

Maxon + EPOS4 + ROS1 + CSP

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Overview

➤ 참고 자료

- https://github.com/Roboprotos/maxon_epos4_ros1
- maxon_EPOS4_ROS1_ros_canopen_Documentation_2022-02.pdf

➤ 수정된 코드 및 github 링크

- https://github.com/Gowoon12/maxon_epos4_ros1_csp.git
- /ShareFolder/04_Lab_Equipment_Related/maxon_epos4_ros1_csp

➤ 테스트 환경

- Ubuntu 20.04 LTS
- ROS Noetic

Catkin workspace 및 패키지 설치

- 기존에 사용하던 catkin_ws의 의존성 문제를 피하기 위해 새로운 catkin workspace를 만드는 것이 좋음
 - mkdir -p ~/maxon_ws/src
 - cd ~/maxon_ws
 - catkin_make
 - source ~/maxon_ws/devel/setup.bash
- 기존에 사용하던 catkin_ws의 의존성 문제를 피하기 위해 새로운 catkin workspace를 만드는 것이 좋음
- maxon_epos4_ros1 패키지 설치 (catkin_make를 사용하면 오류날 수 있어서 maxon_epos4_ros_canopen 만 빌드해야함).
 - cd ~/maxon_ws/src
 - git clone https://github.com/Roboprotos/maxon_epos4_ros1.git
 - cd ..
 - catkin_make --pkg maxon_epos4_ros_canopen
 - source ~/maxon_ws/devel/setup.bash

Hardware setup

➤ CAN cable (CAN-USB)

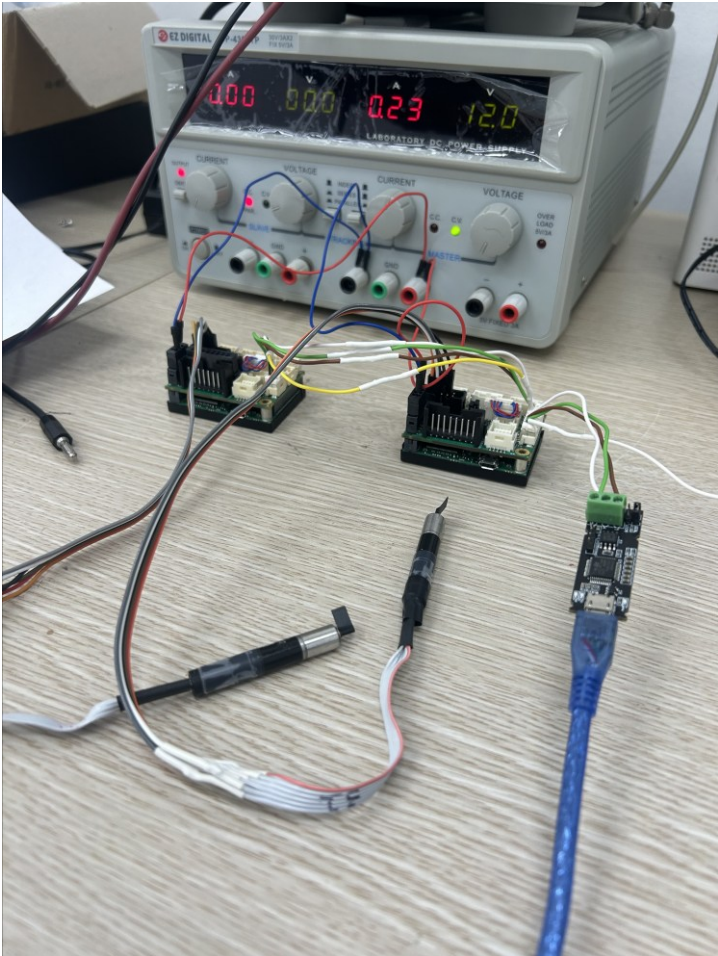
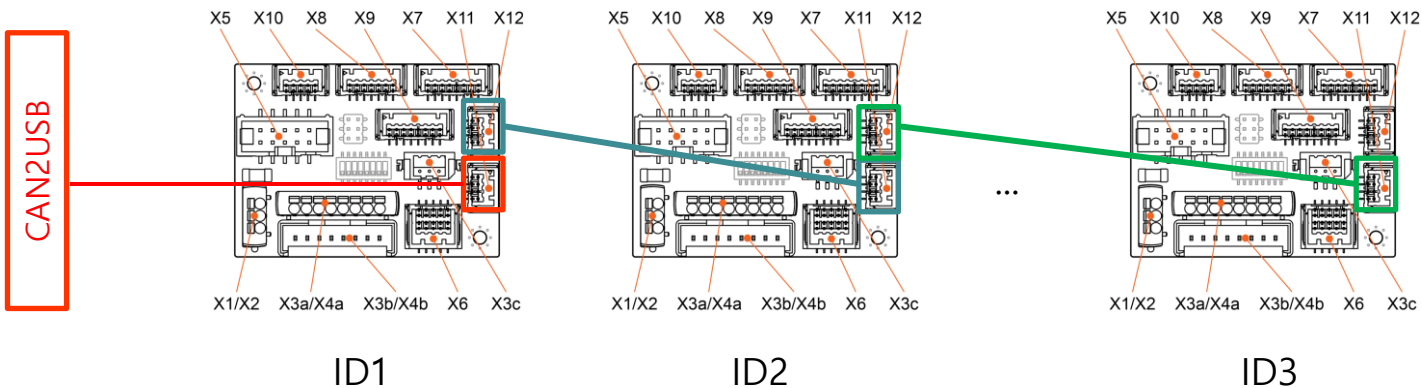
3.3.5.10 CAN 1 (X11) & CAN 2 (X12)



Figure 3-24 CAN 1 connector X11/CAN 2 connector X12

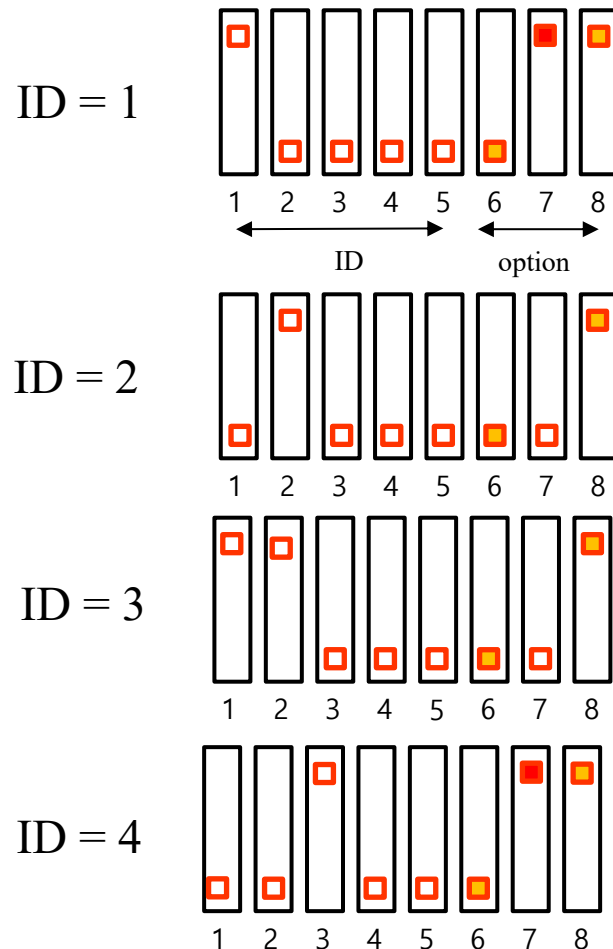
X11/X12 Head A Pin	Prefab Cable Color	520857 Head B Pin	520858 Head B Pin	Signal	Description
1	white	7	1	CAN high	CAN high bus line
2	brown	2	2	CAN low	CAN low bus line
3	green	3	3	GND	Ground
4	Shield	5	4	Shield	Cable shield

Table 3-35 CAN 1 connector X11/CAN 2 connector X12 – Pin assignment



Hardware setup

➤ DIP switch



3.3.7.2 CAN automatic Bit Rate Detection (Compact CAN)

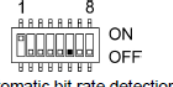
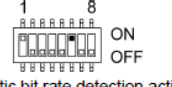
Controller	Switch	OFF	ON
Compact CAN	6		

Table 3-46 DIP switch SW1 – CAN automatic bit rate detection

3.3.7.3 CAN Bus Termination (Compact CAN)

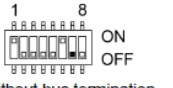
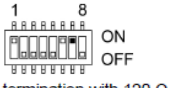
Controller	Switch	OFF 나머지	ON 처음과 마지막
Compact CAN	7		

Table 3-47 DIP switch SW1 – CAN bus termination

3.3.7.4 Digital Input Level

For details → chapter "3.4.7 Digital I/Os" on page 3-68.

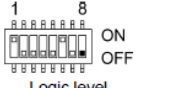
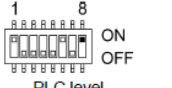
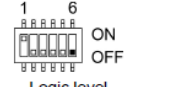
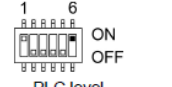
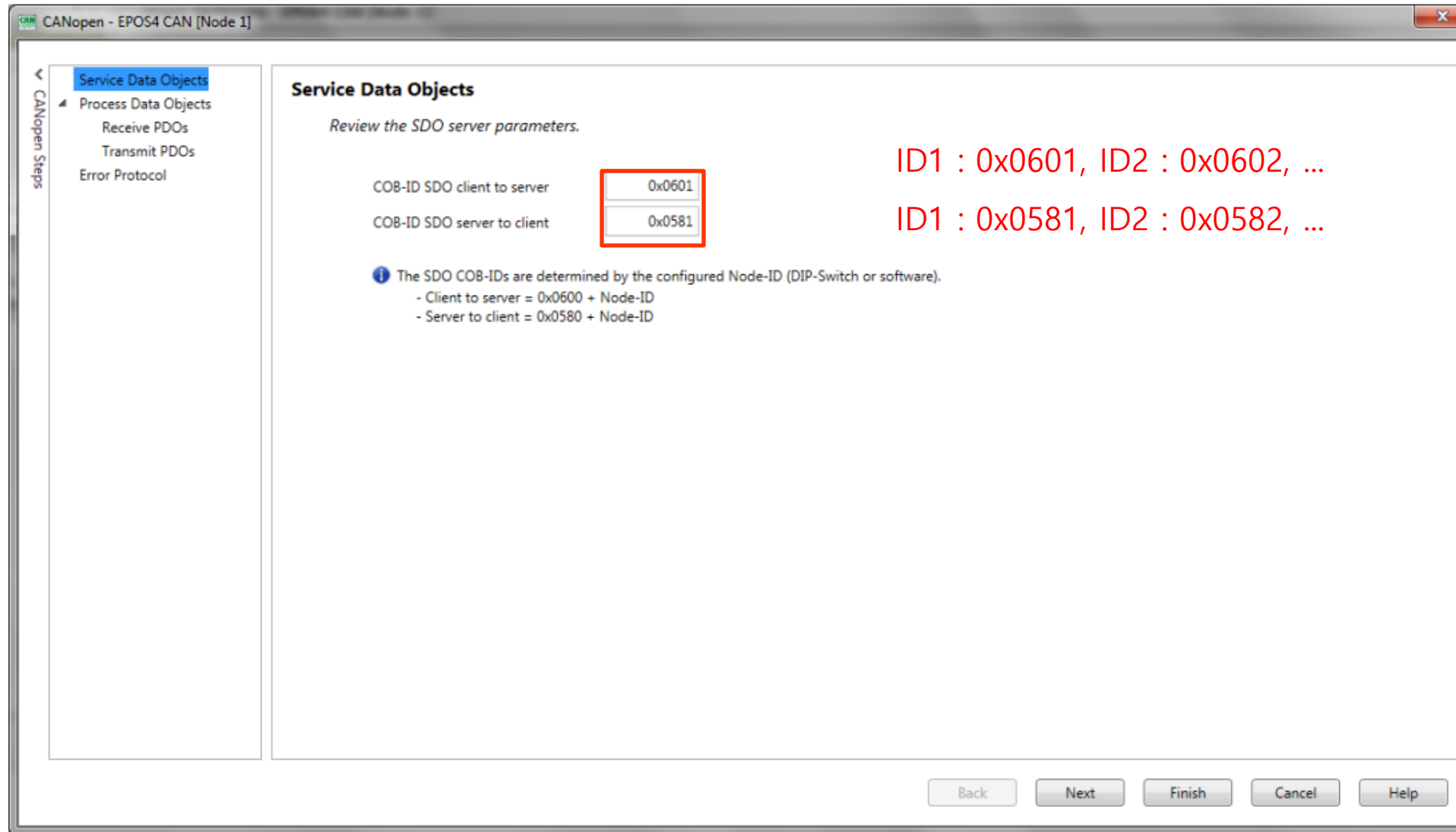
Controller	Switch	OFF	ON
Compact CAN	8		
Compact EtherCAT	6		

Table 3-48 DIP switch SW1 – Digital input level

CANopen setting (EPOS studio)



CANopen setting (EPOS studio)

Service Data Objects
Process Data Objects
Receive PDOs
Transmit PDOs
Error Protocol

Receive PDOs
Configure the Receive PDO parameters and map desired objects.

	COB-ID	Valid	Transmission	Bytes
RxPDO 1	0x0000 0201	<input checked="" type="checkbox"/>	synchronous	6 of 8
Controlword	ID1 : 0x0201, ID2 : 0x0202, ...			2
Target velocity				4
RxPDO 2	0x0000 0301	<input checked="" type="checkbox"/>	synchronous	8 of 8
Target position	ID1 : 0x0301, ID2 : 0x0302, ...			4
Profile velocity				4
RxPDO 3	0x0000 0401	<input checked="" type="checkbox"/>	synchronous	8 of 8
Profile acceleration	ID1 : 0x0401, ID2 : 0x0402, ...			4
Profile deceleration				4
RxPDO 4	0x0000 0501	<input checked="" type="checkbox"/>	synchronous	3 of 8
Target torque	ID1 : 0x0501, ID2 : 0x0502, ...			2
Modes of operation				1

Enter name or index

Name	Index	Bytes
Nominal current	3001-01	4
Output current limit	3001-02	4
Current controller P gain	30A0-01	4
Current controller I gain	30A0-02	4
Position controller P gain	30A1-01	4
Position controller I gain	30A1-02	4
Position controller D gain	30A1-03	4
Position controller FF velocity gain	30A1-04	4
Position controller FF acceleration	30A1-05	4
SI unit position controller I gain	30A1-09	4
Velocity controller P gain	30A2-01	4
Velocity controller I gain	30A2-02	4
Velocity controller FF velocity gain	30A2-03	4
Velocity controller FF acceleration	30A2-04	4
Velocity observer position correct	30A3-01	4
Velocity observer velocity correct	30A3-02	4
Velocity observer load correction	30A3-03	4
Velocity observer friction	30A3-04	4

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CANopen setting (EPOS studio)

Transmit PDOs
Configure the Transmit PDO parameters and map desired objects.

	COB-ID	Valid	RTR	Transmission	Inhibit	Bytes
<input checked="" type="checkbox"/> TxPDO 1	0x0000 0181	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	synchronous	1.0 ms	3 of 8
Statusword						2
Modes of operation display						1
<input checked="" type="checkbox"/> TxPDO 2	0x0000 0281	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	synchronous	1.0 ms	8 of 8
Velocity demand value						4
Velocity actual value						4
<input checked="" type="checkbox"/> TxPDO 3	0x0000 0381	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	synchronous	1.0 ms	8 of 8
Position actual value						4
Velocity actual value averaged						4
<input checked="" type="checkbox"/> TxPDO 4	0x0000 0481	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	synchronous	1.0 ms	0 of 8

Mappable Objects

Name	Index	Bytes
Digital incremental encoder 1 ind	3010-04	4
Analog incremental encoder inde	3011-03	4
SSI special bits trailing data	3012-06	2
SSI special bits leading data	3012-0C	2
Digital incremental encoder 2 ind	3020-04	4
Current actual value averaged	30D1-01	4
Current actual value	30D1-02	4
Torque actual value averaged	30D2-01	2
Velocity actual value averaged	30D3-01	4
Digital inputs logic state	3141-01	2
Digital outputs logic state	3150-01	2
Analog input 1 voltage	3160-01	2
Analog input 2 voltage	3160-02	2
Analog input general purpose A	3162-01	2
Analog input general purpose B	3162-02	2
Analog output 1 voltage	3180-01	2
Analog output 2 voltage	3180-02	2
I2t level motor	3200-01	2

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Object Dictionary (EPOS studio)

- Interpolation time period value : 10ms
- can bit rate : 1kbs (1000000)
- Wizards -> Parameter Import/Export -> Export Parameters to File
- dcf 파일을 저장하여 코드에서 불러와야 함
- Linux → dcf 수정 필요

dcf 파일 수정

```
[2200]
SubNumber=3
SubNumber=2
ParameterName=Power supply
ObjectType=0x9

[2200sub0]
ParameterName=Highest sub-index supported
ObjectType=0x7
DataType=0x5
AccessType=ro
DefaultValue=2
PDOMapping=0
ObjFlags=1
ParameterValue=2
ParameterValue=1

[2200sub1]
ParameterName=Power supply voltage
ObjectType=0x7
DataType=0x6
AccessType=ro
PDOMapping=0
ObjFlags=3

[2200sub2]
ParameterName=Internal valid logic supply
ObjectType=0x7
DataType=0x1
AccessType=ro
PDOMapping=0
ObjFlags=1
```

```
[6098]
ParameterName=Homing method
ObjectType=0x7
DataType=0x2
AccessType=rww
DefaultValue=7
DefaultValue=0
PDOMapping=0
ObjFlags=0
ParameterValue=7
ParameterValue=0
```

- homming 사용 O : 7
- homming 사용 X : 0

패키지 구성

```
maxon_epos4_ros_canopen
├── CMakeLists.txt
├── config
│   ├── canopen_bus_layer.yaml
│   ├── controller_1dof_ppm.yaml
│   ├── controller_2dof_csp.yaml
│   ├── controller_2dof_pvm.yaml
│   ├── epos4_50_15_can_ec90flat_gp52c_mile800_node1.dcf
│   ├── epos4_50_15_can_ec90flat_gp52c_mile800_node1_hm.dcf
│   ├── epos4_50_15_can_ec90flat_gp52c_mile800_node2.dcf
│   ├── node_layer_1dof_ppm_hm.yaml
│   ├── node_layer_1dof_ppm.yaml
│   ├── node_layer_2dof_csp.yaml
│   ├── node_layer_2dof_pvm.yaml
│   └── ros_layer.yaml
├── launch
│   ├── maxon_epos4_canopen_motor_1dof_ppm_hm.launch
│   ├── maxon_epos4_canopen_motor_1dof_ppm.launch
│   ├── maxon_epos4_canopen_motor_2dof_csp.launch
│   └── maxon_epos4_canopen_motor_2dof_pvm.launch
├── LICENSE
├── package.xml
├── scripts
│   └── python_example_1dof_ppm.py
├── src
│   └── cpp_example_1dof_ppm.cpp
└── urdf
    ├── maxon_epos4_1dof_ppm.xacro
    ├── maxon_epos4_2dof_csp.xacro
    └── maxon_epos4_2dof_pvm.xacro
```

- 통신 및 ros
- 1dof ppm mode
- 2dof csp mode
- 실제 dcf 파일로 교체 필요

코드 수정 필요

➤ controller_2dof_csp.yaml

```
joint_names: [base_link1_joint, link1_link2_joint]

joint_state_controller:
  type: joint_state_controller/JointStateController
  publish_rate: 50

# Settings of the controller and associated drive modes
# drive mode : see http://wiki.ros.org/canopen_402

# position controllers
# example using Cyclic Synchronous Position (8) drive mode

joint_trajectory_controller:
  type: position_controllers/JointTrajectoryController
  joints:
    - base_link1_joint
    - link1_link2_joint
  required_drive_mode: 8
  constraints:
    stopped_velocity_tolerance: 20
    base_link1_joint: {trajectory: 50, goal: 50}
    link1_link2_joint: {trajectory: 50, goal: 50}
```

Here are the 3 modes defined in this documentation:

- Profile Position Mode: required_drive_mode: 1
- Profile Velocity Mode: required_drive_mode: 3
- Cyclic Synchronous Position Mode: required_drive_mode: 8

➤ node_layer_2dof_csp.yaml

```
# struct syntax
nodes:
  node1:
    id: 1
    name: base_link1_joint
    eds_pkg: maxon_epos4_ros_canopen # optional package name for relative path
    eds_file: "config/can_communication_id_1.dcf" # path to EDS/DCF file
  node2:
    id: 2
    name: link1_link2_joint
    eds_pkg: maxon_epos4_ros_canopen # optional package name for relative path
    eds_file: "config/can_communication_id_2.dcf" # path to EDS/DCF file

defaults: # optional, all defaults can be overwritten per node
# eds_pkg: my_config_package # optional package name for relative path
# eds_file: "my_config.dcf" # path to EDS/DCF file
dcf_overlay: # "ObjectID": "ParameterValue" (both as strings)
  "60C2sub1": "10" # Interpolation time period value, to be set as the sync/interval_ms value present in canopen_bus_layer.yaml file, 10ms is recommended
  "607Dsub1": "-2147483648" # disable software min limit
  "607Dsub2": "2147483647" # disable software max limit

# "6084": "10000" # Profile deceleration
# "6085": "10000" # Quick-stop deceleration
# "6098": "0" # No homing operation required
# "1016sub1": "0x7F0064" # heartbeat timeout of 100 ms for master at 127
# "1017": "100" # heartbeat producer

# canopen_chain_node settings ..
motor_allocator: canopen::Motor402::Allocator # select allocator for motor layer
# motor_layer: settings passed to motor layer (plugin-specific)
switching_state: 2 # (Operation_Enable), state for mode switching. Drive mode of operation from canopen_402 wiki
pos_to_device: "rint(rad2deg(pos)*400*16/360)" # rad -> inc, for a MILE 800 CPT encoder and a 26:1 gearbox, 3200 = 4*800 --> 4 * 100
pos_from_device: "deg2rad(obj6064*360/400/16)" # actual position [inc] -> rad
vel_to_device: "vel" # rad/s -> mdeg/s
vel_from_device: "obj606C" # actual velocity [mdeg/s] -> rad/s
eff_to_device: "rint(eff)" # just round to integer
eff_from_device: "0" # unset
```

maxon_epos4_ros1_csp / maxon_epos4_ros_canopen / config /

Gowoon12 Add files via upload

Name

...

can_communication_id_1.dcf

can_communication_id_2.dcf

canopen_bus_layer.yaml

controller_1dof_ppm.yaml

controller_2dof_csp.yaml

controller_2dof_pvm.yaml

epos4_50_15_can_ec90flat_gp52c_mile800_node1.dcf

epos4_50_15_can_ec90flat_gp52c_mile800_node1_hm.dcf

epos4_50_15_can_ec90flat_gp52c_mile800_node2.dcf

node_layer_1dof_ppm.yaml

node_layer_1dof_ppm_hm.yaml

node_layer_2dof_csp.yaml

node_layer_2dof_pvm.yaml

ros_layer.yaml

CAN open setup

- CAN-USB 꽂은 후, *lsusb* 로 연결 확인
- `sudo ip link set can0 type can bitrate 1000000`
- `sudo ip link set can0 up`
- `candump can0`

```
gowoon@gowoon-15ZD990-VX50K:~$ lsusb
Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
Bus 001 Device 030: ID 1d50:606f OpenMoko, Inc. canable gs_usb
Bus 001 Device 003: ID 04f2:b678 Chicony Electronics Co., Ltd LG Camera
Bus 001 Device 005: ID 8087:0aaa Intel Corp.
Bus 001 Device 002: ID 062a:4101 MosArt Semiconductor Corp. Wireless Keyboard/Mouse
Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
gowoon@gowoon-15ZD990-VX50K:~$ sudo ip link set can0 type can bitrate 1000000
[sudo] password for gowoon:
gowoon@gowoon-15ZD990-VX50K:~$ sudo ip link set can0 up
gowoon@gowoon-15ZD990-VX50K:~$ candump can0
can0 701 [1] 00
can0 702 [1] 00
```

□

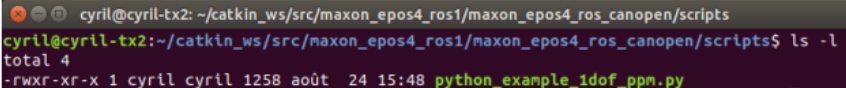
1dof ppm (예제)

- (모든 terminal : source ~/maxon_ws/devel/setup.bash)
- roscore
- roslaunch maxon_epos4_ros_canopen maxon_epos4_canopen_motor_1dof_ppm.launch
- rosservice call /maxon/driver/init
- publish 테스트
- rostopic pub /maxon/canopen_motor/base_link1_joint_position_controller/command std_msgs/Float64 – 10
- python 예제
- rosrund maxon_epos4_ros_canopen python_example_1dof_ppm.py
- cpp 예제
- rosrund maxon_epos4_ros_canopen ccp_example_1dof_ppm.ccp
- rostopic list
- rostopic echo /maxon/joint/

```
$ cd  
~/catkin_ws/src/maxon_epos4_ros1/maxon_epos4_ros_canopen/scripts  
  
$ chmod +x python_example_1dof_ppm.py
```

You can check that it worked by looking whether the following command displays "x" in the user permissions:

```
$ ls -l
```



```
cyril@cyril-tx2: ~/catkin_ws/src/maxon_epos4_ros1/maxon_epos4_ros_canopen/scripts  
cyril@cyril-tx2:~/catkin_ws/src/maxon_epos4_ros1/maxon_epos4_ros_canopen/scripts$ ls -l  
total 4  
-rwxr-xr-x 1 cyril cyril 1258 août 24 15:48 python_example_1dof_ppm.py
```

1dof ppm (예제)

```
18:28 •
/home/gowoon/maxon_ws/src/maxon_epos4_ros1/maxon_epos4_ros_canopen/launch/...
gowoon@gowoon-15ZD990-VX50K:~$ source ~/maxon_ws/devel/setup.bash
gowoon@gowoon-15ZD990-VX50K:~$ roslaunch maxon_epos4_ros_canopen maxon_epos4_canopen_motor_1dof_ppm.launch
... logging to /home/gowoon/.ros/log/e340703c-cdce-11f0-97ba-579f6ff8d57f/roslaunch-gowoon-15ZD990-VX50K-83747.log
Checking log directory for disk usage. This may take a while.
Press Ctrl-C to interrupt
Done checking log file disk usage. Usage is <1GB.

started roslaunch server http://gowoon-15ZD990-VX50K:36333/

SUMMARY
=====

CLEAR PARAMETERS
* /maxon/canopen_motor/

PARAMETERS
* /maxon/canopen_motor/base_link1_joint_position_controller/joint: base_link1_joint
* /maxon/canopen_motor/base_link1_joint_position_controller/required_drive_mode: 1
* /maxon/canopen_motor/base_link1_joint_position_controller/type: position_controll...
* /maxon/canopen_motor/bus/device: can0
* /maxon/canopen_motor/bus/master_allocator: canopen::SimpleMa...
* /maxon/canopen_motor/defaults/eff_from_device: 0
* /maxon/canopen_motor/defaults/eff_to_device: rint(eff)
* /maxon/canopen_motor/defaults/motor_allocator: canopen::Motor402...
* /maxon/canopen_motor/defaults/pos_from_device: obj6064
* /maxon/canopen_motor/defaults/pos_to_device: pos
* /maxon/canopen_motor/defaults/switching_state: 2
* /maxon/canopen_motor/defaults/vel_from_device: obj606C
* /maxon/canopen_motor/defaults/vel_to_device: vel
* /maxon/canopen_motor/heartbeat/msg: 77f#05
* /maxon/canopen_motor/heartbeat/rate: 20
* /maxon/canopen_motor/joint_group_position_controller/joints: ['base_link1_joint']
* /maxon/canopen_motor/joint_group_position_controller/required_drive_mode: 1
* /maxon/canopen_motor/joint_group_position_controller/type: position_controll...
* /maxon/canopen_motor/joint_names: ['base_link1_joint']
* /maxon/canopen_motor/joint_state_controller/publish_rate: 50
* /maxon/canopen_motor/joint_state_controller/type: joint_state_contr...
* /maxon/canopen_motor/nodes/node1/eds_file: config/can_commun...
* /maxon/canopen_motor/nodes/node1/eds_pkg: maxon_epos4_ros_c...
* /maxon/canopen_motor/nodes/node1/ld: 1
* /maxon/canopen_motor/nodes/node1/name: base_link1_joint
* /maxon/canopen_motor/sync/interval_ms: 10
* /maxon/canopen_motor/sync/overflow: 0
* /maxon/robot_description: <?xml version="1.1...
* /roslaunch: noetic
* /rosversion: 1.17.4

NODES
/maxon/
  canopen_motor (canopen_motor_node/canopen_motor_node)
  controller_spawner (controller_manager/controller_manager)

ROS_MASTER_URI=http://localhost:11311

process[maxon/canopen_motor-1]: started with pid [83772]
process[maxon/controller_spawner-2]: started with pid [83773]
[INFO] [1764494909.688459134]: Using fixed control period: 0.010000000
```

```
18:28 •
gowoon@gowoon-15ZD990-VX50K:~$ source ~/maxon_ws/devel/setup.bash
gowoon@gowoon-15ZD990-VX50K:~$ rosservice call /maxon/driver/init
success: True
message: ''
gowoon@gowoon-15ZD990-VX50K:~$
```

➤ 새로운 창에서 초기화 필요

- rosservice call /maxon/driver/init
- rosservice call /maxon/driver/halt
- rosservice call /maxon/driver/recover
- rosservice call /maxon/driver/shutdown

→ 이것만 하면 됨


```
NODES
/maxon/
  canopen_motor (canopen_motor_node/canopen_motor_node)
  controller_spawner (controller_manager/controller_manager)

ROS_MASTER_URI=http://localhost:11311

process[maxon/canopen_motor-1]: started with pid [83772]
process[maxon/controller_spawner-2]: started with pid [83773]
[INFO] [1764494909.688459134]: Using fixed control period: 0.010000000
[INFO] [1764494934.969875385]: Initializing...
[INFO] [1764494934.970096165]: Current state: 1 device error: system:0 internal_error: 0 (OK)
[INFO] [1764494934.970233940]: Current state: 2 device error: system:0 internal_error: 0 (OK)
[ERROR] [1764494937.223159483]: EMCV received: 010000000000000000
[INFO] [1764494937.223441034]: Initializing successful
Loaded '/maxon/canopen_motor/joint_state_controller'
Loaded '/maxon/canopen_motor/base_link1_joint_position_controller'
Started ['/maxon/canopen_motor/joint_state_controller'] successfully
Started ['/maxon/canopen_motor/base_link1_joint_position_controller'] successfully
[maxon/controller_spawner-2] process has finished cleanly
Log file: /home/gowoon/.ros/log/e340703c-cdce-11f0-97ba-579f6ff8d57f/maxon-controller_spawner-2*.log
```

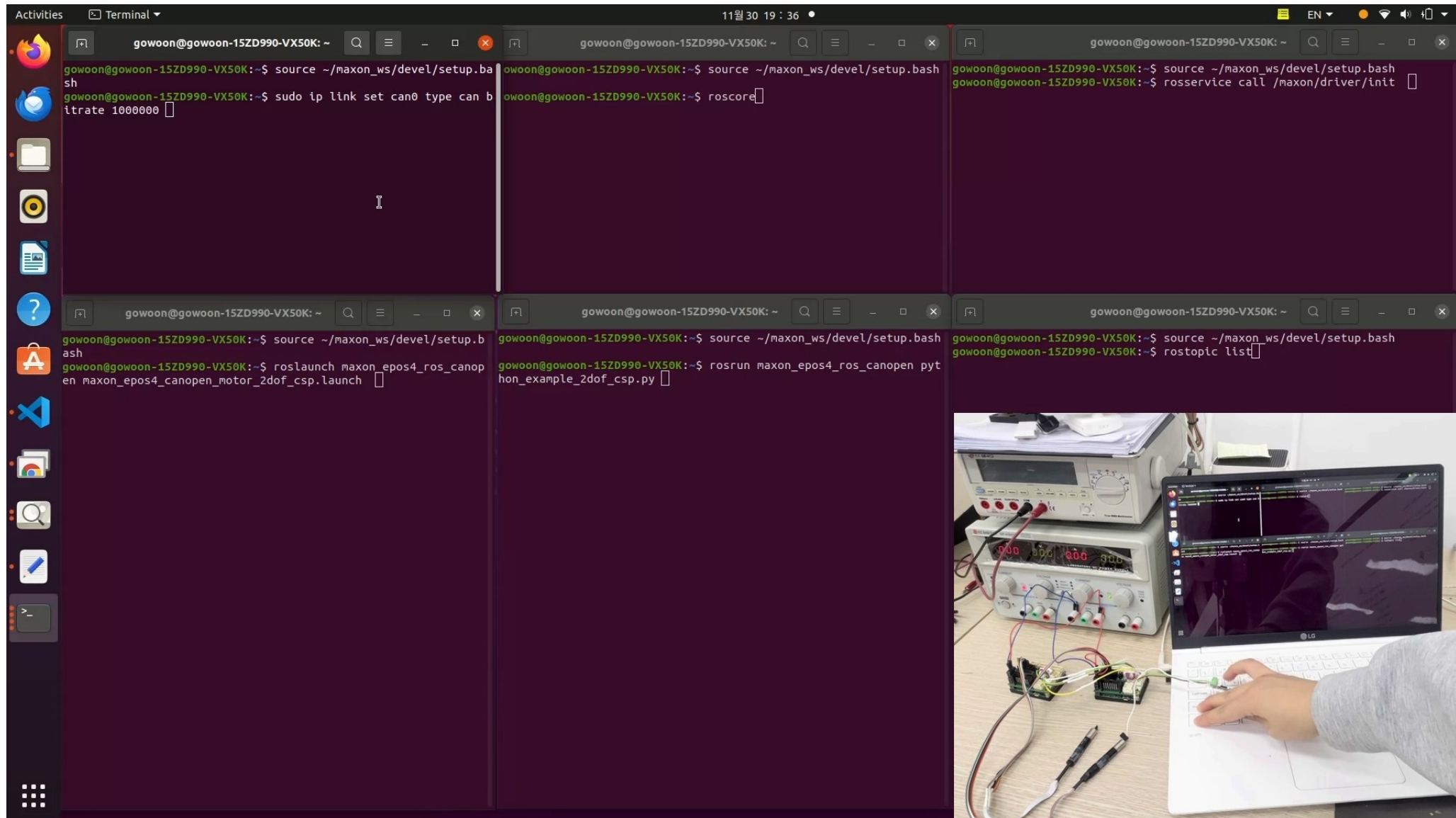
2dof csp mode

- (모든 terminal : source ~/maxon_ws/devel/setup.bash)
- roscore
- roslaunch maxon_epos4_ros_canopen maxon_epos4_canopen_motor_2dof_csp.launch
- rosservice call /maxon/driver/init
- **python 예제 (새로 작성함)** → [maxon_epos4_ros1_csp / maxon_epos4_ros_canopen / scripts /](#)
- rosrun maxon_epos4_ros_canopen python_example_2dof_csp.py
- rostopic list
- rostopic echo /maxon/joint/

 Gowoon12 Add files via upload

Name
..
python_csp_keyboard_control.py
python_csp_realtime_test.py
python_example_1dof_ppm.py
python_example_2dof_csp.py
python_example_csp_motor2_only.py

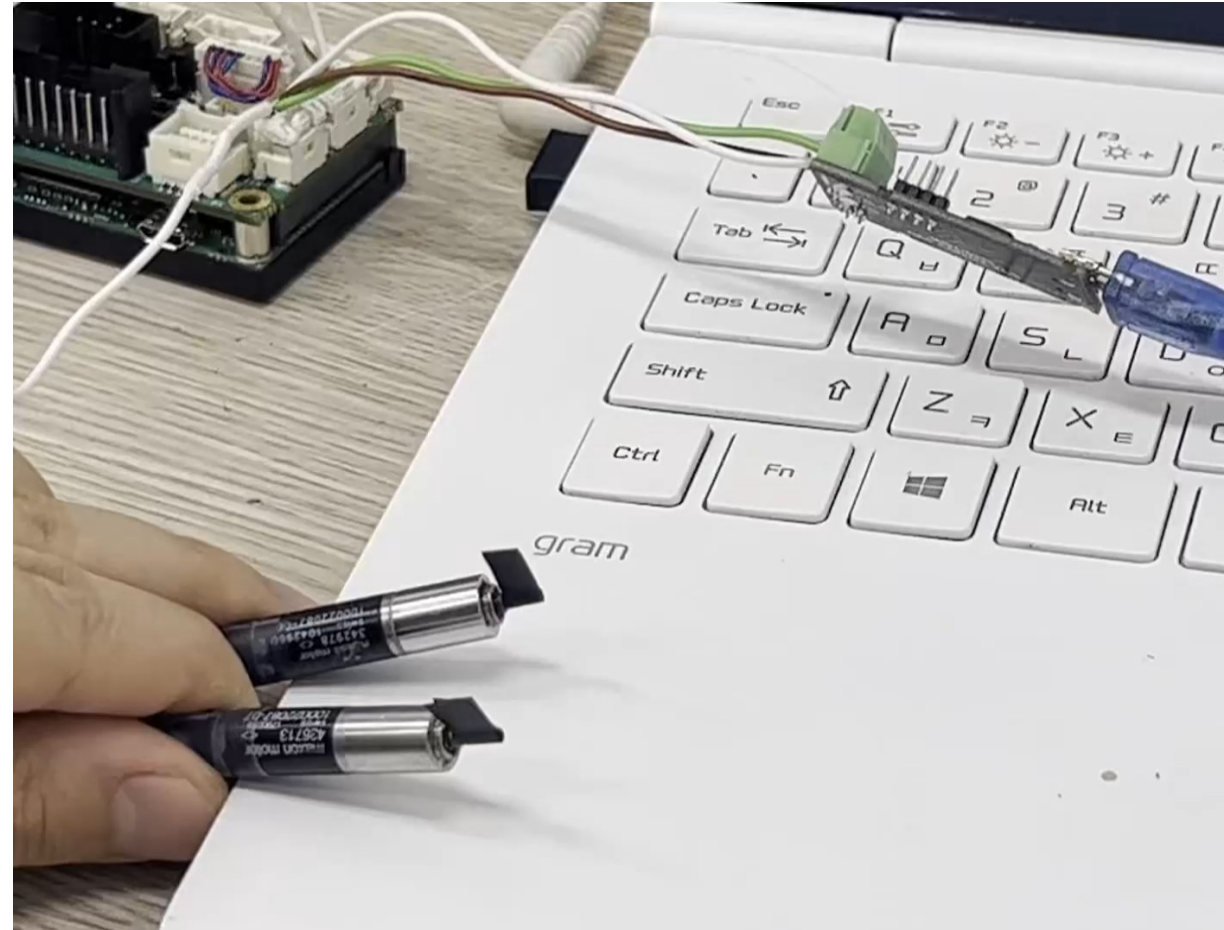
2dof csp mode



2dof csp mode

➤ 약 100hz

```
gowoon@gowoon-15ZD990-VX50K: ~  
[INFO] [1764499188.483207]: Δt = 0.009882 sec (101.2 Hz)  
[INFO] [1764499188.493193]: Δt = 0.009985 sec (100.2 Hz)  
[INFO] [1764499188.503330]: Δt = 0.010072 sec (99.3 Hz)  
[INFO] [1764499188.513115]: Δt = 0.009896 sec (101.1 Hz)  
[INFO] [1764499188.523200]: Δt = 0.010001 sec (100.0 Hz)  
[INFO] [1764499188.533436]: Δt = 0.010184 sec (98.2 Hz)  
[INFO] [1764499188.543104]: Δt = 0.009776 sec (102.3 Hz)  
[INFO] [1764499188.553404]: Δt = 0.010200 sec (98.0 Hz)  
[INFO] [1764499188.563376]: Δt = 0.010011 sec (99.9 Hz)  
[INFO] [1764499188.573198]: Δt = 0.009875 sec (101.3 Hz)  
[INFO] [1764499188.583206]: Δt = 0.009995 sec (100.0 Hz)  
[INFO] [1764499188.593165]: Δt = 0.009976 sec (100.2 Hz)  
[INFO] [1764499188.603390]: Δt = 0.010202 sec (98.0 Hz)  
[INFO] [1764499188.613207]: Δt = 0.009798 sec (102.1 Hz)  
[INFO] [1764499188.623198]: Δt = 0.010015 sec (99.8 Hz)  
[INFO] [1764499188.633383]: Δt = 0.010126 sec (98.8 Hz)  
[INFO] [1764499188.643177]: Δt = 0.009864 sec (101.4 Hz)  
[INFO] [1764499188.653137]: Δt = 0.009978 sec (100.2 Hz)  
[INFO] [1764499188.663300]: Δt = 0.010082 sec (99.2 Hz)  
[INFO] [1764499188.673177]: Δt = 0.009949 sec (100.5 Hz)  
[INFO] [1764499188.683221]: Δt = 0.010027 sec (99.7 Hz)  
[INFO] [1764499188.693213]: Δt = 0.010013 sec (99.9 Hz)  
[INFO] [1764499188.703401]: Δt = 0.010170 sec (98.3 Hz)  
[INFO] [1764499188.713174]: Δt = 0.009764 sec (102.4 Hz)  
[INFO] [1764499188.723251]: Δt = 0.010019 sec (99.8 Hz)  
[INFO] [1764499188.733214]: Δt = 0.010014 sec (99.9 Hz)  
[INFO] [1764499188.743281]: Δt = 0.010022 sec (99.8 Hz)  
[INFO] [1764499188.753122]: Δt = 0.009916 sec (100.8 Hz)  
[INFO] [1764499188.763321]: Δt = 0.010126 sec (98.8 Hz)  
[INFO] [1764499188.773350]: Δt = 0.010021 sec (99.8 Hz)  
[INFO] [1764499188.783104]: Δt = 0.009841 sec (101.6 Hz)  
[INFO] [1764499188.792931]: Δt = 0.009928 sec (100.7 Hz)  
[INFO] [1764499188.803219]: Δt = 0.010168 sec (98.3 Hz)  
[INFO] [1764499188.813042]: Δt = 0.009917 sec (100.8 Hz)
```



Thank you