 | 110 | ADC6 |
| 1 | 0 | 111 | ADC7 |

* **Parent topic:** [Analog Comparator](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-2C6D5553-9283-4192-B127-5E20BB847330.html)

**Register Description**

* [**ADCSRB**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-6709536A-5EAD-4665-843C-8438D7AC270D.html)
ADC Control and Status Register B
* [**ACSR0**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-AD3F0414-AF6E-440B-8E9C-808409746601.html)
Analog Comparator Control and Status Register C
* [**ACSR**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-67EE35C9-97A4-4672-B874-B05B979F7BC6.html)
Analog Comparator Control and Status Register
* [**DIDR1**](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-DBA04151-17FC-4ADF-85EB-9610BB83FD63.html)
Digital Input Disable Register 1

**Parent topic:** [Analog Comparator](https://onlinedocs.microchip.com/pr/GUID-EC8D3BAB-0B5E-454F-AB6E-6A7C91C6F103-en-US-3/GUID-2C6D5553-9283-4192-B127-5E20BB847330.html)