



ADEEB
ROBOTICS

MOTION CONTROL API DOCUMENTATION

Precision. Scalability. Control

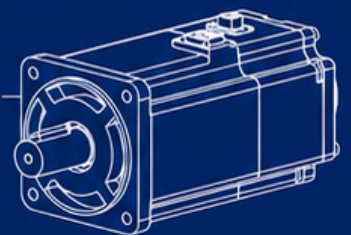
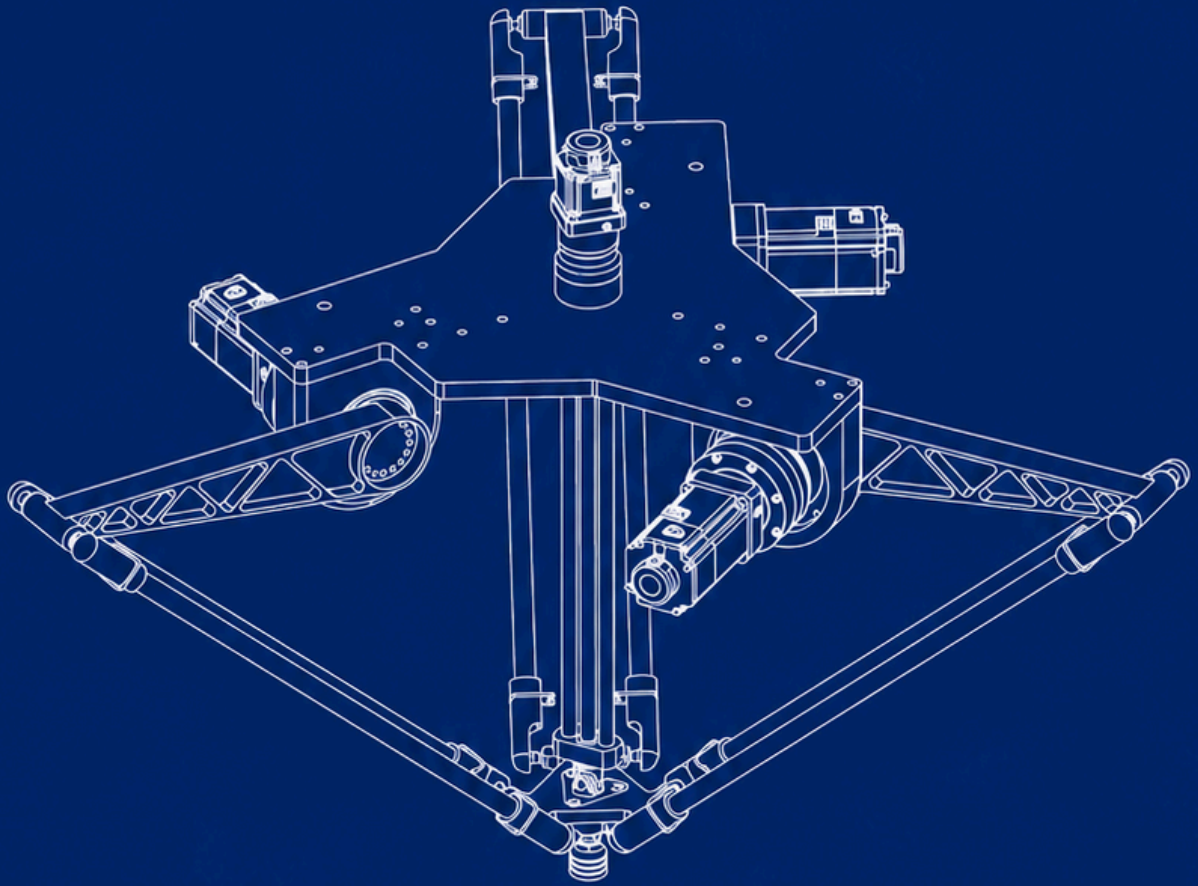


Table of Content

1. Getting Started with Adeeb Robotics Controller	-3-
2. System Information	-3-
2.1. Configuration	-3-
3. Network and Intialization	-3-
3.1. Network Initialization	-3-
3.1.1. Axis Initialization	-3-
3.1.2. EtherCAT State Control	-4-
4. Slave Management	-4-
5. Motion Control	-4-
5.1. Axis Control	-4-
5.2. Group Control	-5-
5.3. Global Control	-6-
5.4. Conveyor Operations	-6-
5.5. Container Operations	-7-
6. EtherCAT Commands	-9-
6.1. CoE (CANopen over EtherCAT) Operations	-9-
6.2. CIA402 Op mode Control	-9-
7. Configuration File	-9-
7.1. Ethernet	-9-
7.2. EtherCAT	-9-
7.3. Move Parameters	-9-
7.3.1. Move Profile	-10-
7.4. Axis	-10-
7.5. Group	-10-
7.5.1. World Limit Type Enum	-10-
7.5.2. Group Type Enum	-10-
7.5.3. End Effector	-11-
7.5.3.1. End Eff Type Enum	-11-
7.5.3.2. Dig Signal	-11-
7.5.4. World Type Enum	-11-
7.6. Camera	-11-
7.7. Conveyor	-12-
7.8. Container	-12-
7.9. Part	-12-
7.10. Cycle	-12-
7.10.1. CyleType Enum	-13-
8. Diagram Quantities	-13-
9. Workspace Coordinate System Defines	-14-
10. Appendix A: Payload Details	-14-
10.1. Config Save Payload Details	-14-
10.2. Number of Slaves Payload Details	-14-
10.3. Axis Payload Details	-15-
10.4. Group Payload Details	-16-
10.5. Conveyor Payload Details	-18-
10.6. Container Payload Details	-19-
10.7. EtherCAT Command Payload Details	-20-
10.7.1. EtherCAT Command Payload Details	-20-
10.7.2. CoE Payload Details	-20-
10.7.3. Cia402 Op mode Payload Details	-21-
11. Appendix B: Motion result error codes	-21-
12. Appendix C: ECAT result error codes	-22-
13. Appendix D: Motion alarm codes	-23-

1. Getting Started with Adeeb Robotics Controller

Thank you for using the Adeeb Robotics Controller software library. To start using the library, open a command prompt or terminal and execute the following command:

```
adeeb_robotics_controller <path_to_config_file>
```

The `config_files` folder contains example configuration files that you may use. For example:

```
adeeb_robotics_controller config_file/delta_config.yml
```

Next, open a separate command prompt or terminal window and run the desired Python motion script:

```
python3 <path_to_python_script>
```

Example motion scripts are available in the `python_scripts` folder. You may use any of these scripts except `arc.py`, which is a helper module. For instance:

```
python3 pack_expo_demo.py
```

Please note that certain Python scripts are intended to be used with specific configuration files. For example:

- `pack_expo_demo.py` and `autorun.py` should be used with `delta_config.yml` or `demo_stand_config.yml`.
- `serial_dh_example.py` is intended to be used with `kuka_7_axis_config.yml`.

Configuration files define system settings, including the robot type and workspace layout, such as conveyor and container positions used for pick-and-place operations.

The Python scripts handle motion control and I/O operations.

Note that on Linux and MacOS, you need to use `sudo` access when running the controller.

2. System Information

API Route	Method	Description	Payload
<code>/get_sw_release_version</code>	GET	Returns the current software release version	String

2.1. Configuration

API Route	Method	Description	Payload
<code>/get_config</code>	GET	Returns the current configuration in JSON format	Config
<code>/save_config</code>	POST	Sets the configuration object in JSON format	ConfigSaveData

3. Network and Initialization

3.1. Network Initialization

API Route	Method	Description	Payload
<code>/init_network</code>	POST	Initiates network initialization request	EcatCmdData
<code>/init_network/<cmd_idx></code>	GET	Checks network initialization response	EcatCmdData

3.1.1. Axis Initialization

API Route	Method	Description	Payload
-----------	--------	-------------	---------

/init_axes	POST	Initiates axes initialization request	MotnCmdData
/init_axes/<cmd_idx>	GET	Checks axes initialization response	MotnCmdData

3.1.2. EtherCAT State Control

API Route	Method	Description	Payload
/req_preop	POST	Initiates pre-operational mode request	EcatCmdData
/req_preop/<cmd_idx>	GET	Checks pre-operational mode response	EcatCmdData
/req_op	POST	Initiates operational mode request	EcatCmdData
/req_op/<cmd_idx>	GET	Checks operational mode response	EcatCmdData

4. Slave Management

API Route	Method	Description	Payload
/get_number_of_slaves	POST	Initiates slave count request	NumSlvsData
/get_number_of_slaves/<cmd_idx>	GET	Checks slave count response	NumSlvsData

5. Motion Control

5.1. Axis Control

API Route	Method	Description	Payload
/axis_servo_on	POST	Initiates servo on request	AxisData
/axis_servo_on/<cmd_idx>	GET	Checks servo on response	AxisData
/axis_servo_off	POST	Initiates servo off request	AxisData
/axis_servo_off/<cmd_idx>	GET	Checks servo off response	AxisData
/axis_move_pos	POST	Initiates absolute position movement request	AxisMovePosData
/axis_move_pos/<cmd_idx>	GET	Checks absolute position movement response	AxisMovePosData
/axis_move_vel	POST	Initiates velocity movement request	AxisMoveVelData
/axis_move_vel/<cmd_idx>	GET	Checks velocity movement response	AxisMoveVelData
/axis_move_rel	POST	Initiates relative position movement request	AxisMoveRelData
/axis_move_rel/<cmd_idx>	GET	Checks relative position movement response	AxisMoveRelData
/axis_move_home	POST	Initiates axis home movement request	AxisData
/axis_move_home/<cmd_idx>	GET	Checks axis home movement response	AxisData
/axis_get_curr_pos	POST	Initiates getting current position request	AxisCurrPosData
/axis_get_curr_pos/<cmd_idx>	GET	Checks getting current position response	AxisCurrPosData
/axis_write_dig_out	POST	Initiates append digital write command to the axis motion queue request	AxisDigData
/axis_write_dig_out/<cmd_idx>	GET	Checks append digital write command to the axis motion queue response	AxisDigData
/axis_read_dig_in	POST	Initiates an immediate (not queued) digital read request	AxisDigData
/axis_read_dig_in/<cmd_idx>	GET	Checks digital read response	AxisDigData
/axis_motion_done	POST	Initiates axis motion done checking request	AxisBoolData
/axis_motion_done/<cmd_idx>	GET	Checks axis motion done checking response	AxisBoolData
/axis_quick_stop	POST	Initiates axis quick stop request	AxisData
/axis_quick_stop/<cmd_idx>	GET	Checks axis quick stop response	AxisData
/axis_clear_alarms	POST	Initiates axis clear alarms request	AxisData
/axis_clear_alarms/<cmd_idx>	GET	Checks axis clear alarms response	AxisData

/axis_get_alarms	POST	Initiates getting axis alarms request	AxisAlarmsData
/axis_get_alarms/<cmd_idx>	GET	Checks getting axis get alarms response	AxisAlarmsData
/axis_zero	POST	Initiates axis zero request, this alters the enco_offst entry in the config file, thus a server restart is required for it to take effect	AxisData
/axis_zero/<cmd_idx>	GET	Checks axis zero response	AxisData
/axis_sleep	POST	Initiates axis sleep request, an axis sleep command is inserted into the motion que.	AxisSleepData
/axis_sleep/<cmd_idx>	GET	Checks axis sleep response	AxisSleepData
/axis_set_spd_prcn	POST	Initiates axis set move profile velocity, acceleration, and jerk, as % of max supported value request	AxisSpdPrcnData
/axis_set_spd_prcn/<cmd_idx>	GET	Checks axis set move profile velocity, acceleration, and jerk, as % of max supported value response	AxisSpdPrcnData
/axis_get_spd_prcn	POST	Initiates axis get move profile velocity, acceleration, and jerk, as % of max supported value request	AxisSpdPrcnData
/axis_get_spd_prcn/<cmd_idx>	GET	Checks axis get move profile velocity, acceleration, and jerk, as % of max supported value response	AxisSpdPrcnData

5.2. Group Control

API Route	Method	Description	Payload
/group_servo_on	POST	Initiates group servo on request	GroupData
/group_servo_on/<cmd_idx>	GET	Checks group servo on response	GroupData
/group_servo_off	POST	Initiates group servo off request	GroupData
/group_servo_off/<cmd_idx>	GET	Checks group servo off response	GroupData
/group_move_pos	POST	Initiates group absolute position movement request	GroupMovePosData
/group_move_pos/<cmd_idx>	GET	Checks group absolute position movement response	GroupMovePosData
/group_move_rel	POST	Initiates group relative position movement request	GroupMoveRelData
/group_move_rel/<cmd_idx>	GET	Checks group relative position movement response	GroupMoveRelData
/group_move_home	POST	Initiates group home movement request	GroupData
/group_move_home/<cmd_idx>	GET	Checks group home movement response	GroupData
/group_end_eff_engage	POST	Initiates group end effector engage request	GroupData
/group_end_eff_engage/<cmd_idx>	GET	Checks group end effector engage response	GroupData
/group_end_eff_eject	POST	Initiates group end effector eject request	GroupData
/group_end_eff_eject/<cmd_idx>	GET	Checks group end effector eject response	GroupData
/group_end_eff_clear	POST	Initiates group enffector clear request	GroupData
/group_end_eff_clear/<cmd_idx>	GET	Checks group end effector clear response	GroupData
/group_get_bgn_pos	POST	Intiates group get next motion queue begin position request	GroupBgnPosData
/group_get_bgn_pos/<cmd_idx>	GET	Checks group get next motion queue begin position response	GroupBgnPosData

/group_get_curr_pos	POST	Intiates group get current position request	GroupCurrPosData
/group_get_curr_pos/<cmd_idx>	GET	Checks group get current position response	GroupCurrPosData
/group_write_dig_out	POST	Initiates append digital write command to the group motion queue request	GroupDigData
/group_write_dig_out/<cmd_idx>	GET	Checks append digital write command to the group motion queue response	GroupDigData
/group_motion_done	POST	Initiates group motion done checking request	GroupBoolData
/group_motion_done/<cmd_idx>	GET	Checks group motion done checking response	GroupBoolData
/group_quick_stop	POST	Intiates group quick stop request	GroupData
/group_quick_stop/<cmd_idx>	GET	Checks group quick stop response	GroupData
/group_clear_alarms	POST	Intiates group clear alarms request	GroupData
/group_clear_alarms/<cmd_idx>	GET	Checks group clear alarms response	GroupData
/group_get_alarms	POST	Intiates group get alarms request	GroupAlarmsData
/group_get_alarms/<cmd_idx>	GET	Checks group get alarms request response	GroupAlarmsData
/group_zero	POST	Intiates group zero request	GroupData
/group_zero/<cmd_idx>	GET	Checks group zero response	GroupData
/group_sleep	POST	Intiates group sleep request	GroupSleepData
/group_sleep/<cmd_idx>	GET	Checks group sleep response	GroupSleepData
/group_set_spd_prcn	POST	Initiates group set move profile velocity, acceleration, and jerk, as % of max supported value request	GroupSpdPrcnData
/group_set_spd_prcn/<cmd_idx>	GET	Checks group set move profile velocity, acceleration, and jerk, as % of max supported value response	GroupSpdPrcnData
/group_get_spd_prcn	POST	Initiates group get move profile velocity, acceleration, and jerk, as % of max supported value request	GroupSpdPrcnData
/group_get_spd_prcn/<cmd_idx>	GET	Checks group get move profile velocity, acceleration, and jerk, as % of max supported value response	GroupSpdPrcnData

5.3. Global Control

API Route	Method	Description	Payload
/clear_alarms	POST	Intiates clear all alarms request	MotnCmdData
/clear_alarms/<cmd_idx>	GET	Checks clear all alarms response	MotnCmdData
/emergency_stop	POST	Intiates emergency stop request	MotnCmdData
/emergency_stop/<cmd_idx>	GET	Checks emergency stop response	MotnCmdData

5.4. Conveyor Operations

API Route	Method	Description	Payload
/conv_set_spd	POST	Initiates conveyor set speed request	ConvSpdData
/conv_set_spd/<cmd_idx>	GET	Checks conveyor set speed response	ConvSpdData
/conv_get_spd	POST	Initiates conveyor get speed request	ConvSpdData
/conv_get_spd/<cmd_idx>	GET	Checks conveyor get speed response	ConvSpdData

/conv_calibrate_pos	POST	Initiates conveyor calibrate position request	ConvCamData
/conv_calibrate_pos/<cmd_idx>	GET	Checks conveyor calibrate position response	ConvCamData
/conv_cam_calibrate_pos	POST	Initiates conveyor camera calibrate position request	GroupConvCamData
/conv_cam_calibrate_pos/<cmd_idx>	GET	Checks conveyor camera calibrate position response	GroupConvCamData
/group_conv_intercept_pickup	POST	Initiates conveyor intercept for pick-up request	GroupConvPickupData
/group_conv_intercept_pickup/<cmd_idx>	GET	Checks conveyor intercept for pick-up response	GroupConvPickupData
/group_conv_intercept_dropoff	POST	Initiates conveyor intercept for drop-off request	GroupConvDropoffData
/group_conv_intercept_dropoff/<cmd_idx>	GET	Checks conveyor intercept for drop-off response	GroupConvDropoffData
/group_conv_descend	POST	Initiates conveyor descend request	GroupConvData
/group_conv_descend/<cmd_idx>	GET	Checks conveyor descend response	GroupConvData
/group_conv_track_pickup	POST	Initiates tracking conveyor pick up request	GroupConvData
/group_conv_track_pickup/<cmd_idx>	GET	Checks tracking conveyor pick up response	GroupConvData
/group_conv_track_dropoff	POST	Initiates tracking conveyor drop-off request	GroupConvData
/group_conv_track_dropoff/<cmd_idx>	GET	Checks tracking conveyor drop-off response	GroupConvData
/group_conv_ascend	POST	Initiates conveyor ascend request	GroupConvData
/group_conv_ascend/<cmd_idx>	GET	Checks conveyor ascend response	GroupConvData
/group_conv_pickup	POST	Initiates group conveyor pickup request	GroupConvPickupData
/group_conv_pickup/<cmd_idx>	GET	Checks group conveyor pickup response	GroupConvPickupData
/group_conv_dropoff	POST	Initiates group conveyor drop-off request	GroupConvDropoffData
/group_conv_dropoff/<cmd_idx>	GET	Checks group conveyor drop-off response	GroupConvDropoffData

5.5. Container Operations

API Route	Method	Description	Payload
/cont_calibrate_pos	POST	Initiates container calibrate position request	ContCamData
/cont_calibrate_pos/<cmd_idx>	GET	Checks container calibrate position response	ContCamData
/cont_cam_calibrate_pos	POST	Initiates container camera calibrate position request	GroupContCamData
/cont_cam_calibrate_pos/<cmd_idx>	GET	Checks container camera calibrate position response	GroupContCamData
/group_cont_intercept_dropoff	POST	Initiates container intercept at drop-off request	GroupContDropoffData

/group_cont_intercept_dropoff/ <cmd_idx>	GET	Checks container intercept at drop-off response	GroupContDropoffData
/group_cont_intercept_pickup	POST	Initiates container intercept at pick-up request	GroupContPickupData
/group_cont_intercept_pickup/ <cmd_idx>	GET	Checks container intercept at pick-up response	GroupContPickupData
/group_cont_intercept_pickup_idx	POST	Initiates group container intercept at part index request	GroupContPickupIdxData
/group_cont_intercept_pickup_idx/ <cmd_idx>	GET	Checks group container intercept at part index response	GroupContPickupIdxData
/group_cont_descend	POST	Initiates container descend request	GroupContData
/group_cont_descend/<cmd_idx>	GET	Checks container descend response	GroupContData
/group_cont_track_dropoff	POST	Initiates tracking container drop-off request	GroupContData
/group_cont_track_dropoff/ <cmd_idx>	GET	Checks tracking container drop-off response	GroupContData
/group_cont_track_pickup	POST	Initiates tracking container pick-up request	GroupContData
/group_cont_track_pickup/ <cmd_idx>	GET	Checks tracking container pick-up response	GroupContData
/group_cont_ascend	POST	Initiates container ascend request	GroupContData
/group_cont_ascend/<cmd_idx>	GET	Checks container ascend response	GroupContData
/group_cont_dropoff	POST	Initiates container drop-off request	GroupContDropoffData
/group_cont_dropoff/<cmd_idx>	GET	Checks container drop-off response	GroupContDropoffData
/group_cont_pickup	POST	Initiates container pick-up request	GroupContPickupData
/group_cont_pickup/<cmd_idx>	GET	Checks container pick-up response	GroupContPickupData
/group_cont_pickup_idx	POST	Initiates group container pickup at part index request	GroupContPickupIdxData
/group_cont_pickup_idx/ <cmd_idx>	GET	Checks group container pickup at part index response	GroupContPickupIdxData
/cont_set_empty	POST	Initiates container set internal part count to zero request	ContData
/cont_set_empty/<cmd_idx>	GET	Checks container set internal part count to zero response	ContData
/cont_set_full	POST	Initiates container set internal part count to full request	ContPartData
/cont_set_full/<cmd_idx>	GET	Checks container set internal part count to full response	ContPartData
/cont_not_empty	POST	Initiates container checking not empty request	ContBoolData
/cont_not_empty/<cmd_idx>	GET	Checks container checking not empty response	ContBoolData
/cont_not_full	POST	Initiates container checking not full request	ContPartBoolData
/cont_not_full/<cmd_idx>	GET	Checks container checking not full response	ContPartBoolData

6. EtherCAT Commands

6.1. CoE (CANopen over EtherCAT) Operations

API Route	Method	Description	Payload
/coe_wr_u8	POST	Initiates U8 write request	CoeU8Data
/coe_wr_u8/<cmd_idx>	GET	Checks U8 write response	CoeU8Data
/coe_wr_u16	POST	Initiates U16 write request	CoeU16Data
/coe_wr_u16/<cmd_idx>	GET	Checks U16 write response	CoeU16Data
/coe_wr_u32	POST	Initiates U32 write request	CoeU32Data
/coe_wr_u32/<cmd_idx>	GET	Checks U32 write response	CoeU32Data
/coe_rd_u8	POST	Initiates U8 read request	CoeU8Data
/coe_rd_u8/<cmd_idx>	GET	Checks U8 read response	CoeU8Data
/coe_rd_u16	POST	Initiates U16 read request	CoeU16Data
/coe_rd_u16/<cmd_idx>	GET	Checks U16 read response	CoeU16Data
/coe_rd_u32	POST	Initiates U32 read request	CoeU32Data
/coe_rd_u32/<cmd_idx>	GET	Checks U32 read response	CoeU32Data

6.2. CIA402 Op mode Control

API Route	Method	Description	Payload
/set_cia402_op_mode	POST	Initiates CIA402 operation mode setting request	Cia402OpModeData
/set_cia402_op_mode/<cmd_idx>	GET	Checks CIA402 operation mode setting response	Cia402OpModeData

Note: All endpoints that have POST/GET pairs follow an asynchronous pattern where the operation is initiated with the POST endpoint and its completion can be checked with the GET endpoint.

7. Configuration File

7.1. Ethernet

Field	Type	Description
interface_name	String	Ethernet interface name
prioritize_usr_space_eth_drv	Boolean	If true, prioritize obtaining slave configuration from ESI file; otherwise use slave EEPROM SSI data

7.2. EtherCAT

Field	Type	Description	Unit
esi_file_path	String	ESI file path	N/A
prioritize_esi_config	Boolean	If true, prioritize obtaining slave configuration from ESI file; otherwise use slave EEPROM SSI data	N/A
cycle_time	32-bit unsigned integer	EtherCAT cycle time, only multiples of 250us is supported	[us]
shift_time	32-bit unsigned integer	DC master frame send to sync0 offset	% of cycle_time
rx_frame_timeout	32-bit unsigned integer	Receive frame timeout, only supported on Linux and MacOS	[us]

7.3. Move Parameters

Name	Field	Type	Unit
------	-------	------	------

move_params	rotational	MoveProfile	deg
	linear	MoveProfile	mm

7.3.1. Move Profile

Name	Fields	Type	Unit
move_profile	max_vel	64-bit float	[unit/s]
	max_acc	64-bit float	[unit/s^2]
	max_dec	64-bit float	[unit/s^2]
	max_jrk	64-bit float	[unit/s^3]

7.4. Axis

Field	Type	Description	Unit
enco_offst	32-bit integer	Encoder offset	[Encoder tics]
gear_ratio	64-bit float	Gear Ratio	N/A
slv_idx	Unsigned integer	Slave index: zero indexed position of axis within the network	N/A
min_pos	64-bit float	Minimum angular position of the rotational motor	[deg]
max_pos	64-bit float	Maximum angular position of the rotational motor	[deg]

7.5. Group

Field	Type	Description	Units
axs_idx_vec	Vector of unsigned integers of length 4	Axes indices	N/A
pos	Vector of 64-bit floating points of length 6	robot frame position relative to world frame, rot convension: alpha beta gamma: x-y'-z" (intrinsic rotations) or z-y-x (extrinsic rotations)	[mm, mm, mm, deg, deg, deg]
world_limits_type	WorldLimitType	World Limit Enum	N/A
group_type	GroupType	Group Type Enum	N/A
end_eff	EndEffConfig	End effector type and digital output configuration	N/A
world_type	WorldType	World Type Enum	N/A

7.5.1. World Limit Type Enum

Value	Fields	Type	Unit
CylindricalZ	z_min	64-bit floating point	[mm]
	z_max	64-bit floating point	[mm]
	r_xy_max	64-bit floating point	[mm]

7.5.2. Group Type Enum

Value	Fields	Type	Unit
Delta	base_radius	64-bit floating point	[mm]
	base_offset	64-bit floating point	[mm]
	upper_arm_length	64-bit floating point	[mm]
	lower_arm_length	64-bit floating point	[mm]
	platform_offset	64-bit floating point	[mm]
	platform_radius	64-bit floating point	[mm]

	motor_angles	64-bit floating vector of length 3	[deg]
	upper_arm_mass	64-bit floating point	[kg]
	lower_arm_mass	64-bit floating point	[kg]
	lower_plate_mass	64-bit floating point	[kg]
	upper_arm_cm_radius	64-bit floating point	[mm]
	upper_arm_cm_inertia	64-bit floating point	[Kg.mm ²]
SerialDH	theta	Vector of size DOF	[deg]
	a	Vector of size DOF	[deg]
	d	Vector of size DOF	[deg]
	alpha	Vector of size DOF	[deg]
	joint_type	Vector of size DOF	JointType
Gantry	N/A	N/A	N/A

7.5.3. End Effector

Name	Fields	Data Type
end_eff	type	EndEffType
	engage	DigSignal
	eject	DigSignal

7.5.3.1. End Eff Type Enum

Data Type	Value
EndEffType	Suction
	Gripper

7.5.3.2. Dig Signal

Name	Fields	Data Type	Unit
DigSignal	axs_idx	Unsigned Integer	N/A
	bit_off	8-bit unsigned integer	[bits]
	delay	64-bit floating point	[s]

7.5.4. World Type Enum

Data Type	Value
WorldType	XYZ
	XYZRz
	XYZRxyz

7.6. Camera

Field	Type	Description	Unit
id	String	camera id in the form of <vendor>-<serial number>	N/A
exposure_time	64-bit floating point	camera exposure time	[us]
pixel_size	64-bit floating point	camera pixel size	[um]
focal_length	64-bit floating point	lens focal length	[mm]
pos	64-bit float vector of size 6	camera frame position relative to world frame, rot convension: alpha beta gamma: x-y'-z" (intrinsic rotations) or z-y-x (extrinsic rotations)	[mm, mm, mm, deg, deg, deg]

7.7. Conveyor

Field	Type	Description	Unit
width	64-bit floating point	conveyor width	[mm]
length	64-bit floating point	conveyor length	[mm]
cam_idx_vec	vector of unsigned integers	cameras used for tracking objects on this conveyor	N/A
pos	64-bit float vector of size 6	conveyor frame position relative to world frame, rot convention: alpha beta gamma: x-y'-z" (intrinsic rotations) or z-y-x (extrinsic rotations)	[mm, mm, mm, deg, deg, deg]
descend_dist	64-bit floating point	descend/ascend distance in z direction in the conv frame during pickup	[mm]

7.8. Container

Field	Type	Description	Unit
width	64-bit floating point	container width	[mm]
length	64-bit floating point	container length	[mm]
height	64-bit floating point	container height	[mm]
width_space	64-bit floating point	space along container width between parts during part dropoff	[mm]
length_space	64-bit floating point	space along container length between parts during part dropoff	[mm]
cam_idx_vec	vector of unsigned integers	cameras used for calibrating the position of this container	N/A
pos	64-bit float vector of size 6	container frame position relative to world frame, rot convention: alpha beta gamma: x-y'-z" (intrinsic rotations) or z-y-x (extrinsic rotations)	[mm, mm, mm, deg, deg, deg]
descend_dist	64-bit floating point	descend/ascend distance in z direction in the conv frame during pickup	[mm]

7.9. Part

Field	Type	Description	Unit
width	64-bit floating point	width of the part	[mm]
length	64-bit floating point	length of the part	[mm]
height	64-bit floating point	height of the part	[mm]
mass	64-bit floating point	mass of the part	[kg]
inertia_zz	64-bit floating point	inertia about the center of mass in the z direction	[Kg.mm ²]
label	String	string, either "", "alphabetic", "alphanumeric", or "text", used to detect if 180 degree rotation is needed or not	N/A
max_linear_error	64-bit floating point	percentage of acceptable error in width or length when identifying parts	N/A

7.10. Cycle

Field	Type	Description	Unit
grp_idx	Unsigned Integer	Group index	N/A
cnv_idx	Unsigned Integer	Conveyor index	N/A
cnt_idx	Unsigned Integer	Container index	N/A

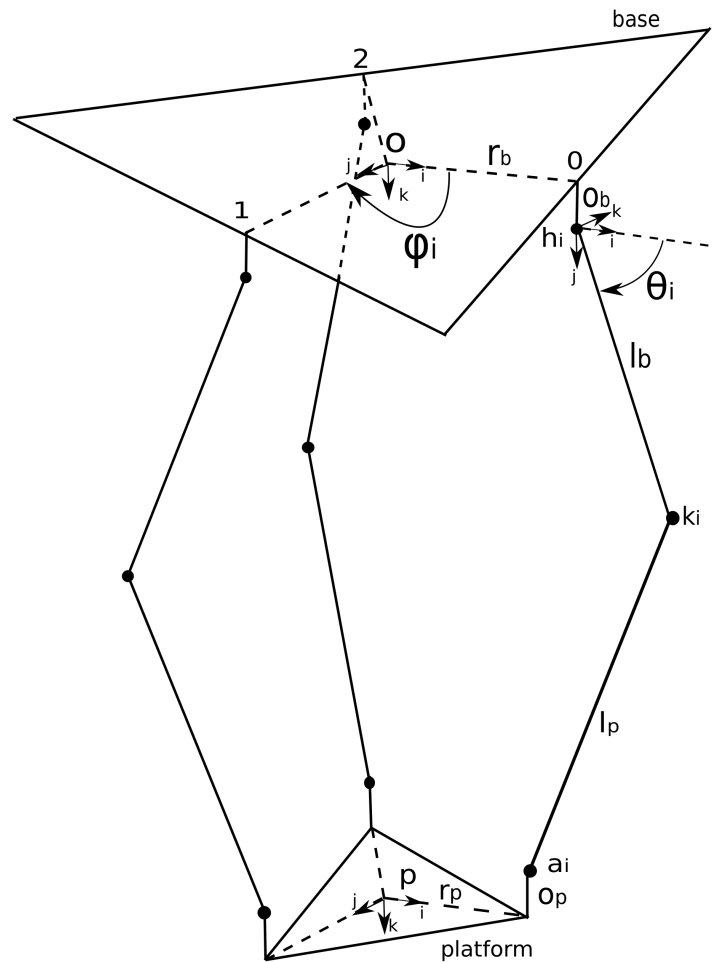
prt_idx	Unsigned Integer	Part index	N/A
prcn	8-bit unsigned integer	Motion speed, max value is 255	% max speed
cnv_pickup_timeout	64-bit floating point	How long a conveyor intercept or pickup call keeps attempting to find a part using the camera	[s]
cnv_spd	64-bit floating point	Conveyor speed	[mm/s]
cycle_type	CycleType	Conveyor to container or container to conveyor	N/A
start_signal	DigSignal	Digital input signal for cycle to start	N/A
done_signal	DigSignal	Digital output signal when cycle is done	N/A

7.10.1. CycleType Enum

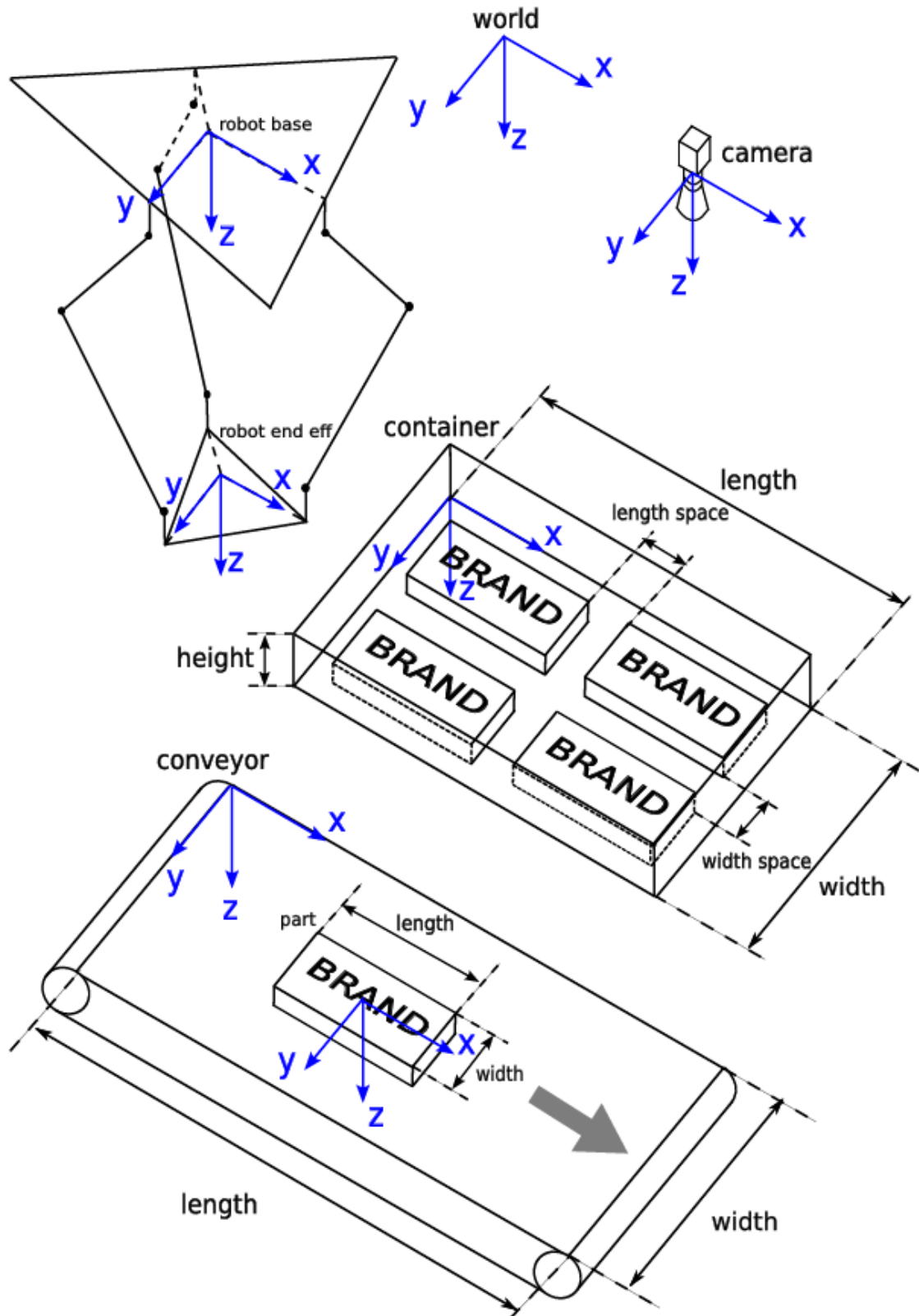
Data Type	Value	Description
CycleType	CnvToCnt	Conveyor to container
	CntToCnv	Container to conveyor
	N/A	N/A

8. Diagram Quantities

Symbol	Description
φ_i	Motor Angle
θ_i	Joint Angle
r_b	Base Radius
O_b	Base Offset
l_b	Base Leg Length
l_p	Platform Leg Length
O_p	Platform Offset
r_p	Platform Radius



9. Workspace Coordinate System Defines



10. Appendix A: Payload Details

10.1. Config Save Payload Details

Payload	Fields	Description	Types	Units
ConfigSaveData	config	Configuration	Config	N/A
	file_name	Config file name	String	N/A

10.2. Number of Slaves Payload Details

Payload	Fields	Description	Types	Units
---------	--------	-------------	-------	-------

NumSlvsData	num_slaves	Number of slaves	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C : ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.3. Axis Payload Details

Payload	Fields	Description	Types	Units
AxisData	axs_idx	Axis index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisCurrPosData	axs_idx	Axis index	Unsigned Integer	N/A
	curr_pos	Current position	64-bit floating point	[mm] or [deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisMovePosData	axs_idx	Axis index	Unsigned Integer	N/A
	end_pos	End position	64-bit Floating Point	[mm] or [deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisMoveVelData	axs_idx	Axis index	Unsigned Integer	N/A
	end_vel	End velocity	64-bit Floating Point	[mm/s] or [deg/s]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisMoveRelData	axs_idx	Axis index	Unsigned Integer	N/A
	rel_pos	Relative position	64-bit Floating Point	[mm] or [deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisDigData	axs_idx	Axis index	Unsigned Integer	N/A
	bit_off	Bit Offset	8-bit Unsigned Integer	[Bits]
	val	Value	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisBoolData	axs_idx	Axis index	Unsigned Integer	N/A
	val	Value	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A

	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisAlarmsData	axs_idx	Axis index	Unsigned Integer	N/A
	alarms	See Appendix D: Motion alarm codes .	Vector of 16-bit Unsigned Integers	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisSleepData	axs_idx	Axis index	Unsigned Integer	N/A
	t_tot	Total time	64-bit float	[s]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
AxisSpdPrcnData	axs_idx	Axis index	Unsigned Integer	N/A
	prcn	Motion speed, max value is 255	8-bit Unsigned Integer	% max speed
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.4. Group Payload Details

Payload	Fields	Description	Types	Units
GroupData	grp_idx	Group index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupMovePosData	grp_idx	Group index	Unsigned Integer	N/A
	end_pos	End position	64-bit Floating Vector	[mm] or [deg]
	coord_type	Coordinate type: "Joint or World"	String	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupMoveRelData	grp_idx	Group index	Unsigned Integer	N/A
	rel_pos	Relative position	64-bit Floating Vector	[mm] or [deg]
	coord_type	Coordinate type: "Joint or World"	String	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

GroupDigData	grp_idx	Group index	Unsigned Integer	N/A
	axs_idx	Axis index	Unsigned Integer	N/A
	bit_off	Bit offset	8-bit Unsigned Integer	[Bits]
	val	value	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupBoolData	grp_idx	Group index	Unsigned Integer	N/A
	val	Value	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupBgnPosData	grp_idx	Group index	Unsigned Integer	N/A
	coord_type	Coordinate type: "Joint or World"	String	N/A
	bgn_pos	Begin position	64-bit Floating Vector	[mm] or [deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupCurrPosData	grp_idx	Group index	Unsigned Integer	N/A
	joint_pos	Joint position	64-bit Floating Vector	[mm] or [deg]
	world_pos	World position	64-bit Floating Vector	[mm] or [deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupAlarmsData	grp_idx	Group index	Unsigned Integer	N/A
	alarms	See Appendix D: Motion alarm codes .	Vector of 16-bit Unsigned Integers	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupSleepData	grp_idx	Group index	Unsigned Integer	N/A
	t_tot	Total time	64-bit Floating Vector	[s]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes .	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupSpdPrcnData	grp_idx	Group index	Unsigned Integer	N/A
	prcn	Motion speed, max value is 255	8-bit Unsigned Integer	% max speed
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A

	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
MotnCmdData	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.5. Conveyor Payload Details

Payload	Fields	Description	Types	Units
ConvSpdData	cnv_idx	Conveyor index	Unsigned Integer	N/A
	cnv_spd	Conveyor speed	64-bit floating point	[mm/s]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
ConvCamData	cnv_idx	Conveyor index	Unsigned Integer	N/A
	cam_idx	Camera index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupConvCamData	grp_idx	Group index	Unsigned Integer	N/A
	cnv_idx	Conveyor index	Unsigned Integer	N/A
	cam_idx	Camera index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupConvData	grp_idx	Group index	Unsigned Integer	N/A
	cnv_idx	Conveyor index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupConvPickupData	grp_idx	Group index	Unsigned Integer	N/A
	cnv_idx	Conveyor index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A
	label	Label	String	N/A
	drop_rz	Rz drop position in group frame, only applicable to groups with XYZRz world type, also ignored on Gripper end eff types, because gripper position has to match part orientation	64-bit Floating Point	[deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B : Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupConvDropoffData	grp_idx	Group index	Unsigned Integer	N/A
	cnv_idx	Conveyor index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A

	drop_rz	Rz drop position in group frame, only applicable to groups with XYZRz world type, also ignored on Suction end eff types, because drop of position is influenced by the prior pickup position	64-bit Floating Point	[deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.6. Container Payload Details

Payload	Fields	Description	Types	Units
ContCamData	cnt_idx	Container index	Unsigned Integer	N/A
	cam_idx	Camera index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupContCamData	grp_idx	Group index	Unsigned Integer	N/A
	cnt_idx	Container index	Unsigned Integer	N/A
	cam_idx	Camera index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupContDropoffData	grp_idx	Group index	Unsigned Integer	N/A
	cnt_idx	Container index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A
	drop_rz	Rz drop position in group frame, only applicable to groups with XYZRz world type, also ignored on Suction end eff types, because drop of position is influenced by the prior pickup position	64-bit Floating Point	[deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupContPickupData	grp_idx	Group index	Unsigned Integer	N/A
	cnt_idx	Container index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A
	drop_rz	Rz drop position in group frame, only applicable to groups with XYZRz world type, also ignored on Gripper end eff types, because gripper position has to match part orientation	64-bit Floating Point	[deg]
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupContPickupIdxData	grp_idx	Group index	Unsigned Integer	N/A
	cnt_idx	Container index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A

	drop_rz	Rz drop position in group frame, only applicable to groups with XYZRz world type, also ignored on Gripper end eff types, because gripper position has to match part orientation	64-bit Floating Point	[deg]
	i_idx	Container position index along the x axis	Unsigned Integer	N/A
	j_idx	Container position index along the y axis	Unsigned Integer	N/A
	k_idx	Container position index along the z axis	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
GroupContData	grp_idx	Group index	Unsigned Integer	N/A
	cnt_idx	Container index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
ContData	cnt_idx	Container index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
ContPartData	cnt_idx	Container index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
ContBoolData	cnt_idx	Container index	Unsigned Integer	N/A
	val	N/A	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
ContPartBoolData	cnt_idx	Container index	Unsigned Integer	N/A
	prt_idx	Part index	Unsigned Integer	N/A
	val	N/A	Boolean	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix B: Motion result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.7. EtherCAT Command Payload Details

10.7.1. EtherCAT Command Payload Details

Payload	Fields	Description	Types	Units
EcatCmdData	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C: ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.7.2. CoE Payload Details

Payload	Fields	Description	Types	Units
---------	--------	-------------	-------	-------

CoeU8Data	slv_idx	Slave index	Unsigned Integer	N/A
	index	CoE index value	16-bit Unsigned Integer	N/A
	sub_index	CoE sub-index value	8-bit Unsigned Integer	N/A
	val	Read or write CoE object value	8-bit Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C: ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
CoeU16Data	slv_idx	Slave index	Unsigned Integer	N/A
	index	CoE index value	16-bit Unsigned Integer	N/A
	sub_index	CoE sub-index value	8-bit Unsigned Integer	N/A
	val	Read or write CoE object value	16-bit Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C: ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A
CoeU32Data	slv_idx	Slave index	Unsigned Integer	N/A
	index	CoE index value	16-bit Unsigned Integer	N/A
	sub_index	CoE sub-index value	8-bit Unsigned Integer	N/A
	val	Read or write CoE object value	32-bit Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C: ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

10.7.3. Cia402 Op mode Payload Details

Payload	Fields	Description	Types	Units
Cia402OpModeData	slv_idx	Slave index	Unsigned Integer	N/A
	op_mode	Cia402 mode of operation	8-bit Unsigned Integer	N/A
	cmd_idx	Unique command index	64-bit Unsigned Integer	N/A
	rslt	See Appendix C: ECAT result error codes.	16-bit Unsigned Integer	N/A
	done	Request response	Boolean	N/A

11. Appendix B: Motion result error codes

Value	Description
0x0000	Success
0x1001	Initialization axes network error
0x1002	Invalid axis index
0x1003	Invalid group index
0x1004	Invalid conveyor index
0x1005	Invalid container index
0x1006	Invalid part index
0x1007	Invalid camera index
0x1008	Invalid digital io bit offset
0x1009	Axis index not in group
0x100A	Motion commanded while not servoed on
0x100B	Joint position limits reached
0x100C	Joint velocity limits reached

0x100D	Joint torque limits reached
0x100E	World position limits reached
0x100F	World velocity limits reached
0x1010	World torque limits reached
0x1011	Small or zero length trajectory append dropped
0x1012	Servo off commanded while motion running
0x1013	Axis and group command traj attempting to move the same axis
0x1014	Conveyor part not found
0x1015	Conveyor speed not set
0x1016	Conveyor speed exceeds group speed, it is not possible for the robot to catch up with or to track the conveyor
0x1017	Conveyor intercept solution did not converge, often due to conveyor running too fast relative to the robot
0x1018	Conveyor vert traj failed, max x vel/acc required during move exceeded
0x1019	Move append while an alarm present
0x101A	Move append while a vel move is running
0x101B	Move append joint traj to a world trajectory on a group that has non unique inv kin solution, is not allowed
0x101C	Quick stop append traj failed, quick stop already running
0x101D	Motion command mismatch
0x101E	Forward kinematics unreachable
0x101F	Inverse kinematics non convergent
0x1020	Inverse kinematics unreachable
0x1021	Inverse kinematics singularity
0x1022	No end effector config available
0x1023	Container was being filled by parts of one type, and then switched to another part type before getting full
0x1024	A dropoff with auto fill was made while the container is already full
0x1025	A pickup with auto empty was made while the container is already empty
0x1026	Container fill index invalid
0x1027	Speed percent can't be zero
0x1028	Emergency stop pressed
0x1029	Motion axis internal fault occurred
0x102A	Calibration letter not found
0x102B	Camera Id provided in the config file not found
0x102C	Camera fixed image path provided in the config file invalid or not found
0x1FFF	Unspecified motion error

12. Appendix C: ECAT result error codes

Value	Description
0x0000	Success
0x0001	Version string length insufficient
0x0002	Invalid slave index
0x0003	Uninitialized slave index
0x0004	Uninitialized station address
0x0005	Working counter not incremental
0x0006	Frame receive time out
0x0007	Frame command mismatch

0x0008	ESI file not found
0x0009	SM data cat section not found in SSI
0x000A	Register response mismatch
0x000B	SSI maximum byte length reached
0x000C	Max retries reached, while polling coe sm1 response mbox ready status
0x000D	CoE mbox emergency
0x000E	CoE mbox abort code
0x000F	Cia operational mode maximum retries reached
0x0010	Ecat command mismatch
0x0011	CoE object unsupported
0x0FFF	Unspecified ethercat error

13. Appendix D: Motion alarm codes

Alarms should normally not occur. If they do occur, they are typically because serial DH chain inverse kinematics either encountered an error or the robot joint pos/vel limits were reached during motion. When an alarm occurs, a quick stop motion command is automatically generated, in order to safely stop all motion. Additionally, no motion or io commands may be done before an alarm clear command is made. Note that alarm clear commands clear all queued motion and io commands. Any of the error codes in appendix B, may correspond to an alarm. Alarm codes equal 0x1000 plus the value of the corresponding error code. For example, if joint velocity limits are reached, while a 7 axis robotic arm is running motion, motion will stop, and an alarm code 0x200B will be generated. Note that axis and group alarms are treated entirely separately. For example, an axis will not necessarily have an alarm, even if it belongs to a group of axes and that group does have an alarm.