3.9.3. Output current limitation according to I^2t method

The I^2t method is to prevent the motor from overheating. This method is based on the model of the motor's thermal dynamics which serves as the foundation for this technique. Its parameters are Nominal current and Thermal time constant winding. When the motor's I^2t level approaches 100%, the procedure reduces the output current to the nominal current. This limit is deactivated when the I^2t level of the motor falls below 90% again. Keep in mind that the Nominal current is specified under particular heat dissipation conditions and at a set ambient temperature (often 25 °C). The aforementioned settings need to be changed if these requirements are not met.

Rather than providing the thermal time constant of the winding τ_{th}, the motor manufacturer may provide the peak current Ipeak and the peak current duration Tpeak. In this case, the thermal time constant winding τ_{th} can be calculated using the following equation:

$$\tau_{th} = -\frac{T_{peak}}{\ln\left(1-\left(\frac{I_N^2}{I_{peak}^2}\right)\right)}$$

where

ln : natural logarithm function

τ_{th} : thermal time constant winding

T_{peak} : Time during which peak current is permitted

I_{peak} : Peak current

I_N : Nominal current

The figure below shows the maximum duration of the peak current before the I^2t current limit is activated, assuming that the I^2t level motor starts at 0%. The peak current duration is normalized by the thermal time constant winding on the horizontal axis (x-axis). The vertical axis (y-axis) represents the magnitude of the peak current normalized by the nominal current.

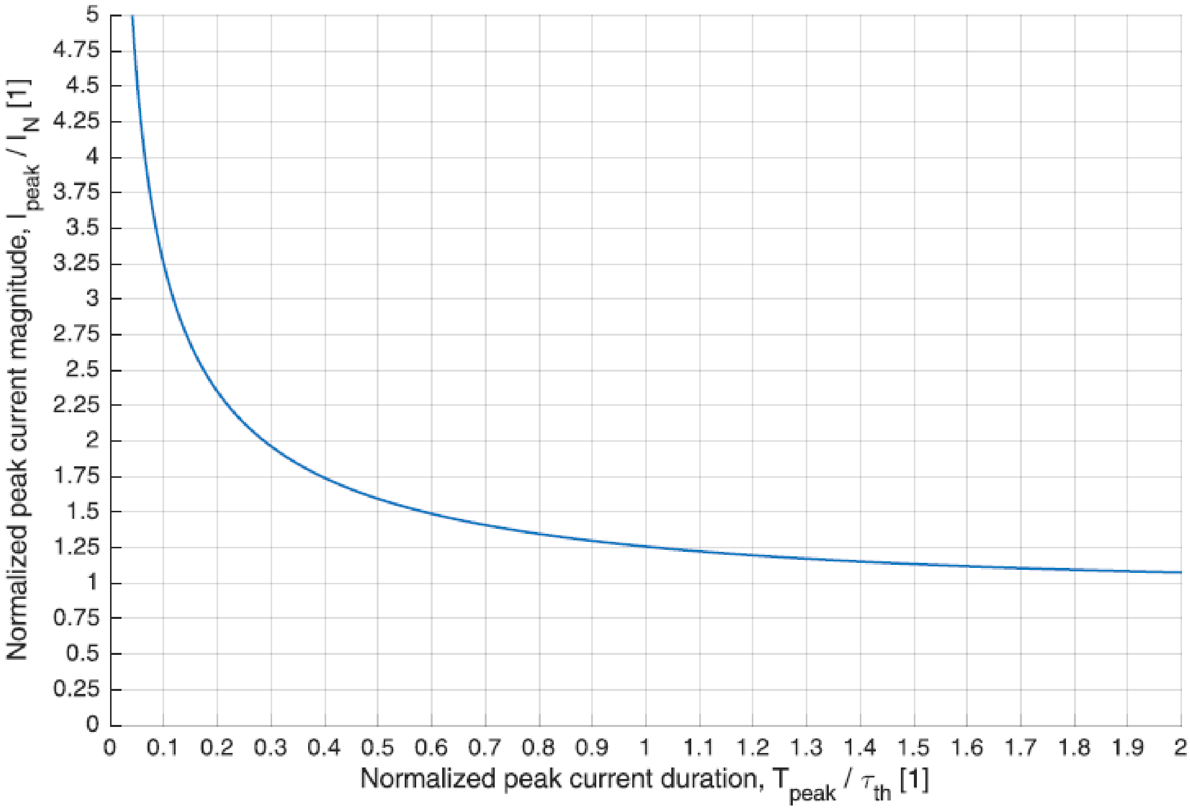

Figure 16. Normalized peak current magnitude vs. normalized peak current duration

The following figure Cyclic mode standardized vs. standardized "ON time" shows the maximum I_{on} for continuous operation without reaching the I^2t current limit, with a given motor current duty cycle and T_{total}.

1. Motor Current Duty Cycle:
   - Represented on the horizontal axis.
   - Defined as Duty Cycle = T_{total}/T_{on}
   - This ratio represents the proportion of time the motor current is ON (T_{on}) in relation to the total cycle time (T_{total}).
2. 'ON Time' Current magnitude (I_{on}) normalized:
   - Shown on the vertical axis.
   - It is the ON time current magnitude (I_{on}), normalized with the motor's nominal current (IN). Essentially, this shows how much larger the ON current can be compared to the motor's typical operating current.
3. Total Time (T_{total}) and thermal time constant winding (τ_{th}):
   - Each curve on the graph represents a different ratio of the total time (T_{total}) to the thermal time constant winding (τ_{th}).
   - The thermal time constant winding is a measure of how quickly the motor heats up and cools down. Different ratios of T_{total} to τ_{th} will affect how much current the motor can handle during the ON phase without overheating.
4. Interpreting the Graph:
   - The graph is used to determine the maximum permissible Ion for continuous operation without exceeding the I^2t limit for a given duty cycle and total time.
   - For a specified duty cycle (T_{on}/T_{total}), the graph shows the maximum I_{on} (as a multiple of IN) that can be applied without causing thermal damage to the motor.
   - Different curves are useful for motors with different thermal properties (as indicated by τ_{th}).

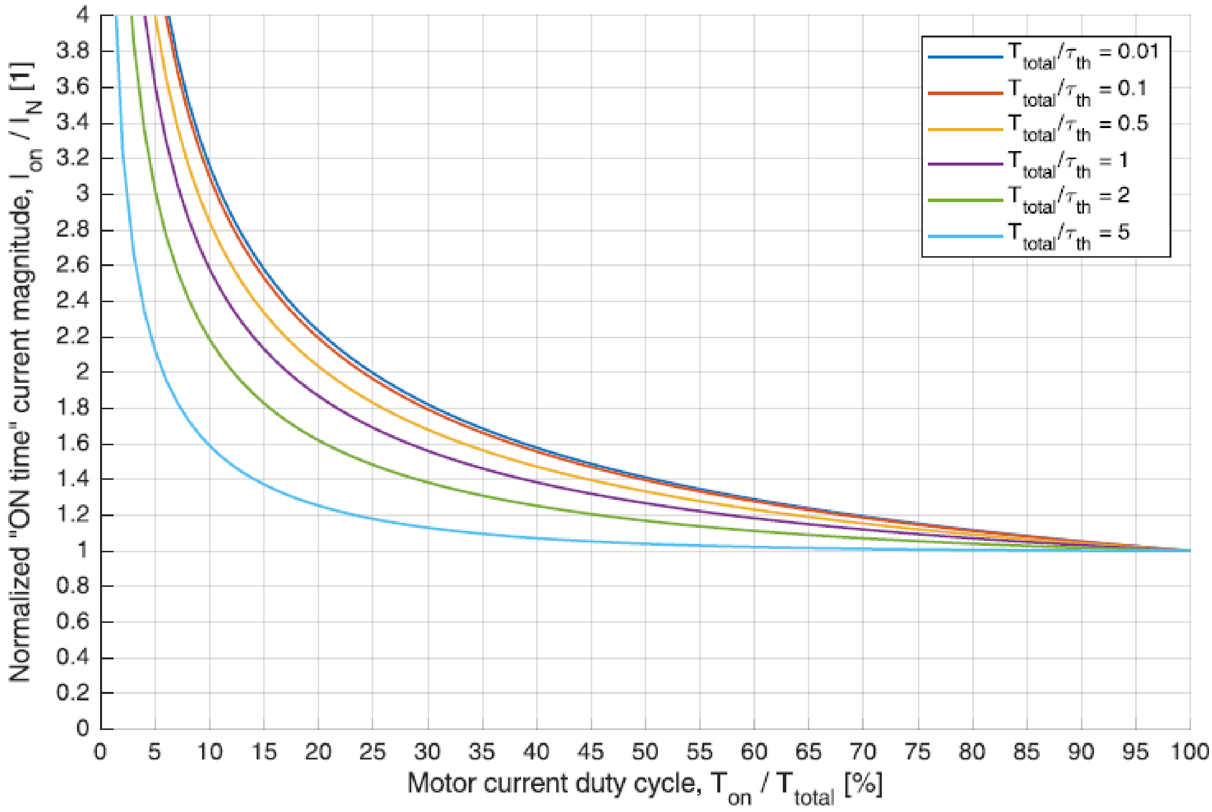

Figure 17. Cyclic mode standardized vs. standardized "ON time"

1. Identify the relevant curve on the graph:
   - Since the period of the current (T_{total}) is the same as the thermal time constant winding (τ_{th}), which is 2.8s in this case, you should use the purple curve in the figure Cyclic mode standardized vs. standardized "ON time".
2. Find the Intersection on the graph:
   - Locate the point where the motor current duty cycle of 10% intersects with the purple curve on the graph.
3. Read the normalized 'ON Time' current magnitude (I_{on}) Value:
   - From the intersection point, read the y-axis value, which represents the normalized 'ON time' current magnitude. In this example, it's approximately 2.6.
4. Calculate the maximum 'ON Time' current magnitude (I_{on}):
   - Since the y-axis is normalized with the nominal current (IN), the actual Ion can be calculated by multiplying the normalized value by the nominal current.
   - Formula: I_{on} = normalized I_{on} × nominal current
   - In this example: Ion=2.6×1470 mA=3822 mA.

Therefore, for this specific motor configuration operating in an ON-OFF cyclic mode with a duty cycle of 10%, the maximum 'ON time' current magnitude that can be applied without exceeding the motor's thermal limits is approximately 3822 mA.