EZ10 Gen1

Automatic Command Sequence Description for R&D purposes

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Revision History

Revision number	Date	Author	Proofreaders	Changes
A0	2020/03/10	TTH	NPE	Initial version

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1. Introduction

1.1. Purpose of this document

The aim of this document is to present the sequence to command an EZ10 Gen0 / Gen1 vehicle in automatic mode. This document will also present every restriction applicable in automatic mode.

Applicable for vehicles equipped with the core control version 1810.R3.

1.2. Applicable/referenced documents

#	Ref.	Title	Version
1	EM-EZ10PROD-IDD-00008	EZ10_Gen0_Gen1_CAN_Interface_Definition_Document	rev1810.R3_R&D
2	EM-RD622018-USG-00086	EZ10_Gen0	EN-revA1
3	EM-RD622018-USG-00087	EZ10_Gen1	EN-revA1
4	EM-EZ10PROD-IDD-00013	EZ10_Gen1_Ethernet_Architecture_Definition_Document	EN-revA0
5	EM-EZ10PROD-IDD-00009	EZ10_Gen0_Gen1_EZ10_Command_for_R&D_purposes	EN-revA1

1.3. Acronyms

USG	User Guide
IDD	Interface Definition Document
EStop	Emergency Stop
SStop	Soft stop
TC	Traction Controller (1238)
Safety PLC	Safety Programmable Logic Controller
MECU	Main Electronic Control Unit (1310)
LMS	Laser Measurement Sensor

FSB	Fail safe brake
ELB	Electric Brakes
KSI	Key Switch Input
KVAR	Power relay
TBC	To Be Confirmed
TBD	To Be Defined

2. Restrictions in Automatic Mode

List of what is not possible and what is mandatory in automatic mode

<u>Safety chain restrictions:</u>

- **3 ways to set an Estop in automatic mode:**
    - By human action
        - Estop buttons: 3 buttons on the opposite side of the door
    - By software action
        - Estop signal from navigation: c_EStop_PCNav_Not_Requested - 0x214.0.7 - 1=No emergency stop requested
        - Estop heartbeat from navigation: Nav_PC_Hearbeat - 0x214.0.3 - if this signal's period is between 48 and 192ms, no emergency stop will be triggered.

<u>Motion restrictions:</u>

- **Motion limits:** Motion values are limited. A value received outside of the expected range will be limited to the maximum value authorized.
    - max speed [-5.6m/s;5.6m/s]
    - max angle [-18°;18°]
    - max accel [0.3m/s²;2m/s²]
    - max decel [-0.3m/s²;-1.5m/s²]

- **Motion value automatic limitations:**
    - Speed is limited for angles superior to 3° in order to respect a maximum lateral acceleration of 1.2m/s² (5.6m/s max for 3° ; 2.27m/s for 18°)
    - While speed is decreasing to respect the angle request, the max angle is limited to respect a maximum lateral acceleration of 1.4m/s²)

- **Motion value variation limits (max angle variation)**
    - The steering value shall not vary faster than 0.25rad/s (meaning 0.005rad max between 2 frames at T=20ms).
    - A steering variation superior to 0.30rad/s (meaning a variation > to 0.006rad between 2 frames) will trigger an **Emergency Stop**

<u>Vehicle configuration restrictions:</u>

- **Vehicle configuration** (Ramp, warning on stop, LED column) is **memorised in the 1310** controller. This means that when you start a new automatic script, the configuration is already available in the controller.
- As it is already configured in the controller but not in the script, it is encouraged to **resend the whole configuration at the beginning** of an automatic script to prevent configuration overwrite when changing the configuration of one option.
- For example if you want to disable the ramp, you must either resend the whole configuration or first retrieve the vehicle configuration.

<u>Doors commands restrictions:</u>

- **Doors can be commanded in automatic mode only when the vehicle is parked and informed that it is at a station**.

3. Vehicle Control Sequence in Automatic Mode

Sequence to move a vehicle:

Step N°	Step Description	Comments
1	**Turn on the vehicle**	Initialisation is over when doors are closed and doors buttons are available.
2	**Rearm the vehicle**	Vehicle is rearmed via 1 signal in manual mode: - Physical button in interior user access hatch
3	**Set initial conditions for automatic mode:** - Set Heartbeat at 0.1Hz (Mandatory) - Set Estop signal to On (Mandatory) - Set configuration (Optional) - Activate the LED column - Force warning lights when stopped - Enable ramp usage	- Heartbeat will be declared in failure if a period of the signal is received with a period that is not between 48ms and 192ms. (slightly delayed Estop) - <u>Heartbeat signal:</u> Nav_PC_Hearbeat - 0x214.0.3 - If the Estop signal is equal to 0, the vehicle will immediately trigger an Estop if it is in automatic mode. - <u>Estop signal:</u> c_EStop_PCNav_Not_Requested - 0x214.0.7 - To set the configuration : - We shall **indicate to go in configuration mode:** PC_CAN_Config_Param - 0x293.3.0 - 1=Configuration mode active - **Configure warning lights when stopped:** PC_CAN_PAR_Warning_On_Null_Speed - 0x293.3.2 - 1=Warning are active on null speed - **Configure ramp use:** PC_CAN_PAR_Use_Ramp - 0x293.3.5 - 1=Ramp can be used - **Configure LED column:** PC_CAN_PAR_Use_Led_Column - 0x293.3.6 - 1=Use LED column - Other bits shall be set to 0. Bits 3.1, 3.3, 3.4 and 3.7
4	**Switch to Automatic mode** - Interrior access hatch switch (Mandatory)	
5	**Send motion commands** - Traction - Steering - Acceleration / Deceleration rate - Accessories control (Optional)	Cf **Restrictions in Automatic Mode** for restrictions on those signals. Once a speed command is received different from 0 and applicable (no Estop or SStop is active), when the vehicle releases its failsafe brake the trambell is

	- Rearm the vehicle (Optional)	heard. The trambell is heard only if the vehicle was considered stopped (FSB engaged). Motion CAN frame = 0x193 Motion signals: - c_PCN_Acceleration_Setpoint = 0x193.0.0 - c_PCN_Speed_Setpoint = 0x193.2.0 - c_PCN_Front_Steering_Setpoint = 0x193.4.0 - c_PCN_Rear_Steering_Setpoint = 0x193.6.0 It is the computer's responsibility to ensure that a c_PCN_Acceleration_Setpoint positive value is sent when the c_PCN_Speed_Setpoint speed is higher than the current speed and that a c_PCN_Acceleration_Setpoint negative value is sent when c_PCN_Speed_Setpoint speed is lower than the current speed
6	**Stop at a station** - Declare the vehicle at a station - Accessories Control (optional)	Stop the vehicle and declare it at a station in order to give access to the door and ramp control. - Vehicle is at a station signal: Stop_Station - 0x214.0.2 - 1=Vehicle is at a station Accessories can be updated: - to signal that the vehicle is stopped (for example activate the warning lights if the vehicle is not configured for "warning at null speed") - to ring the bell before closing the doors … More information about accessories is available in the "EM-EZ10PROD-IDD-00009-EN-revA1_EZ10_Gen0_Gen1_EZ10_Command_for_R&D_purposes" document

7	**Command access organs**
	
	- Command the doors
	- Command the ramp
		Doors can be controlled by automatic commands or left to the user but even if it is left to the user the availability of the button is conditioned by the "**at a station**" signal and the "**Vehicle_Stopped_4_States**" state (And/or the presence of an Estop for user commands).
		     - Doors movement request in auto: Doors_Request - 0x214.0.0 - 1=a door movement is requested
		     - Ramp unfold request in auto: Ramp_Request - 0x214.0.1 - 1=a ramp movement is requested
		Doors cannot be opened in automatic mode if the vehicle is not at a station and parked (0x194.4.1 sent by the PLC shall be at 1)
		
		at null speed).

8	**Restart motion commands**	The motion commands will be taken into account only once the doors are detected closed and the ramp is detected folded. If either is not in the expected

		configuration, a soft stop is set and the applicable traction command is forced to 0.
9	**Stop the vehicle in a clean manner** - Reset every motion command - Reset the accessory control (optional) - Switch to manual mode (Mandatory) - Reset initial conditions for automatic mode (stop the script) - Press a physical Estop to immobilise the vehicle and leave it in a safe state - Turn OFF the vehicle	

4. Code sequence example

The following lines present every CAN data modification leading to a vehicle movement sequence.

Before switching to automatic mode (vehicle is rearmed)

```
while ()                                          //start the Heartbeat management loop
{
        if ((0x214.byte0 & 0x08) == 0)
                0x214.byte0 = 0x214.byte0 | 0x08
        else
                0x214.byte0 = 0x214.byte0 & 0xF7
}
0x214.byte0 = 0x214.byte0 | 0x80                  //Estop set to OFF (1=No Estop)
        monitor 0x394.5.7                         //1=Estop is not requested
0x293.byte0 = 0x293.byte0 | 0x01                  //Enter config mode
0x293.byte0 = 0x293.byte0 | 0x04                  //Activate warnings on null speed
0x293.byte0 = 0x293.byte0 | 0x20                  //Enable ramp usage
0x293.byte0 = 0x293.byte0 | 0x40                  //Activate LED column use
0x293.byte0 = 0x293.byte0 & 0xFE                  //Exit config mode
```

Switch to automatic mode

```
        monitor 0x194.2.7                         //0=Vehicle is in auto mode
0x193.byte0-1 = 500                               //Set acceleration to 0.5m/s²
0x193.byte2-3 = 1000                              //Set traction command to 1m/s
0x193.byte4-5 = 2000                              //Set the front wheel angle to 0.2rad
0x193.byte6-7 = 2000                              //Set the rear wheel angle to 0.2rad
        monitor 0x213.byte0-1                     //Check speed feedback
        monitor 0x213.byte2-3                     //Check front steering feedback
        monitor 0x213.byte4-5                     //Check rear steering feedback
…                                                 //Send motion/accessories requests
0x193.byte0 = -800                                //Set deceleration to -0.8 m/s²
0x193.byte2 = 0                                   //Set traction command to 0m/s
        monitor 0x194.4.3                         //1=Vehicle is standing still (FSB)
        monitor 0x194.4.2                         //1=Vehicle is parked (standstill + ELB)
0x214.byte0 = 0x214.byte0 | 0x04                  //Vehicle is at a station
0x214.byte0 = 0x214.byte0 | 0x01                  //Request a movement of the doors
0x214.byte0 = 0x214.byte0 & 0xFE                  //After a couple of cycles door request can
                                                   be turned off
        monitor 0x194.1.0                         //1=Doors are opened
```

Doors is open, passenger go in/out

0x214.byte0 = 0x214.byte0 | 0x01	//Request to close the doors
0x214.byte0 = 0x214.byte0 & 0xFE	//After a couple of cycles door request can be turned off
monitor 0x194.1.2	//1=Door Obstruction (doors are reopening)
monitor 0x194.1.1	//1=Doors are closed
0x214.byte0 = 0x214.byte0 & 0xFB	//Vehicle is no longer at a station this prevents to allow user requests for doors when the vehicle is stopped for example at a red light
0x193.byte0-1 = 500	//Set acceleration to 0.5m/s²
0x193.byte2-3 = 2000	//Set traction command to 2m/s
…	//Send motion/accessories requests

Estop from obstacle detection

monitor 0x194.0.4	//1=Obstacle detected
monitor 0x194.0.4	//0=No Obstacle detected
monitor 0x194.4.6	//1=No Estop cause present, vehicle can be rearmed
monitor 0x194.0.7	//1=Vehicle can be rearmed

Rearm the vehicle

The vehicle takes into account the data from frame 0x193 (it can be interesting to reset those data in case of Estop to have a controller restart)

…	//Send motion/accessories requests
0x193.byte0-1 = -800	//Set deceleration to -0.8 m/s²
0x193.byte2-3 = 0	//Set traction command to 0m/s
monitor 0x194.4.3	//1=Vehicle is standing still (FSB)
monitor 0x194.4.2	//1=Vehicle is parked (standstill + ELB)

(When vehicle is stopped) Switch to manual mode:

monitor 0x194.2.7	//1=Vehicle is in manual mode
0x214.byte0 = 0x214.byte0 & 0x7F	//Estop set to ON (0=Estop)
monitor 0x394.5.7	//0=Estop is requested in auto mode
monitor 0x194.4.6	//1=NoEstop cause present (as we are in manual the previous error is not taken into account
Heartbeat loop can be stopped	//To prevent unexpected mode switch (vehicle locked if manu/auto switch is turned)
Press a Estop to immobilise the vehicle	//To prevent unexpected movements via the RCU
monitor 0x194.4.6	//0=Estop cause present
monitor 0x194.2.0	//0=Estop is a physical Estop (button)