TwinCAT protocol

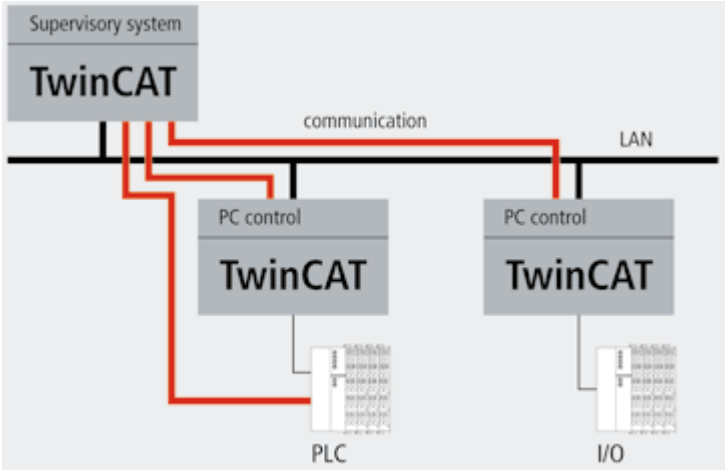
Functionality

Architecture

The Beckhoff TwinCAT software (**T**he **Win**dows **C**ontrol and **A**utomation **T**echnology) system turns any compatible PC into a real-time controller with a multi-PLC system, NC axis control, programming environment and operating station. TwinCAT replaces conventional PLC and NC/CNC controllers as well as operating devices.
The TwinCAT software devices can be distributed: TwinCAT PLC programs can run on the PCs or on Beckhoff Bus Terminal Controllers. A "message router" manages and distributes all the messages, both in the system and via TCP/IP connections.

The TwinCAT protocol enables to connect to any such TwinCAT system both on the machine or distributed over a TCP/IP network. It uses the AMS router (“message router”) provided by Beckhoff to do so.

In case of a distributed architecture, all communication is run over the standard Ethernet network interface of a PC.



Variable Definition

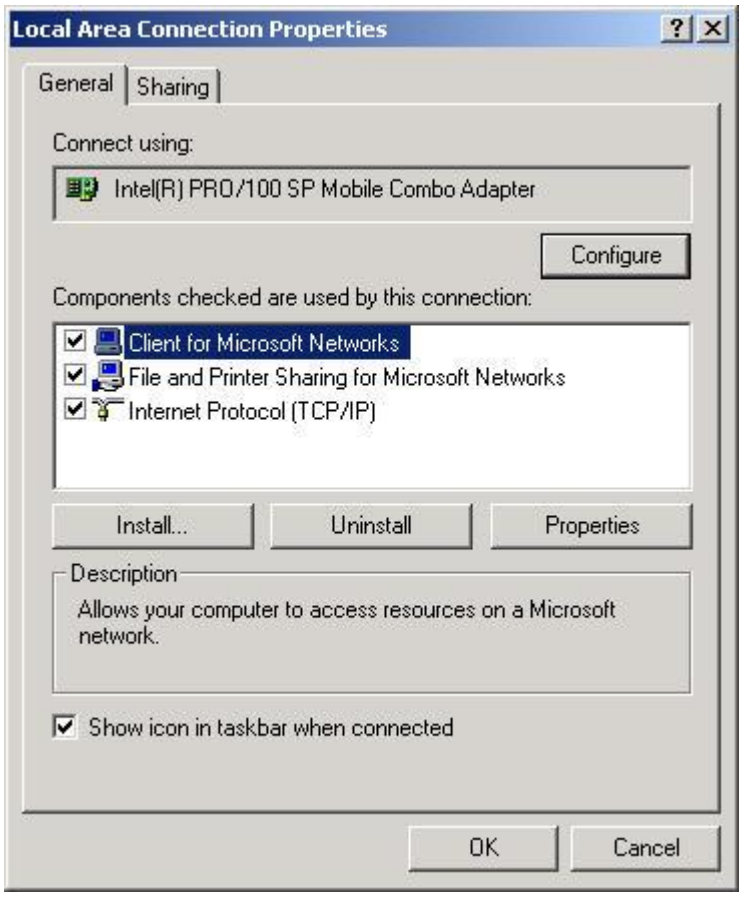
Unlike standard driver where an address and a number of contiguous data are requested, the TwinCAT driver allows to define a set of variables you wish to access.

The set of variables is defined using a standard ASCII file which defines both the variable name in the TwinCAT system as well as its size in byte.

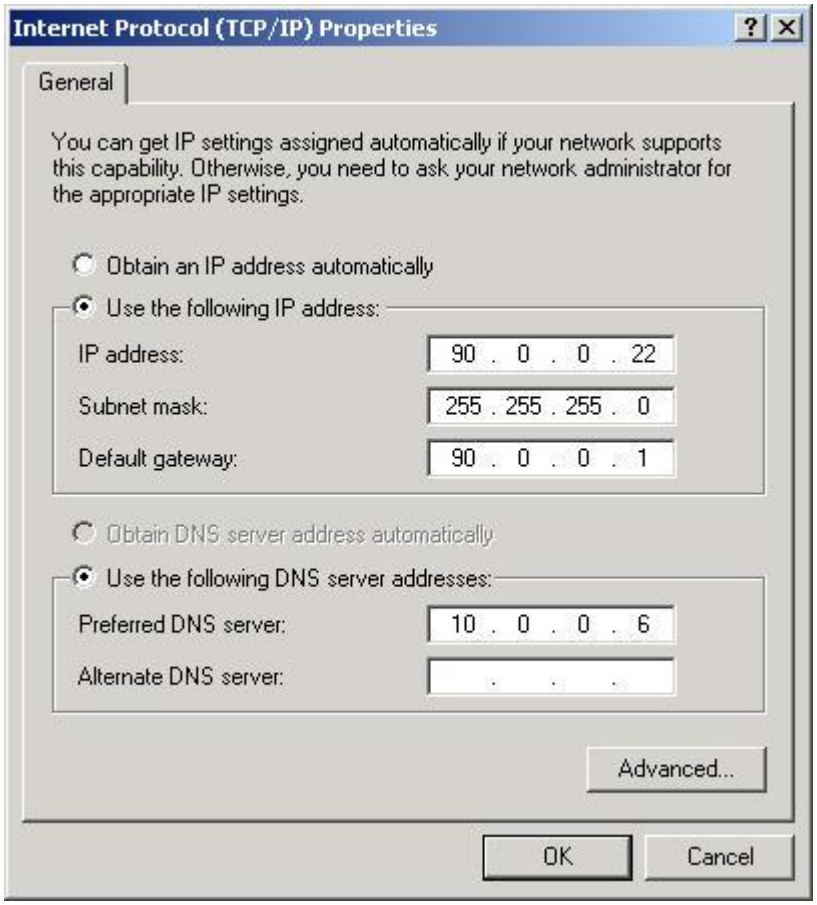
PC's Configuration

Network card

The computer needs to be equipped with a standard network card.
Its network IP must be compatible with the IP structure set-up for your industrial network. When setting the address of the equipment, check the PC network card IP address in order to be in the mask range.
To access this box, press “Start\Control Panel\Network”. Choose the “Protocols” tab then, click on “Properties”.



Network address



If the subnet mask is 255.255.255.0, the equipment IP address should have the same 3 first values as the PC IP address (in this example: 90.0.0).
Choose a different number for the 4th parameter of the equipment IP address (make sure that this new address is free on the network). For instance if the PC IP address is 90.0.0.22, the equipment address should be 90.0.0.x

Once set-up and the PC re-initialized, it is recommended to test that the cable and the PLC is properly configured with the right address.
For instance if your PLC is set at address 90.0.0.100, open a command prompt and type:

```
C:> ping 90.0.0.100
```

You should get a reply from the PLC. If not that means that either your configuration (most likely at the PLC end) is wrong or that you have a cabling problem (using a cross cable to a hub is a common one). Please refer to the Step S7 software for the PLC configuration.

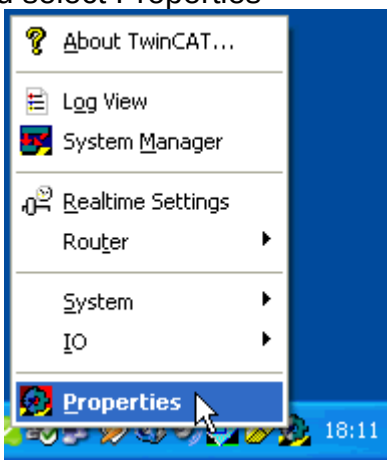
Beckhoff AMS router

The “message router” needs to be installed on the machine running the supervisor.
It comes free of charge with any TwinCAT software pack. The minimum version to use is 2.9.
If you do not need any TwinCAT system on your machine please just install TwinCAT- CP. Once the installation is done you should see the following icon on your Window Toolbar.

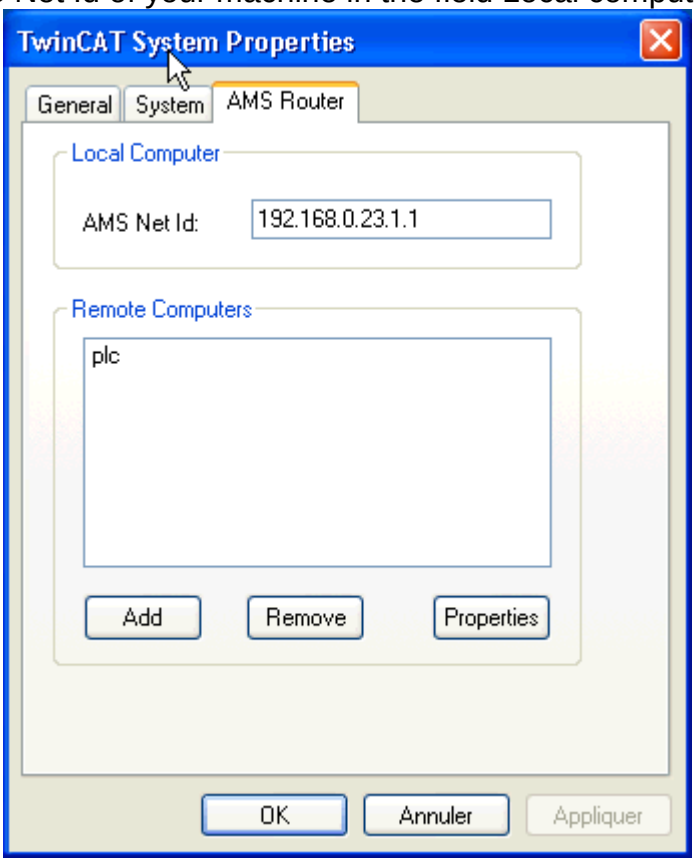
AMS router configuration

In a distributed configuration, each PC on the network needs to have a unique AMS Net Id. To allow 2 PC to communicate you need to add in the AMS router definition the remote computer.
In order to do so please follow the steps

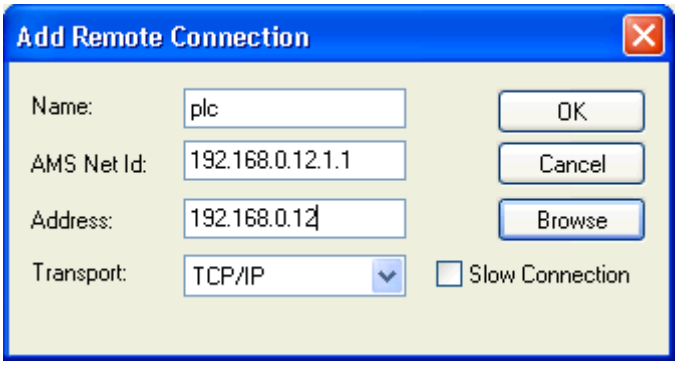
1 - Right click on the Icon and select Properties



2 – Select the tab “AMS Router”
3 – Enter the AMS Net Id of your machine in the field Local computer.



4 – To Add a remote computer click on Add and enter the parameter of the remote computer.



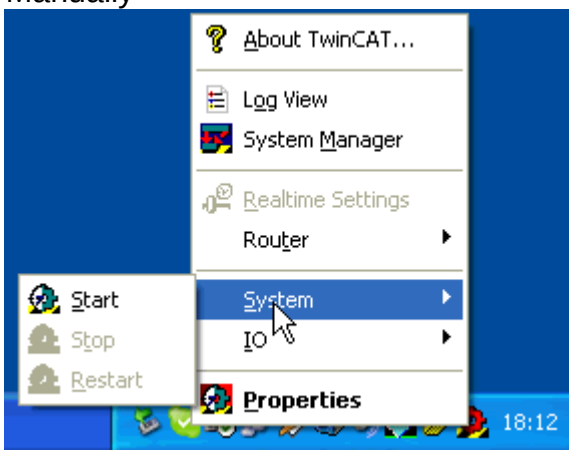
5 – Repeat the step 4 as many time as you have computer you want to communicate with.

6 – You need to proceed the same way on the remote computer.

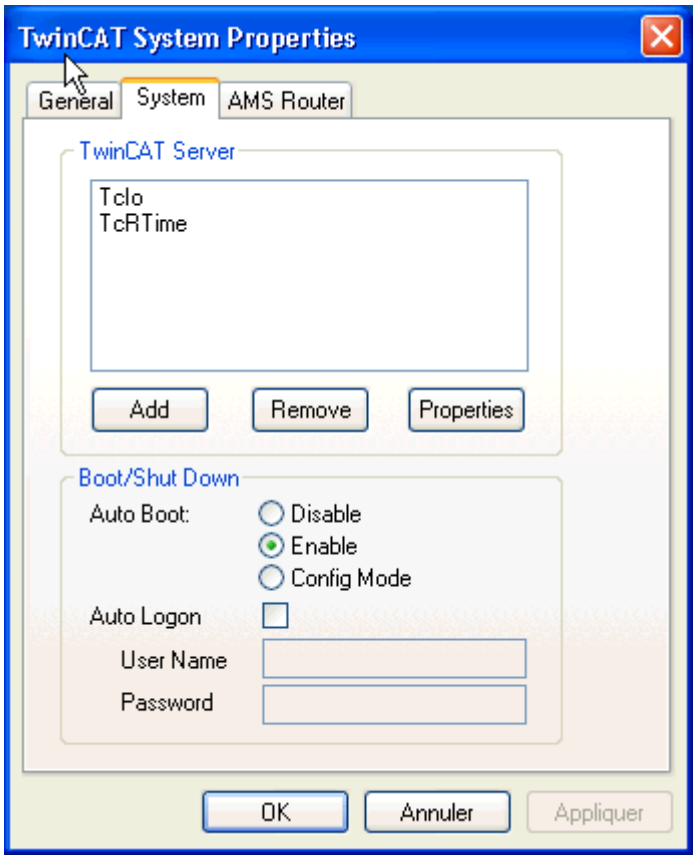
AMS router start-up

The message router needs to be start for the communication to work.
There is two ways to do so

1- Manually



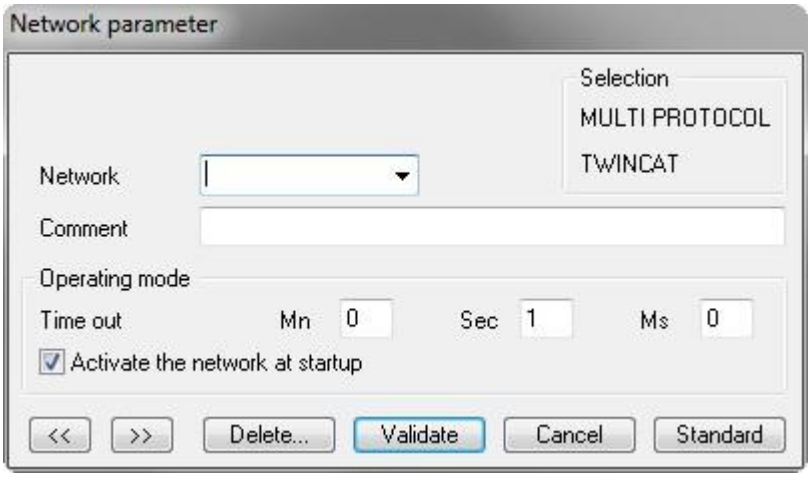
2- Automatically
Select Properties, select the Tab System and pick Enable



Communication configuration

Network configuration

Select the environment **MULTI PROTOCOL** and choose **TWINCAT**.

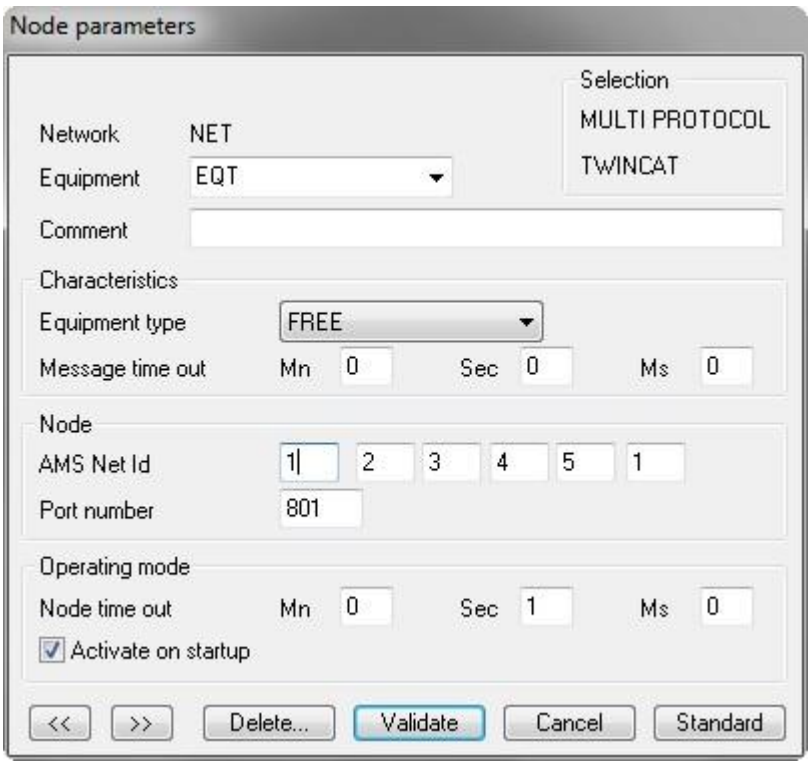


Network configuration

Operating mode

- **Time out:** Leave default value. The time out is not used
- **Activate the network at start-up:** Enable to start the network when CIMWAY starts. The network can also be started by SCADA BASIC program using the CIMWAY verb.

Equipment configuration



Equipment configuration.

Characteristics

- **Equipment type:** Please leave the default value
- **Virtual:** Not supported. Please do not select.
- **Message time-out:** Always set to 0.

Node

- **AMS Net Id:** Enter AMS Net Id of the equipment.
- **Port Number:** Enter the port to be used

Port for PLC	801
Port for PLC (Runtime system 2)	811
Port for PLC (Runtime system 3)	821
Port for PLC (Runtime system 4)	831
Port for logger	100
Port for IO	300
Port for SPS	400
Port for NC	500
Port for ISG	550
Port for PCS	600

Operating mode

- **Time Out:** Maximum waiting time between a request and the reply from the equipment.
- **Activate on start-up**: Enable to start the equipment when the network is started. The equipment can also be started by SCADA BASIC program using the CIMWAY verb.

Frame configuration

TwinCAT Variable definition file

The TwinCAT variable definition for a frame is done using an ASCII file.
The file must be located in the C directory of the project.
The file name must be the name of the frame preceded by the equipment and network name.
For example if you have a network called NET, an equipment called EQT and a Frame called T1, the file name must be “NET_EQT_T1.dat”

The file format is

```
Variable Name,Size
```

Where Variable Name is the name of the variable in the TwinCAT program.
Size is the size of the variable in byte.

For example
The content of file name NET_EQT_T1.DAT

```
MAIN.MYWORD1,2
MAIN.MYWORD2,2
MAIN.MYBIT1,1
MAIN.MYBIT2,1
MAIN.MYBIT3,1
MAIN.MYBIT4,1
MAIN.MYFLOAT,4
MAIN.MYDOUBLE,4
```

The order in which the TwinCAT variables are defined is important.
It provides the order of the mapping gives the definition of the mapping of the Supervisor variable onto the frame.

Address selection

The driver only permits WORD frame definition.
The start address of the frame, as well as the data type, is not used by the driver.

Only the size is important. The number of data must correspond to the global size of all variable you wish to access.

For the above example the TwinCAT variable definition global size is 16 (2+2+1+1+1+1+4+4). Therefore the size of T1 must be 16 bytes = 8 words.

The name of the frame has to be T1.

Variable link

Since the variables you wish to access in the TwinCAT program are heterogeneous the variable mapping needs to be done manually in the “varexp.dat”. The file location is in your project the C directory of your project.

N°	Description	T	L	Value
30 – AD	Reserved	N	2	
31 – AE	Network name	C	8	
32 – AF	Node name	C	12	
33 – AG	Frame name	C	20	
34 – AH	Variable format	C	1	B ► Bit U ► 16bits unsigned integer I ► 16bits signed integer L ► 32bits unsigned integer I ► 32bits singed integer F ► 32bits real C ► 8bits unsigned byte c ► 8bits signed byte S ► string ending by ‘\0’ T ► fixed string
35 – AI	Variable byte offset in the frame	N	2	
36 – AJ	Bit offset in the byte specified in the byte offset field	N	2	
37 – AK	Variable size expressed in number of bit	N	2	

For the file NET_EQT_T1.DAT we get the following result.

```
CTV,57,PLC1,FLOW1,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,U,0,0,16,…
CTV,58,PLC1,FLOW2,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,U,2,0,16,…
CMD,53,PLC1,CMD1,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,B,4,0,1,…
CMD,54,PLC1,OPEN1,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,B,5,0,1,…
CMD,55,PLC1,CMD2,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,B,6,0,1,…
CMD,56,PLC1,OPEN2,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,B,7,0,1,…
CTV,60,PLC1,SP1,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,F,8,0,32,,…
CTV,59,PLC1,CPT,,,,,,"","",,,,,,E,…,1,NET,EQT,T1,L,12,0,32,,…
```

Please not that the name of the database variable does not need to match the name given in the TwinCAT variable definition file. It is the byte offset which makes thre correspondance

PLC1.FLOW1 correspond to the TwinCAT variable MAIN.MYWORD1
PLC1.FLOW2 correspond to the TwinCAT variable MAIN.MYWORD2
PLC1.CMD1 corresponds to the TwinCAT variable MAIN.MYBIT1 Etc..

Please not that:

- Word variable byte offset MUST be a multiple of 2
- Double and Float variable byte offset MUST be a multiple of 4
- There is no restriction for a BIT and Text variable.

Limits

Version of target ADS Device

ADS itself is just the transport layer, but the requested TwinCAT device has to support the ADS-Command. Supported by TwinCAT PLC (from 2.7 B511 / from 2.8 B718 / 2.9 ff all)

Number of TwinCAT Variable per frame

The PLC is processing the request before starting the next PLC cycle.
As a result one request with 200.000 TwinCAT variable would cause that PLC would collect and copy 200.000 variables into one single ADS response, before starting next PLC. So this large number of ads-sub-commands will jitter the PLC execution !
We highly recommend to not request more than 500 TwinCAT variable per frame

Frame size

The size of the WORD frame defined in the supervisor must be greater or equal to twice the sum of all the variable size defined in the variable definition file. Failure to do so will prevent you to link the variable all the variable you wish to access

Error Code

On frame errors the error code can be obtained either in the event viewer or the general communication window Configuration/Communication/ Equipment.

Common Error Code

Code	*Description*
0x0007	Equipment (Remote computer) not configured in the AMS router
0x0012	AMS Router not started
0x1000	Cannot open the variable definition file. Please check its name correspond to a valid frame name
0x1001	Error in allocating driver buffer memory
0x1002	No variable found in write request
0x1003	The global size of the TwinCAT variable definition exceed 2097152 bytes (please note that for each variable there is an additional 4 bytes for error handling)
0x2751	TCP/IP cable disconnected
0x3xxx	Variable not found in the equipment. xxx correspond to the index (in hexadecimal) of the variable in TwinCAT variable definition file.
0x6xxx	Size of the variable mismatch. xxx correspond to the index (in hexadecimal) of the variable in TwinCAT variable definition file.
0x6000	Write request error One of the written variable size in the variable link does not correspond to the size specified in the TwinCAT variable definition file. Write every individual varilabe to check which on is the faulty one.

Additional Error code

Code	*Description*
0x0001	Internal error
0x0002	No Rtime
0x0003	Allocation locked memory error
0x0004	Insert mailbox error
0x0005	Wrong receive HMSG
0x0006	target port not found
0x0008	Unknown command ID
0x0009	Bad task ID
0x000A	No IO
0x000B	Unknown AMS command
0x000C	Win 32 error
0x000D	Port not connected
0x000E	Invalid AMS length
0x000F	Invalid AMS Net ID
0x0010	Low Installation level
0x0011	No debug available
0x0013	Port already connected
0x0014	AMS Sync Win32 error
0x0015	AMS Sync Timeout
0x0016	AMS Sync AMS error
0x0017	AMS Sync no index map
0x0018	Invalid AMS port
0x0019	No memory
0x001A	TCP send error
0x001B	Host unreachable
0x0500	Router: no locked memory
0x0502	Router: mailbox full

0x0700	error class <device error>
0x0701	Service is not supported by server
0x0702	invalid index group
0x0703	invalid index offset
0x0704	reading/writing not permitted
0x0705	parameter size not correct
0x0706	invalid parameter value(s)
0x0707	device is not in a ready state
0x0708	device is busy
0x0709	invalid context (must be in Windows)
0x070A	out of memory
0x070B	invalid parameter value(s)
0x070C	not found (files, ...)
0x070D	syntax error in command or file
0x070E	objects do not match
0x070F	object already exists
0x0710	symbol not found
0x0711	symbol version invalid
0x0712	server is in invalid state
0x0713	AdsTransMode not supported
0x0714	Notification handle is invalid
0x0715	Notification client not registered
0x0716	no more notification handles
0x0717	size for watch too big
0x0718	device not initialized
0x0719	device has a timeout
0x071A	query interface failed
0x071B	wrong interface required
0x071C	class ID is invalid
0x071D	object ID is invalid
0x071E	request is pending
0x071F	request is aborted

0x0720	signal warning
0x0721	invalid array index
0x0740	Error class <client error>
0x0741	invalid parameter at service
0x0742	polling list is empty
0x0743	var connection already in use
0x0744	invoke ID in use
0x0745	timeout elapsed
0x0746	error in win32 subsystem
0x0748	ads-port not opened
0x0750	internal error in ads sync
0x0751	hash table overflow
0x0752	key not found in hash
0x0753	no more symbols in cache