BECKHOFF

Technical Accelerator 2025

Engineering Challenge Workbook

Objective

Congratulations – you've just been contracted to help configure & test the latest, greatest ride vehicles at the local theme park.

This particular attraction is comprised of 5 vehicles with their own IPC and safety circuit.

The job today is to set up FSoE over EAP to the vehicle(s) around you, and to follow a synchronized encoder position from the lead vehicle, so that all are following the same motion profile.

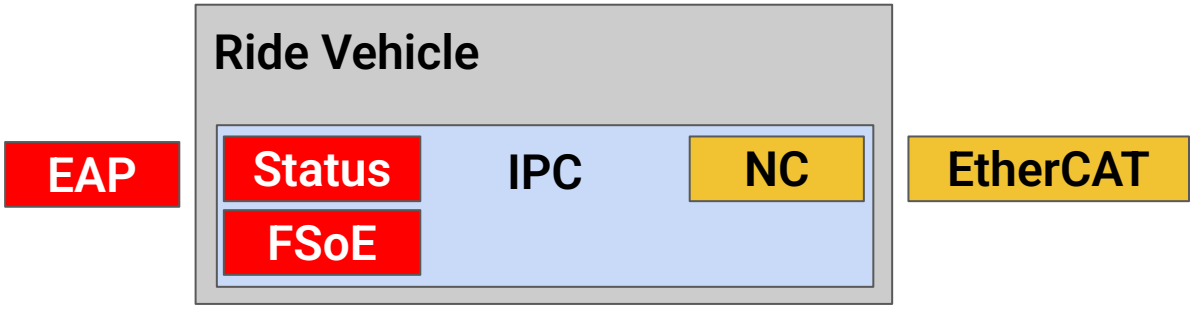
Your team will have to work with the other teams to complete the job, remember that none of this works without the others.

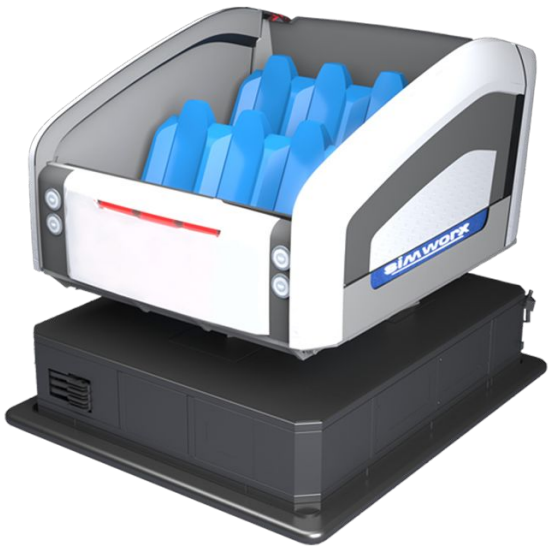
EAP

Use EAP Unicast for the com status check & send FSoE data to the vehicle in front and/or behind you.

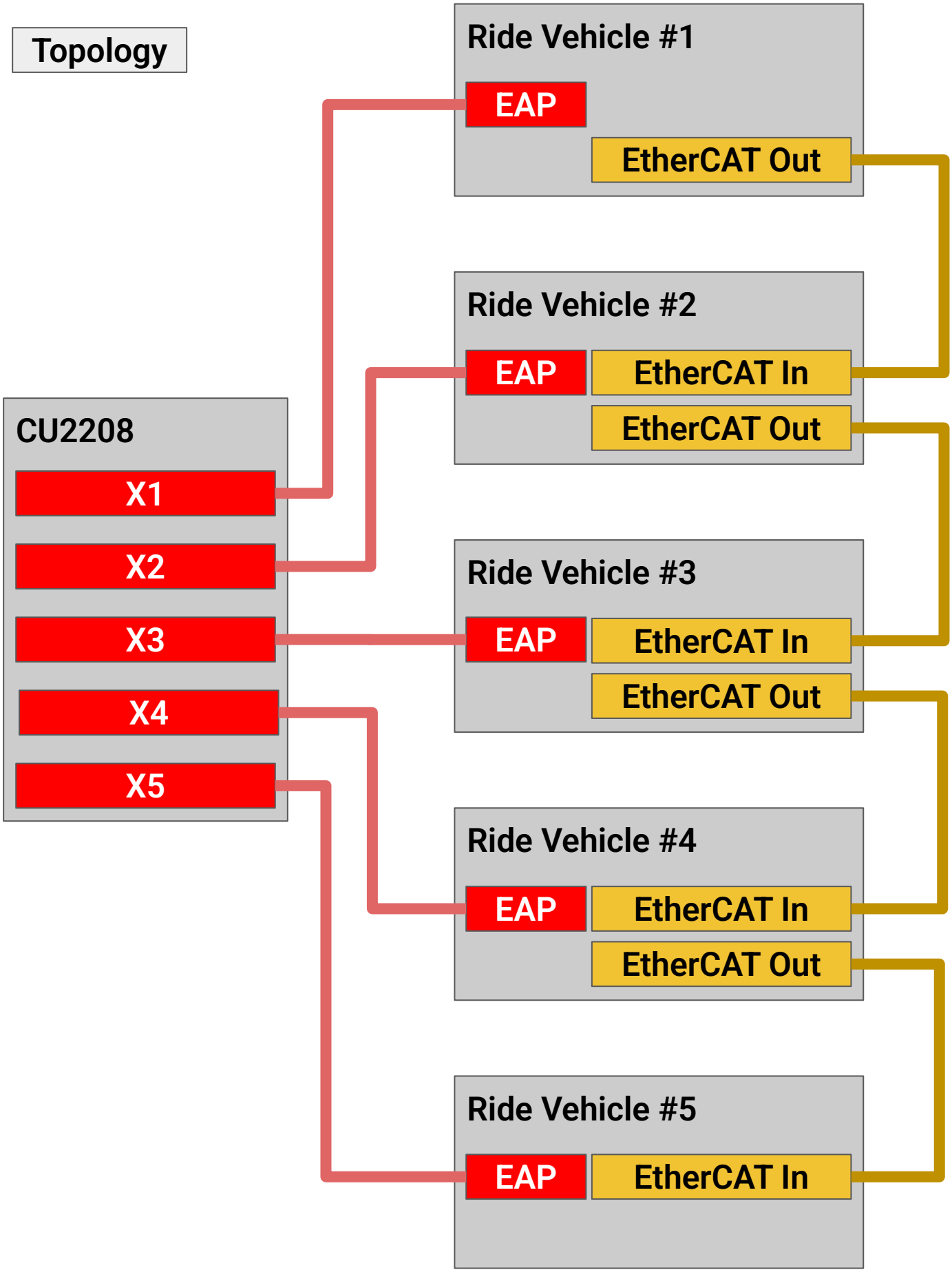
EtherCAT

Use EtherCAT to receive and forward the encoder data from the lead vehicle. This data will be used for gearing your own vehicle axis.





Topology


Ride Vehicle #1
EAP
EtherCAT Out
Ride Vehicle #2
EAP
EtherCAT In
EtherCAT Out
CU2208
X1
X2
X3
X4
X5
Ride Vehicle #3
EAP
EtherCAT In
EtherCAT Out
Ride Vehicle #4
EAP
EtherCAT In
EtherCAT Out
Ride Vehicle #5
EAP
EtherCAT In

Status

BOOL datatype

Subscriber - Data In
VarData = communication status from vehicle in front

Publisher - Data Out
VarData = communication status to vehicle behind

FSoE

FSOE_6 datatype

Subscriber - Data In
FSoE Data[0] = safety status from vehicle in front
***hint also labeled as Safe Data Byte 0[0] in TwinSAFE**

Publisher - Data Out
FSoE Data[0] = safety status to vehicle behind
***hint also labeled as Safe Data Byte 0[0] in TwinSAFE**

NC

UDINT datatype

nDataIn1 = encoder data from lead vehicle

FSoE

If you are the last vehicle, you only require a slave-to-master connection.

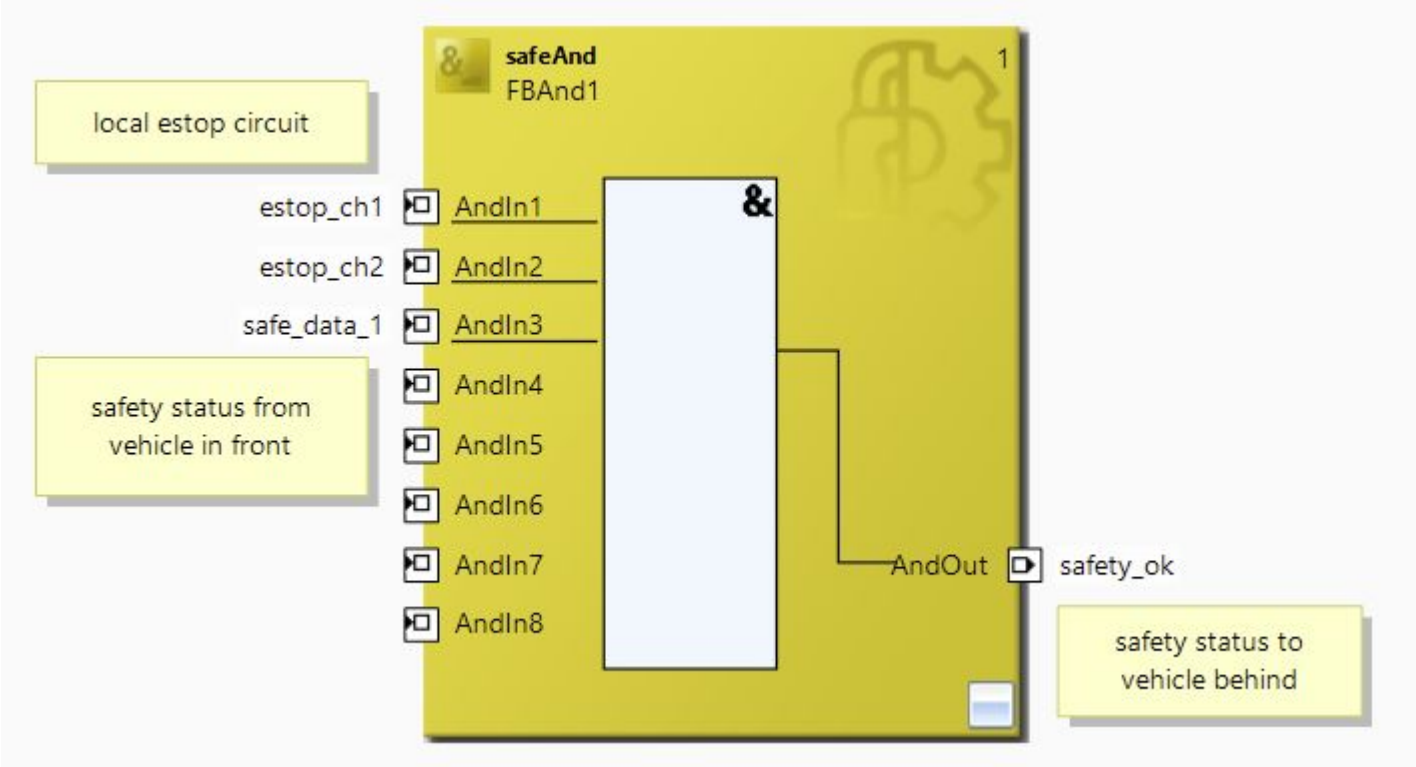
If you you have a vehicle in front and behind you, you will require both a master-to-slave and slave-to-master connection.

Safe Addresses are NOT related to the dip switch address.

The Safe Address should be unique to the connection and shared between the devices.

Example :

- **Connection 1, master (30) to slave (30)**
- **Connection 2, slave (40) to master (40)**

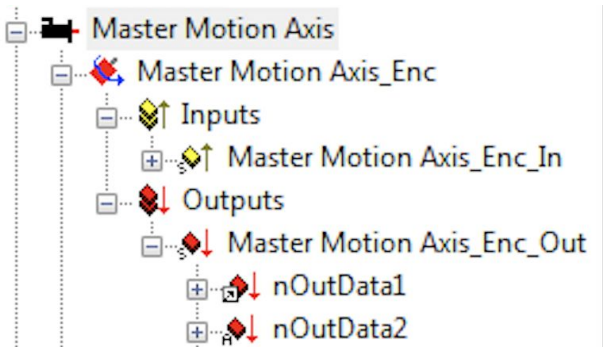


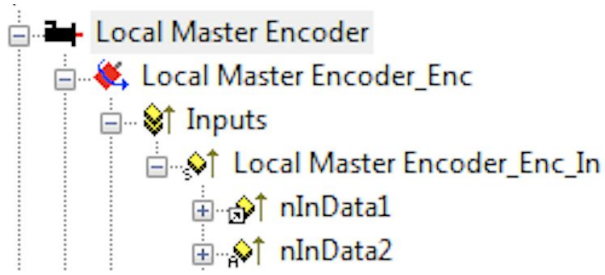
NC

To implement this configuration, the physical axis on one controller is replicated by creating a virtual encoder axis on a second controller. Then the Encoder Position of the real axis is transmitted cyclically via the EtherCAT slave interface.

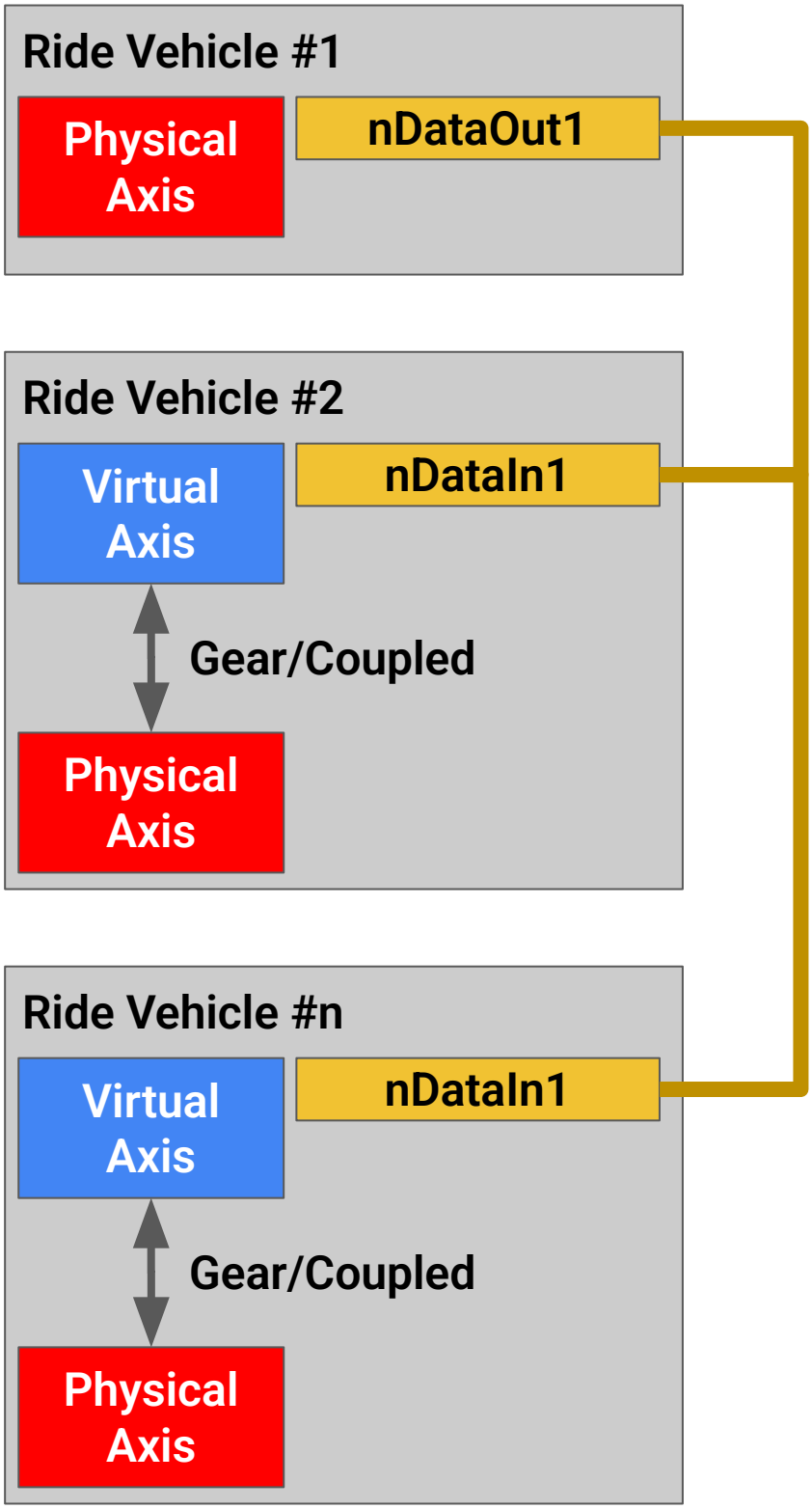
The variables that need to be transferred are the Encoder output Position of the Axis on one PC must be linked to the Encoder Input of and Encoder Axis on the second PC.

The Master Axis current commanded position is distributed cyclically and synchronously to the other PC and the replicated Local Master Axis become 1:1 copies of the Master axis.





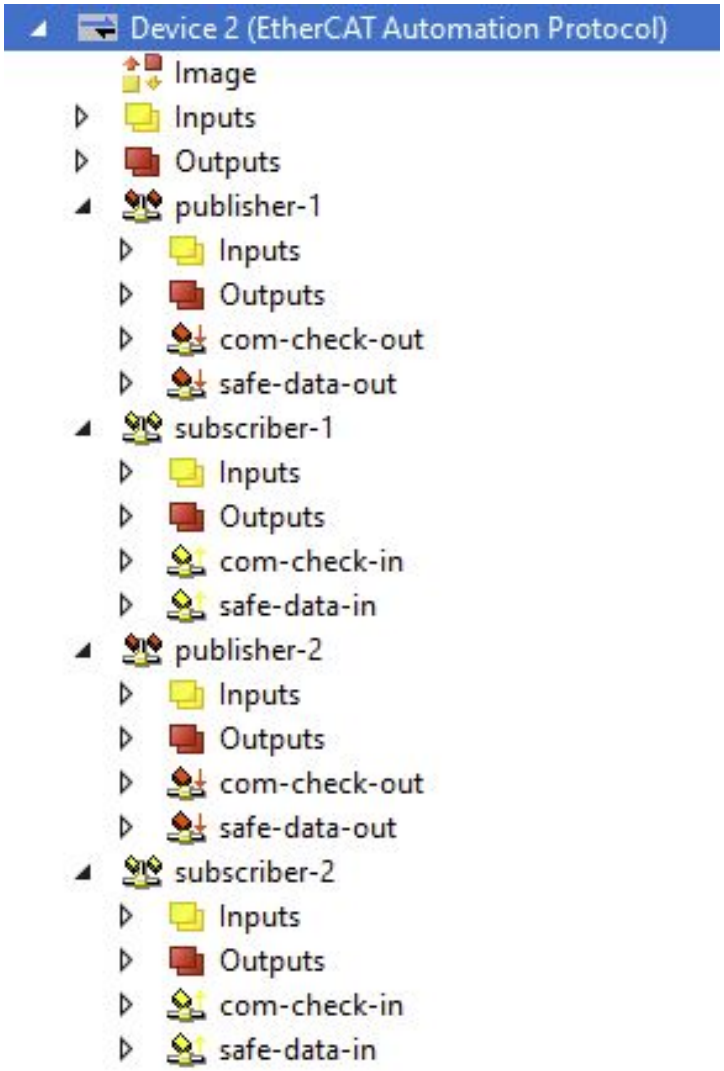
Axis Sync


Ride Vehicle #1
Physical Axis
nDataOut1
Ride Vehicle #2
Virtual Axis
nDataIn1
Gear/Coupled
Physical Axis
Ride Vehicle #n
Virtual Axis
nDataIn1
Gear/Coupled
Physical Axis

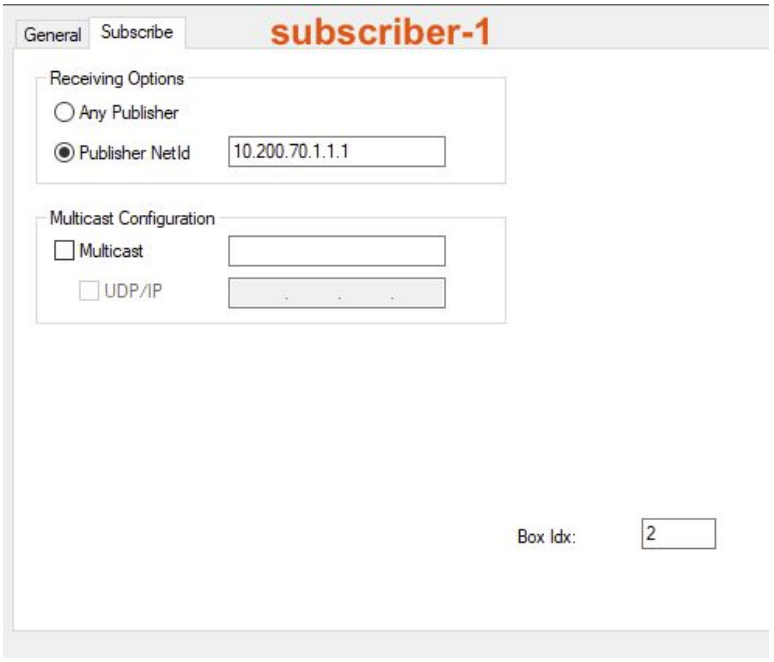
Check List

Objective	Status
Configure & test local safety	
Configure & test EAP	
Configure & test FSoE over EAP	
Set up virtual encoder axis	
Configure EtherCAT slave interface	
Link encoder data	
Request EtherCAT “scan” from lead vehicle	
Test axis synchronicity	

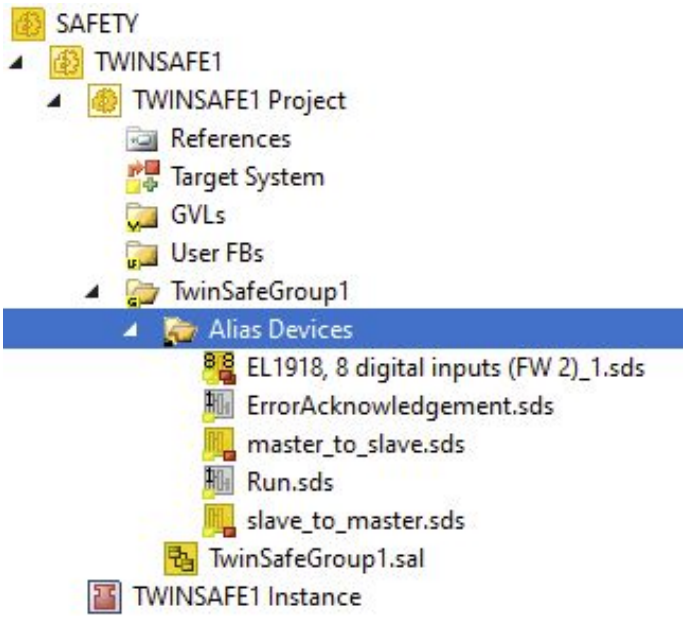
Cheat Sheet

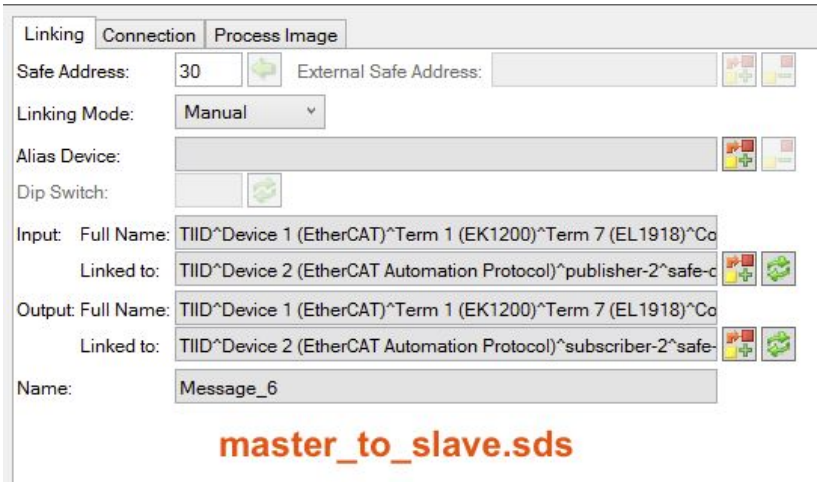

Device 2 (EtherCAT Automation Protocol)
Image
Inputs
Outputs
publisher-1
Inputs
Outputs
com-check-out
safe-data-out
subscriber-1
Inputs
Outputs
com-check-in
safe-data-in
publisher-2
Inputs
Outputs
com-check-out
safe-data-out
subscriber-2
Inputs
Outputs
com-check-in
safe-data-in

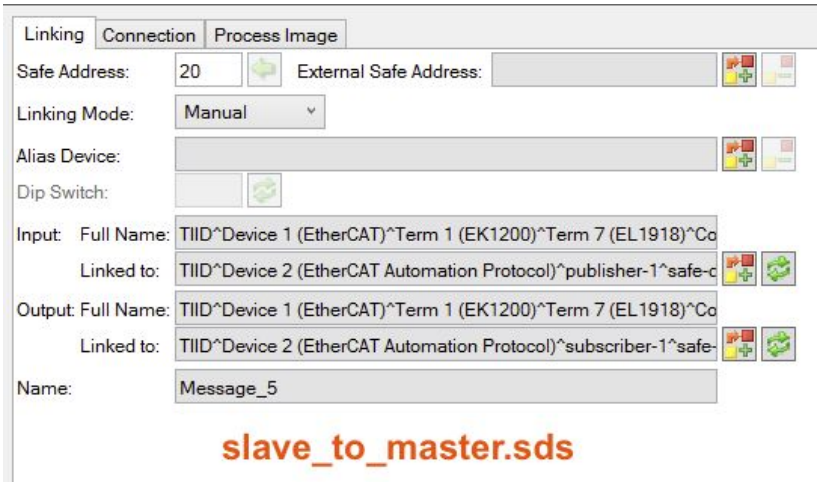

General
Publish
publisher-1
Sending Options
RT-Ethernet (Ether Type 88A4h)
Broadcast
Multicast
Unicast
MAC Address
AMS NetId
10.200.70.1.1.1
UDP/IP
Broadcast
Multicast
Unicast
Default Gateway:
0 . 0 . 0 . 0
ARP Retry Interval (ms):
1000
Disable Subscriber Monitoring
Target Address Online Changeable
Data Exchange
Divider
1
Modulo:
0
VLAN Support
Enable
Priority:
Id:
Initial State
Disable Initially
Box Idx:
1


General
Subscribe
subscriber-1
Receiving Options
Any Publisher
Publisher NetId
10.200.70.1.1.1
Multicast Configuration
Multicast
UDP/IP
Box Idx:
2

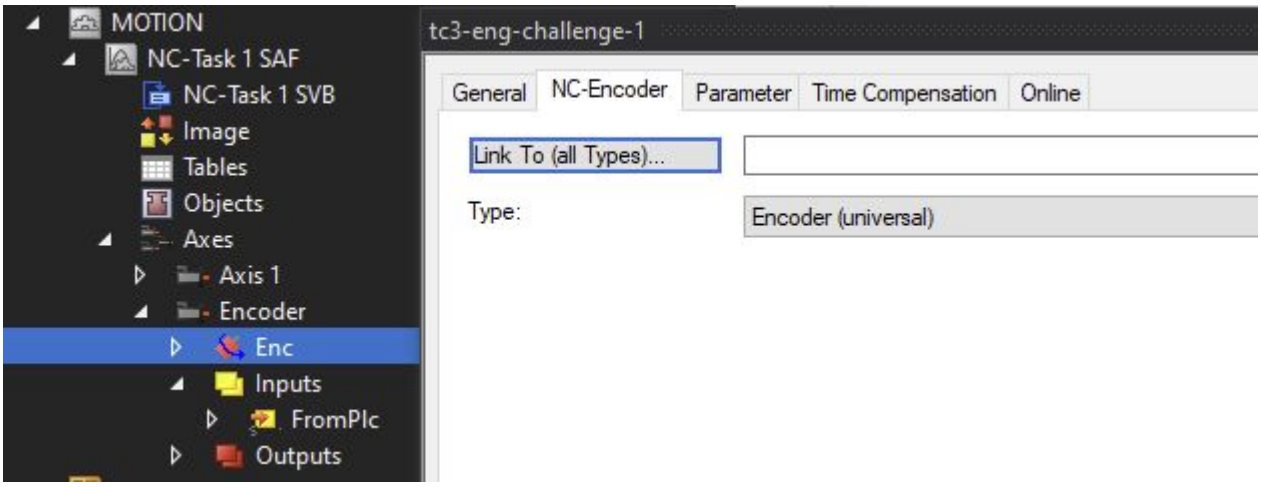
Cheat Sheet

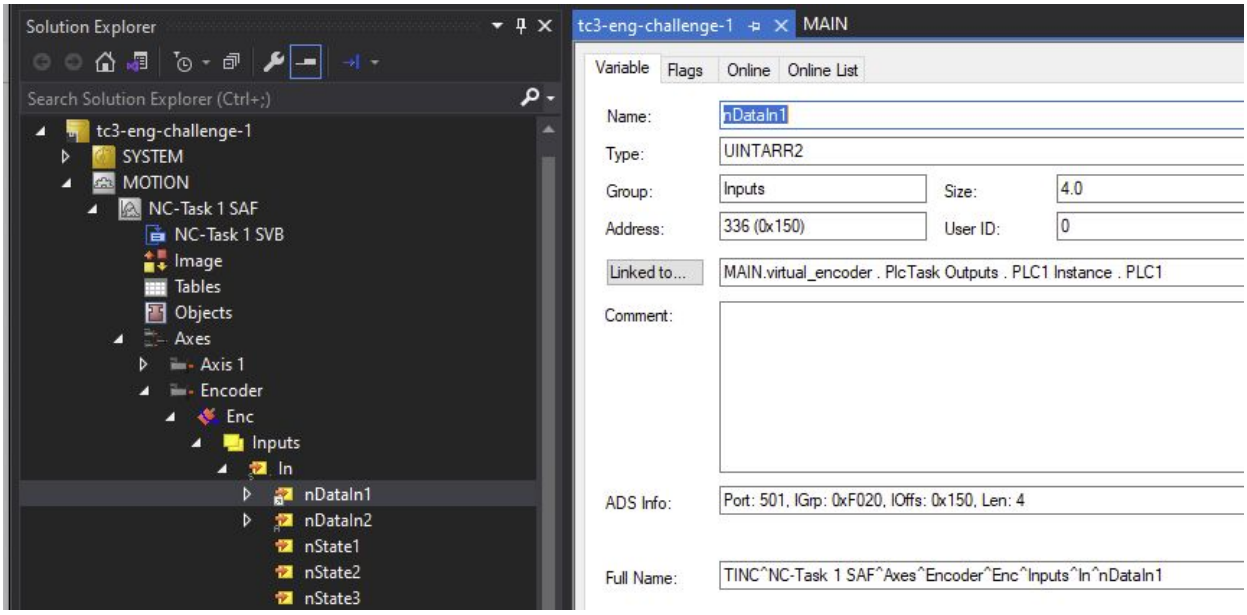

SAFETY
TWINSAFE1
TWINSAFE1 Project
References
Target System
GVLs
User FBs
TwinSafeGroup1
Alias Devices
EL1918, 8 digital inputs (FW 2)_1.sds
ErrorAcknowledgement.sds
master_to_slave.sds
Run.sds
slave_to_master.sds
TwinSafeGroup1.sal
TWINSAFE1 Instance


Linking
Connection
Process Image
Safe Address: 30
External Safe Address:
Linking Mode: Manual
Alias Device:
Dip Switch:
Input: Full Name: TIID^Device 1 (EtherCAT)^Term 1 (EK1200)^Term 7 (EL1918)^Co
Linked to: TIID^Device 2 (EtherCAT Automation Protocol)^publisher-2^safe-c
Output: Full Name: TIID^Device 1 (EtherCAT)^Term 1 (EK1200)^Term 7 (EL1918)^Co
Linked to: TIID^Device 2 (EtherCAT Automation Protocol)^subscriber-2^safe-
Name: Message_6
master_to_slave.sds


Linking
Connection
Process Image
Safe Address: 20
External Safe Address:
Linking Mode: Manual
Alias Device:
Dip Switch:
Input: Full Name: TIID^Device 1 (EtherCAT)^Term 1 (EK1200)^Term 7 (EL1918)^Co
Linked to: TIID^Device 2 (EtherCAT Automation Protocol)^publisher-1^safe-c
Output: Full Name: TIID^Device 1 (EtherCAT)^Term 1 (EK1200)^Term 7 (EL1918)^Co
Linked to: TIID^Device 2 (EtherCAT Automation Protocol)^subscriber-1^safe-
Name: Message_5
slave_to_master.sds

Cheat Sheet


MOTION
NC-Task 1 SAF
NC-Task 1 SVB
Image
Tables
Objects
Axes
Axis 1
Encoder
Enc
Inputs
FromPlc
Outputs
tc3-eng-challenge-1
General
NC-Encoder
Parameter
Time Compensation
Online
Link To (all Types)...
Type:
Encoder (universal)


Solution Explorer
Search Solution Explorer (Ctrl+;)
tc3-eng-challenge-1
SYSTEM
MOTION
NC-Task 1 SAF
NC-Task 1 SVB
Image
Tables
Objects
Axes
Axis 1
Encoder
Enc
Inputs
In
nDataIn1
nDataIn2
nState1
nState2
nState3
tc3-eng-challenge-1
MAIN
Variable
Flags
Online
Online List
Name:
nDataIn1
Type:
UINTARR2
Group:
Inputs
Size:
4.0
Address:
336 (0x150)
User ID:
0
Linked to...
MAIN.virtual_encoder . PlcTask Outputs . PLC1 Instance . PLC1
Comment:
ADS Info:
Port: 501, IGrp: 0xF020, IOffs: 0x150, Len: 4
Full Name:
TINC^NC-Task 1 SAF^Axes^Encoder^Enc^Inputs^In^nDataIn1