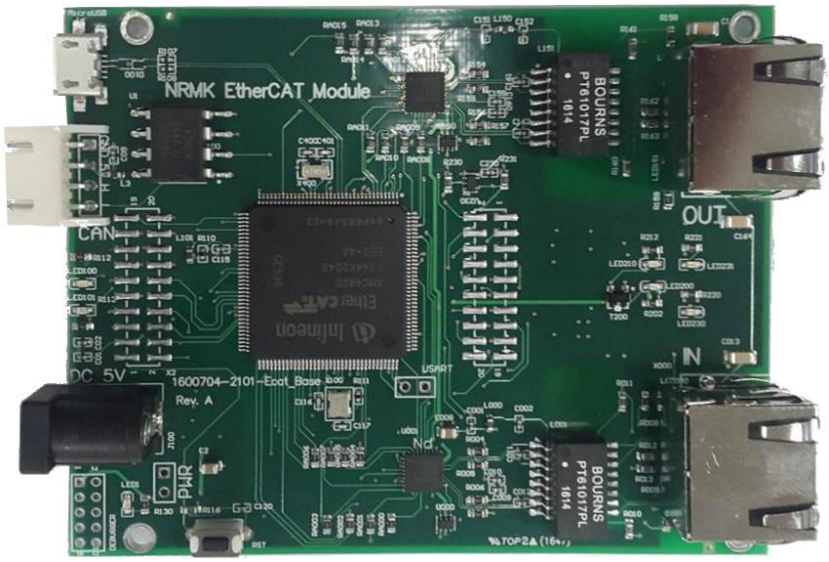
6 Axis Force Torque Sensor
RFT Series

EtherCAT I/F Manual
REVISION 2.2



ROBOTOUS INC.

Contents

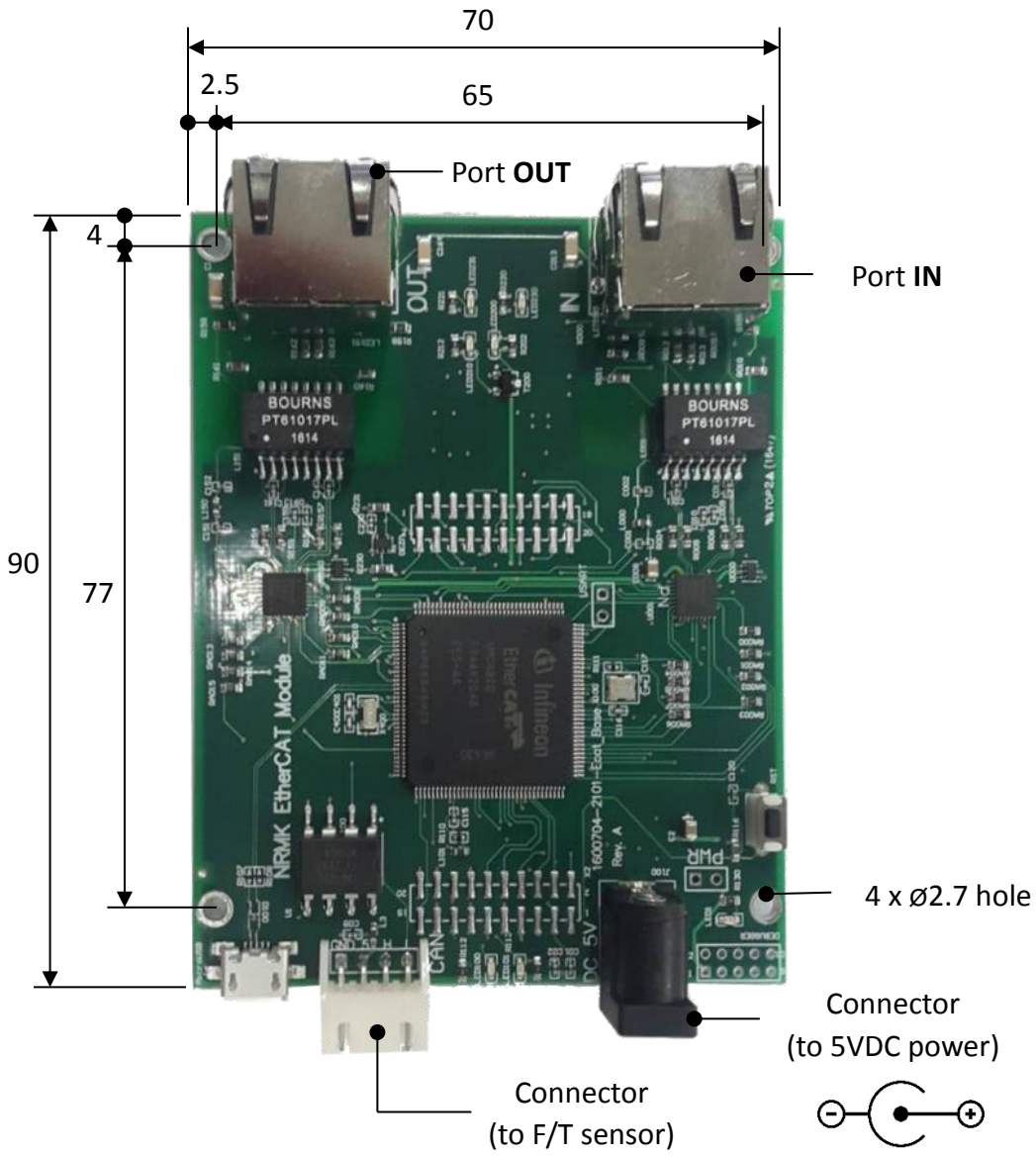
1. EtheCAT I/F Adapter

1.1. Concept

- The EtherCAT adapter is used to interface between an EtherCAT master and RFT series.
- The EtherCAT adapter uses CAN(Control Area Network) interface to communicate with the RFT series.
- The PDOs of EtherCAT were implemented based on CAN communication packet for the RFT series. Please refer to the installation and operation manual of RFT sensor series for more information about the CAN packet.

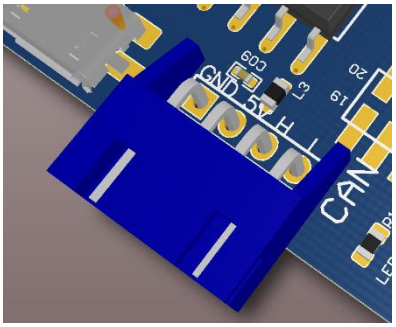
1.2. Hardware

- Layout and dimension



EtheCAT adapter(RFTEC-01)

- Dimension(mm): 70(W) x 96(D) x 18(H)



Pin-map of the JST 4 pin 2.54mm pitch header:

1. GND
2. 5Vdc
3. CAN High
4. CAN Low

- Please use JST XHP-4 connector on the sensor side for CAN communication.

2. PDO(Process Data Object) Interface

2.1. Process data input objects: 0x6000

Subindex	Object Name	Data Type	Description
1	CanRx1_id	UINT16	*Transmitter ID #1 of the force/torque sensor *The EtherCAT adapter handles this variable automatically.
2	CanRx1_len	UINT16	*Data size of CAN message *The EtherCAT adapter handle this variable automatically.
3 ~ 10	CanRx1_data_d1 ~ CanRx1_data_d8	8 x UINT8	*D1~D8 of data field of response packet with Transmitter ID #1
11	CanRx2_id	UINT16	*Transmitter ID #2 of the force/torque sensor *The EtherCAT Adapter handles this variable automatically.
12	CanRx2_len	UINT16	*Data size of CAN message *The EtherCAT adapter handles this variable automatically.
13 ~ 20	CanRx2_data_d1 ~ CanRx2_data_d8	8 x UINT8	*D1~D8 of data field of response packet with Transmitter ID #2
21	Raw_Fx	INT16	*Raw data of Fx
22	Raw_Fy	INT16	*Raw data of Fy
23	Raw_Fz	INT16	*Raw data of Fz
24	Raw_Tx	INT16	*Raw data of Tx
25	Raw_Ty	INT16	*Raw data of Ty
26	Raw_Tz	INT16	*Raw data of Tz
27	OverloadStatus	UINT8	*Flag for overload occurrence *If each components of force and torque exceed its rated load capacity by more than 20%, the corresponding bit is set to 1, and reset to 0 if not.
28	ErrorFlag	UINT8	*The force/torque sensor sends data continuously by the command "Start F/T Data Output". *ErrorFlag is set when the EtherCAT adapter cannot receive any data from the force/torque sensor. *Interval of checking: 100msec

2.2. Process data output objects: 0x7000

Subindex	Object Name	Data Type	Description
1	ConfigParam	UINT32	*Command variable for EtherCAT I/F *Mapping between the command variable and D1~D4 of data field of command packet *Little-endian: 0x44332211 → D1=11, D2=22, D3=33, D4=44

2.3. PDOs for force/torque data

- Raw_xx(input object): 0x6000.21 ~ 0x6000.26

Subindex	Object Name	Data Type	Description
21	Raw_Fx	INT16	*Raw data of Fx
22	Raw_Fy	INT16	*Raw data of Fy
23	Raw_Fz	INT16	*Raw data of Fz
24	Raw_Tx	INT16	*Raw data of Tx
25	Raw_Ty	INT16	*Raw data of Ty
26	Raw_Tz	INT16	*Raw data of Tz

  - Scaling for force: Raw_data / force_divider
  - Scaling for torque: Raw_data / torque_divider
  - Please refer to the operation manual for more information about the dividers.

- OverloadStatus(input object): 0x6000.27

Subindex	Object Name	Data Type	Description
27	OverloadStatus	UINT8	*Flag for overload occurrence

OverloadStatus							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
XX	XX	Fx	Fy	Fz	Tx	Ty	Tz

- ConfigParam(output object): 0x7000.1

Subindex	Object Name	Data Type	Description
1	ConfigParam	UINT32	*Command variable for EtherCAT I/F

2.4. Notices

- The EtherCAT master writes and reads PDOs of EtherCAT slaves periodically.
- The EtherCAT adapter sends a command to force/torque sensor only when there is any change in the output object "ConfigParam" to reduce CAN communication load between the EtherCAT adapter and the force/torque sensor.
- Use the output object "ConfigParam" to send a command to the force/torque sensor using EtherCAT I/F. Refer to the section 3.6 in the operation manual for more information about various commands.
- Note that the default setting of filter is OFF and the default data output rate is 200Hz.

3. Basic Instructions

3.1. Notice

- A user has to send the command “Start F/T Data Output” in order to measure and receive force and torque data from the sensor. Otherwise, the F/T sensor stays idle even after applying power.
- The F/T sensor can save current parameter settings which is valid even after rebooting it. However, the sensor does not save the following commands: “Start F/T Data Output”, “Stop F/T Data Output”, and “Set Bias”.
- The following commands only are executable during measuring force and torque data: “F/T Data Output Stop” and “Set Bias”. The rest of commands are available in idle state or after executing the command of “Stop F/T Data Output Stop”.

3.2. How to measure force & toque from the sensor with default setting

- Step 1. Send the command “Strat F/T Data Output” [Command ID = 11(0x0B)].
  - ConfigParam = **0x00 00 00 0B**
- Step 2. Receive force and torque data from the sensor.

3.3. How to measure force & torque after setting parameters

- Step 1. Send a command for parameter setting of the sensor. (Refer to Section 3.6 Packet Definition.)
- Step 2. Receive a corresponding response packet and check whether there was an error in processing the command.
- Step 3. Send the command “Strat F/T Data Output”.
  - ConfigParam = **0x00 00 00 0B**
- Step 4. Receive force and torque data from the sensor.

3.4. How to set a parameter while measuring force and torque.

- Step 1. Send the command “Stop F/T Data Output” [Command ID = 12(0x0C)]
  - ConfigParam = **0x00 00 00 0C**
- Step 2. Send a command for setting a parameter.
- Step 3. Receive a corresponding response packet and check whether there was an error in processing the command.
- Step 4. Send the command “Strat F/T Data Output”.
  - ConfigParam = **0x00 00 00 0B**
- Step 5. Receive force and torque data from the sensor.

3.5. How to set bias while measuring force and torque

- Step 1. Send the command “Strat F/T Data Output” [Command ID = 11(0x0B)].

- ConfigParam = **0x00 00 00 0B**

- Step 2. Send the command “Set Bias” [Command ID = 17(0x11)]
  - Biasing: ConfigParam = **0x00 00 01 11**
  - Unbiasing: ConfigParam = **0x00 00 00 11**
- Step 3. Receive force and torque data from the sensor.

4. Setting the S/W Filter

4.1. Setting Filter

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	**D3**	**D2**	**D1**	**Example**
XX	Filter Parameter	Filter Type	ID	1st order low-pass, cutoff 100Hz ConfigParam = **0x00 05 01 08**

- ID: Command ID = 8(0x08)
- Filter Type: 0(No Filter) | 1(1st order low-pass filter)
- Filter Parameter: Refer to section 5.6.9 in the operation manual for more detailed information.

- Data Field of the Response Packet

Data Field															
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**D13**	**D14**	**D15**	**D16**
ID	R1	R2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

- ID: Response ID = 8(0x08)
- R1: Result of command processing [1(0x01) : success, 0(0x00): failure]
- R2: Error Code, refer to Section 5.8 Error Codes

4.2. Read Filter Setting

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	**D3**	**D2**	**D1**	**Example**
XX	XX	XX	ID	1st order low-pass, cutoff 100Hz ConfigParam = **0x00 00 00 09**

- ID: Command ID = 9(0x09)

- Data Field of the Response Packet

Data Field															
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
ID	R1	R2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

- ID: Response ID = 9(0x09)
- R1: Filter Type
- R2: Filter Parameter

4.3. Filter Parameter

Filter Type	Filter Parameter	Cutoff Frequency [Hz]	Remarks (Setting Filter)
0(0x00)	0(0x00)	No filter (default)	ConfigParam = **0x00 00 00 08**
1(0x01)	0(0x00)	No filter	ConfigParam = **0x00 00 01 08**
1(0x01)	1(0x01)	500	ConfigParam = **0x00 01 01 08**
1(0x01)	2(0x02)	300	ConfigParam = **0x00 02 01 08**
1(0x01)	3(0x03)	200	ConfigParam = **0x00 03 01 08**
1(0x01)	4(0x04)	150	ConfigParam = **0x00 04 01 08**
1(0x01)	5(0x05)	100	ConfigParam = **0x00 05 01 08**
1(0x01)	6(0x06)	50	ConfigParam = **0x00 06 01 08**
1(0x01)	7(0x07)	40	ConfigParam = **0x00 07 01 08**
1(0x01)	8(0x08)	30	ConfigParam = **0x00 08 01 08**
1(0x01)	9(0x09)	20	ConfigParam = **0x00 09 01 08**
1(0x01)	10(0x0A)	10	ConfigParam = **0x00 0A 01 08**
1(0x01)	11(0x0B)	5	ConfigParam = **0x00 0B 01 08**
1(0x01)	12(0x0C)	3	ConfigParam = **0x00 0C 01 08**
1(0x01)	13(0x0D)	2	ConfigParam = **0x00 0D 01 08**
1(0x01)	14(0x0E)	1	ConfigParam = **0x00 0E 01 08**

5. Handling the F/T Data Output

5.1. Start F/T Data Output

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	D3	D2	D1	Example
XX	XX	XX	ID	ConfigParam = **0x00 00 00 0B**

- ID: Command ID = 11(0x0B)

- Data Field of the Response Packet

Data Field															
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16
ID	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	XX	XX

- ID: Response ID = 11(0x0B)
- R1 ~ R12: Each components of force & torque are composed of 2 parameters as follows:
  - R1: Fx's upper byte, R2: Fx's lower byte
  - R3: Fy's upper byte, R4: Fy's lower byte
  - R5: Fz's upper byte, R6: Fz's lower byte
  - R7: Tx's upper byte, R8: Tx's lower byte
  - R9: Ty's upper byte, R10: Ty's lower byte
  - R11: Tz's upper byte, R12: Tz's lower byte
  - Refer to Section 3.6.11 Read F/T Data to get real force & torque values.
- R13: Status of Overload, refer to Section 3.6.11 in the operation manual
- Use Raw_xx(input object) for read force/torque data output from the sensor. Please refer to Section 6.6.11 in the operation manual for more detailed information.

5.2. Stop F/T Data Output

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	D3	D2	D1	Example
XX	XX	XX	ID	ConfigParam = **0x00 00 00 0C**

- ID: Command ID = 12(0x0C)

- Data Field of the Response Packet
  - This command is not followed by any response packet.

5.3. Set Data Output Rate

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	D3	D2	D1	Example
XX	XX	Output Rate Parameter	ID	ConfigParam = **0x00 00 00 0F**

- ID: Command ID = 15(0x0F)
- Output Rate Parameter:
  - Default : 0 [200Hz]
  - Refer to Section 3.6.16 Allowable Data Output Rate in the operation manual.

- Data Field of the Response Packet

Data Field															
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**D13**	**D14**	**D15**	**D16**
ID	R1	R2	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

  - ID : Response ID = 15(0x0F)
  - R1 : Result of command processing [1(0x01): success, 0(0x00): failure]
  - R2 : Error codes, refer to Section 5.8 Error Codes

- Note that a high data output rate may not work at a low baud-rate.

5.4. Read Data Output Rate

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	**D3**	**D2**	**D1**	**Example**
XX	XX	XX	ID	ConfigParam = **0x00 00 00 10**

  - ID: Command ID = 16(0x10)

- Data Field of the Response Packet

Data Field															
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**D13**	**D14**	**D15**	**D16**
ID	R1	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

  - ID: Response ID = 16(0x10)
  - R1: Refer to Section 3.6.16 Allowable Data Output Rate in the operation manual.

5.5. Output Rate Parameter

Output Rate Parameter	Output rate [Hz]	ConfigParam
0x00	200	ConfigParam = **0x00 00 00 0F**
0x01	10	ConfigParam = **0x00 00 01 0F**
0x02	20	ConfigParam = **0x00 00 02 0F**
0x03	50	ConfigParam = **0x00 00 03 0F**
0x04	100	ConfigParam = **0x00 00 04 0F**
0x05	200	ConfigParam = **0x00 00 05 0F**
0x06	333	ConfigParam = **0x00 00 06 0F**
0x07	500	ConfigParam = **0x00 00 07 0F**

0x08	1000	ConfigParam = **0x00 00 08 0F**

- Default Baud Rate: 1Mbps Fixed
- Default Output Rate: 0(0x00) [200Hz]

5.6. Set Bias

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	**D3**	**D2**	**D1**	**Example**
XX	XX	Bias Parameter	ID	Biasing: ConfigParam = **0x00 00 01 11** Unbiasing: ConfigParam = **0x00 00 00 11**

  - ID: Command ID = 17(0x11)
  - Bias Parameter: [Biasing: 1(0x01) | Unbiasing: 0(0x00)]
- Data Field of the Response Packet
  - This command is not followed by any response packet.

5.7. Read count of Overload Occurrence

- ConfigParam (EtherCAT Command Variable)

ConfigParam(Little-edian)				
D4	**D3**	**D2**	**D1**	**Example**
XX	XX	XX	ID	ConfigParam = **0x00 00 00 12**

  - ID: Command ID = 18(0x12)
- Data Field of the Response Packet

Data Field															
D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**D13**	**D14**	**D15**	**D16**
ID	R1	R2	R3	R4	R5	R6	XX	XX	XX	XX	XX	XX	XX	XX	XX

  - ID: Response ID = 18(0x12)
  - R1 : Number of overload occurrence of Fx
  - R2 : Number of overload occurrence of Fy
  - R3 : Number of overload occurrence of Fz
  - R4 : Number of overload occurrence of Tx

- R5 : Number of overload occurrence of Ty
- R6 : Number of overload occurrence of Tz
- Maximum count of overload occurrence: 255 (0xFF)

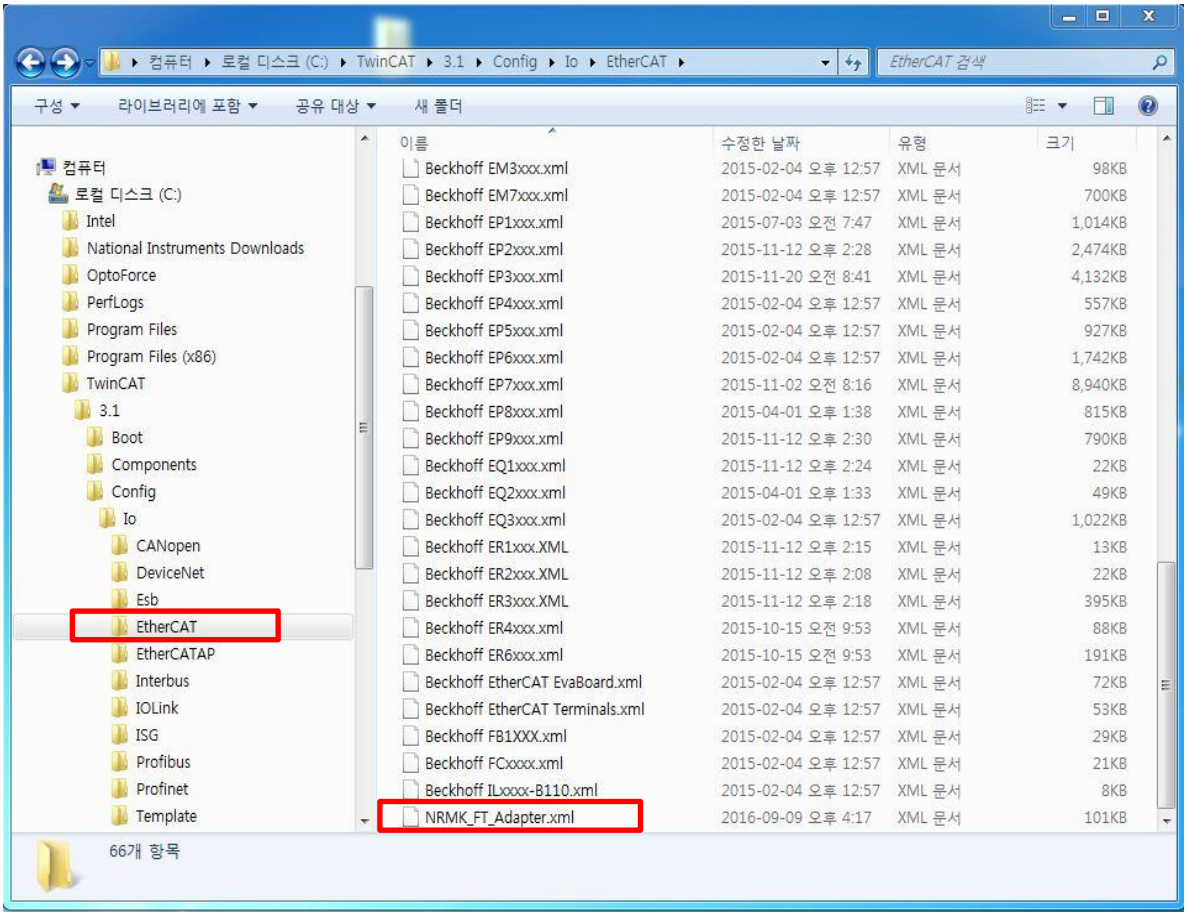
5.8. Error Codes

Error Code	Description
1(0x01)	Unsupported command
2(0x02)	Out of range error, a parameter such as ID, baud-rate, filter parameter, (etc.) is out of allowable range
3(0x03)	Failed to set parameters

6. Testing the EtherCAT Adaper Using TwinCAT

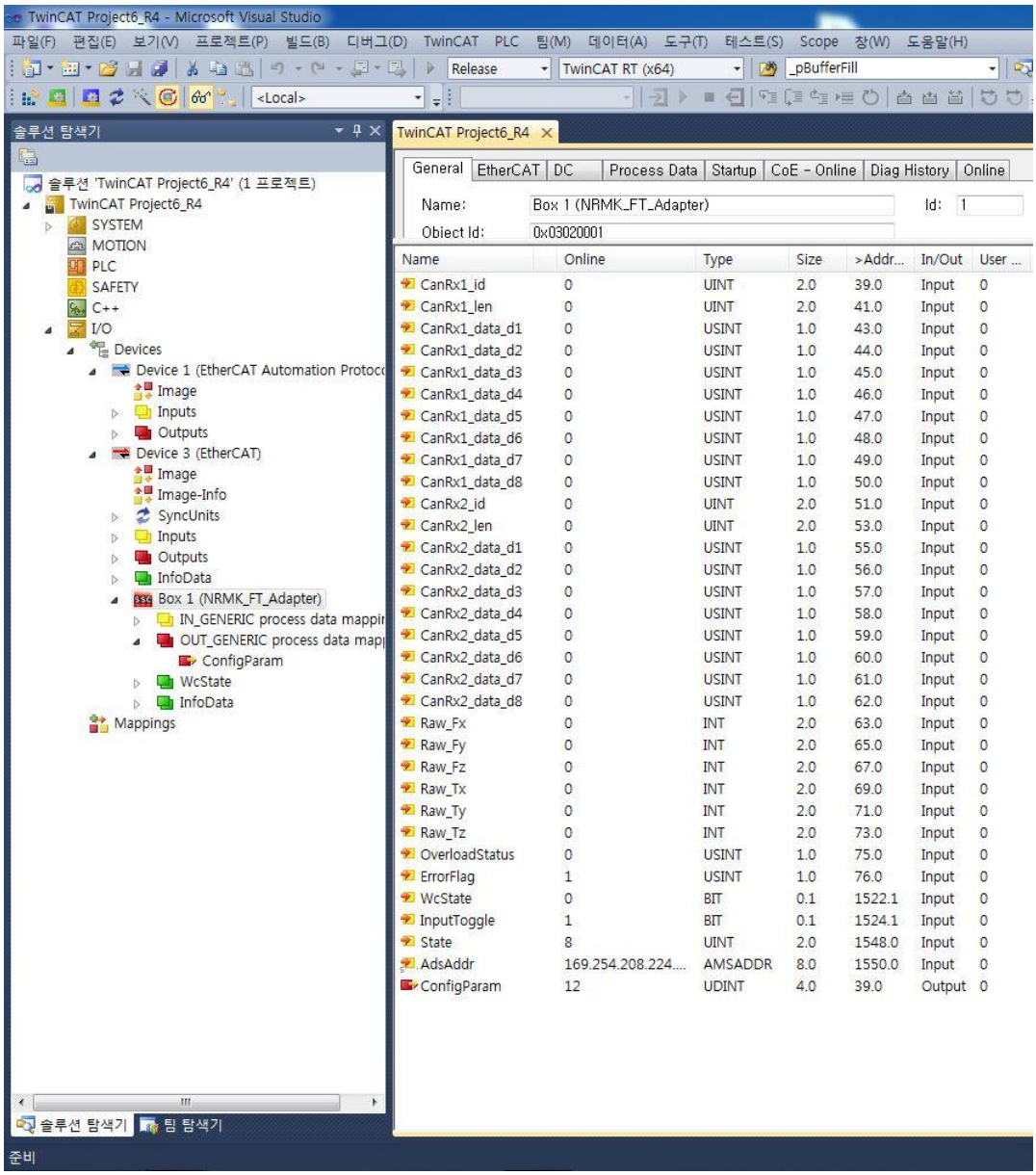
6.1. ESI(EtherCAT Slave Inforamtion) XML File for TwinCAT (Windows 7, TwinCAT Ver 3.1)

- XML file name: **NRMK_FT_Adapter_R4.xml**
- Location of XML file: **C:\TwinCAT\3.1\Config\Io\EtherCAT**



6.2. Sequence of Testing

- Step 1. Create a TwinCAT project using Visual Studio.
- Step 2. Connect a LAN cable to port **IN** on the EtherCAT adapter..
- Step 3. Turn on the EtherCAT adapter.
- Step 4. Scan the device.
- Step 5. Activate the TwinCAT in free-run mode
- Step 6. Change the object “ConfigParam” to start F/T data output from the sensor.
  - ConfigParam = **0x00 00 00 0B**
- Step 7. Observe whether the objects “Raw_xx” change or not.



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