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Application Note: Hazardous Movement Configuration

Date:	04/18/2023
Revision:	1
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Background

This note is intended to provide guidelines for Applications to meet EN1175:2020, Section 4.5.6.3 Unintended truck behavior while truck is moving:

"EN 1175:2020, Section 4.5.6.3 The following behaviour caused by an electrical failure is considered hazardous: a) no reaction of reverse or neutral travel direction when demanded by the operator;" NOTE List item a) is only relevant for trucks with ***separate direction selector****.*

b) acceleration unrelated to the operator input and uncontrollable by operator adjustment of speed control (accelerator) during travel operation on level ground that: (for combined throttle and direction design like walkie)

— is higher than 30 % of the maximum acceleration achievable by the truck under no fault condition
and/or
— which results in a speed that exceeds the operator requested speed setpoint by more than 20 % of maximum speed achievable by the truck under no fault condition.

Clause a) Curtis interprets as it is hazardous if the vehicle is moving in either direction, operator requests the opposite direction, and the vehicle doesn't slow down.
It is also hazardous if the vehicle is moving in either direction, the operator requests neutral, and the vehicle doesn't slow down.

Clause b) Curtis interprets and simplifies this to acceleration unrelated to the operator input and (higher than 30 % of maximum acceleration or which results in a speed that exceeds the operator requested set point by more than 20 % of maximum speed). "Acceleration unrelated to the operator input" is further interpreted as acceleration in the opposite direction of the difference between the operator speed request and the motor speed. So this hazard occurs when the operator commands a speed in the same direction as travel, the vehicle is going faster than commanded and accelerates more than a certain rate or is not slowing down and exceeds the speed request by a certain amount.

Translated Safety Requirements

Hazardous Movement Type 1 (failure to respond to neutral or direction change request)

- The following **shall** be considered hazardous conditions:
    - The motor is moving forward (Motor_RPM > Zero_Speed_Threshold), reverse is requested (speed target < 0), and the motor doesn't slow down (measured accel >=0).
    - The motor is moving forward (Motor_RPM > Zero_Speed_Threshold), neutral is requested (speed target = 0), and the motor doesn't slow down (measured accel >=0).
    - The motor is moving reverse (Motor_RPM < Zero_Speed_Threshold), foward is requested (speed target > 0), and the motor doesn't slow down (measured accel <=0).
    - The motor is moving reverse (Motor_RPM < Zero_Speed_Threshold), neutral is requested (speed target = 0), and the motor doesn't slow down (measured accel <=0).
- If any of the above conditions exist for longer than a programmable hazardous direction response time, then a Hazardous Movement fault Hazardous Movement Fault **shall** be set, which performs a shutdown interlock.
    - Note: Interlock Braking Function then brings the motor to a stop and must be setup properly for this to work. Interlock Braking Supervision must also be configured.
- Setting the hazardous direction response time = 0 **shall** disable this check. NOTE: this is not an EN1175:2020 compliant setting.

Hazardous Movement Type 2 (motor accelerates the wrong way or too fast)

- The following **shall** be considered hazardous conditions:
    - The requested speed is in the same direction as motor, the motor is going faster than commanded, and the motor accelerates more than a programmable acceleration limit (*Hazardous_Accel*).
        - NOTE: this acceleration limit (*Hazardous_Accel*) must be set to not more than 30% over the maximum acceleration to be compliant to EN1175:2020 section Section 4.5.6.3
    - The requested speed is in the same direction as motor, the motor is going faster than commanded, the motor is not slowing down, and the motor exceeds the requested speed by more than a programmable speed limit (*Hazardous_Speed_Error*)
        - NOTE: this speed limit (*Hazardous_Speed_Error*) must be set to not more than 20% over the maximum speed to be compliant to EN1175:2020 section Section 4.5.6.3
- If any of the above conditions exist for longer than a programmable hazardous throttle response time, then a Hazardous Movement fault **shall** be set, which performs a shutdown interlock.
- Setting the hazardous throttle response time = 0 **shall** disable this check. NOTE: this is not an EN1175:2020 compliant setting.

Parameters and Variables Required

Parameter/Variable	Description	Access Level	Scaling	Resolution	Range (minimum)
Hazardous Direction Response Time	If the hazardous conditions in type 1 exist longer than this time, then the Hazardous Movement fault is set. Setting this to zero disables this check. The value chosen will need to be based on the vehicle's worst case conditions but is expected to be between ~0.5 - 2 seconds.	RW: OEM Factory	ms	<=100 ms	0-10,000 ms
Hazardous Type1 Timer	Count up/down timer used for type 1. Can compare directly to Hazardous direction response time to see how close to tripping fault.	R: <=OEM Factory	ms	<= 10 ms	0-10,000 ms
Hazardous Accel	Hazardous accel for type 2.	RW: OEM Factory	rpm/s	<= 10 rpm/s	0-10,000 rpm/s
Hazardous Speed Error	Hazardous speed error for type 2.	RW: OEM Factory	rpm	<= 1 rpm	0-20,000 rpm
Hazardous Throttle Response Time	If the hazardous conditions in type 2 exist longer than this time, then the Hazardous Movement fault is set. Setting this to zero disables this check. The value chosen will need to be based on the vehicle's worst case conditions but is expected to be between ~0.5 - 2 seconds.	RW: OEM Factory	ms	<=100 ms	0-10,000 ms
Hazardous Type2 Timer	Count up/down timer used for type 2. Can compare directly to Hazardous throttle response time to see how close to tripping fault.	R: <=OEM Factory	ms	<=10 ms	0-10,000 ms

Table 1 Parameter Summary

Hazardous Accel: Hazardous Accel should be set at 30% of the maximum acceleration capability of the truck. Typical_Max_Speed/(Min(Accel_Rate_HS_SpdM,Accel_Rate_LS_SpdM))*0.3. Or run the truck full throttle on flat ground with no load and take 30% of the measured acceleration.

Hazardous Speed Error: should be set at 20% of the maximum speed of the truck

Hazardous_Direction_Response_Time/ Hazardous_Throttle_Response_Time should be set such that we do not get nuisance faults under the worst case scenario. This would usually be low speed start/stops at maximum load on the maximum rated grade of the truck. A value of 0 disables the fault. For testing set the response time to be very high (>2s) and set deccel rate to be slower(eg: 5 sec) and monitor the following values in TACT while testing. Typically, the two response time parameters will be setup the same. For vehicles that do not have a separate direction selector, the Hazardous_Direction_Response_Time may be set to 0 to disable this fault and still be compliant with EN1175.

Hazardous Type1 Timer/ Hazardous Type2 Timer: Take the difference between the minimum and starting point of Hazardous_TypeX_Timer and use at least 1.5x that as the setting for hazardous_Throttle_Response_Time. You may need to set it higher due to the noise/quantization of the measured acceleration.

TACT traces to show A walkie with full load running down on a ramp, Throttle_response_Time is set to (2 s)

Figure1 shows around 100ms count down for the fault conditions when motor RPM is greater than hazardous speed target. Figure2 shows time for the throttle command from 0 to 100% is around 500ms for the walkie on a full load down to a ramp. In this case, the hazardous_throttle_response_time should be no less than 500ms.

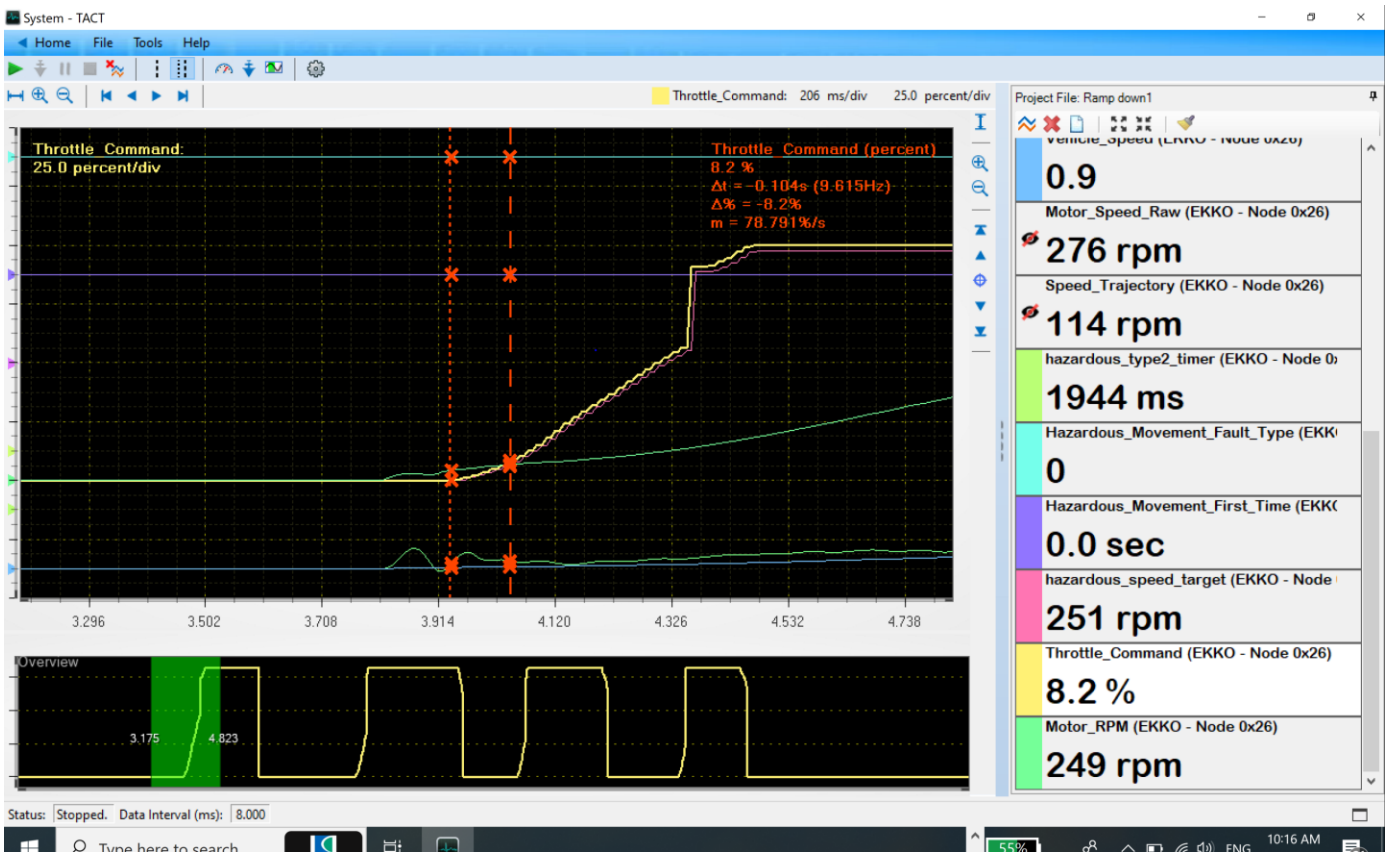
System - TACT
Home
File
Tools
Help
Throttle_Command: 206 ms/div 25.0 percent/div
Throttle_Command:
25.0 percent/div
Throttle_Command (percent)
8.2 %
Δt = −0.104s (9.615Hz)
Δ% = -8.2%
m = 78.791%/s
3.296
3.502
3.708
3.914
4.120
4.326
4.532
4.738
Overview
3.175
4.823
Project File: Ramp down1
0.9
Motor_Speed_Raw (EKKO - Node 0x26)
276 rpm
Speed_Trajectory (EKKO - Node 0x26)
114 rpm
hazardous_type2_timer (EKKO - Node 0x
1944 ms
Hazardous_Movement_Fault_Type (EKK
0
Hazardous_Movement_First_Time (EKK
0.0 sec
hazardous_speed_target (EKKO - Node
251 rpm
Throttle_Command (EKKO - Node 0x26)
8.2 %
Motor_RPM (EKKO - Node 0x26)
249 rpm
Status: Stopped. Data Interval (ms): 8.000
Type here to search
10:16 AM

Fig 1

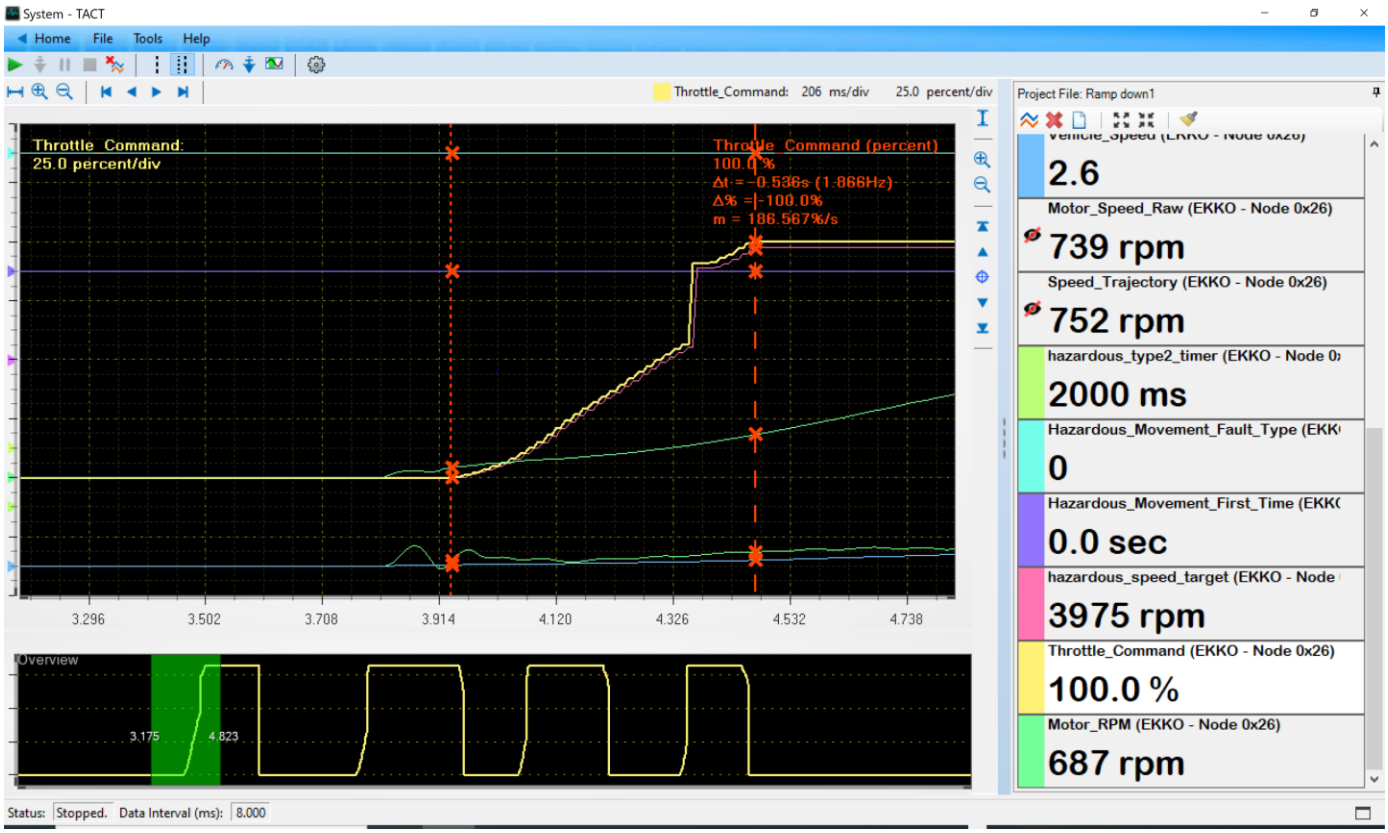
System - TACT
Home
File
Tools
Help
Throttle_Command: 206 ms/div 25.0 percent/div
Throttle_Command:
25.0 percent/div
Throttle_Command (percent)
100.0 %
Δt = -0.536s (1.866Hz)
Δ% = -100.0%
m = 186.567%/s
3.296
3.502
3.708
3.914
4.120
4.326
4.532
4.738
Overview
3.175
4.823
Project File: Ramp down1
2.6
Motor_Speed_Raw (EKKO - Node 0x26)
739 rpm
Speed_Trajectory (EKKO - Node 0x26)
752 rpm
hazardous_type2_timer (EKKO - Node 0x
2000 ms
Hazardous_Movement_Fault_Type (EKK
0
Hazardous_Movement_First_Time (EKK
0.0 sec
hazardous_speed_target (EKKO - Node
3975 rpm
Throttle_Command (EKKO - Node 0x26)
100.0 %
Motor_RPM (EKKO - Node 0x26)
687 rpm
Status: Stopped. Data Interval (ms): 8.000

Fig2