

non-PWM modes refer to [Table 13-1 on page 134](#). For fast PWM mode refer to [Table 13-2 on page 135](#), and for phase correct and phase and frequency correct PWM refer to [Table 13-3 on page 135](#).

A change of the COM1x1:0 bits state will have effect at the first compare match after the bits are written. For non-PWM modes, the action can be forced to have immediate effect by using the FOC1x strobe bits.

13.9 Modes of Operation

The mode of operation, i.e., the behavior of the Timer/Counter and the Output Compare pins, is defined by the combination of the *Waveform Generation mode* (WGM13:0) and *Compare Output mode* (COM1x1:0) bits. The Compare Output mode bits do not affect the counting sequence, while the Waveform Generation mode bits do. The COM1x1:0 bits control whether the PWM output generated should be inverted or not (inverted or non-inverted PWM). For non-PWM modes the COM1x1:0 bits control whether the output should be set, cleared or toggle at a compare match (See [Section “13.8” on page 124](#).)

For detailed timing information refer to [“Timer/Counter Timing Diagrams” on page 132](#).

13.9.1 Normal Mode

The simplest mode of operation is the *Normal mode* (WGM13:0 = 0). In this mode the counting direction is always up (incrementing), and no counter clear is performed. The counter simply overruns when it passes its maximum 16-bit value (MAX = 0xFFFF) and then restarts from the BOTTOM (0x0000). In normal operation the *Timer/Counter Overflow Flag* (TOV1) will be set in the same timer clock cycle as the TCNT1 becomes zero. The TOV1 Flag in this case behaves like a 17th bit, except that it is only set, not cleared. However, combined with the timer overflow interrupt that automatically clears the TOV1 Flag, the timer resolution can be increased by software. There are no special cases to consider in the Normal mode, a new counter value can be written anytime.

The Input Capture unit is easy to use in Normal mode. However, observe that the maximum interval between the external events must not exceed the resolution of the counter. If the interval between events are too long, the timer overflow interrupt or the prescaler must be used to extend the resolution for the capture unit.

The Output Compare units can be used to generate interrupts at some given time. Using the Output Compare to generate waveforms in Normal mode is not recommended, since this will occupy too much of the CPU time.

13.9.2 Clear Timer on Compare Match (CTC) Mode

In *Clear Timer on Compare* or CTC mode (WGM13:0 = 4 or 12), the OCR1A or ICR1 Register are used to manipulate the counter resolution. In CTC mode the counter is cleared to zero when the counter value (TCNT1) matches either the OCR1A (WGM13:0 = 4) or the ICR1 (WGM13:0 = 12). The OCR1A or ICR1 define the top value for the counter, hence also its resolution. This mode allows greater control of the compare match output frequency. It also simplifies the operation of counting external events.

The timing diagram for the CTC mode is shown in [Figure 13-6](#). The counter value (TCNT1) increases until a compare match occurs with either OCR1A or ICR1, and then counter (TCNT1) is cleared.