pbsFEP

pbsControl

SCADA Communication Gateway

User Manual

V1 RC16

Jan 2020

www.pbsControl.com

1	Kamjoo bayat	Create Ver 1.0 document	March - 2019
2	Kamjoo Bayat	V1.0 RC8	May - 2019
3	Kamjoo Bayat	V1.0 RC9	May -2019
4	Kamjoo Bayat	V1.0 RC10	June -2019
5	Kamjoo Bayat	V1.0 RC16	Jan -2020
6			

Changes in V1.0 RC16 20 Jan 2020

- Enhancing System Stability
- Adding System Tag for CROB for external DNP3 Master commands
- Enhancing Online Modification of FEP

Changes in V1.0 RC16 1 Dec 2019

- DNP Master enhancement
- Adding Redundancy in Oracle Data Logging for Server IP and SID
- Adding Redundancy in Ignition Integration for Server IP and SID
- Adding new System Tag for Ignition Table Update by Truncate Tables
- Fixing problems in online tags Editing /Adding/Deleting
- Providing Multiple Threads for Oracle data logging. Max 16 Threads
- adding system tag for DNP3 toggling channel redundancy
- adding CSV exporting facility for DNP3 Master RTU
- Adding Multiple CROB Command in DNP3 driver

Changes in V1.0 RC10 23 June 2019

- Adding sys.G41_opctagname , Var , Value , CMD and status to DNP3 driver
- Fixing updating problem in sys.CROB_Status for DNP3 driver tag
- Fixing SOE Tag time label problem in dnp3 master driver
- Fixing problem when Online Enable/Disable RTU in DNP3 driver

Changes in V1.0 RC9 20 May 2019

- no need to restart FEP when Adding New RTU to FEP

- Adding Event Description for tags
- Fixing Data Archiving Problems
- Fixing Data Time problem in DNP3 Slave Library

Changes in V1.0 RC8 6 May 2019

- Adding Kernel Redundancy
- Adding IEC104 Driver in Downlink
- Finalizing Periodic Logging in Database
- Adding License to Kernel
- Flexibility in Data Logging table
- Separating cyclic and events data logging tables
- Adding Channel Redundancy for TCP Connection for DNP3 Downlinks
- Adding SYS.CROB_opctagname tag for DNP3 Downlinks
- Adding SYS.ActiveChannel tag for DNP3 Downlinks

Table of content

1 – Introduction

pbsFEP is new Product from pbsControl . Final target for pbsFEP is communication gateway between DNP3, IEC101/104 /Modbus,IEC61850/MQTT/TASE2 and OPC UA protocols.

In This version, pbsFET only supports DNP3/IEC104 and OPC UA protocols.

pbsFET has two parts:

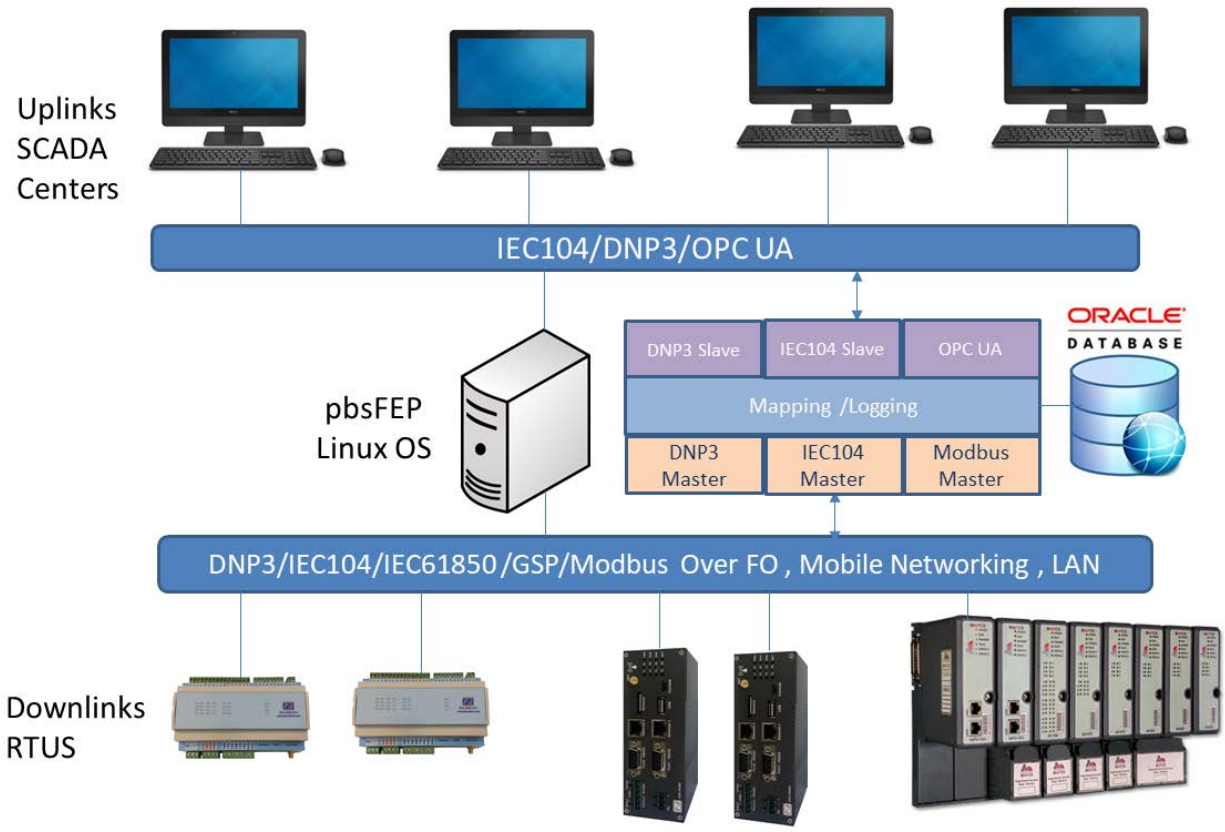
- Configurator that is running on Windows OS
- Runtime Kernel that is running on Linux OS

DNP3 Master/slave kernel ,IEC101/104 Master Slave and ModbusRTU/TCP master/Slave are developed in pbsControl Company. For OPC UA we used https://open62541.org/ project.

pbsFET supports DNP3 Slave functionality. You can connect up to 7 DNP3 Master to pbsFET.

Based on following structure, there are uplink and downlink connections in pbsFEP. Uplinks are SCADA centers . pbsFEP will provide data for uplink connections .

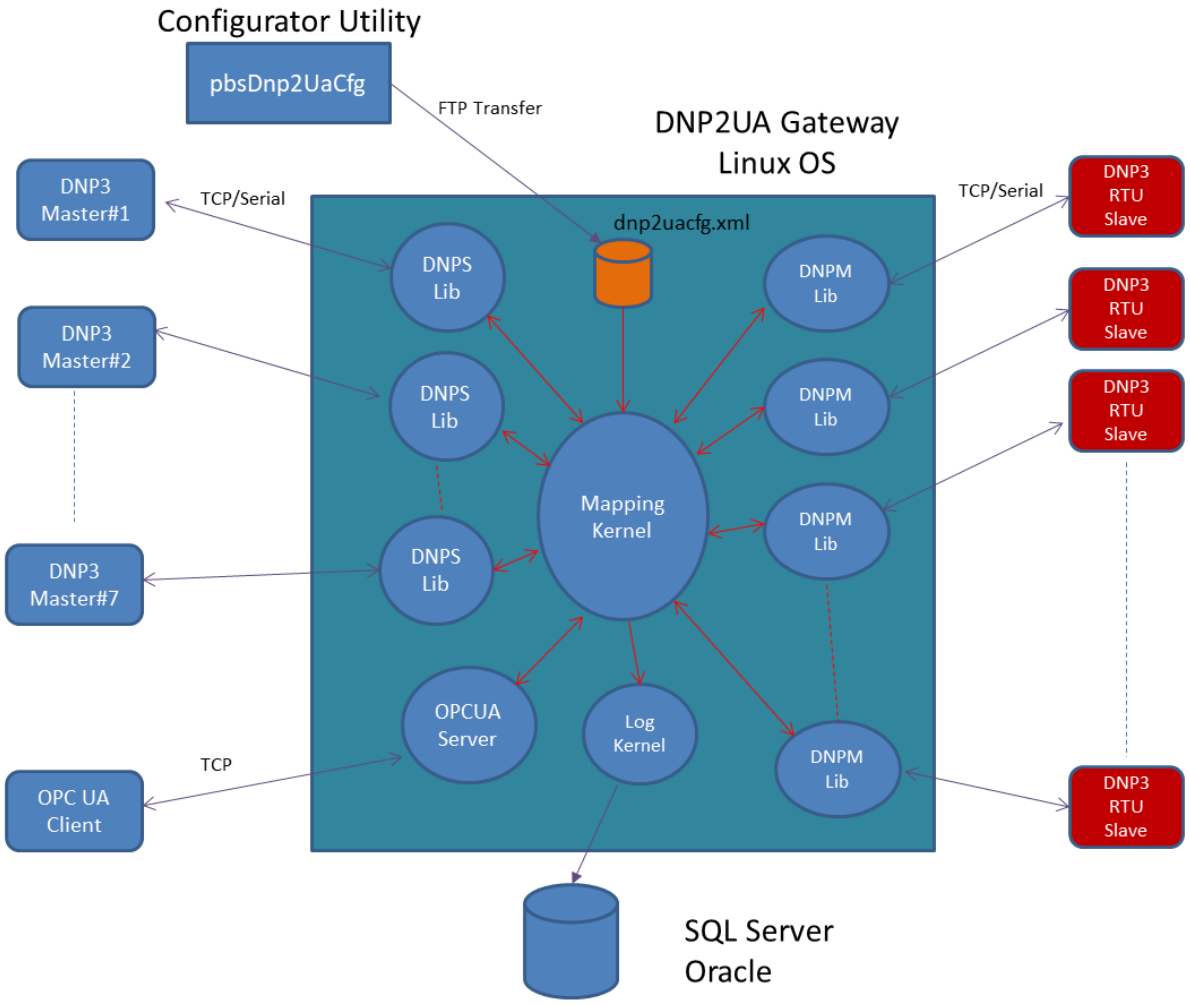
In V1.0 RC4 , we supports 7 DNP3 uplink connections and OPC UA Server . (pbsFEP is DNP3 Slave and OPC UA is Server)



Downlink connections, are RTU Connections. Downlink Connections in pbsFEP are TCP Client Connections. DNP3 Master, IEC104 Master, Modbus Master are samples for Downlinks connections.

2 – Driver Structure and Installation

In following figure, you can see structure of pbsFEP Gateway:



Gateway Operation:

pbsFEPLX Linux Runtime is loading dnp2uacfg.xml file and Start to load DNP3 Master /IEC104 Master / Slave and OPC UA Libraries. When you are doing configuration , you can select any name for configuration file , at transfer time Configurator will change name to dnp2uacfg.xml .

For each Downlink RTU, One DNP/IEC104/Modbus Master library is loaded to memory. This Library is responsible for communication with downlink RTU.

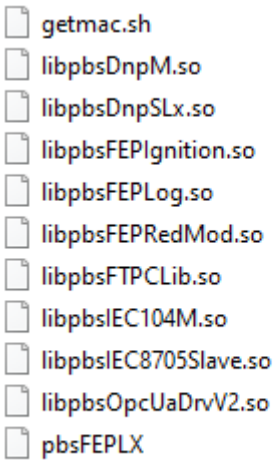
Maximum seven DNP3 Slave libraries can be loaded to connect to seven DNP3 Master Software. (Uplinks)

One OPC UA Server library is loaded to communicate with different OPC UA client software's.

pbsFEP is responsible to map tags between DNP3 Master /IEC104 Master , DNP3 Slave and OPC UA Libraries.

Logging Kernel is archiving SOE (Sequence of Events) and other RTU analog data to MS SQL Server or Oracle database.

In following figure you can see typical files and folders for runtime kernel in Linux:



Inside dnpsi1 to dnpsi7 folders are dnp3 salve libraries that will load dynamically by main application (pbsFEPLX).

These folders are making automatically by pbsFEPLX program.

For each DNP3/IEC104 Master library pbsFELPX will make one folder with name RTU0, RTU1, RTU2…RTUN

libpbsDnpM.so is DNP3 Master library . DNP3 Master library communicates with DNP3 Slave RTUS.(Downlinks)

libpbsIEC104M.so IEC870-5-104 master Library for communication with downlink RTUS .

libpbsOpcUaDrv2.so is OPC UA Server library .

libpbsLog.so is logging kernel for Oracle and MS SQL Server.

libpbsFEPRedMod.so is responsible for handling redundancy between two FEP kernel .

libpbsDnpSLx.so is DNP3 Slave Library . (Uplink)

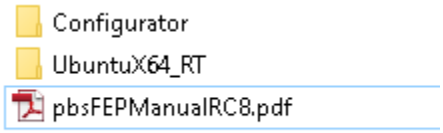
dnp2uacfg.xml is configuration file that is providing by Configurator Software .

You need to install ftpd on linux for transferring dnp2uacf.xml from Windows Eng Station to Linux Server.

2 – Driver Configuration

For configuration of system, you need to use pbsFEPCfg.exe utility. Download Configurator from www.pbscontrol.com and unzip it in any folder in Eng Station. For proper running of configurator you need to install Dot Net Framework 4.0 on Eng Station.

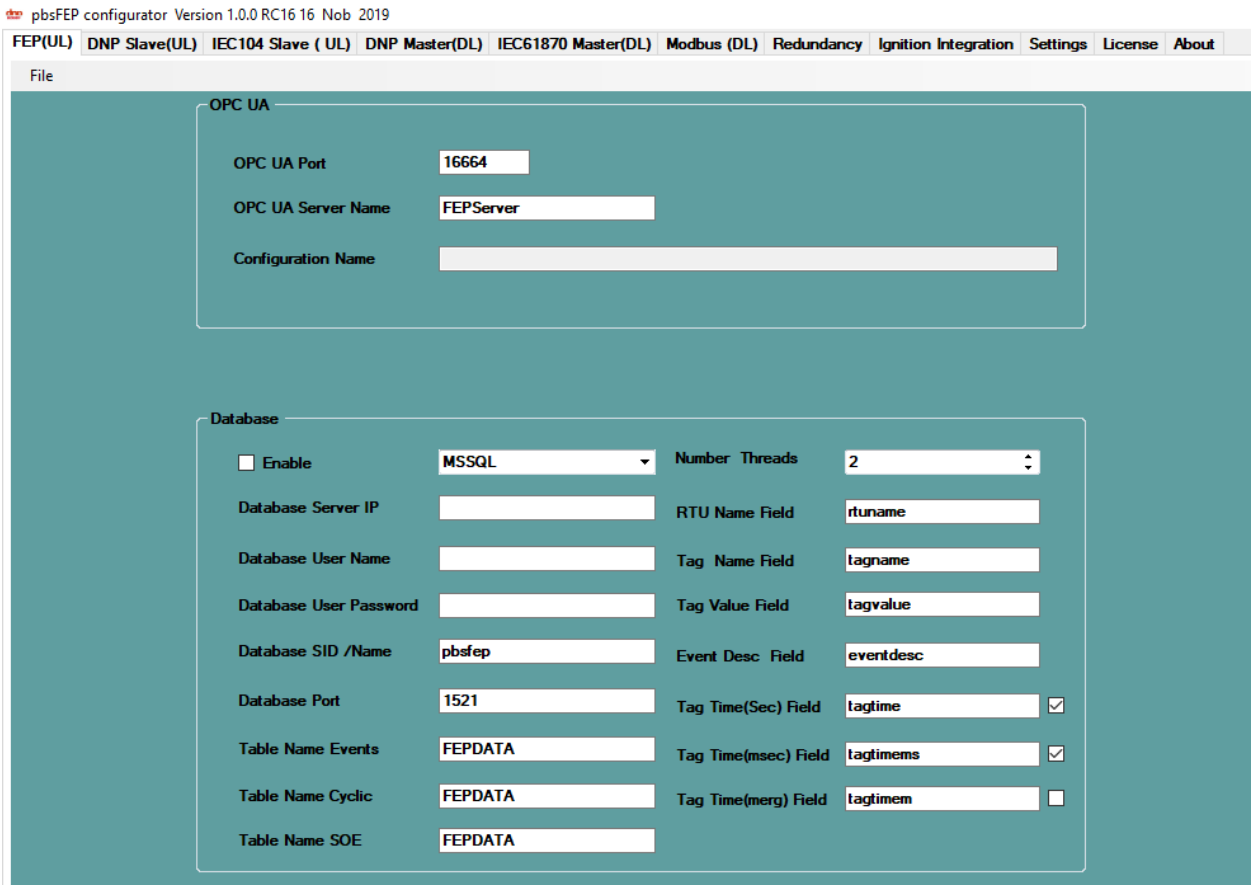
Download pbsFEP and unzip it. You can see following folder :



Configurator Folder: Windows GUI for configuration of FEP

UbuntuX64_RT: Runtime kernel for Ubuntu X64 Platform.

After running configurator, you will see following page:



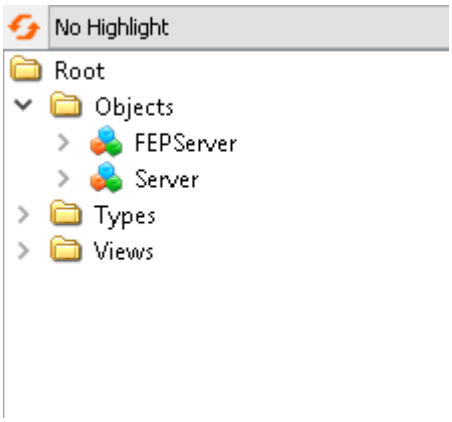
In this page, UL Is notation for uplink and DL is notation for Downlink.

FEP(UL) page

You can set parameters for OC UA and Database connection in FEP Page.

OPC UA Port: TCP/IP Port number for communicating with uplinks.

OPC UA Server Name: Server Name that is showing when Client is Browsing Gateway. As an example if you put “FEPServer”, at OPC UA browser you will see following configuration:

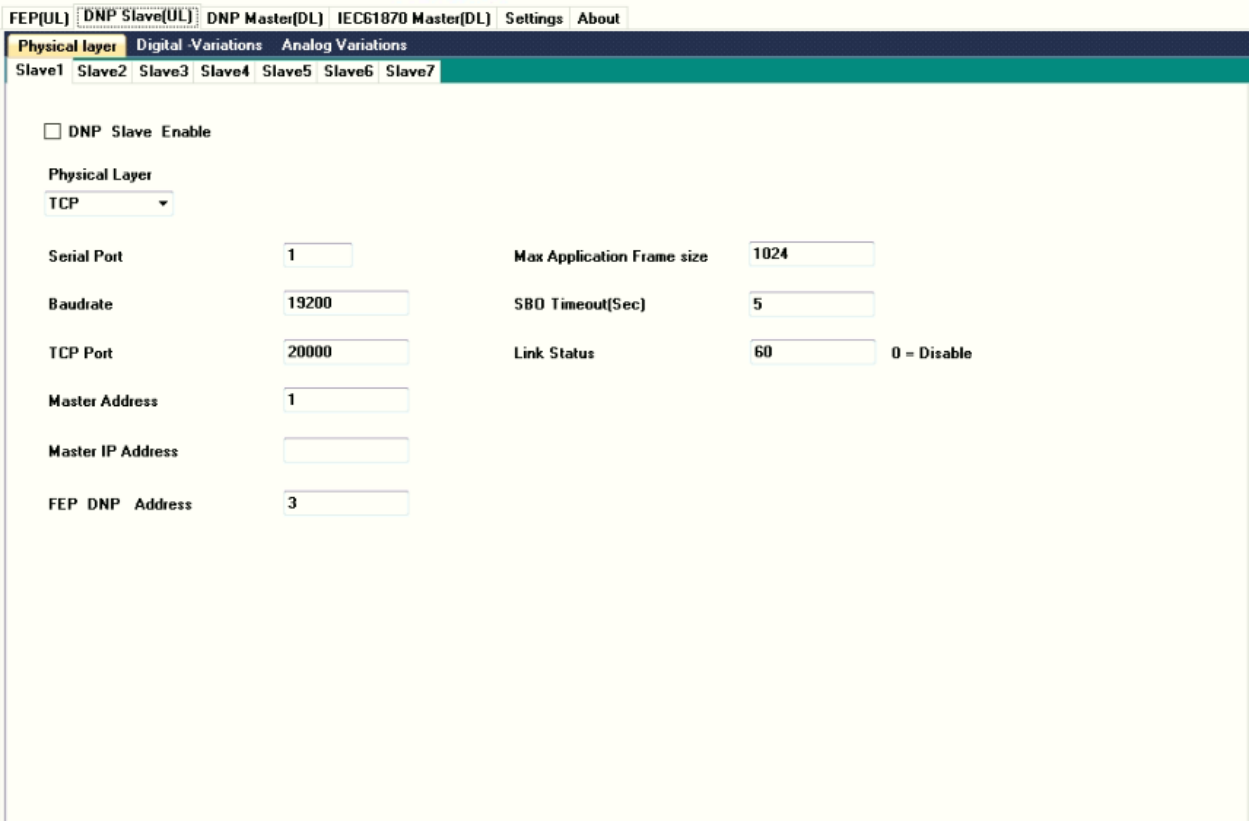


Configuration Name: Full Path of Active configuration

Database Enable: If checked gateway will save all downlink tags into Database. You can use MS SQL Server or Oracle for archiving tags changes. For Detail information about Data logging please refer to part 5.

DNP Slave(UL) Page

You can set DNP3 Slave connection with master SCADA in DNP Slave Page. Up to 7 Concurrent connections is possible with Gateway. For each connection you can set different parameters but all connection will use same tag definition.



DNP Slave Enable: if checked Connection is enable.

Physical layer: You can select Serial connection or TCP Connection. For Serial connection, Port name has following format ttyS0, ttyS1,ttyS2,…

Serial Port: Port Number. As an example If you want to use ttyS0 on the Linux Server, you should set Serial port to 1.

Baud rate: Serial Communication Baud rate.

TCP Port: TCP Port for Number for this Connection. By default DNP3 Port number is 20000. You need to set different TCP port number for each Connection.

Master Address: DNP3 Master Address.

Master IP Address: Master IP Address. If set to blank all IP can connect. Otherwise only specified IP can connect to Gateway.

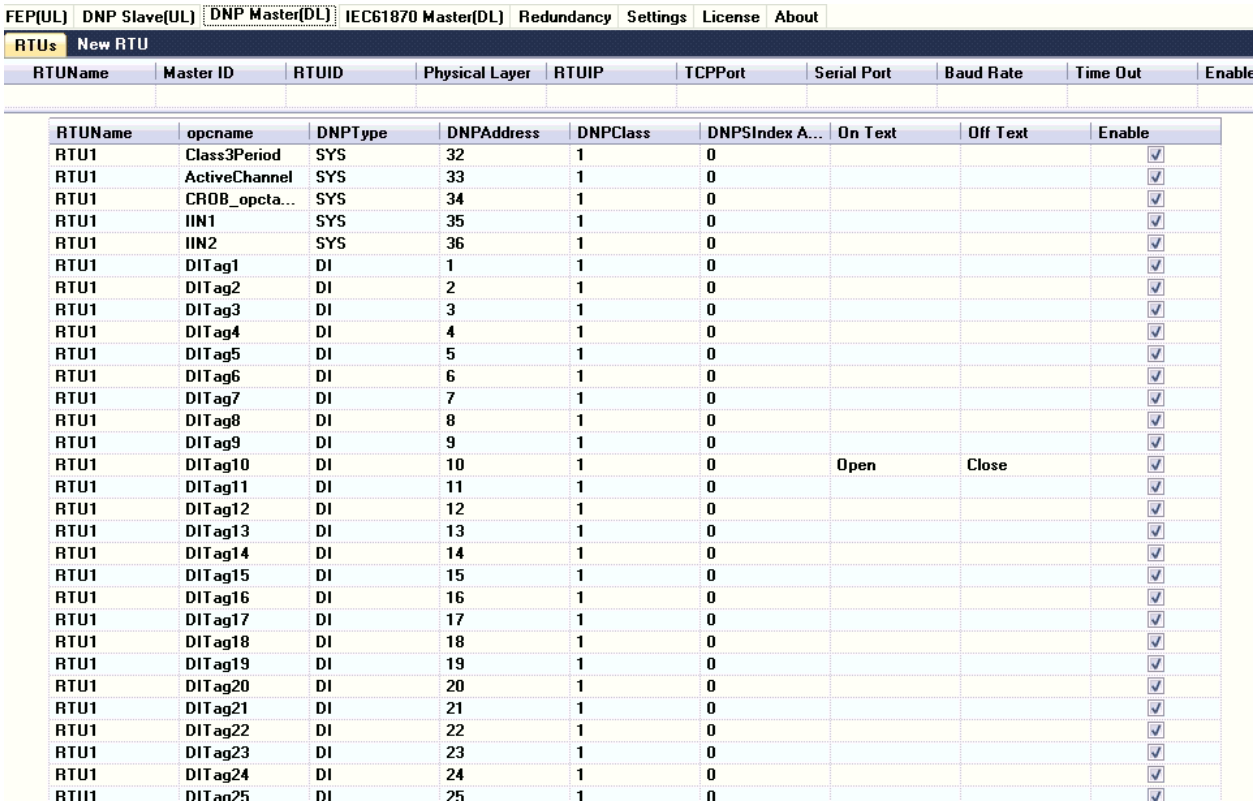
FEP DNP Address: Gateway Slave DNP3 Address.

Maximum Application Frame Size: Maximum Frame size that will send by gateway to Master.

SBO Time Out (Sec): Time Out for select before operates command (in Second).

Link Status (Sec): Link Status Frame Period Time. If Set to 0, it is disable.

DNP Master Page(DL):

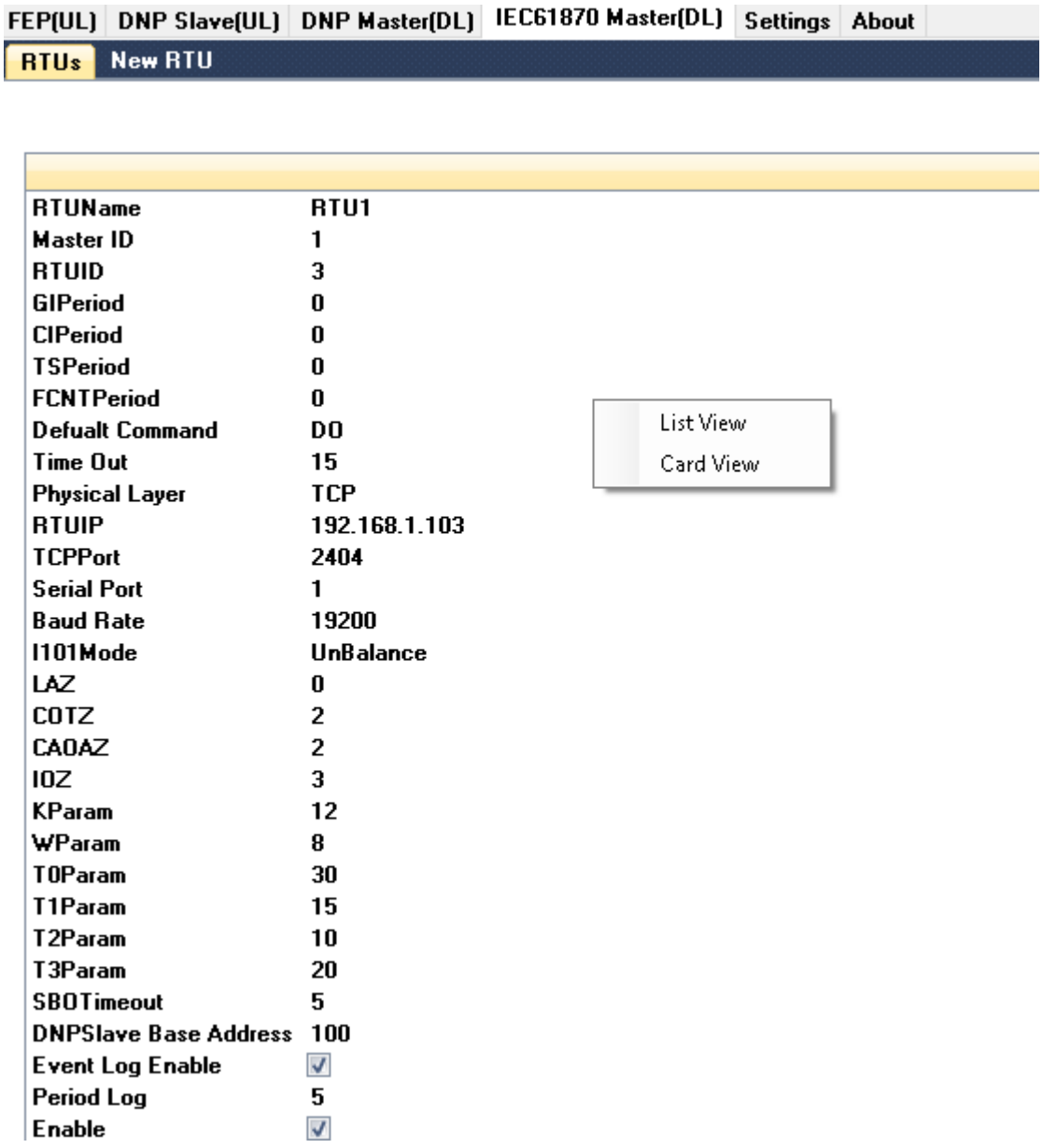


RTUName	opcname	DNPType	DNPAddress	DNPClass	DNPSIndex A...	On Text	Off Text	Enable
RTU1	Class3Period	SYS	32	1	0			☑
RTU1	ActiveChannel	SYS	33	1	0			☑
RTU1	CROB_opcta...	SYS	34	1	0			☑
RTU1	IIN1	SYS	35	1	0			☑
RTU1	IIN2	SYS	36	1	0			☑
RTU1	DITag1	DI	1	1	0			☑
RTU1	DITag2	DI	2	1	0			☑
RTU1	DITag3	DI	3	1	0			☑
RTU1	DITag4	DI	4	1	0			☑
RTU1	DITag5	DI	5	1	0			☑
RTU1	DITag6	DI	6	1	0			☑
RTU1	DITag7	DI	7	1	0			☑
RTU1	DITag8	DI	8	1	0			☑
RTU1	DITag9	DI	9	1	0			☑
RTU1	DITag10	DI	10	1	0	Open	Close	☑
RTU1	DITag11	DI	11	1	0			☑
RTU1	DITag12	DI	12	1	0			☑
RTU1	DITag13	DI	13	1	0			☑
RTU1	DITag14	DI	14	1	0			☑
RTU1	DITag15	DI	15	1	0			☑
RTU1	DITag16	DI	16	1	0			☑
RTU1	DITag17	DI	17	1	0			☑
RTU1	DITag18	DI	18	1	0			☑
RTU1	DITag19	DI	19	1	0			☑
RTU1	DITag20	DI	20	1	0			☑
RTU1	DITag21	DI	21	1	0			☑
RTU1	DITag22	DI	22	1	0			☑
RTU1	DITag23	DI	23	1	0			☑
RTU1	DITag24	DI	24	1	0			☑
RTU1	DITag25	DI	25	1	0			☑

You can define Downlink RTUs by this page.

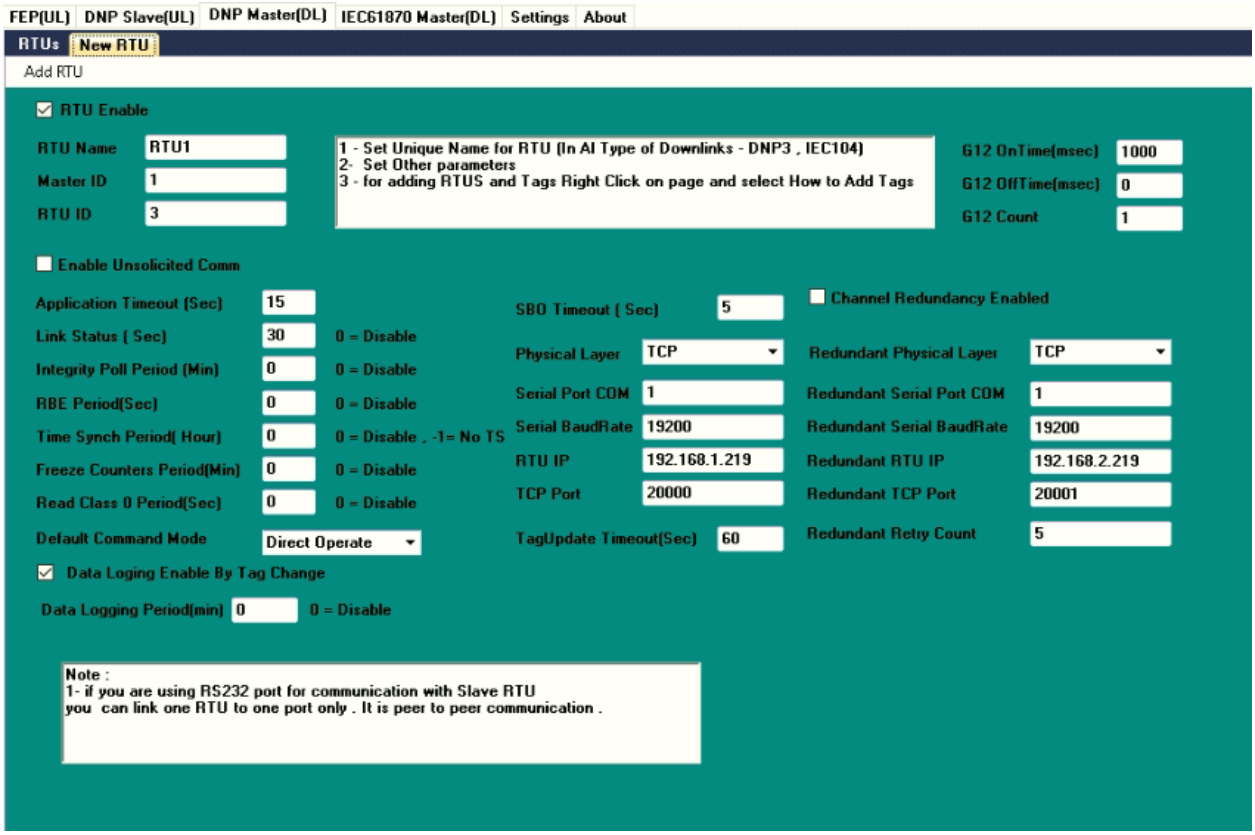
In RTUs page you can see list of defined RTU and tags.

Right click on List you can change view to List and card as following :



In card View mode you can easily change downlink RTU parameters after you add RTU to configuration .

For adding New RTU, Select “New RTU” page:



RTU Name: Select unique name for each RTU. Do not use Special characters like Space, - , . name should be unique for all downlink RTUS (DNP3 , IEC104, Modbus,..)

Master ID: DNP3 Master ID for this Link.

RTU ID: DNP3 RTU Slave ID.

Enable Unsolicited Communication: If Checked RTU will send changes to Gateway without gateway request.

Application Timeout (Sec): Application layer Timeout in Sec.

Link Status (Sec): Link Status Period in Second. If set to 0 , it is disabled.

Integrity Poll Period (Min): Period for sending Integrity Poll to RTU in Min.

RBE Period (Sec): Period for Sending RBE Frame in Second.

Time synch Period (Min): Period for Sending Time Synch Command to RTU. If set to -1 , DNP3 Master Driver will never send Time sync to RTU . We consider there is another way for time synchronization for RTU.

Freeze Counter Period (Min): Period for Sending Freeze Command to RTU in Min.

Read class 0 Period (Sec): Period for reading class 0 Tags (Current Status of All Tags) in RTU in second.

Default command Mode: You can select between Direct Operate or Select Before Operate.

Physical Layer: Physical layer with RTU. You can use TCP or Serial. If you use Serial, you can connect only one RTU

to one Serial Port. You can use RS485 port but still you can connect only one RTU.

Serial Port: Port Number of Serial Port . Serial port name Should be in ttyS0 , ttyS1 , … Format . As an example if you want to use ttyS2 on the server you need to use 3 for Serial port.

Baud Rate: Serial Communication Baud Rate.

RTU IP: IP of RTU for communication in TCP mode.

TCP Port: TCP port number for communication with RTU.

SBO Timeout(Sec) : When Command mode is SBO (select before Operate) master sends first Select Command to RTU , Master monitor RTU Answer for Select in SBO Timeout sec , if RTU answer before this time correctly , Master Driver sends Operate to RTU , otherwise no action will handle by master driver .

Tag Update Timeout(Sec) : pbsFEP will check RTU Tags are updating in this time or not . If Tags are getting update , System Tag sys.UpdatingTags value is 1 , if not getting update in this period , sys.Updatetags value will set to 0 .

Channel Redundancy Enable : If Checked pbsFEP communicates with RTU IP First , When Connection Failed for Redundant Retry Count Parameter , pbsFEP will switch to Redundant RTU IP and TCP Port .

If Redundant IP Failed for retry Count , then pbsFEP will switch to Main IP and TCP Port .

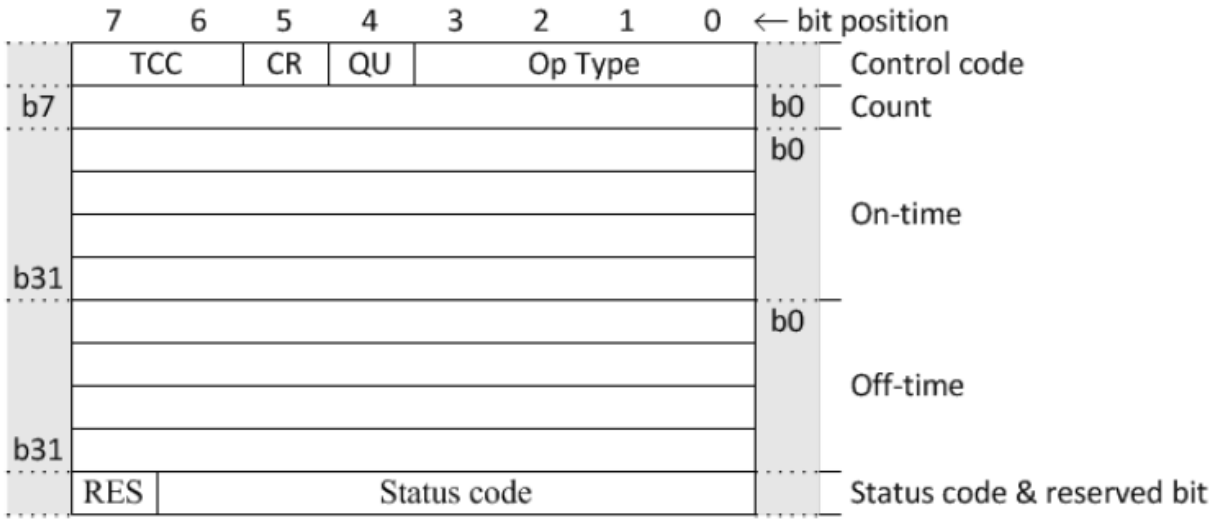
RTU System Tag SYS.ActiveChannel shows Active connection . If it is on Main Connection , SYS.ActiveChannel is 1 .

If it is on redundant Connection , SYS.ActiveChannel is 2.

SYS.ToggleChannel RTU System Tag SYS.ToggleChannel is used for toggling between channels

G12OnTime(msec),G12OffTime(msec), G12Count :

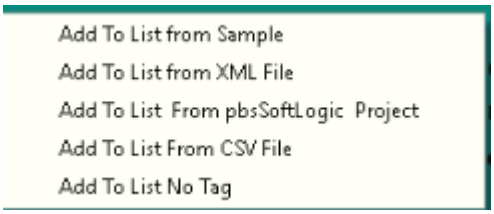
In DNP3 standard Group12 is Digital Output Command . structure of command is as following :



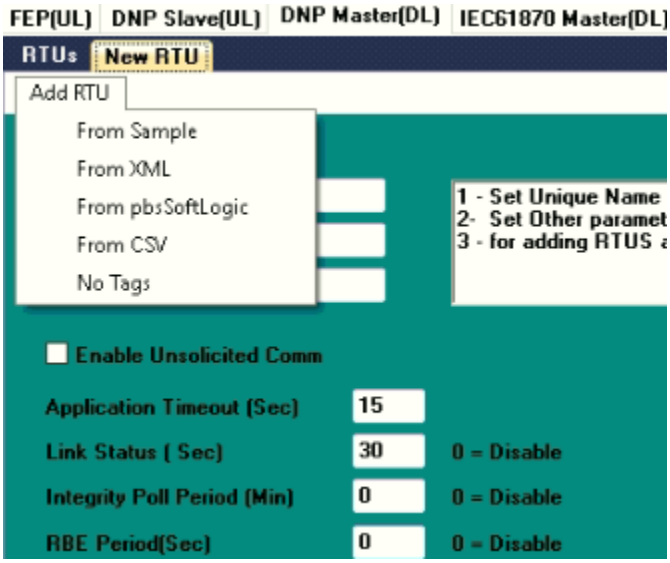
G12OnTime is mapped to on-time field ,G12OffTime is mapped to off-time field and G12Count is mapped to Count field.

From OPC UA client software , you can set Control Field by using DOBS data type . please refer to DOBS Section.

After Setting above parameters, Right click on page. You can add RTU Tags by following methods:



You can use the Menu bar at left side too.



- Add To List from Sample : It will add following tags
  - 8 Digital input (DI)
  - 8 analog input (AI)
  - 8 Floating Input (FI)
  - 8 Double Bit Binary Input (DPI)
  - 8 Counter (CNT)
  - 8 Freeze Counter (FCNT)
  - 8 Digital Output Block (Command) (DOB)
  - 8 Digital Output Block Status (DOBS)
  - 8 Analog Output Block (command) (AOB)
  - 8 Analog Output Block Status(AOBS)
  - 8 Float Output Block (Command) (FOB)
  - 8 Float Output Block Status (FOBS)

- Add To List From XML file: Configurator will read tags from XML file with following format. You can find one sample file in Configurator folder.(Tags.xml)

```
<tags>
        <tag dnptype="DI" dnpaddress="1" dnpclass="1" opcname="tagdi1" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DI" dnpaddress="2" dnpclass="1" opcname="tagdi2" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DI" dnpaddress="3" dnpclass="1" opcname="tagdi3" DNPSIndexAddress="0" enable="1" />

        <tag dnptype="AI" dnpaddress="1" dnpclass="1" opcname="tagai1" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="AI" dnpaddress="2" dnpclass="1" opcname="tagai2" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="AI" dnpaddress="3" dnpclass="1" opcname="tagai3" DNPSIndexAddress="0" enable="1" />


        <tag dnptype="FI" dnpaddress="11" dnpclass="1" opcname="tagFi1" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="FI" dnpaddress="12" dnpclass="1" opcname="tagFi2" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="FI" dnpaddress="13" dnpclass="1" opcname="tagFi3" DNPSIndexAddress="0" enable="1" />


        <tag dnptype="DOB" dnpaddress="1" dnpclass="1" opcname="tagdob1" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="2" dnpclass="1" opcname="tagdob2" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="3" dnpclass="1" opcname="tagdob3" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="4" dnpclass="1" opcname="tagdob4" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="5" dnpclass="1" opcname="tagdob5" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="6" dnpclass="1" opcname="tagdob6" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="7" dnpclass="1" opcname="tagdob7" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="DOB" dnpaddress="8" dnpclass="1" opcname="tagdob8" DNPSIndexAddress="0" enable="1" />


        <tag dnptype="AOB" dnpaddress="1" dnpclass="1" opcname="tagaob1" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="AOB" dnpaddress="2" dnpclass="1" opcname="tagaob2" DNPSIndexAddress="0" enable="1" />
        <tag dnptype="AOB" dnpaddress="3" dnpclass="1" opcname="tagaob3" DNPSIndexAddress="0" enable="1" />

</tags>
```

dnptype : you can set DI , AI , FI , DOB , DOBS , AOB , AOBS,FOB, FOBS, DO , AO ,FO , CNT , FCNT , DPI , DOBF , AOBF, FOBF

- DI : Digital input Read By Master with differ net variations , DNP Group1 , 2
- AI : Analog input Read By Master with different variations , DNP Group 30,32

- CNT : Counter Read By Master with different variations DNP Group 20, 22
- FCNT : Frozen Counter Read By Master with different variations DNP Group 21, 23
- FI : Float Input : DNP Group 30 , 32 , Variation 5
- DOB : Digital Output Block Write by master with different mode DNP Group 12
- AOB : Analog Output Block Write by master with different mode , DNP Group 41
- DO : DO Status Read By Master with different variations , DNP Group 10,11
- AO : AO Status Read By Master with different variations , DNP Group 40,42
- DPI : Double Bit Binary Read By Master with different variations , DNP Group 3,4
- FOB : Float Output Block , Group 41
- FO : Float Output Status , Group 40 , 42
- DOBS , AOBS , FOBS Tag Flag for DOB , AOB and FOB tag type . Please refer to DOBS Tags.
- DOBF , AOBF , FOBF are Command feedback for DOB , AOB and FOB . Please refer to DOBS Tags.

Following Type are using same DNP Address space :

- AI , FI
- AOB , FOB
- AO , FO
- CNT tags and FCNT tags should have same DNP address.
- For each DOB tag , you can define one DOBS , DOBF tag with same DNP Address .
- For each AOB tag , you can define one AOBS,AOBF tag with same DNP Address .
- For each FOB tag , you can define one FOBS,FOBF tag with same DNP Address .

  If you did not define DOBS , AOBS and FOBS tags , Default command will execute for DOB , AOB and FOB tags .

Dnpaddress : DNP3 Tag Address .

Dnpclass : DNP3 Tag Class . (0 , 1, 2, 3)

Opcname : name of Signal for Data Archiving and OPC UA Server .

DNPSindexAddress : When you define RTU , you can set DNPSlave Base Address for RTU . DNPSlave Base Address and DNPSINdexAddress will define tag dnp3 Slave address . Suppose you set DNPSlave Base address to 100 and DNPSIndexAddress to 5, then Tag DNP3 Slave Address is 105. This address will use for uplink connection with 7 Master SCADA.

If DNPSIndexAddress is set to 0, then Tag is not defined in Uplink Database for connection with 7 Master SCADA.

For each RTU you should select proper Base Address which is not make conflict in uplink DNP3 Tags address.

Add To List from pbsSoftLogic Project: You can directly import pbsSoftLogic DNP3 Slave Driver tags to Gateway.

pbsSoftLogic is Open RTU programming IDE for Linux/WinCE/QNX/Win32 based controllers.

Add To List From CSV File : You can use CSV file for defining Downlink tags . There is a sample file in configurator folder.(Tags.csv)

CSV file should have following format:

	A	B	C	D	E	F	G	H	I	J
1	item	name	type	address	class	saddressindex	OnText	OffText	enable	
2	1	tagdi1	DI	1	1	0	Open	Close	1	
3	2	tagdi2	DI	2	1	0			1	
4	3	tagai1	AI	1	1	0			1	
5	4	tagai2	AI	2	1	0			1	
6	5	TagFI3	FI	3	1	0			1	
7	6	TagFI4	FI	4	1	0			1	
8	7	TagCNT1	CNT	1	1	0			1	
9	8	TagCNT2	CNT	2	1	0			1	
10	9	TagFCNT1	FCNT	1	1	0			1	
11	10	TagFCNT2	FCNT	2	1	0			1	
12	11	TagDOB1	DOB	1	1	0			1	
13	12	TagDOB2	DOB	2	1	0			1	
14	13	TagDOBS1	DOBS	1	1	0			1	
15	14	TagDOBS2	DOBS	2	1	0			1	
16	15	TagAOB1	AOB	1	1	0			1	
17	16	TagAOB2	AOB	2	1	0			1	
18	17	TagDPI1	DPI	1	1	0			1	
19	18	TagDPI2	DPI	2	1	0			1	
20										
21										

First Row is used for defining CSV elements, so not be read by configurator.

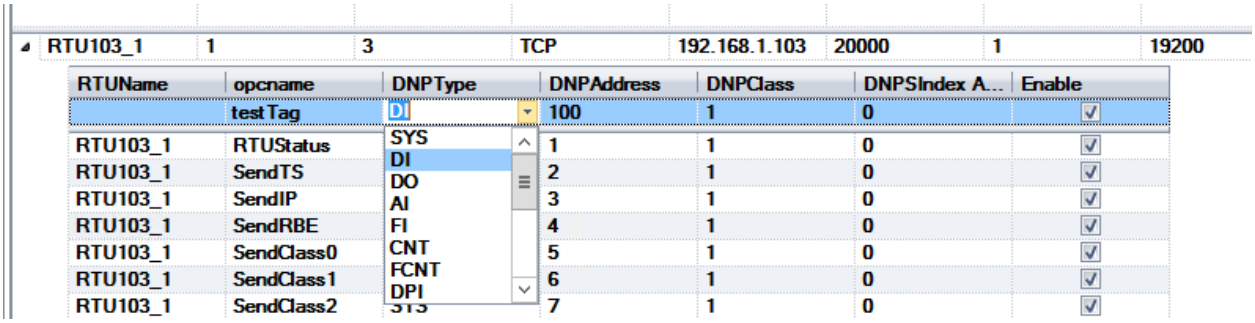
Real format of above csv file is like following image :

```
item,name,type,address,class,saddressindex,OnText,OffText,enable
1,tagdi1,DI,1,1,0,Open,Close,1
2,tagdi2,DI,2,1,0,,,1
3,tagai1,AI,1,1,0,,,1
4,tagai2,AI,2,1,0,,,1
5,TagFI3,FI,3,1,0,,,1
6,TagFI4,FI,4,1,0,,,1
7,TagCNT1,CNT,1,1,0,,,1
8,TagCNT2,CNT,2,1,0,,,1
9,TagFCNT1,FCNT,1,1,0,,,1
10,TagFCNT2,FCNT,2,1,0,,,1
11,TagDOB1,DOB,1,1,0,,,1
12,TagDOB2,DOB,2,1,0,,,1
13,TagDOBS1,DOBS,1,1,0,,,1
14,TagDOBS2,DOBS,2,1,0,,,1
15,TagAOB1,AOB,1,1,0,,,1
16,TagAOB2,AOB,2,1,0,,,1
17,TagDPI1,DPI,1,1,0,,,1
18,TagDPI2,DPI,2,1,0,,,1
20
```

Configurator read above file format and finds tag definition based on above definition.

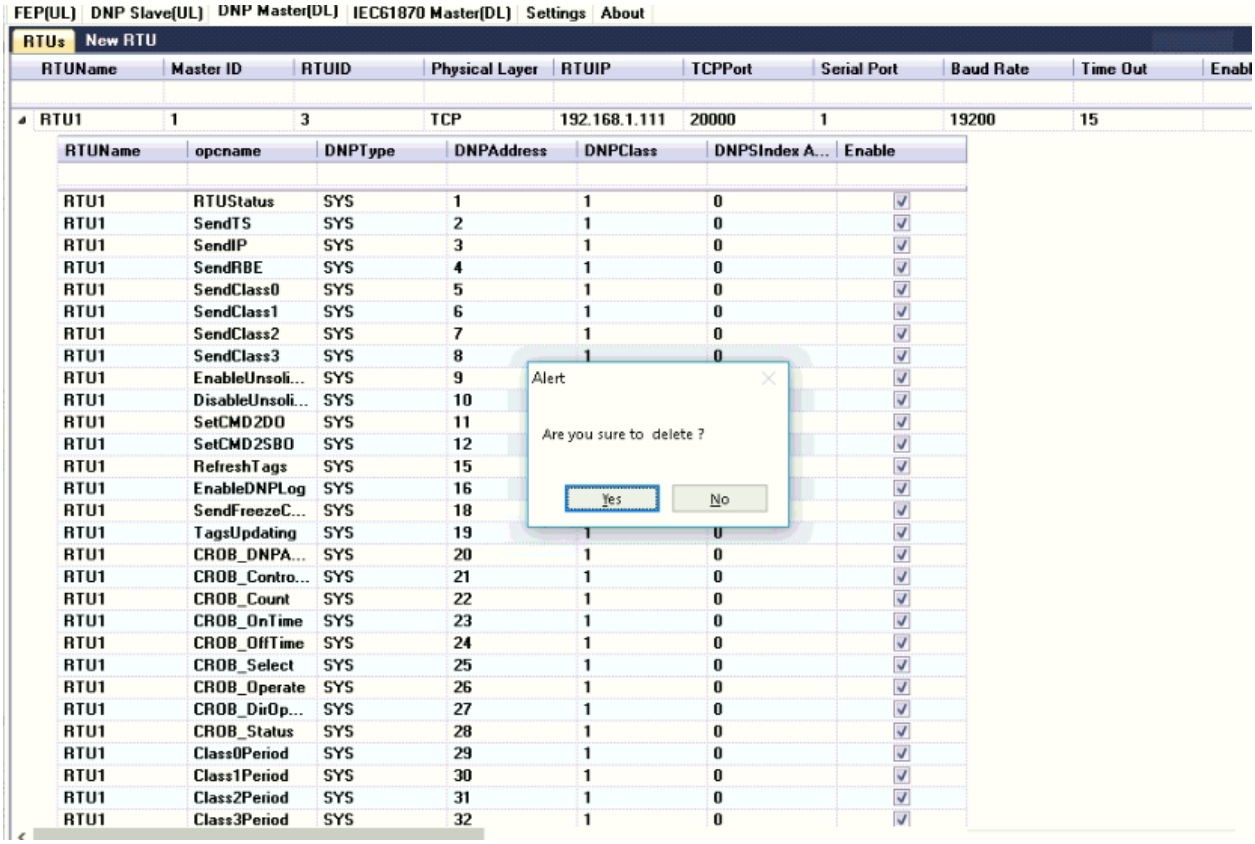
For Editing RTU Parameter, you can directly change parameters on Grid. After changing a parameter, always press Enter key to finally accept by Configurator.

You can add new Tag Manually. Please notice, no need to write RTU Name and just fill tag parameters as following figure:

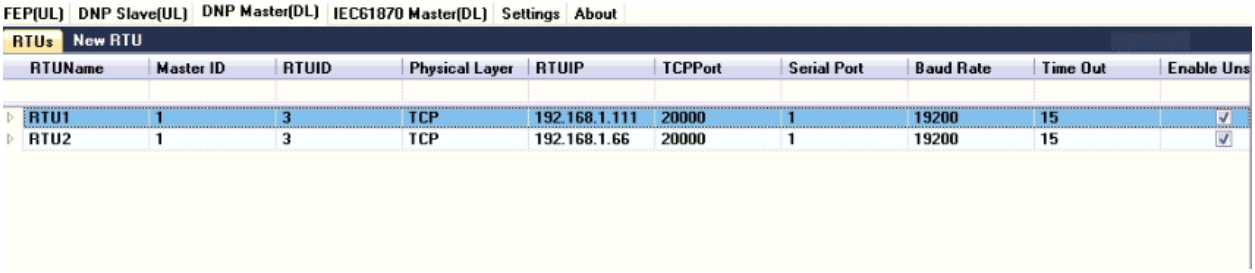


After Writing opcname , select Tag Type from Drop Box , set DNP3 Address and class and Slave index and finally make it enable . Press on Enter Key to accept New Tag.

For deleting one RTU, Select RTU in Grid and press DEL Button. It will delete RTU with Tags after getting confirmation from user.

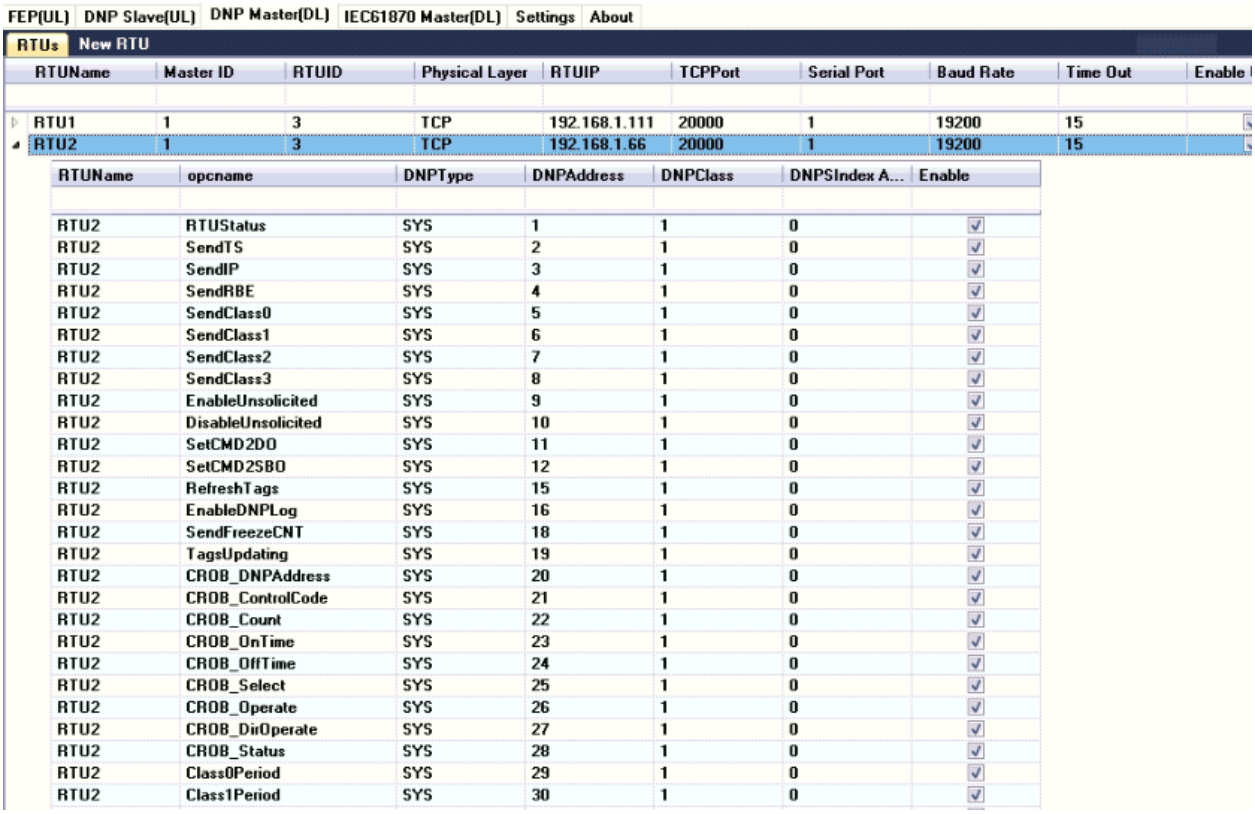

FEP(UL) DNP Slave(UL) DNP Master(DL) IEC61870 Master(DL) Settings About
RTUs New RTU
RTUName Master ID RTUID Physical Layer RTUIP TCPPort Serial Port Baud Rate Time Out Enabl
RTU1 1 3 TCP 192.168.1.111 20000 1 19200 15
RTUName opcname DNPType DNPAddress DNPClass DNPSIndex A... Enable
RTU1 RTUStatus SYS 1 1 0
RTU1 SendTS SYS 2 1 0
RTU1 SendIP SYS 3 1 0
RTU1 SendRBE SYS 4 1 0
RTU1 SendClass0 SYS 5 1 0
RTU1 SendClass1 SYS 6 1 0
RTU1 SendClass2 SYS 7 1 0
RTU1 SendClass3 SYS 8 1 0
RTU1 EnableUnsoli... SYS 9
RTU1 DisableUnsoli... SYS 10
RTU1 SetCMD2DO SYS 11
RTU1 SetCMD2SBO SYS 12
RTU1 RefreshTags SYS 15
RTU1 EnableDNPLog SYS 16
RTU1 SendFreezeC... SYS 18
RTU1 TagsUpdating SYS 19 1 0
RTU1 CROB_DNPA... SYS 20 1 0
RTU1 CROB_Contro... SYS 21 1 0
RTU1 CROB_Count SYS 22 1 0
RTU1 CROB_OnTime SYS 23 1 0
RTU1 CROB_OffTime SYS 24 1 0
RTU1 CROB_Select SYS 25 1 0
RTU1 CROB_Operate SYS 26 1 0
RTU1 CROB_DirOp... SYS 27 1 0
RTU1 CROB_Status SYS 28 1 0
RTU1 Class0Period SYS 29 1 0
RTU1 Class1Period SYS 30 1 0
RTU1 Class2Period SYS 31 1 0
RTU1 Class3Period SYS 32 1 0
Alert
Are you sure to delete ?
Yes
No

Suppose you define two RTUs in configurator, then you should see following page but with your parameters:



RTUName	Master ID	RTUID	Physical Layer	RTUIP	TCPPort	Serial Port	Baud Rate	Time Out	Enable Uns
RTU1	1	3	TCP	192.168.1.111	20000	1	19200	15	☑
RTU2	1	3	TCP	192.168.1.66	20000	1	19200	15	☑

Select one RTU and expand Grid. You can see RTU Tags:



RTUName	Master ID	RTUID	Physical Layer	RTUIP	TCPPort	Serial Port	Baud Rate	Time Out	Enable
RTU1	1	3	TCP	192.168.1.111	20000	1	19200	15	
RTU2	1	3	TCP	192.168.1.66	20000	1	19200	15	

RTUName	opcname	DNPType	DNPAddress	DNPClass	DNPSIndex A...	Enable
RTU2	RTUStatus	SYS	1	1	0	☑
RTU2	SendTS	SYS	2	1	0	☑
RTU2	SendIP	SYS	3	1	0	☑
RTU2	SendRBE	SYS	4	1	0	☑
RTU2	SendClass0	SYS	5	1	0	☑
RTU2	SendClass1	SYS	6	1	0	☑
RTU2	SendClass2	SYS	7	1	0	☑
RTU2	SendClass3	SYS	8	1	0	☑
RTU2	EnableUnsolicited	SYS	9	1	0	☑
RTU2	DisableUnsolicited	SYS	10	1	0	☑
RTU2	SetCMD2DO	SYS	11	1	0	☑
RTU2	SetCMD2SBO	SYS	12	1	0	☑
RTU2	RefreshTags	SYS	15	1	0	☑
RTU2	EnableDNPLog	SYS	16	1	0	☑
RTU2	SendFreezeCNT	SYS	18	1	0	☑
RTU2	TagsUpdating	SYS	19	1	0	☑
RTU2	CROB_DNPAddress	SYS	20	1	0	☑
RTU2	CROB_ControlCode	SYS	21	1	0	☑
RTU2	CROB_Count	SYS	22	1	0	☑
RTU2	CROB_OnTime	SYS	23	1	0	☑
RTU2	CROB_OffTime	SYS	24	1	0	☑
RTU2	CROB_Select	SYS	25	1	0	☑
RTU2	CROB_Operate	SYS	26	1	0	☑
RTU2	CROB_DirOperate	SYS	27	1	0	☑
RTU2	CROB_Status	SYS	28	1	0	☑
RTU2	Class0Period	SYS	29	1	0	☑
RTU2	Class1Period	SYS	30	1	0	☑

There are system Tags for each RTU that is defined by configurator. Sys tags are determined by their Address not Name.

- RTUStatus (Read Only) Shows Status of RTU as following:
  - 0 Disconnected
  - 10 Gateway Connect to RTU
  - 20 Send Time Synch
  - 30 Send IP
  - 31 Waiting for Data
  - 40 Connection Closeting
  - 100 Online. Gateway received Data from RTU

  RTUStatus Address is 1.
- SendTS : Send Time Synch to RTU . When Changed from 0 to 1 , Gateway will send Time Synch command to RTU . SendTS Address is 2 .
- SendIP : Send Integrity poll Command to RTU . When Changed from 0 to 1 , Gateway will send IP command to RTU. SendIP address is 3.
- SendRBE . Send RBE Command to RTU . When Changed from 0 to 1 , Gateway will send RBE command to RTU. SendRBE address is 4.
- SendClass0 . Read Class 0 (Current Value of all Tags) Command to RTU . When Changed from 0 to 1 ,

Gateway will send Read Class0 command to RTU. SendClass0 address is 5.

- SendClass1 . Read Class Command to RTU . When Changed from 0 to 1 , Gateway will send Read Class1 command to RTU. SendClass1 address is 6.
- SendClass2 . Read Class 2 Command to RTU . When Changed from 0 to 1 , Gateway will send Read Class2 command to RTU. SendClass2 address is 7.
- SendClass3 . Read Class 3 Command to RTU . When Changed from 0 to 1 , Gateway will send Read Class3 command to RTU. SendClass3 address is 8.
- EnabledUnsolicited : When Change from 0 to 1 , Gateway will Send enable Unsolicited communication to RTU . Unsolicited Communication may be disable in RTU . EnabledUnsolicited Address is 9.
- DisableUnsolicited : When Change from 0 to 1 , Gateway will Send Disable Unsolicited communication to RTU . DisableUnsolicited Address is 10.
- SetCMD2DO : When Change from 0 to 1 , Default command is changed to Direct operate . SetCMD2DO address is 11.

- SetCMD2SBO : When Change from 0 to 1 , Default command is changed to Select Before operate . SetCMD2SBO address is 12.
- ToggleChannel: When change value it will toggle communication channel if Channel redundancy is enabled .
- EnableDNPLog : When Change to 1 , pbsFEP start to log RTU DNP3 Frames for analyzing communication . When Change to 0 , DNP Logging is disabled.Enable DNP Trace address is 16 .
- SendFreezeCNT : When change from 0 to 1 , pbsFEP send Freeze Counter command to RTU . Freeze Counter address is 18 .
- TagsUpdating : It is read only tag . Please refer to following description :
    - Tag Update Timeout(Sec) : pbsFEP will check RTU Tags are updating in this time or not . If Tags are getting update , System Tag sys.TagsUpdating value is 1 , if not getting update in this period , sys.TagsUpdating value will set to 0 .
- CROB_DNPAddress , CROB_ControlCode , CROB_Count , CROB_OnTime , CROB_OffTime: With

Setting these tags OPC client can send CROB request to RTU for different DNP Address , Control Code , Count , On-time and off-time parameter . at OPC Client , first you should set above Tags and then Use one of CROB_Select , CROB_Operate or CROB_DirOperate Signal to initiate Request .

- CROB_Select , CROB_Operate , CROB_DirOperate, CROB_DirOperateNoACK: After setting CROB Tags , you should change One of these tags from 0 to 1 to send request to RTU .
- CROB_Status: You can see Status field of CROB request for Specified DNP Address in CROB_Status Tag .
- CROB_SBOTimeOut: you can set SBO Time Out in Sec for CROB Object by This System Tag .
- CROB_opctagname: You can use CROB_DNPAddress or use CROB_opctagname to select DOB DNP Address . CROB_opctagname has string type , and it is name of DOB OPC Tag to be activate by CROB_Select/CROB_Operate/CROB_DirOperate Commands.When you change CROB_opctagname , pbsFEP will search in All DOB Tags for specified RTU and if find DOB Tag name Identical with

CROB_opctagname , it will get DNP3 Address and set CROB_DNPAddress internally .

- Class0Period, Class1Period, Class2Period, Class3Period: With setting these Tags, OPC Client can change Class0,1 , 2, 3 polling period in Sec .
-
- IIN1 : Address 35 ,shows Internal Indication Bayte1 of RTU
- IIN2 : Address 36,shows Internal Indication Bayte1 of RTU

Internal Indications

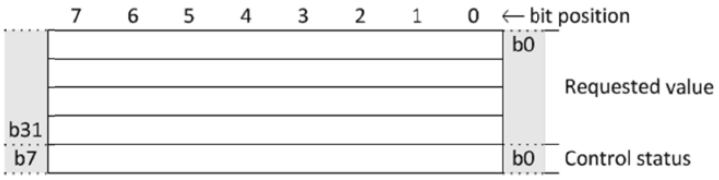
LSB	
IIN1.0	Broadcast
IIN1.1	Class 1 events
IIN1.2	Class 2 events
IIN1.3	Class 3 events
IIN1.4	Need time
IIN1.5	Local control
IIN1.6	Device trouble
IIN1.7	Device restart
MSB	
IIN2.0	Function code not supported
IIN2.1	Object unknown
IIN2.2	Parameter Error
IIN2.3	Event buffer overflow
IIN2.4	Already executing
IIN2.5	Configuration corrupt
IIN2.6	Reserved
IIN2.7	Reserved

- SendTSPeriod: Address 37 , OPC UA Client can set Time synch in Min for RTU . This parameter is persistence in pbsFEP . Means its last value is saved in HDD , so when pbsFEP is restarting , it will set latest value which is written by OPC UA Client . pbsFEP is checking every minute changes of this parameter .
- SendIPPeriod: Address 38, OPC UA Client can set Integrity Poll Period in Min for RTU . This parameter is persistence in pbsFEP . Means its last value is saved in HDD , so when pbsFEP is restarting , it will set latest value which is written by OPC UA Client . pbsFEP is checking every minute changes of this parameter .
-
- SendRBEPeriod: Address 39, OPC UA Client can set Read By Event Period (Class1 , 2,3,) in Min for RTU . This parameter is persistence in pbsFEP . Means its last value is saved in HDD , so when pbsFEP is restarting , it will set latest value which is written by OPC UA Client . pbsFEP is checking every minute changes of this parameter .
-

- G41_opctagname: Address 40 , G41 Group in DNP3 is uses for writing Analog value to RTU . G41_opctagname has string type and OPC UA Client is written signal name on it . if pbsFEP find signal in defined opc tags , it will read DNP3 address of tag and keep internally . otherwise will set DNP3 address to -1 .
- G41_Var: Address 41 , OPC UA Client writes Analog Output Variation on this signal .

Group 41 (Analog Output Command) has 4 variation :

- Variation 1 : 32 bit



A.20.1.2.2 Formal structure

INT32: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is –2 147 483 648 to +2 147 483 647.

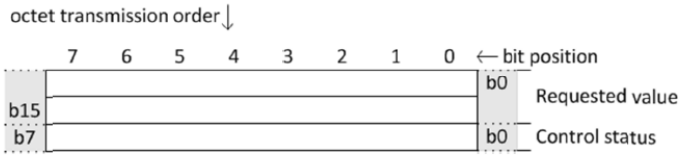
UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See Table 11-7 for descriptions of control-related status codes.

Range is 0 to 255.

- Variation 2 : 16 Bit



A.20.2.2.2 Formal structure

INT16: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is –32 768 to +32 767.

UINT8: Control status.

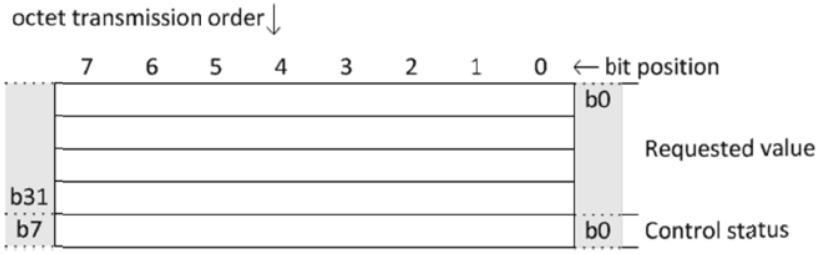
This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

-

- Variation 3 : Floating Point



A.20.3.2.2 Formal structure

FLT32: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is approximately -3.4×10^{38} to $+3.4 \times 10^{38}$.

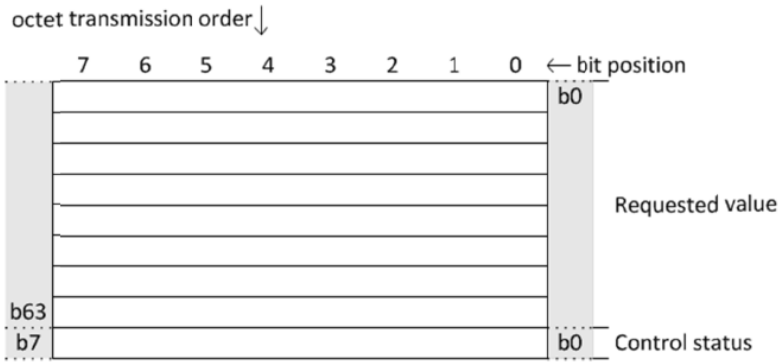
UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

- Variation 4 :



A.20.4.2.2 Formal structure

FLT64: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is approximately -1.7×10^{308} to $+1.7 \times 10^{308}$.

UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

- G41_Value: Address 42 , Analog Output Value
- G41_CMD: Address 43 , When OPC UA Client change G41_CMD signal from 0 to 1 (False to True) Analog Output Command with Above parameters will send to RTU . Only Direct Operate supports for Analog Outputs . When OPC UA Client change G41_CMD from 1 to 0 (True to False) G41_Status signal value changes to -1 . when command execute it will show result of command based on following value .

- G41_Status: Address 44 , status of command execution , which is number as following :

Table 11-7—Control-related status codes

Code number	Identifier name	Description
0	SUCCESS	Request accepted, initiated, or queued.
1	TIMEOUT	Request not accepted because the *operate* message was received after the *arm* timer timed out. The *arm* timer was started when the *select* operation for the same point was received.
2	NO_SELECT	Request not accepted because no previous matching *select* request exists. (An *operate* message was sent to activate an output that was not previously armed with a matching *select* message.)
3	FORMAT_ERROR	Request not accepted because there were formatting errors in the *control* request (either *select, operate,* or *direct operate*).
4	NOT_SUPPORTED	Request not accepted because a control operation is not supported for this point.
5	ALREADY_ACTIVE	Request not accepted, because the control queue is full or the point is already active.
6	HARDWARE_ERROR	Request not accepted because of control hardware problems.
7	LOCAL	Request not accepted because Local/Remote switch is in Local position.
8	TOO_MANY_OBJS	Request not accepted because too many objects appeared in the same request.
9	NOT_AUTHORIZED	Request not accepted because of insufficient authorization.
10	AUTOMATION_INHIBIT	Request not accepted because it was prevented or inhibited by a local automation process.
11	PROCESSING_LIMITED	Request not accepted because the device cannot process any more activities than are presently in progress.
12	OUT_OF_RANGE	Request not accepted because the value is outside the acceptable range permitted for this point.
13 to 125	RESERVED	Reserved for future use.
126	NON_PARTICIPATING	Sent in request messages indicating that the outstation shall not issue or perform the control operation.[a]
127	UNDEFINED	Request not accepted because of some other undefined reason.

[a] Control status code 126, NON_PARTICIPATING, may be used as a test or "no-op". Specific control-related objects may have further explanation for using this code. An outstation shall not reject requests with this status code or report parameter error in IIN2.2 unless there is some other reason to do so.

- CROB_Add2List,CROB_DirOperateList, CROB_DirOperateNoACKList ,CROB_ClearList : you

can send up to 32 CROB to RTU with one command by following sequence :

- 1-Set CROB_DNPAddress , CROB_ControlCode ,CROB_Count , CROB_OnTime and CROB_OffTime
- 2 - Change CROB_Add2List
- Repeat Step 1 and 2 for All CROB that you want to send to RTU . maximum 32 CROB is supported .
- 3 – Call CROB_DirOperateList to Send command to RTU . Only Direct Operate and Direct Command without ACK are supported for Multiple CROB .
- 4 – Change CROB_Clear from 0 to 1 to clear List

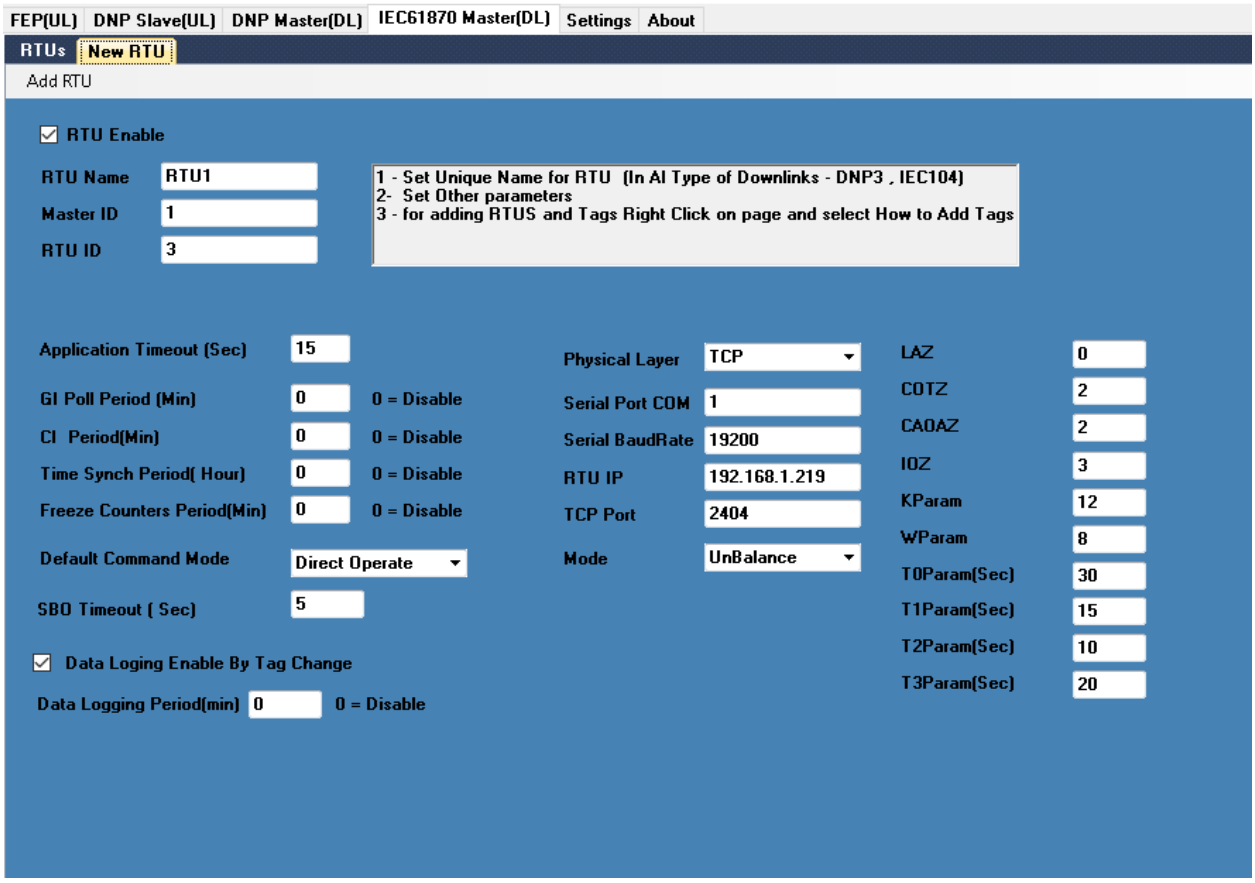
- DisableRTU: When changed from 0 to 1 , RTU communication will disable with RTU . When Signal change to 0 , it will be Enable .

DNP3 RTU system tags :

opcname	DNPType	DNPAddress
RTUStatus	SYS	1
SendTS	SYS	2
SendIP	SYS	3
SendRBE	SYS	4
SendClass0	SYS	5
SendClass1	SYS	6
SendClass2	SYS	7
SendClass3	SYS	8
EnableUnsolicited	SYS	9
DisableUnsolicited	SYS	10
SetCMD2DO	SYS	11
SetCMD2SBO	SYS	12
ToggleChannel	SYS	15
EnableDNPLog	SYS	16
SendFreezeCNT	SYS	18
TagsUpdating	SYS	19
CROB_DNPAddress	SYS	20
CROB_ControlCode	SYS	21
CROB_Count	SYS	22
CROB_OnTime	SYS	23
CROB_OffTime	SYS	24
CROB_Select	SYS	25
CROB_Operate	SYS	26
CROB_DirOperate	SYS	27
CROB_Status	SYS	28
Class0Period	SYS	29
Class1Period	SYS	30
Class2Period	SYS	31
Class3Period	SYS	32
ActiveChannel	SYS	33
CROB_opctagname	SYS	34
IIN1	SYS	35
IIN2	SYS	36
SendTSPeriod	SYS	37
SendIPPeriod	SYS	38
SendRBEPeriod	SYS	39
G41_opctagname	SYS	40
G41_Var	SYS	41
G41_Value	SYS	42
G41_CMD	SYS	43
G41_Status	SYS	44
CROB_Add2List	SYS	45
CROB_DirOperateList	SYS	46
CROB_ClearList	SYS	47
ChannelRedundancyEnabled	SYS	48
DisableRTU	SYS	49
CROB_SBOTimeOut	SYS	50

IEC104 Master Page(DL):

For adding IEC104 RTU to configuration use IEC61870 Master Tab . Like DNP3 you can easily add new RTU by "New RTU" Page:



RTU Name : Name of RTU . Should be unique for all Downlink RTUs (DNP3/IEC104/Modbus)

Master ID : originator Address that is set in RTU

RTU ID : IEC104 ID of RTU

GI Poll Period(min) : Cyclic period time to send GI to RTU by pbsFEP . If is it set to 0 , pbsFEP is not send automatically GI to RTU in cyclic mode .

CI Poll Period(min) : Cyclic period time to send Counter interrogation to RTU by pbsFEP . If is it set to 0 , pbsFEP is not send automatically CI to RTU in cyclic mode . For Reading Counters you need to send CI to RTU .

Time Synch Period(Hour) : Cyclic period time to send Time synch to RTU by pbsFEP . If is it set to 0 , Cyclic Send of Time synch is disable .

Freeze Counter Period(Hour) : Cyclic period time to send Freeze Counter command to RTU by pbsFEP . If is it set to 0 , Cyclic Send of Freeze Command is disable .

Default Command mode : select from Direct Operate or Select before execute .

SBO Time Out(Sec) : Select Before Operate Timeout in pbsFEP .

Data Logging Enable by Tag Change : if Enabled , pbsFEP will log all RTU tag changes with time of changes in Data base .

Data Logging Period(min) : if Enabled , pbsFEP will log RTU data to database at minute . Suppose this parameter is set to 5 . The pbsFEP will log RTU data at 5 , 10 , 15, 20 , 25 , 35, 40, 45, 50, 55, 60 , … minutes . It will save all data independent of Tag Changes . Means if tag changed or not changed , FEP will log data at minute specified .

Physcial Layer : Select between TCP and RS232

When select TCP , FEP will communicate by IEC104

When Select RS232 , FEP will communicate by IEC101

Serial Port(COM) : Serial Port for IEC101 Communication. Serial port name Should be in ttyS0 , ttyS1 , … Format . As an example if you want to use ttyS2 on the server you need to use 3 for Serial port.

Serial Baud Rate : Communication baud rate for IEC101 Protocol .

RTU IP : RTU IP address that is used for IEC104 protocol .

TCP Port : TCP Port that is used for IEC104 protocol . Standard Port Number for IEC104 is 2404 .

Mode : IEC101 Communication Mode .

Unbalance (Master /Slave)

Balance (This Is Like DNP3 Unsolicited communication)

LAZ : IEC101 Link Address Size . address Field of The Link. Select between 0 , 1, 2 . Only Used for IEC101 Communication

COTZ : IEC101 Cause of Transition Size . 1 or 2 . Only Used for IEC101 Communication

CAOAZ : IEC101 common Address of ASDU Size . 1 or 2 . Only Used for IEC101 Communication

IOZ : IEC101 Information Object address Size . 1 or 2 or 3. Only Used for IEC101 Communication

In following figure you can see IEC101 Frame format .

LAZ = Link Address Size

COTZ = COT Size

CAOAZ = ASDU Address Size

IOZ = Information Object Address Size

IEC 101 Frame Format, Variable length		
Data unit	**Name**	**Function**
Start Frame	Start Character	*Indicates start of Frame*
	Length Field (*2)	*Total length of Frame*
	Start Character (repeat)	*Repeat provided for reliability*
	Control Field	*Indicates control functions like message direction*
	Link Address (*0,1 or 2*)	*Normally used as the device / station address*
Data Unit Identifier	Type Identifier	*Defines the data type which contains specific format of information objects*
	Variable Structure Qualifier	*Indicates whether type contains multiple information objects or not*
	COT (*1 or 2*)	*Indicates causes of data transmissions like spontaneous or cyclic*
	ASDU Address (*1 or 2*)	*Denotes separate segments and its address inside a device*
Information Object	Information Object Address (*1 or 2 or 3*)	*Provides address of the information object element*
	Information Elements (n)	*Contains details of the information element depending on the type*
Information Object-2	-----	
-----	-----	
Information Object-m		
Stop Frame	Checksum	*Used for Error checks*
	Stop Char	*Indicates end of a frame*

K Param : IEC104 K Parameter

W Param : IEC104 W Parameter

From IEC104 Standard:

The value of *k* shall indicate the maximum number of sequentially numbered I format APDUs that the DTE may have outstanding (i.e. unacknowledged) at a given time. Each I frame is sequentially numbered and may have the value 0 through modulus *n* minus 1, where "modulus" is the modulus of the sequence numbers which is defined by the parameter *n*. The value of *k* shall never exceed *n* – 1 for modulo *n* operation (see 2.3.2.2.1 and 2.4.8.6 of the ITU-T X.25 recommendation).

- The transmitter stops the transmission at *k* unacknowledged I format APDUs.
- The receiver acknowledges at the latest after receiving *w* = I format APDUs*
- The maximum number of *k* is *n* – 1 for modulo *n* operation.

Maximum range of values of *k*: 1 to 32767 (2^{15}–1) APDUs, accuracy 1 APDU.

Maximum range of values of *w*: 1 to 32767 APDUs, accuracy 1 APDU (recommendation: *w* should not exceed two-thirds of *k*).

T0 Param : IEC104 T0 Parameter

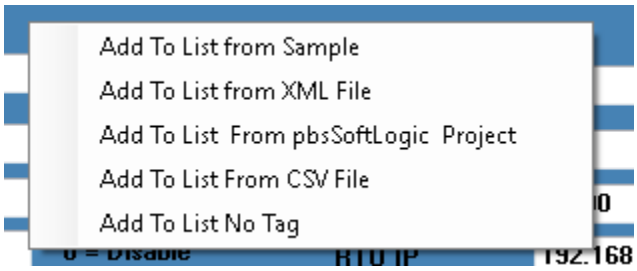
T1Param:IEC104 T1 Parameter(Communication Timeout)

T2 Param : IEC104 T2 Parameter (S Format Period)

T3 Param : IEC104 T3 Parameter (Test Frame Period)

For adding tags to RTU you should follow same rules like DNP3.

After setting RTU name and other parameters , right click on page . you can see following menu :



You can use also AddRTU menu at top of this page . Both has same functionalies.

Add To List From Sample : will add following tags to RTU :

- 8 DI Tags (Digital input)
- 8 AI Tags (Analog Input)
- 8 FI Tags (Float Input)
- 8 DPI Tags (Double Point Binary)
- 8 CNT Tags (Counter)

- 8 FCNT Tags (Freeze Counter Tags)
- 8 DO Tags (Digital Output Command)
- 8 AO Tags (Analog Output Command)
- 8 FO Tags (8 Float Output Command)
- 8 DPO Tags (8 Double Point Binary Command)

DI , AI , FI , DPI , CNT , FCNT , DO , AO , FO , DPO are all data types that you can use .

Add From XML File: Will read Tags from sample XML file

There is a sample file in Configurator folder , TagsIEC.xml . you can edit this file to make Project Specific RTU Tags .

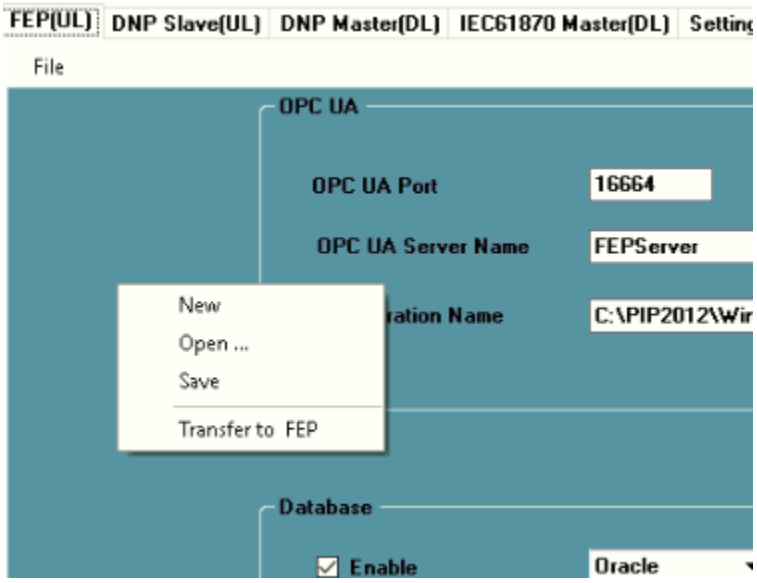
Add To List From pbsSoftLogic project : If you use pbsSoftLogic for RTU configuration and programming , you can easily port IEC tags to pbsFEP . There is a sample pbsSoftLogic IEC tags in Configurator folder \pbsSoftLogicSample\IECSTags.xml .

Add To List from CSV File : you can use CSV File to define RTU Tags . There is sample CSV File in configurator folder TagsIEC.csv . you can use and edit this file to make your RTU Tag File .

Add To List No Tags : It is just add RTU to List without Adding any Tags . you should add Tags Manually to RTU.

Saving configuration

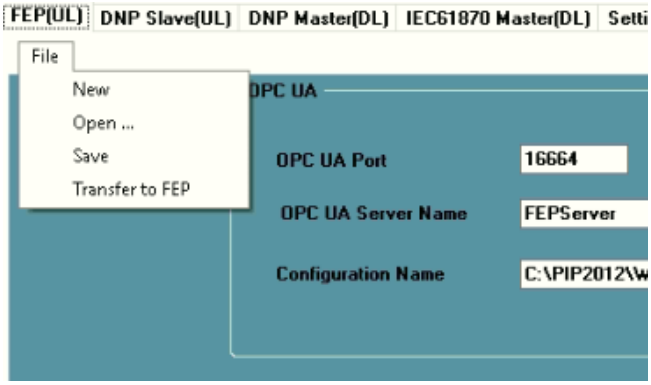
When you finish Configuration, you should save it. Right click on FEP Page. You can see following menu command:



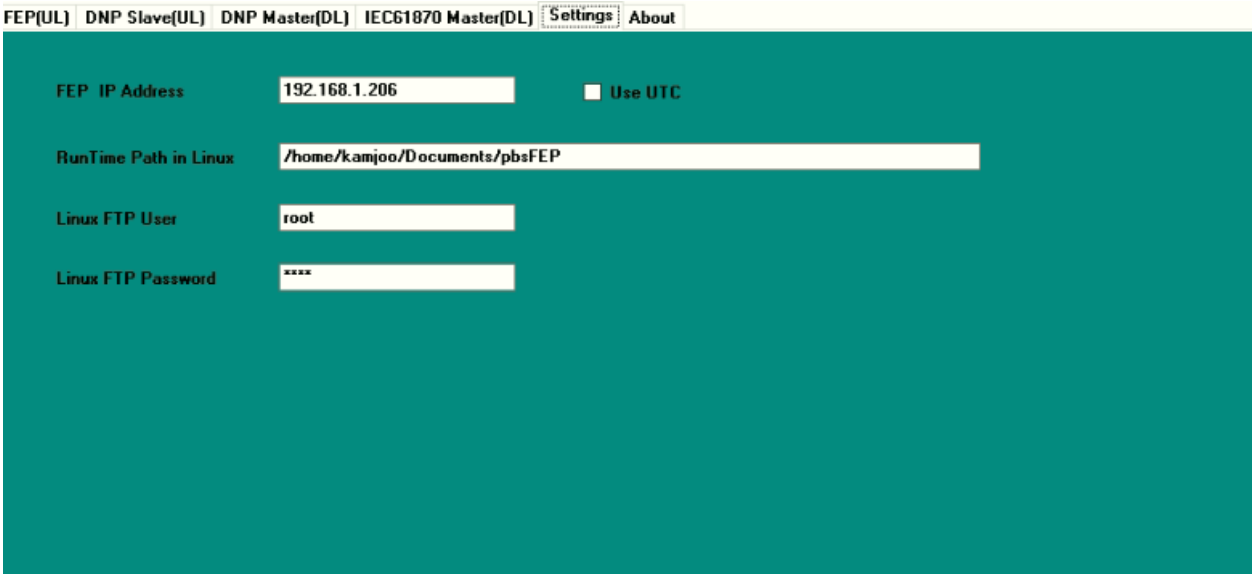
Select Save and if you did not save it before, configurator is asking you the path and name of file.

You can open a saved configurator , by open … command .

You can use menu at top to save configuration too.



For transferring to controller ,you need to set following parameters in Setting page :



FEP IP address : Is IP address of Linux Server that Gateway installed

Runtime Path in Linux : Path of Gateway Folder in Liux Server. FTP user should has read/write access to this path.

FTP address and Password . use by configurator to transfer configuration to server .

Use UTC : if checked , system time in Gateway is consider UTC not Local time .

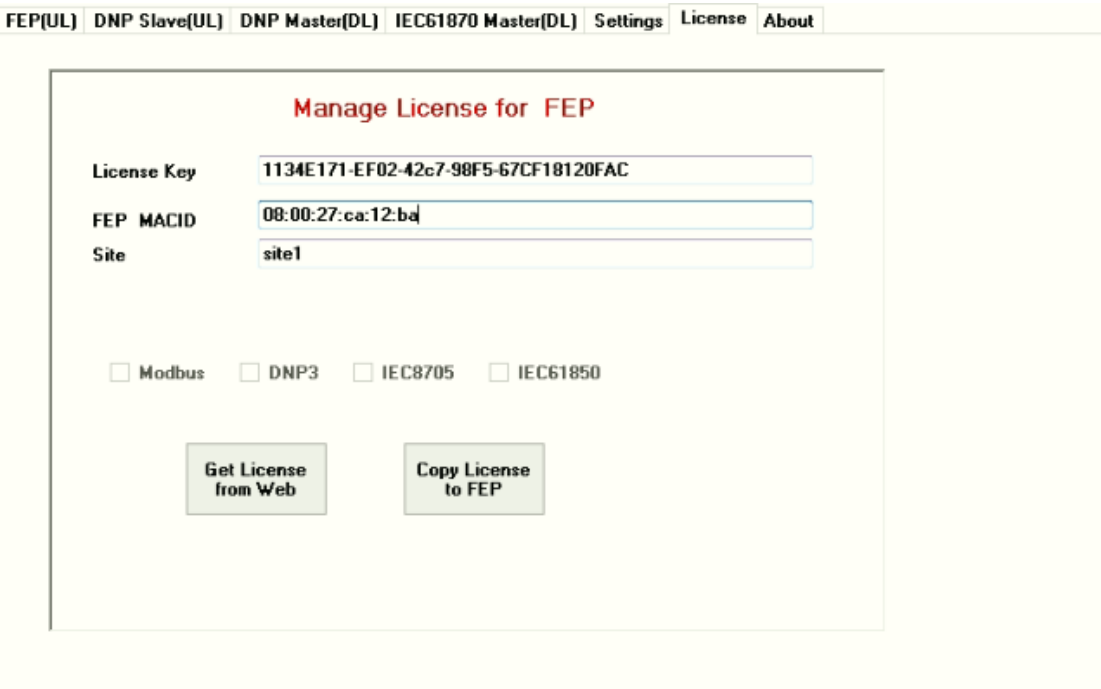
RTUS and gateway should have same Time zone.

Licensing pbsFEP

pbsFEP without License is working for 2 Hours with full functionalities . For final project, you need to purchase license from www.pbscontrol.com

For enabling license, you need to have a license key from supplier.

Select License Tab in configurator:



You need to have Ethernet port MAC ID of your Linux OS.There is simple script in pbsFEP runtime folder getmac.sh run it in linux and it will give you MAC ID of linux . use first one to enable license .

Fill site name and then click on "get License from Web" your Configurator PC should be connected to internet to get license . after a few seconds , license file is ready to transfer to FEP server . Click on "Copy License to FEP"

4- Runtime on Linux

pbsFEP Is running on Linux OS. Compiled version for Ubuntu X64 , Debian X86 and Debian ARMv4 CPU are ready from www.pbscontrol.com web site .

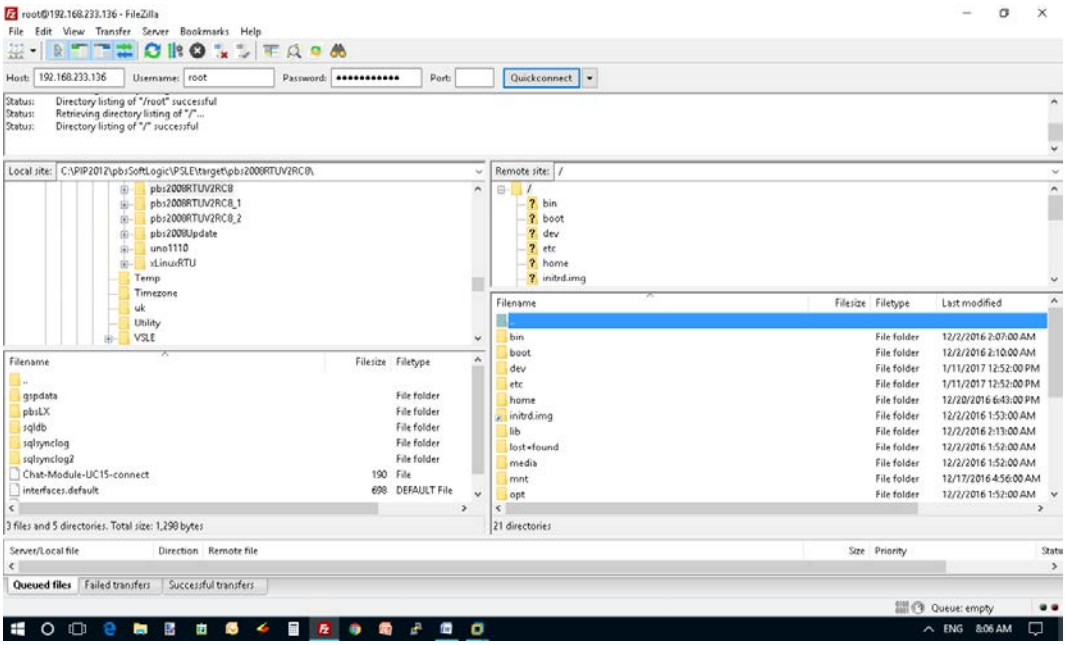
Make a folder in Linux and copy runtime kernel inside folder . Please use utilities like FileZilla to transfer Files between windows and Linux .

Working with FileZilla

You can use FileZilla client utility to explore and edit Linux Files and directories.

Download filezilla from https://filezilla-project.org/

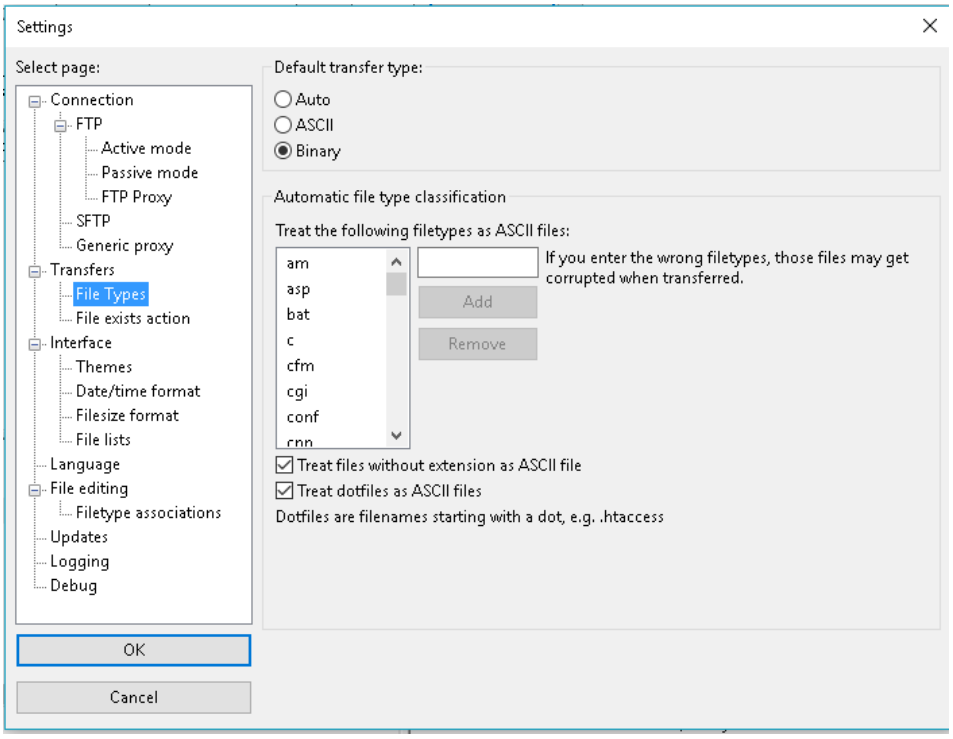
Run filezilla client you will see following page :



Type server IP at host field. Type root and root password in user name and password fields .

Linux directories are showing at right panels and your PC directories at left s panels.

Note : for transferring files between Windows and Linux /WinCE Systems , always set Transfer File Type to Binary. you can find this option in Edit Menu , Setting menu and Transfers Segment .



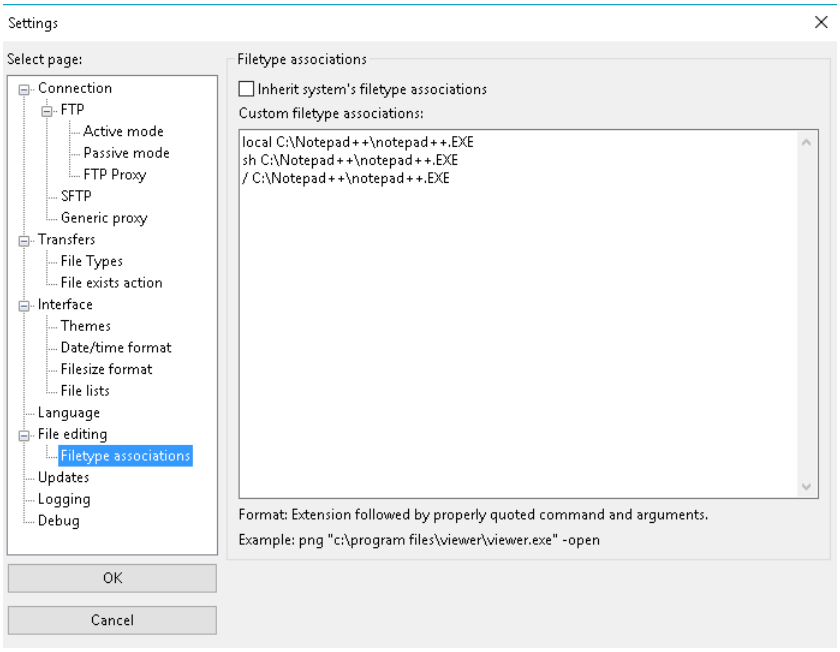
By default it is set to "Auto" that is damaging Linux files at transfer time from Windows to RTU.

For editing RTU configuration files in windows you need to use NotePad++ Editor to not damage Text file format when transfer to windows System .

Install NotePad++ utility from https://notepad-plus-plus.org/

At first time that you View/Edit any Linux Configuration file , Filezilla will ask you for Custom Editor .

In this Stage set Nodepad++ as default editor in Filezilla . This will change File Editing Option in Setting page as following :



After transferring runtime kernel to Linux , connect to Linux by telnet or SSH and change pbsFEPLX program mode to execution by following command :

chmod +x pbsFEPLX

For running gateway use following command:

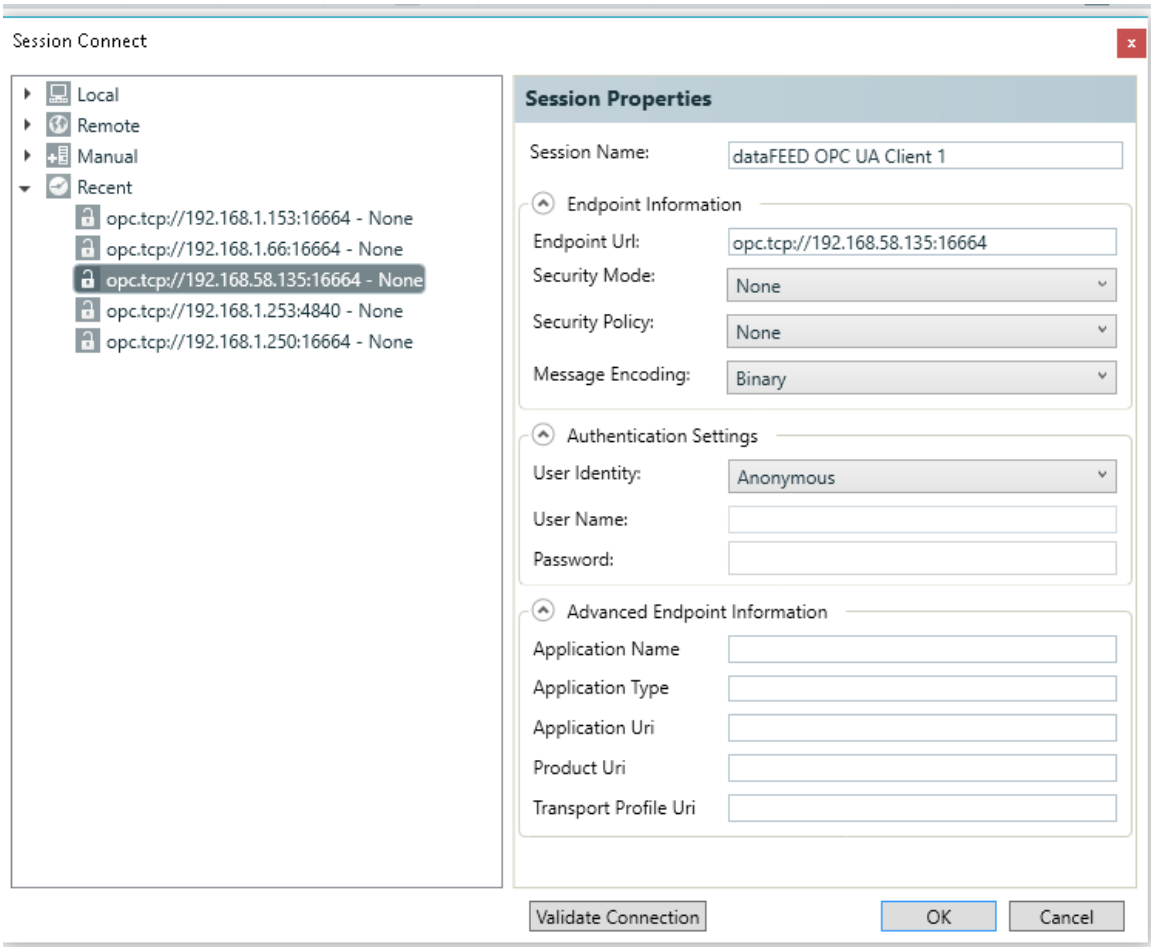
./ pbsFEPLX

For automatic startup of Gateway, please get support from your company Linux administrator, because it is different for each version of Linux.

OPC UA Connection

You can use any standard OPC UA Browser Like Softing or UaExpert to connect to gateway .

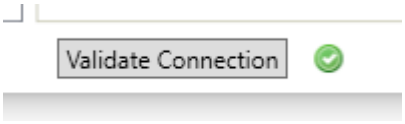
Download and run Softing DataFeed OPC Client. In Project Pane, Double click on Add Session :



In Endpoint Url : type opc.tcp://192.168.58.135:16664

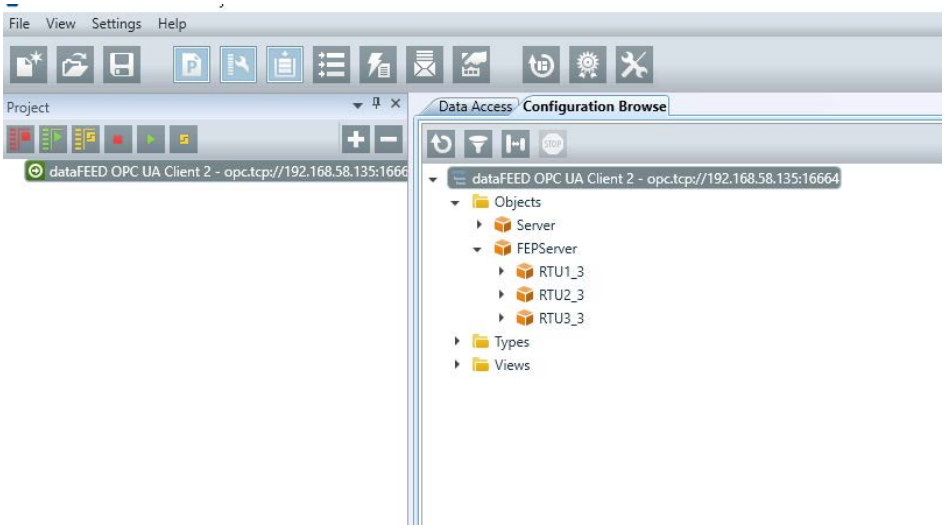
Change 192.168.58.135 to your Linux IP address and change 16664 to port that you set in OPC UA Setting of Gateway .

Click on validate connection and wait for validation.

If connection validated, you will see a small green circle close to button. 

Please check your Firewall setting for OPC UA Port number. If OPC UA Port is blocked, you couldn't connect to Gateway. Please get support from network administrator.

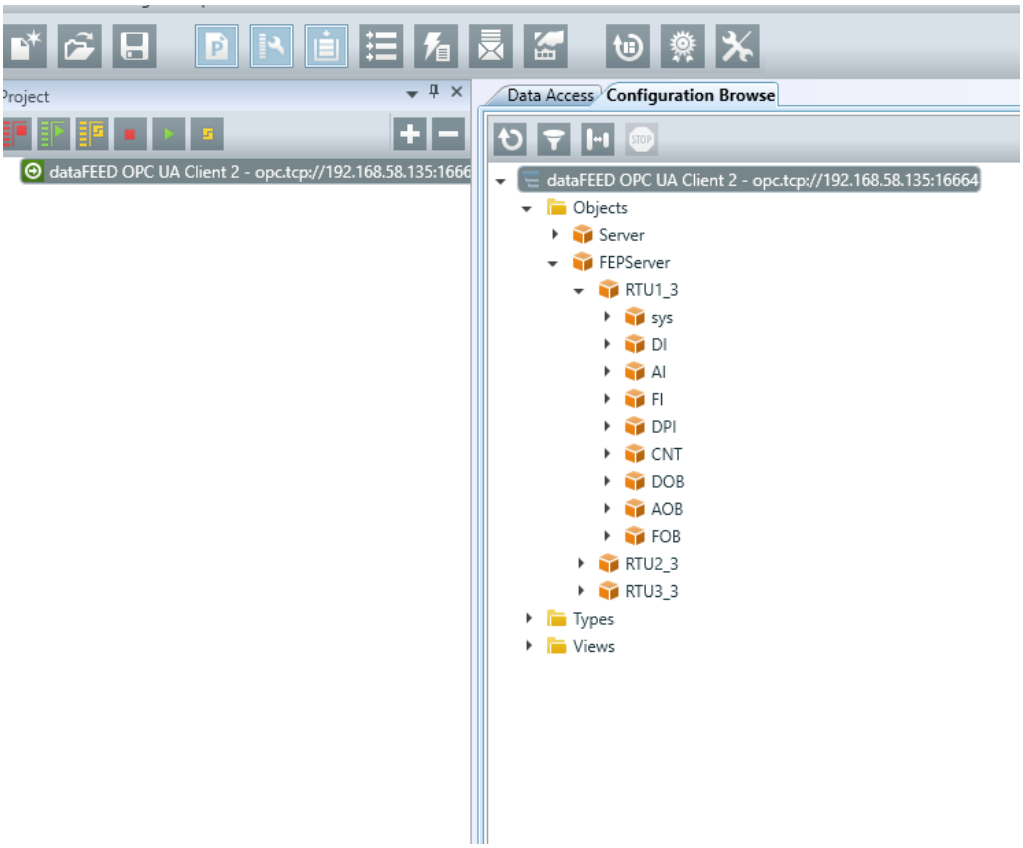
Click on OK Button you will see Gateway Server at Configuration Browser page :



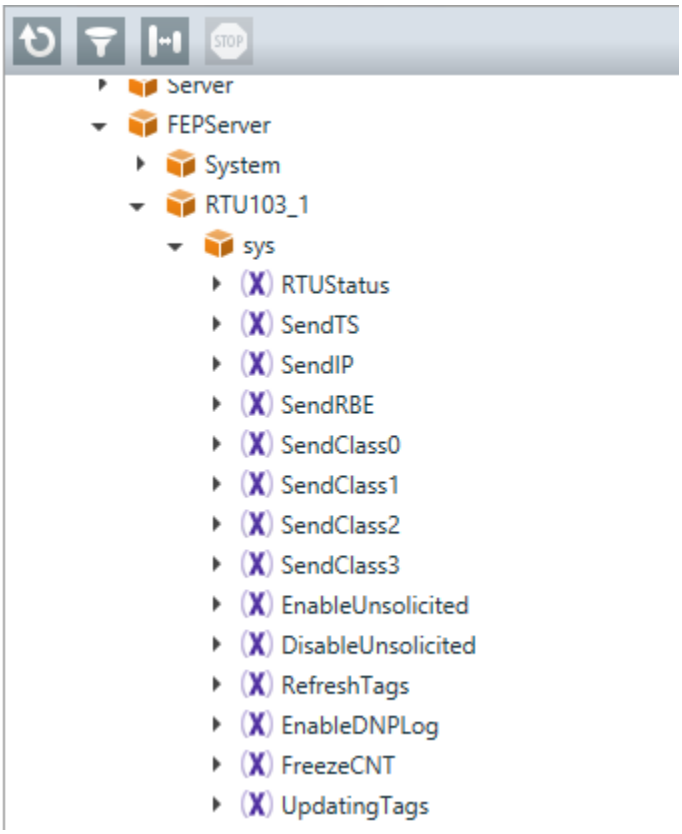
FEPServer is the server name that you set in OC UA Page of configurator.

Under FEPServer , you can see list of RTUS . RTU name is make by RTU name that is selected in configuration time and RTU ID.

Open one RTU , you can see tag list .



There is a specific folder for SYS tags . you will find all system tags in this folder .



For other RTU tags , if you put dot "." In tag name , gateway will make folder based on "."

Suppose you add following tags to RTU :

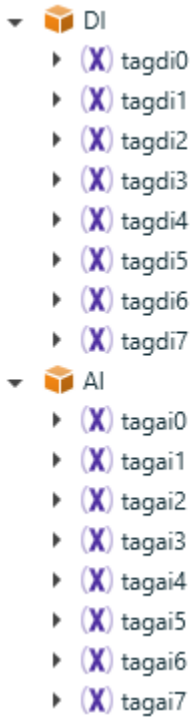
DI.DI1

DI.DI2

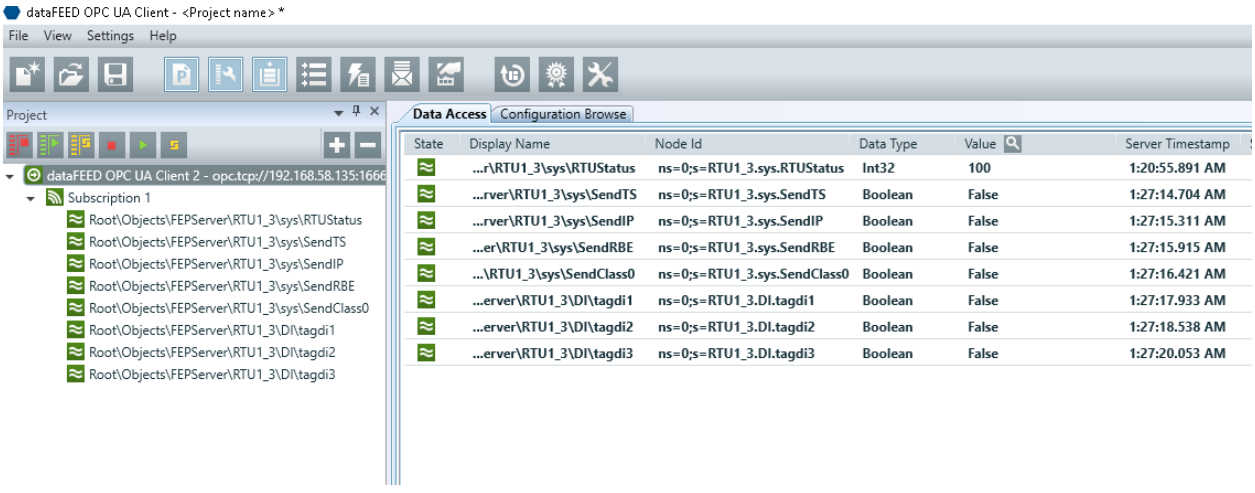
AI.AI1

AI.AI2

Then gateway will define two folder for DI and AI and puts DI1 and DI2 in DI folder and AI1 and AI2 in AI Folder.



Double click on Tag Name, Browser will add tag to Data Access page:

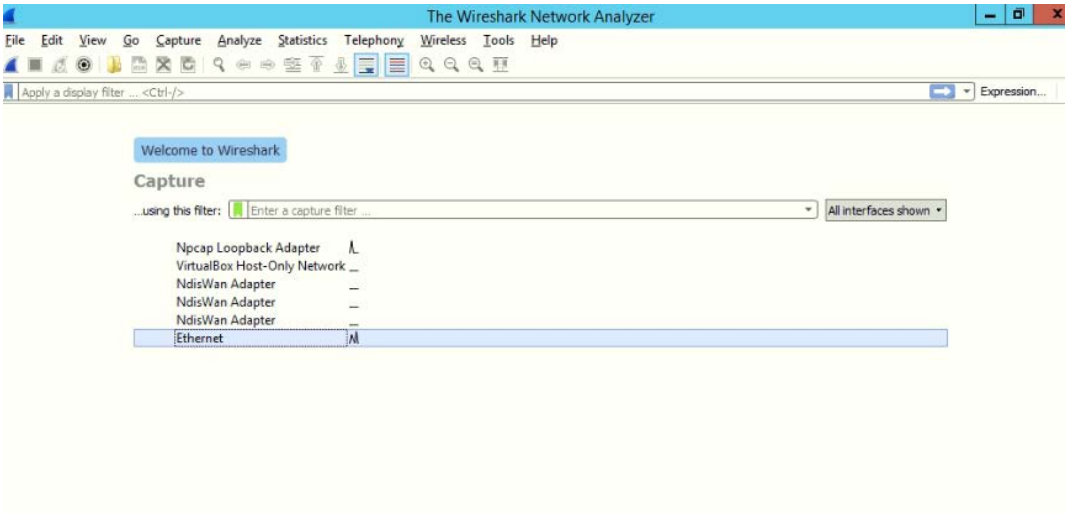


You can see tag value and change them from this page.

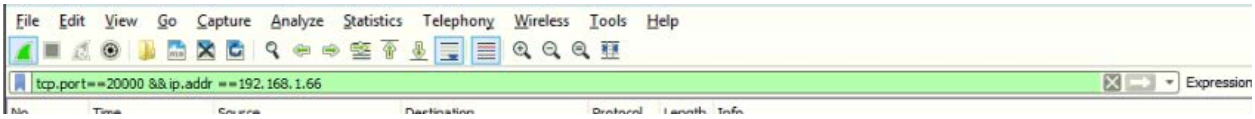
You can use wireshark software to monitor and analyze DNP3 /IEC04 communication between Downlink RTUs and pbsFEP.

Wireshark is free protocol analyzer . please download from https://www.wireshark.org/

Run Wireshark and select Ethernet port that you want to monitor communication.

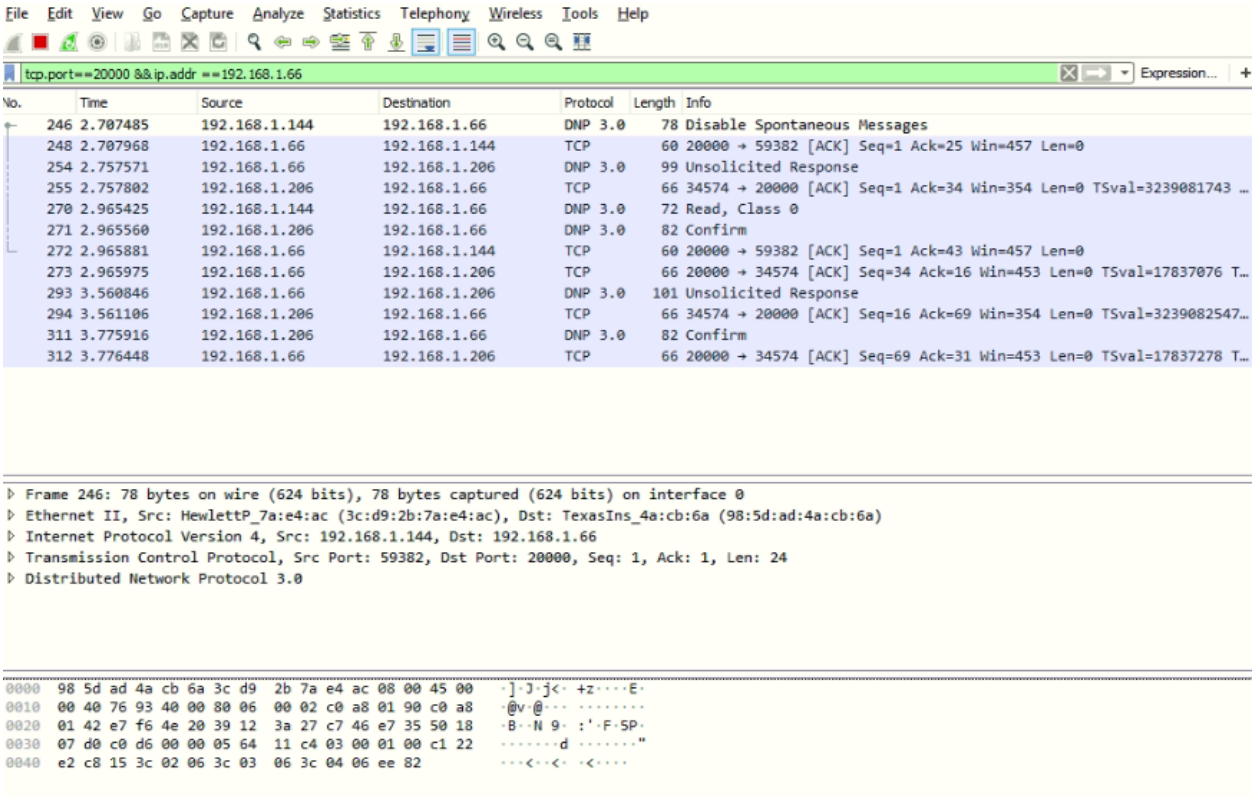


You can use filter for focusing on specific IP and TCP port like following :

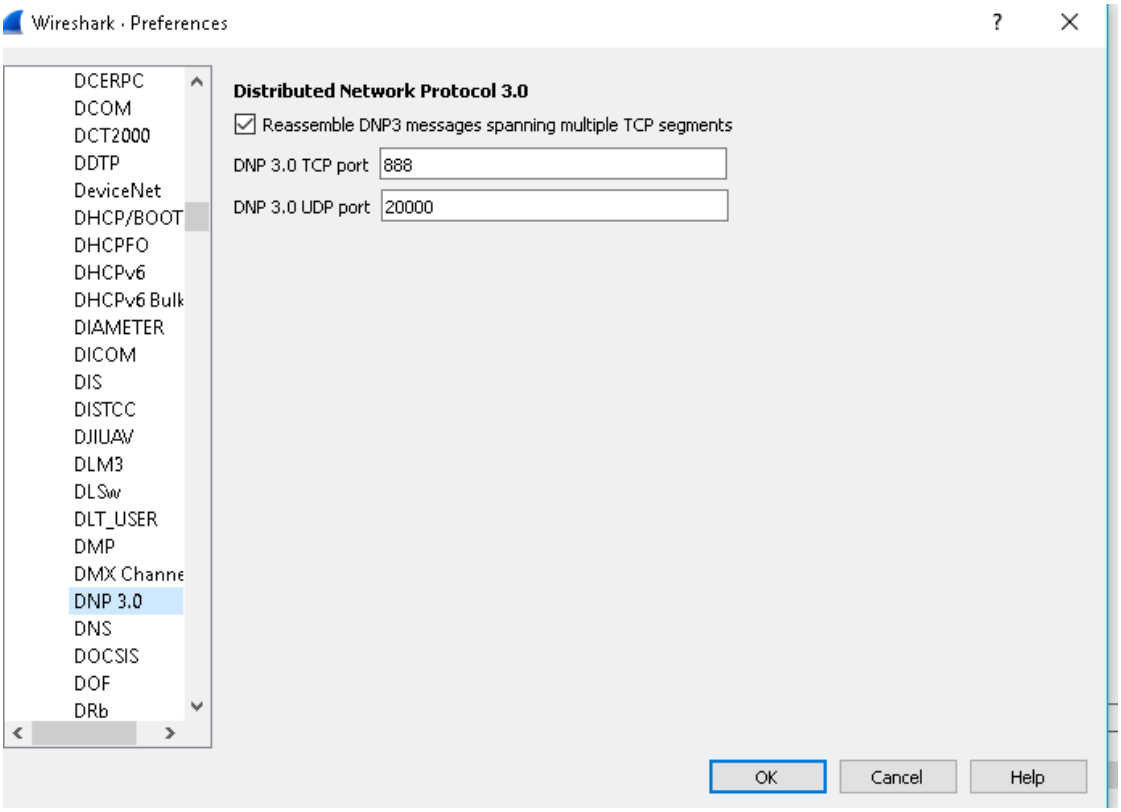


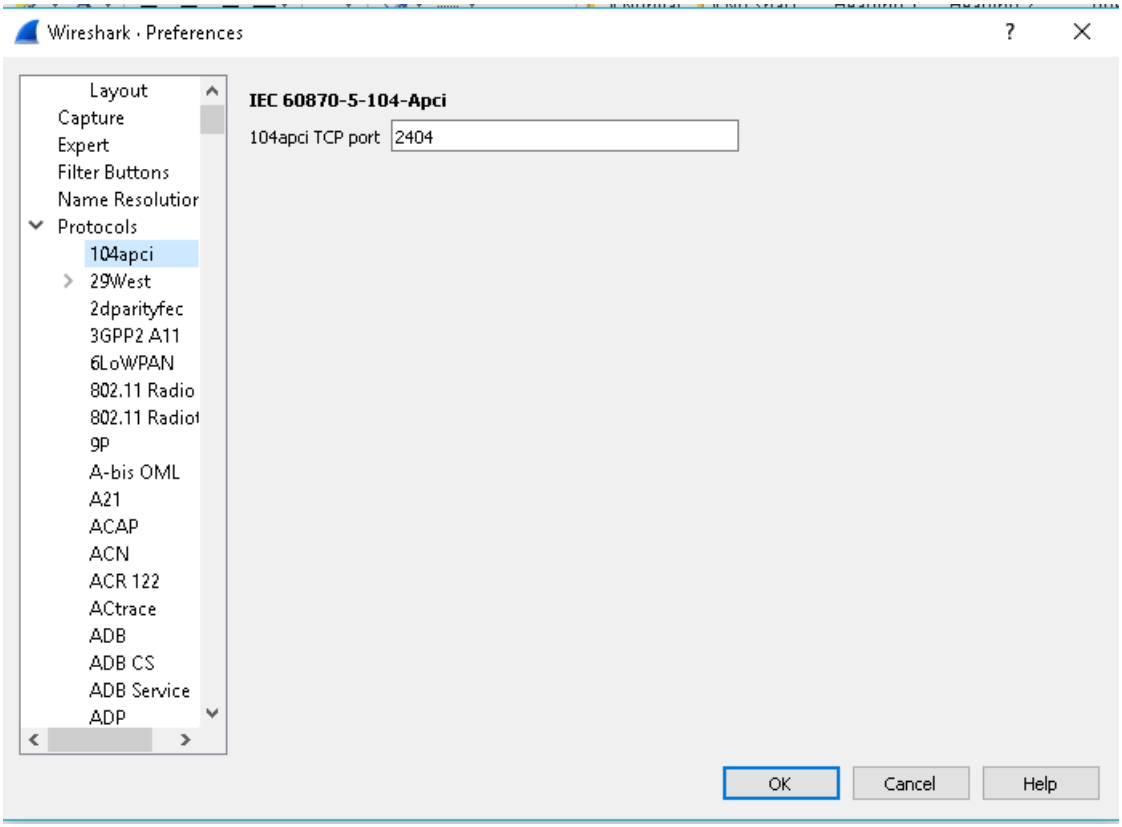
For starting capturing , click on Shark icon at top . and then click on blue arrow at right to enable filter . For above filter , you can see All DNP3 Frames between

pbsFEP (IP 192.168.1.206) and Specified RTU IP (192.168.1.66) as following :



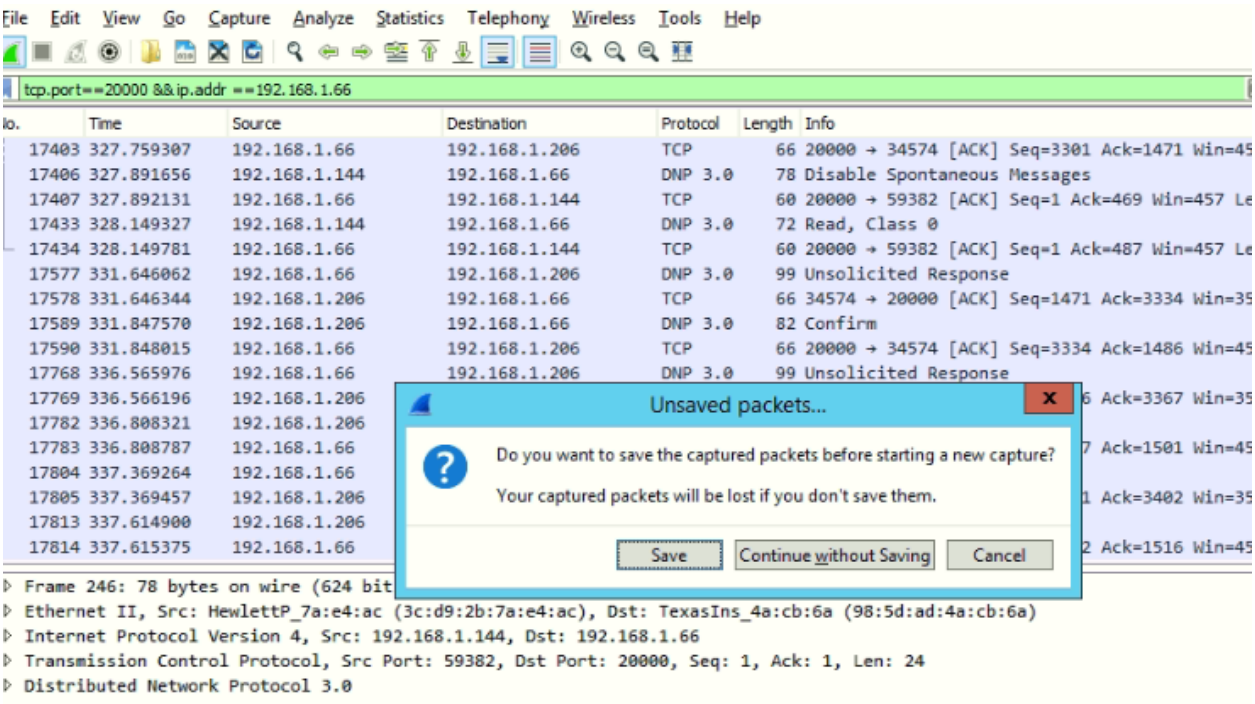
Because TCP port 20000 is specified for DNP3 , if you use other port for DNP3 communication , then Wireshark will show you frames but couldn't understand this is DNP3 frame. So for testing communication always use port 20000 for DNP3 , port 2404 for IEC104 and port 512 for modbusTCP. you can change default DNP3 and IEC104 port number in Wireshark from Edit/Prefrence/Protocols menu and select DNP3 or IEC104 and change Default port number .


Wireshark · Preferences
DCERPC
DCOM
DCT2000
DDTP
DeviceNet
DHCP/BOOT
DHCPFO
DHCPv6
DHCPv6 Bulk
DIAMETER
DICOM
DIS
DISTCC
DJIUAV
DLM3
DLSw
DLT_USER
DMP
DMX Channe
DNP 3.0
DNS
DOCSIS
DOF
DRb
Distributed Network Protocol 3.0
Reassemble DNP3 messages spanning multiple TCP segments
DNP 3.0 TCP port 888
DNP 3.0 UDP port 20000
OK
Cancel
Help


Wireshark · Preferences
Layout
Capture
Expert
Filter Buttons
Name Resolutior
Protocols
104apci
29West
2dparityfec
3GPP2 A11
6LoWPAN
802.11 Radio
802.11 Radiot
9P
A-bis OML
A21
ACAP
ACN
ACR 122
ACtrace
ADB
ADB CS
ADB Service
ADP
IEC 60870-5-104-Apci
104apci TCP port 2404
OK
Cancel
Help

When you have problem in communication in your project , you can save all frames and send to pbscontrol company for analyzing pbsFEP operation .

For saving frames , click on Stop red button . Then click again on Start Capturing , Wireshark with answer you for saving frames .



click on save button and select file for saving frames .

We can open your save file by Wireshark and see all the detail of communication between RTU and pbsFEP .

It will help us too much to increase pbsFEP performance and operation with different type of RTUs.

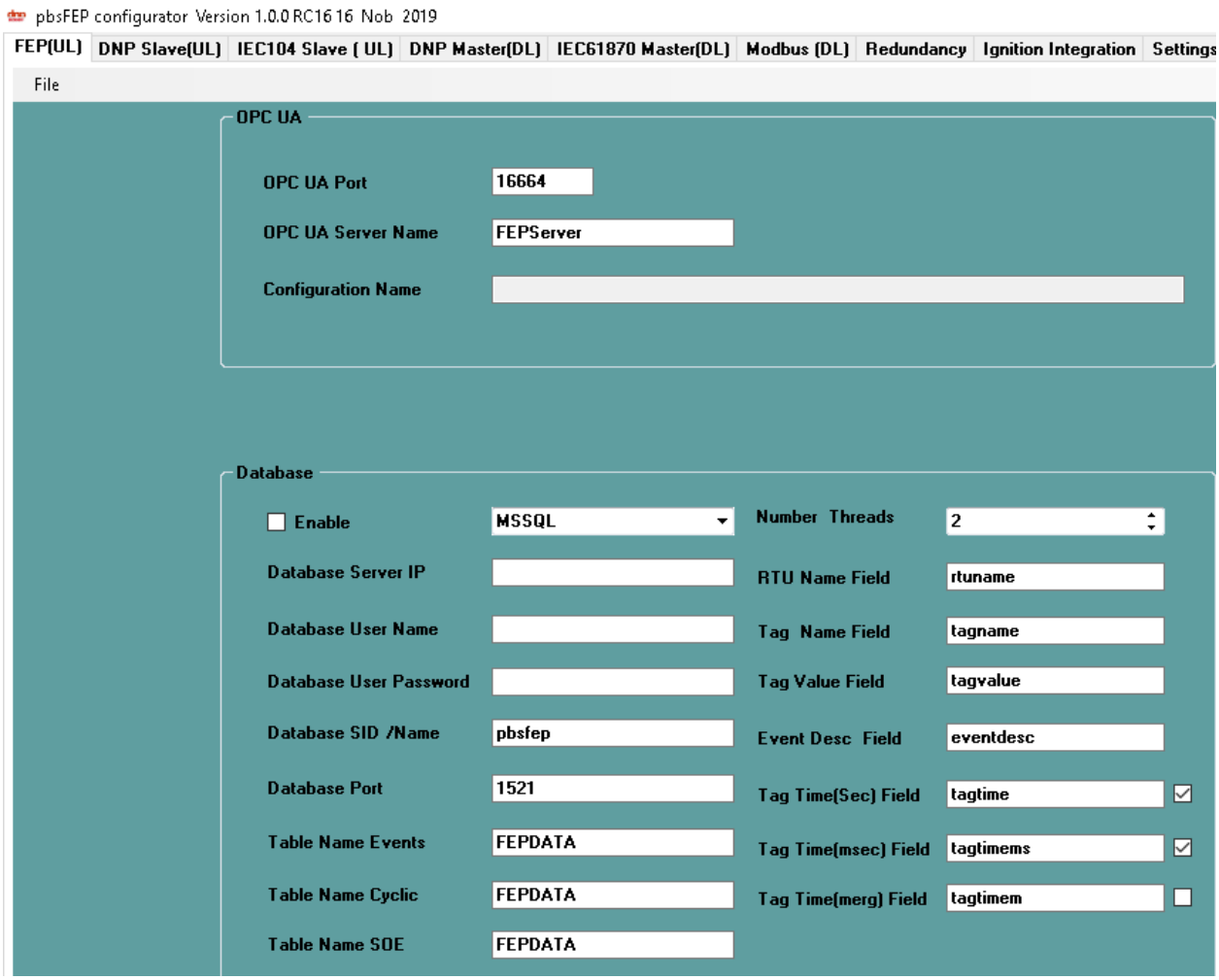
With Wireshark you can see detail of DNP3 /IEC104/Modbus frames .

5 - Data logging configuration

pbsFEP can save downlink RTU data in Oracle or MS SQL Server database .

Oracle Data base can be installed at same FEP System or on another Server , but SQL Server should be on another server because SQL server is running on Windows .

At FEP page in configurator you can see following page :



Click on Enable to Enabling for all RTUs data logging on Oracle or SQL Server .

For interfacing with Oracle we used odpi API and for SQL Server , we used freetds API .

In FEP Server , you need to install freetds by following command :

```
sudo apt-get install -y freetds-bin freetds-common freetds-dev
```

For Oracle, you need to install Oracle Instance client on the Server.

Download the Instant Client installer first. Install alien package to be able to install rpm packages by typing following command in terminal.

sudo apt-get install alien

Once that is done, locate the rpm files and execute the following:

sudo alien -i oracle-instantclient*-basic*.rpm

sudo alien -i oracle-instantclient*-sqlplus*.rpm

sudo alien -i oracle-instantclient*-devel*.rpm

Installing libaio is needed. The following command will install it:

sudo apt-get install libaio1

Create Oracle configuration file and update the configuration by running the following command:

sudo vi /etc/ld.so.conf.d/oracle.conf

/usr/lib/oracle/19.3/client64/lib/

sudo ldconfig

For connecting to database:

#sqlplus<sername>/<password>@<host>:<port>/<service name>

Database Server IP: Specify Oracle or SQL Server IP address. For Oracle you can set two Redundant IP address separating by; Like 192.168.1.10;192.168.1.20

Database User Name: Asking your database Administrator to make a User and put User name in this field . Connect and Insert at least should be grant to user.

Database User Password: Password of defined User.

Database SID/ Name: For Oracle there is SID name and for SQL Server this field is name of Database. For oracle you can set two redundant SID separating by ; like SID1;SID2

Database Port : For Oracle Set this filed with port number that is defined when Administrator defined database.by default it is 1521 , 1522 or 1523 .

Table Name Event: you can use default names in this page or change name of Tables and fields. this parameter is name of table that is used for events archiving .

Table Name Cyclic: you can use default names in this page or change name of Tables and fields. this parameter is name of table that is used for Cyclic Data archiving .

If you use same name for both , all data will archive in one table .

RTU Name Field: Name of Column in Event table or cyclic table for RTU name .

Tag Name Field: Name of Column in Event table or cyclic table for Tag name .

Event Description Field: Name of Column in Event table or cyclic table for Event Description.

Tag Value Field: Name of Column in Event table or cyclic table for Tag Value.

RTU Name Field: Name of Column in Event table or cyclic table for RTU name .

Tag Time (Sec) Field: Name of Column in Event table or cyclic table for Tag time Seconds part .

Tag Time (msec) Field: Name of Column in Event table or cyclic table for Tag time milliseconds part.

Tag Time (merg) Field: Name of Column in Event table or cyclic table for Tag time which is merge of Second field and millisecond field.

Following select are valid for tag time:

- Select only Tag Time (Second)
- Select Tag Time (Sec) and Millisecond
- Select Only Tag Time (merg)

Your database administrator , should make a database and define FEPDATA Table as following which is defined by Oracle SQL Developer :

FEPDATA

Columns | Data | Model | Constraints | Grants | Statistics | Triggers | Flashback | Dependencies | Details | Partitions | Indexes | SQL

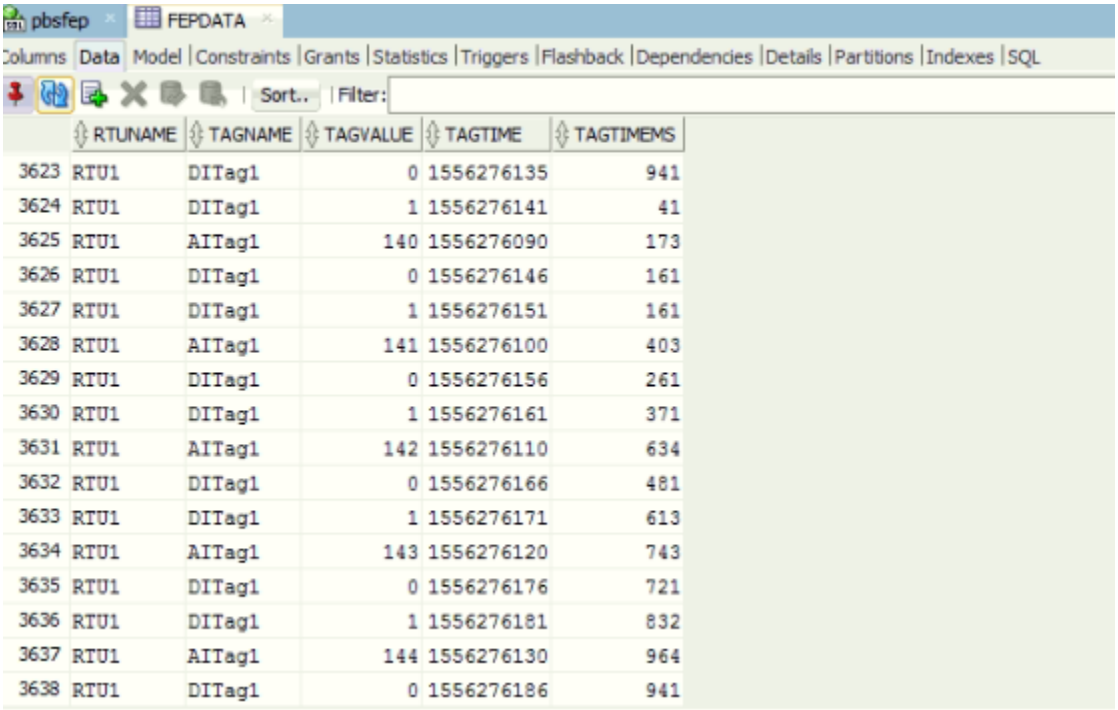
Sort.. | Filter:

	RTUNAME	TAGNAME	TAGVALUE	TAGTIME	TAGTIMEMS	EVENTDESC	TAGTIMEM
255	RTU2	FITag1	3908.5...	(null)	(null)	(null)	1560949485000
256	RTU2	FITag64	3908.5...	(null)	(null)	(null)	1560949485000
257	RTU2	DITag2	1	(null)	(null)	(null)	1560949485000
258	RTU2	DITag124	1	(null)	(null)	(null)	1560949485000
259	RTU1	DITag10	0	(null)	(null)	bahar	1558287290083
260	RTU2	DITag2	0	(null)	(null)	(null)	1560949490000
261	RTU2	DITag124	0	(null)	(null)	(null)	1560949490000
262	RTU2	FITag1	3918.8...	(null)	(null)	(null)	1560949495000
263	RTU2	FITag64	3918.8...	(null)	(null)	(null)	1560949495000
264	RTU2	DITag2	1	(null)	(null)	(null)	1560949495000
265	RTU2	DITag124	1	(null)	(null)	(null)	1560949495000
266	RTU2	AITag1	379	(null)	(null)	(null)	1560949495000
267	RTU1	DITag10	1	(null)	(null)	baran	1558287295106
268	RTU2	DITag2	0	(null)	(null)	(null)	1560949500000
269	RTU2	DITag124	0	(null)	(null)	(null)	1560949500000
270	RTU1	DITag10	0	(null)	(null)	bahar	1558287300127

```
CREATE TABLE "KAMJOO2"."FEPDATA"
 (    "RTUNAME" VARCHAR2(64 BYTE) NOT NULL ENABLE,
  "TAGNAME" VARCHAR2(256 BYTE) NOT NULL ENABLE,
  "TAGVALUE" FLOAT(126) NOT NULL ENABLE,
  "TAGTIME" NUMBER,
  "TAGTIMEMS" NUMBER,
  "EVENTDESC" VARCHAR2(64 BYTE),
  "TAGTIMEM" NUMBER
 ) SEGMENT CREATION IMMEDIATE
PCTFREE 10 PCTUSED 40 INITRANS 1 MAXTRANS 255
NOCOMPRESS LOGGING
 STORAGE(INITIAL 65536 NEXT 1048576 MINEXTENTS 1 MAXEXTENTS 2147483645
 PCTINCREASE 0 FREELISTS 1 FREELIST GROUPS 1
 BUFFER_POOL DEFAULT FLASH_CACHE DEFAULT CELL_FLASH_CACHE DEFAULT)
 TABLESPACE "USERS" ;
```

You can check connection with database with Oracle SQL Developer first . you need to define Specified TCP port for Firewall system in Oracle Server and check that all necessary Oracle Services are running properly for correct connection .

You can see logged data by Oracle SQL Developer :


pbsfep FEPDATA

Columns | Data | Model | Constraints | Grants | Statistics | Triggers | Flashback | Dependencies | Details | Partitions | Indexes | SQL

Sort.. | Filter:

	RTUNAME	TAGNAME	TAGVALUE	TAGTIME	TAGTIMEMS
3623	RTU1	DITag1	0	1556276135	941
3624	RTU1	DITag1	1	1556276141	41
3625	RTU1	AITag1	140	1556276090	173
3626	RTU1	DITag1	0	1556276146	161
3627	RTU1	DITag1	1	1556276151	161
3628	RTU1	AITag1	141	1556276100	403
3629	RTU1	DITag1	0	1556276156	261
3630	RTU1	DITag1	1	1556276161	371
3631	RTU1	AITag1	142	1556276110	634
3632	RTU1	DITag1	0	1556276166	481
3633	RTU1	DITag1	1	1556276171	613
3634	RTU1	AITag1	143	1556276120	743
3635	RTU1	DITag1	0	1556276176	721
3636	RTU1	DITag1	1	1556276181	832
3637	RTU1	AITag1	144	1556276130	964
3638	RTU1	DITag1	0	1556276186	941

Archived fields are as following:

- RTUName (Max 64 char)
- TagName (Max 256 Char)
- EventDesc(Max 64 Char)
- TagValue Double
- Tag Time in Second from 1/1/1970

- TagTimems : millisecond of Tag time

In oracle SQL developer you can see string readable format for time label by following query :

```
SELECT RTUNAME as "Station Name",
               TAGNAME as "Device Name",
               TAGVALUE as "Value",
               TO_CHAR(TIMESTAMP '1970-01-01 00:00:00 GMT' + NUMTODSINTERVAL(TAGTIMEM/1000,
               'SECOND'),'mm/dd/yyyy hh24:mi:ss') as "Timestamp"
FROM FEPDATA
```

For MS SQL Server define a database and define FEPDATA Table with following script to database:

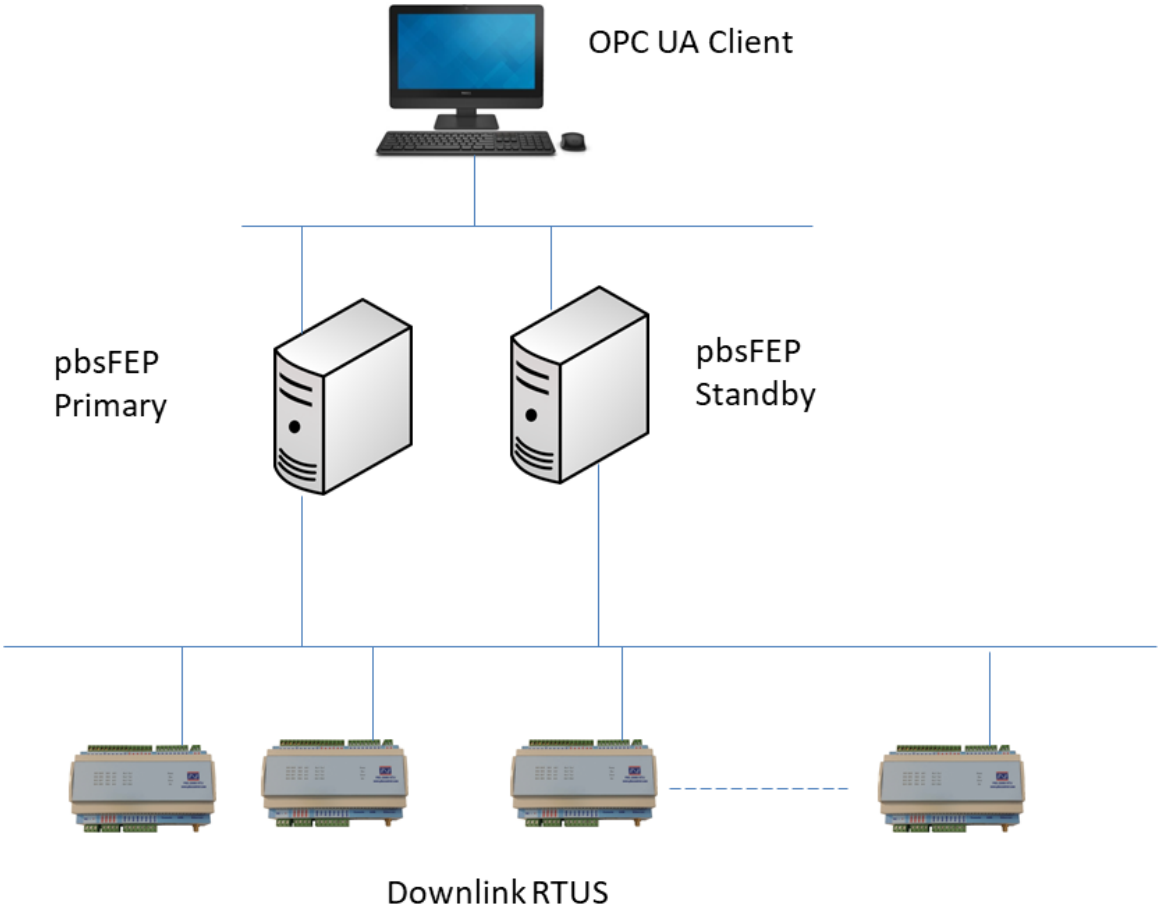
```
USE [pbsHMI]
GO

/****** Object:  Table [dbo].[FEPDATA]    Script Date: 4/26/2019 1
SET ANSI_NULLS ON
GO

SET QUOTED_IDENTIFIER ON
GO

CREATE TABLE [dbo].[FEPDATA](
    [rtuname] [nvarchar](64) NOT NULL,
    [tagname] [nvarchar](256) NOT NULL,
    [tagvalue] [real] NOT NULL,
    [tagtime] [bigint] NOT NULL,
    [tagtimems] [int] NOT NULL
) ON [PRIMARY]

GO
```

- RTUName (Max 64 char)
- TagName (Max 256 Char)
- EventDesc(Max 64 Char)
- TagValue Double

- Tag Time in Second from 1/1/1970
- TagTimems : millisecond of Tag time

Redundancy Operation

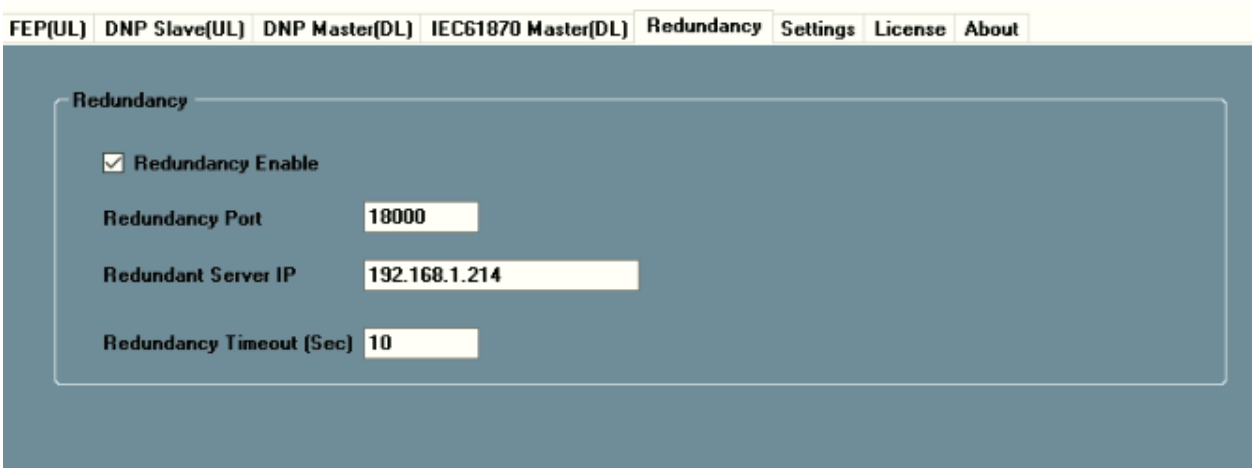
In following figure you can see pbsFEP Redundancy concepts:



Primary FEP is active and communicates with Downlink RTUS.

Standby FEP is standby and not communicate with Downlink RTUS.

You can see following parameters in Configurator for redundancy:



Redundancy Enable : Enables FEP redundancy

Redundancy port : TCP port that is used for redundancy

Redundancy Server IP : IP address for the other server .

Redundancy timeout : timeout that is check by Standby to switch to primary if primary failed .

When one server is loading it will do following tasks :

1- For Redundancy Timeout Sec , checking for any TCP connection on Redundancy Port . if other server is connected , then this FEP is standby .
2- If no other server is connect to FEP , So it is working at primary . Primary FEP is sending TCP connect request periodically to find standby server when loaded .
3- If primary failed , standby is not receiving any data from primary, So standby will check for redundancy timeout sec and after that it will work as primary .

Standby FEP is not communicating with Downlink RTUS and no data logging.
At runtime there is OPC UA tags SYS.RedStatus which is shows redundancy status for this FEP .
SYS.RedStatus = 1 , Primary
SYS.RedStatus = 2 , Standby

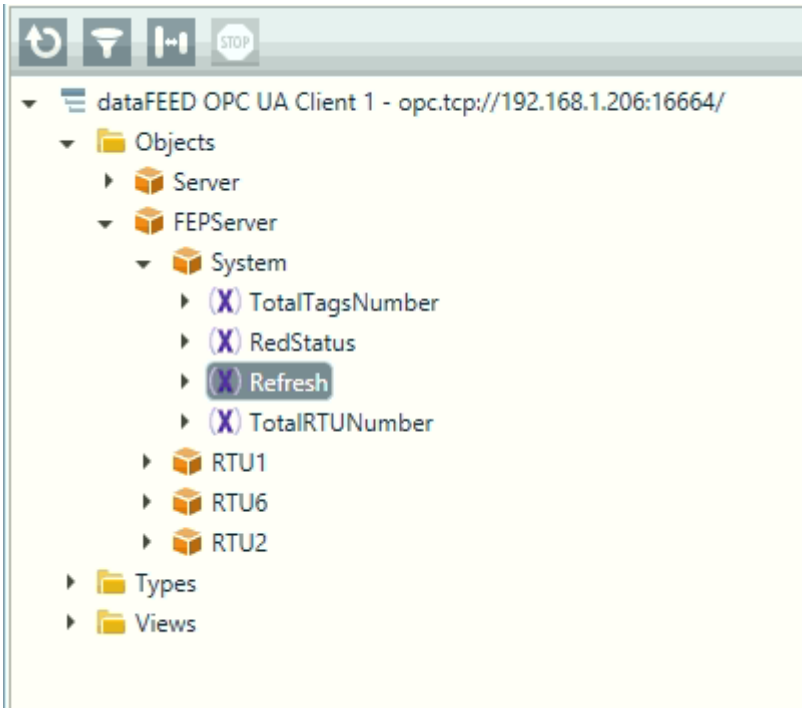
OPC UA Client should support Redundancy for connection with FEP Servers . This means you should define two IP address in OPC UA Client . So OPC UA Client

will connect to one of them and when couldn't communicate with that channel will switch to other Link .

Online Operation of pbsFEP

You can add new RTU to pbsFEP without Restarting FEP .

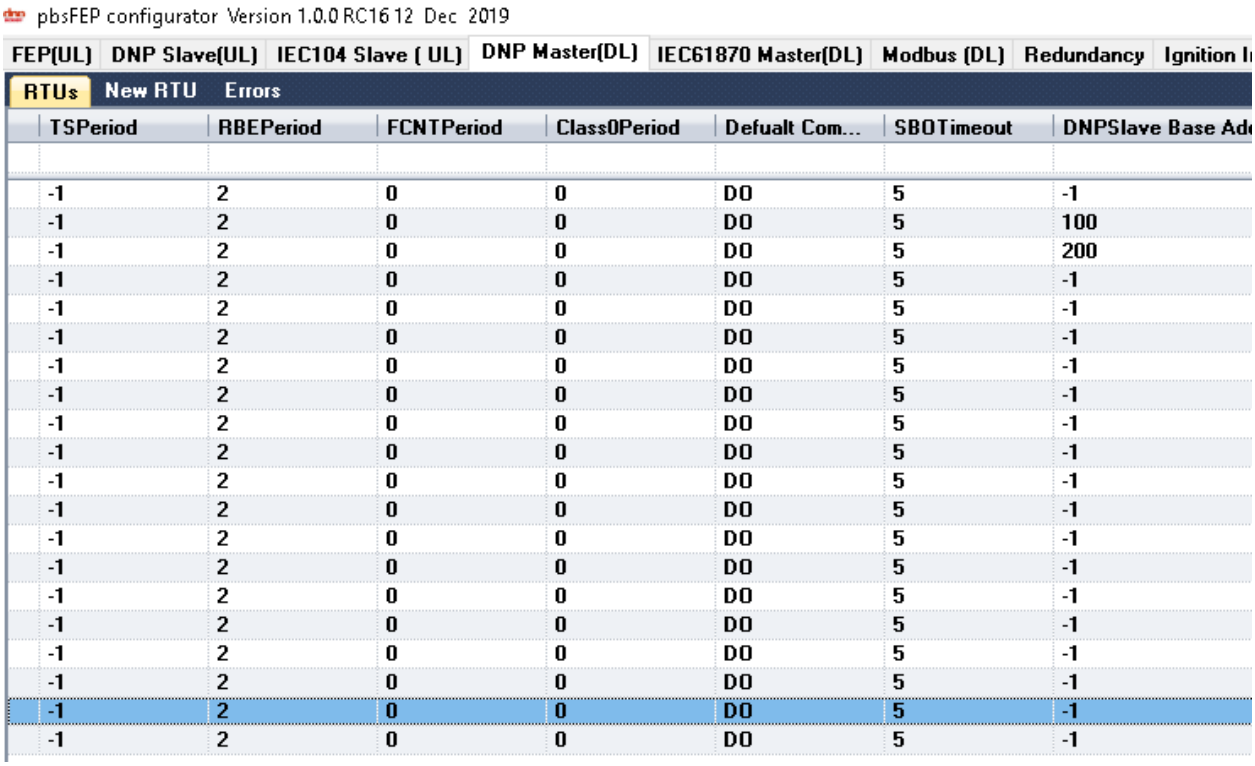
After adding New RTU to configurator and transfer to Runtime kernel , change system.Refresh Tag from 0 to 1. This will add new RTU to FEP and make it operational.



It is not possible to delete RTU online . you can only add new RTU and make RTU Disable by RTU SYS.DisableRTU Enable by System.refresh Tag .

6 – DNP3 Slave System tags

Following system tags are added to DNP3 Slave kernel of FEP if DNPSIndexAddress is not -1 and DNPSlaveBAseAdd is not set to -1. If you set DNPSlaveBAseAdd to -1, FEP will not defined any DNP Slave Tag for this RTU.



TSPeriod	RBEPeriod	FCNTPeriod	Class0Period	Defualt Com...	SBOTimeout	DNPSlave Base Ad
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	100
-1	2	0	0	DO	5	200
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1
-1	2	0	0	DO	5	-1

In above figure only for 2 RTU , system tags will defined in DNP3 Slave Kernel .

RTU Status – Tag Address = 1 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd , AI

CROB_Address – Tag Address = 20 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,AOB

CROB_ControlCode – Tag Address = 21, DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd,AOB

CROB_Count – Tag Address = 22 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd,AOB

CROB_OnTime – Tag Address = 23 , DNP3 Address in DNP3 Slave Kernel DNPSlaveBaseAdd+DNPSIndexAdd,AOB

CROB_OffTime – Tag Address = 24 , DNP3 Address in DNP3 Slave Kernel DNPSlaveBaseAdd+DNPSIndexAdd,AOB

CROB_Select – Tag Address = 25 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_Operate – Tag Address = 26 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_DirOperate – Tag Address = 27 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_Status – Tag Address = 28 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,AI

CROB_Add2List – Tag Address = 45 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_DirOperateList – Tag Address = 46 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_ClearList – Tag Address = 47 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_SBOTimeout – Tag Address = 50 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,AOB

CROB_DirOperateNoACK– Tag Address = 51 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

CROB_DirOperatenoACKList – Tag Address = 52 , DNP3 Address in DNP3 Slave Kernel = DNPSlaveBaseAdd+DNPSIndexAdd ,DOB

With above system tags , any external DNP3 Master Software can send CROB commands to RTUs through FEP.

7- Gateway Specification

- Number of Downlink Connection: 256
- Number of Tag for each Downlink RTU: 5000
- Number of DNP3 Uplink connection : 7
- Number of DNP3 Uplink Tags : 1,0240
- DNP3 Level 3 Implementation
- Following DNP Functions are not Supported in V3 RC5 :

  File Transfer , Group 0 , Data Set , Virtual Terminal
- RS485 Mode is not supported. (no Collision Avoidance)
- Receiver Inter character Timeout : Not Checked
- UDP Datagram is not supported
- Confirmation in Data Link Layer is always Off .
- Supported Qualifier :
  - Prefix 0 Range 0,1,2
  - Prefix 1 Range 7,8,9
  - Prefix 2 Range 7,8,9
  - Prefix 3 Range 7,8,9
- Supported Groups :
  - DI Group 1 , Variation 1,2,3
  - DI Group 2 : Variation 1 ,2

- DPI Group 3 : Variation 2
- DPI Group 4 : Variation 1 , 2
- DO Group 10 : Variation 1,2
- DO Group 11 : Variation 1 , 2
- DOB Group 12 : Variation 1
- CNT Group 20 : Variation 1 , 2, 5,6
- CNT Group 21 : Variation 1,2,5,6,9,10
- CNT Group 22 : Variation 1 , 2, 5, 6
- CNT Group 23 : Variation 1 , 2, 5, 6
- AI Group 30 : Variation 1 , 2, 3, 4, 5, 6
- AI Group 32 : Variation 1,2,3,4,5,6,7,8
- AO Group40 : Variation 1,2,3,4
- AOB Group 41 : Variation 1
- AO Group 42 : Variation 1,2,3,4,5,6,7,8

8 – DNP3 Concepts

In DNP3 main data types are Digital(Binary) Input, Analog Input, Double Bit Binary Input, Counter, Frozen Counter, Digital(Binary) Outputs Status, Analog Output Status, Digital Output Command and Analog Output Command.

Any DNP3 Tag has current value (Class0) and buffered value (Class 1 , 2, 3) . Based on DNP3 Standard there is no priority for different class 1 , 2 and 3 .

When a DNP3 tag has class0 , it means tag value changes will not buffer with proper time label .

When DNP3 tag has class 1 , 2 or 3 , it mean tag value changes will buffer inside RTU with proper time of change .

In DNP3 for separating Static value of tags and event value (Buffered Data), Tag Group concepts will use.

The most common Groups are as following:

Group 1 is Static value of Digital Input Tag

Group 2 is event buffer of Digital Input Tag

Notice that these two groups refer to same DI tag. Group 1 shows current value and Group 2 shows event buffered.

Group 3 is Double Bit Binary Input Current value

Group 4 is Event Buffer of Double Bit Binary Input.

Double Bit Binary Input from DNP3 Document:

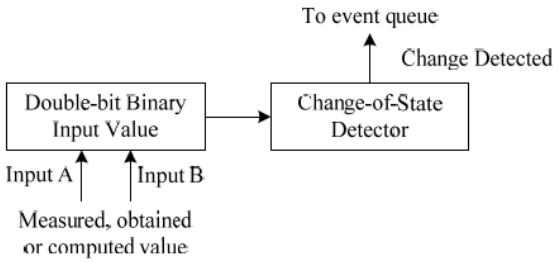


Figure 11-8—Double-bit binary input model

A double-bit binary input point is modeled as two single-bit binary inputs that are indivisibly linked together.

The four input states are defined in **Table 11-14**.

Table 11-14—Double-bit binary input states

State value (UINT2)	State name	Description	Corresponding state if a single-bit binary input were used instead
0	INTERMEDIATE	Transitioning between end conditions	—
1	DETERMINED_OFF	End condition, determined to be OFF	0
2	DETERMINED_ON	End condition, determined to be ON	1
3	INDETERMINATE	Abnormal or custom condition	—

Group 10 is Digital Output Status current value.

Group 11 is Digital Output Event Buffer.

Group 12 is Digital Output Command.

Group 20 is Counter static value.

Group 21 is Frozen Counter Static Value.

Group 22: event buffered of Counters

Group 23: Event buffered of Frozen Counters.

Group 30 is Static value of Analog Input

Group 32 is Event Buffer of Analog Input

Group 40 is Static value of Analog Outputs Status

Group 41 is Analog Output Command.

Group 42 Event Buffer of Analog Output

Group 50 is Data Time.

Group 80 is Internal Indication.

Internal Indication Concept: at any DNP3 Frame from Slave to master direction, There is 2 Bytes called Internal indication . (IIN) IIN is not in frames from Master to salve direction .

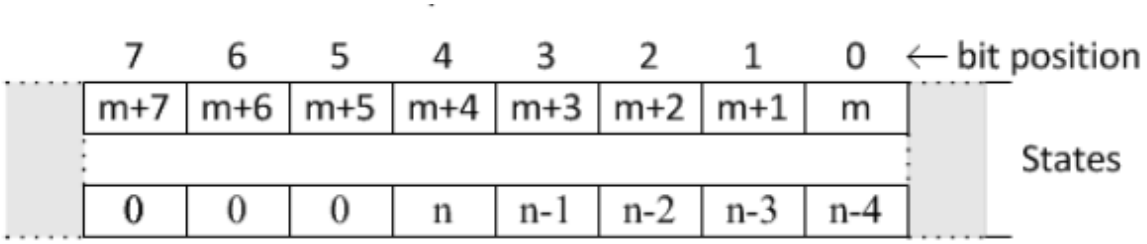
IIN definition is as following:

Index	Bit	Name
0	IIN1.0	BROADCAST
1	IIN1.1	CLASS_1_EVENTS
2	IIN1.2	CLASS_2_EVENTS
3	IIN1.3	CLASS_3_EVENTS
4	IIN1.4	NEED_TIME
5	IIN1.5	LOCAL_CONTROL
6	IIN1.6	DEVICE_TROUBLE
7	IIN1.7	DEVICE_RESTART
8	IIN2.0	NO_FUNC_CODE_SUPPORT
9	IIN2.1	OBJECT_UNKNOWN
10	IIN2.2	PARAMETER_ERROR
11	IIN2.3	EVENT_BUFFER_OVERFLOW
12	IIN2.4	ALREADY_EXECUTING
13	IIN2.5	CONFIG_CORRUPT
14	IIN2.6	RESERVED_1
15	IIN2.7	RESERVED_2

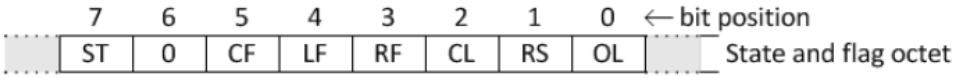
Tag Variation : in DNP3 Master can read data from RTU by different presentations . Suppose in first read master wants to read analog Input from address 1 to 100 by 32bit format and in second scan master read same analog in put in 16 bit format . So Variations are refer to same tag Group.

Each Group has different variations.

Group 1, Static value of Digital Input, Variation is packed format.



Variation 2 is with flag:



A.2.2.2.2 Formal structure

BSTR8: Flag Octet

Bit 0:	ONLINE
Bit 1:	RESTART
Bit 2:	COMM_LOST
Bit 3:	REMOTE_FORCED
Bit 4:	LOCAL_FORCED
Bit 5:	CHATTER_FILTER
Bit 6:	Reserved, always 0
Bit 7:	STATE—Has a value of 0 or 1, representing the state of the physical or logical input.

What is concept of Default variation?

Suppose master wants to read all tags in class 1.in this query master is not determine variation for Slave. Only master is asking for class1 tags. For this type of Master request, default variation should be set in RTU.

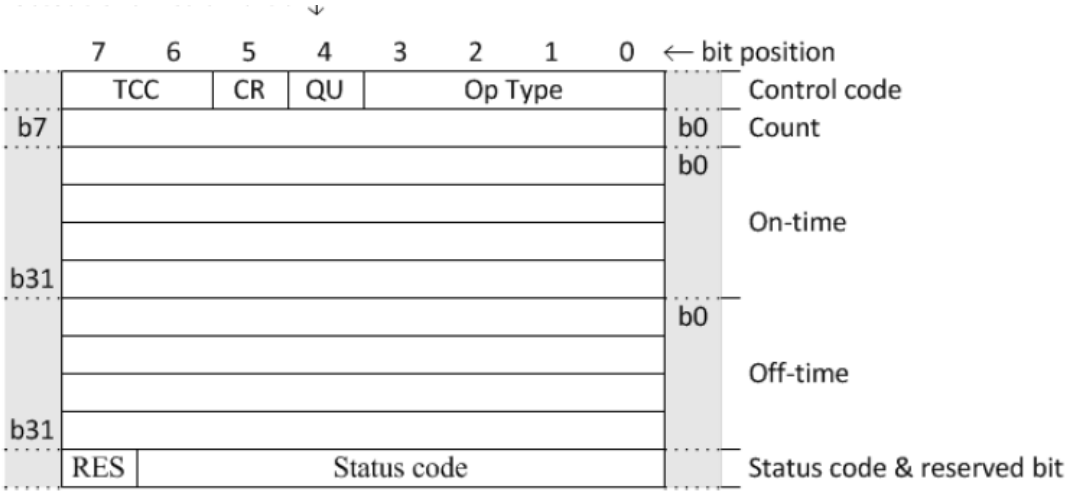
For following command default variation will use:

- Master is asking for class 0 tags
- Master is asking for class 1 tags
- Master is asking for class 2 tags
- Master is asking for class 3 tags
- Master is Sending Integrity poll (IP) Means master is asking class 0 , 1, 2 and 3 in one request
- Master is Sending RBE (Read Events) means Master is asking class 1, 2 and 3 in one request. Master wants to read only tags changes, not static value of all tags.
- Unsolicited communication. When Slave is sending tag changes to master without master request.

DOBS Data Type

By help of DOBS datatype you can write with different configuration from uplinks to Slave RTU. (Downlinks)

First will look at DNP3 Digital output Block Data Type from Standard:



UINT4: Control code, Operation Type field [Op Type].

This field is used in conjunction with the *TCC* field to specify a control operation. See operational functions (**A.8.1.3.2**) for additional details. The code names are:

0: NUL

1: PULSE_ON

2: PULSE_OFF

3: LATCH_ON

4: LATCH_OFF

5 to 15: Undefined

BSTR1: Control code, Queue field [QU].

This field is obsolete. The master shall always set this bit to 0. Outstations that receive a g12v1 object with this bit set shall return a status code NOT_SUPPORTED in the response.

BSTR1: Control code, Clear field [CR].

Support for this field is optional. If the device supports commands with the clear bit set:

— It shall support the case where the Op Type code is NUL, and may support the command for other Op Type values.

— When the clear bit is set, the device shall remove pending control commands for that index and stop any control operation that is in progress for that index. The indexed point shall go to the state that it would have if the command were allowed to complete normally. If a non-NUL Op Type code is requested, the new command shall be initiated immediately after the cancellation actions complete.

When the clear bit is set and the *TCC* - *Op Type* combination is not supported, the device shall return status code NOT_SUPPORTED in the response.

UINT2: Control code, Trip-Close Code field [TCC].

This field is used in conjunction with the *Op Type* field to specify a control operation. See operational functions for additional details. The code names are

0: NUL

1: CLOSE

2: TRIP

3: RESERVED

UINT8: Count.

This is the number of times the outstation shall execute the operation. Counts greater than 1 generate a series of pulses or repeated operations for the point. Both *On-time* and *Off-time* values are obeyed as illustrated in the figures under timing illustrations, subject to the comments regarding timing in interpreting the time fields.

Implementation of a zero-count functionality is optional. A count value of 0 indicates that the output operation shall not be executed. Setting the count value to 0 is a useful technique for testing communications without affecting an output. When the outstation receives a 0 value, it shall:

— Not change the output.

— Ignore the On-time and Off-time values.

— Return the same status code as if the execution had been attempted.

An outstation shall return status code NOT_SUPPORTED in the response when the count value is 0 in the request and the outstation does not implement the zero-count functionality.

UINT32: On-time.

This is the duration, expressed as the number of milliseconds, that the output drive remains active. See interpreting the time fields for more details.

UINT32: Off-time.

This is the duration, expressed as the number of milliseconds that the output drive remains non-active. See interpreting the time fields for more details.

UINT7: Status code.

This value shall be set to 0 in request messages.

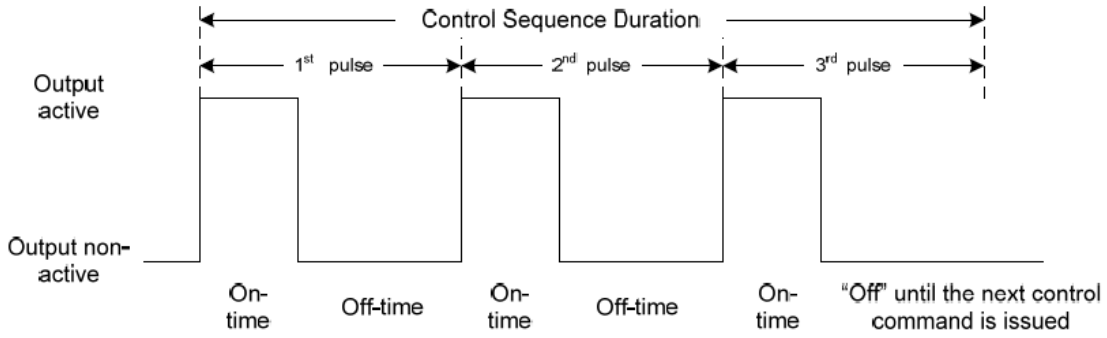
In response messages, this value represents the status of the selected or executed command. See **Table 11-7** for descriptions of control-related status codes.

BSTR1: Reserved [RES].

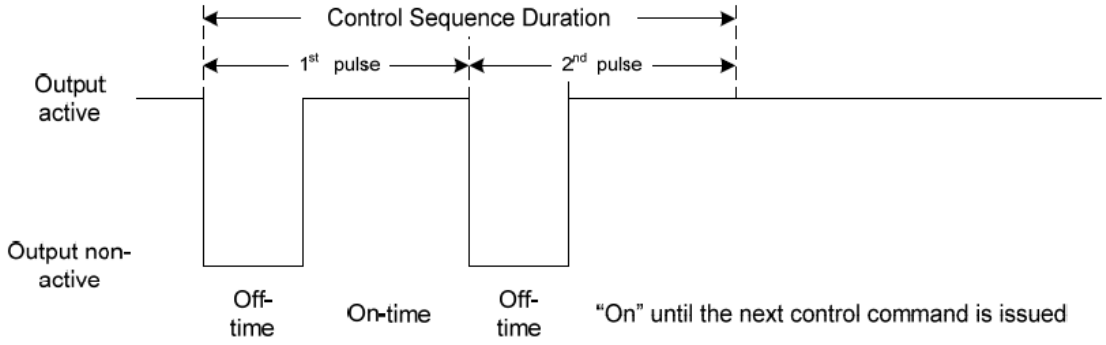
This bit is reserved. The master and outstation shall always set it to 0.

A.8.1.3.1 Timing illustrations

This subclause illustrates just two of the many timing possibilities that can appear in a g12v1 object.



PULSE ON with Count = 3



PULSE OFF with Count = 2 (Not interoperable)

A.8.1.3.2 Operational functions

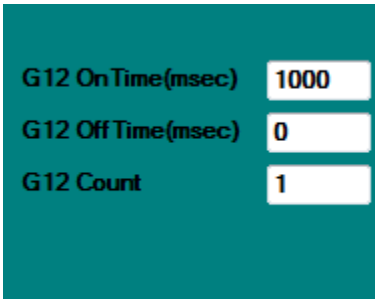
A.8.1.3.2.1 Interoperable commands

Only a few of the 64 possible *TCC* and *Op Type* field bit combinations are interoperable. **Table A-1** indicates, for each point index, which commands are optional, preferred, not permitted, or not interoperable, depending on which point model is implemented.

Table A-1—Interoperable control commands

TCC field	Op Type field	Point model in outstation	Support requirements
NUL	NUL	All	Optional
NUL	PULSE_ON	Activation	May support
		Complementary latch	Not permitted
		Complementary two-output	Not permitted
NUL	LATCH_ON	Activation	May support
		Complementary latch	Preferred support
		Complementary two-output	May support
NUL	LATCH_OFF	Activation	May support
		Complementary latch	Preferred support
		Complementary two-output	May support
CLOSE	PULSE_ON	Activation	May support
		Complementary latch	May support
		Complementary two-output	Preferred support
TRIP	PULSE_ON	Activation	May support
		Complementary latch	May support
		Complementary two-output	Preferred support
All other combinations		All	Not interoperable

DOBS s mapped to control Filed of Command only . other parameters are determined by RTU Parameters.



In uplink Software you need to change Control Field Based on following table:

Table A-2 indicates for a single point index, what action the outstation performs based on the contents of the interoperable control codes and the point model implemented.

Table A-2—Actions performed by outstation for interoperable commands

Row #	Control code	TCC field	Op Type field	Clear field	Action
1	0x00	NUL	NUL	0	Does not initiate an action or change an in-progress or pending command. Values in *On-time* and *Off-time* fields are ignored.
2	0x20	NUL	NUL	1	Cancel in-progress and pending commands. Values in *On-time* and *Off-time* fields are ignored.
3	0x01	NUL	PULSE_ON	0	For activation model, set output to active for the duration of the *On-time*. For both complementary models, return NOT_SUPPORTED status.

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Row #	Control code	TCC field	Op Type field	Clear field	Action
4	0x21	NUL	PULSE_ON	1	For activation model, cancel in-progress and pending commands and then set output to active for the duration of the *On-time*. For both complementary models, return NOT_SUPPORTED status.
5	0x03	NUL	LATCH_ON	0	For activation model, set output to active for the duration of the *On-time*. For complementary latch model, set the output to active. For complementary two-output model, set the close output to active for the duration of the *On-time*.
6	0x23	NUL	LATCH_ON	1	Cancel in-progress and pending commands. Afterwards, initiate the action specified in row 5.
7	0x04	NUL	LATCH_OFF	0	For activation model, set output to active for the duration of the *On-time*. For complementary latch model, set the output to inactive. For complementary two-output model, set the trip output to active for the duration of the *On-time*.
8	0x24	NUL	LATCH_OFF	1	Cancel in-progress and pending commands. Afterwards, initiate the action specified in row 7.
9	0x41	CLOSE	PULSE_ON	0	For activation model, set output to active for the duration of the *On-time*. For complementary latch model, set the output to active. For complementary two-output model, set the close output to active for the duration of the *On-time*.
10	0x61	CLOSE	PULSE_ON	1	Cancel in-progress and pending commands. Afterwards, initiate the action specified in row 9.
11	0x81	TRIP	PULSE_ON	0	For activation model, set output to active for the duration of the *On-time*. For complementary latch model, set the output to inactive. For complementary two-output model, set the trip output to active for the duration of the *On-time*.
12	0xA1	TRIP	PULSE_ON	1	Cancel in-progress and pending commands. Afterwards, initiate the action specified in row 11.

When Value of DOBS is changing, DNP3 Kernel will get then changes and Saves value of DOBS Tag.
Suppose you want to send close command to RTU , then you can set DOBS to 0x41

When you change DOB Tag value from 0 to 1 ,(DOB Tag that has same address as DOBS) , DNP Driver sends G12V1 With specified Flag that is saved in DOBS Tag to RTU .
If DOBS Tag is not defined for DOB Tag , Then default operation (Direct Operate or Select Before Operate) Will execute when DOB Tag Value change from 0 to 1 .

Sequence of Sending DOB Command with defined DOBS Tag:

- Set Value of DOBS Tag and Write to pbsFEP
- Change DOB Tag with same address of DOBS from 0 to 1.

If you define DOBF Tag, then you can see result of command in this tag based on following Table:

Table 11-7—Control-related status codes

Code number	Identifier name	Description
0	SUCCESS	Request accepted, initiated, or queued.
1	TIMEOUT	Request not accepted because the *operate* message was received after the *arm* timer timed out. The *arm* timer was started when the *select* operation for the same point was received.
2	NO_SELECT	Request not accepted because no previous matching *select* request exists. (An *operate* message was sent to activate an output that was not previously armed with a matching *select* message.)
3	FORMAT_ERROR	Request not accepted because there were formatting errors in the *control* request (either *select, operate,* or *direct operate*).
4	NOT_SUPPORTED	Request not accepted because a control operation is not supported for this point.
5	ALREADY_ACTIVE	Request not accepted, because the control queue is full or the point is already active.
6	HARDWARE_ERROR	Request not accepted because of control hardware problems.
7	LOCAL	Request not accepted because Local/Remote switch is in Local position.
8	TOO_MANY_OBJS	Request not accepted because too many objects appeared in the same request.
9	NOT_AUTHORIZED	Request not accepted because of insufficient authorization.
10	AUTOMATION_INHIBIT	Request not accepted because it was prevented or inhibited by a local automation process.
11	PROCESSING_LIMITED	Request not accepted because the device cannot process any more activities than are presently in progress.
12	OUT_OF_RANGE	Request not accepted because the value is outside the acceptable range permitted for this point.
13 to 125	RESERVED	Reserved for future use.
126	NON_PARTICIPATING	Sent in request messages indicating that the outstation shall not issue or perform the control operation.[a]
127	UNDEFINED	Request not accepted because of some other undefined reason.

[a] Control status code 126, NON_PARTICIPATING, may be used as a test or "no-op". Specific control-related objects may have further explanation for using this code. An outstation shall not reject requests with this status code or report parameter error in IIN2.2 unless there is some other reason to do so.

When you send command DOBF value is change to -1 .

When command is executed correctly, DOBF value will change to 0. In error time you will get one of above codes .suppose you send Trip Command for DNP3 Address that is not in RTU , then you will get 4 in DOBF Tag .

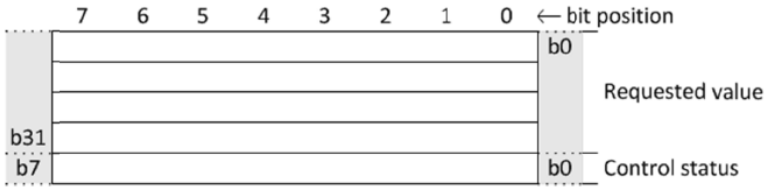
AOBS and FOBS Data Type

AOB Data type is link to DNP3 Group 41 . (var 1 , 2)

FOB Data type is link to DNP3 Group 41 . (var 3 , 4)

Group 41 (Analog Output Command) has 4 variation :

Variation 1 : 32 bit



A.20.1.2.2 Formal structure

INT32: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is –2 147 483 648 to +2 147 483 647.

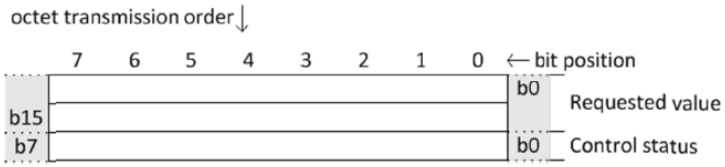
UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

Variation 2 : 16 Bit



A.20.2.2.2 Formal structure

INT16: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is –32 768 to +32 767.

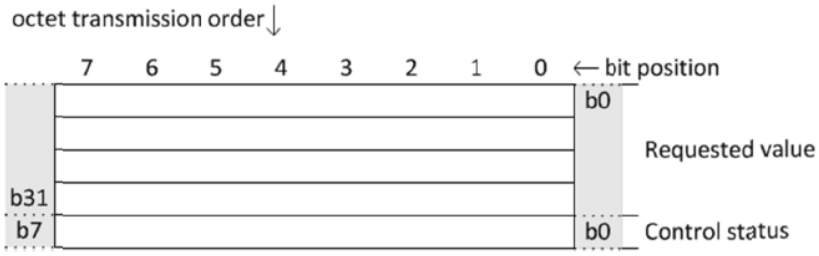
UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

Variation 3 : Floating Point



A.20.3.2.2 Formal structure

FLT32: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is approximately -3.4×10^{38} to $+3.4 \times 10^{38}$.

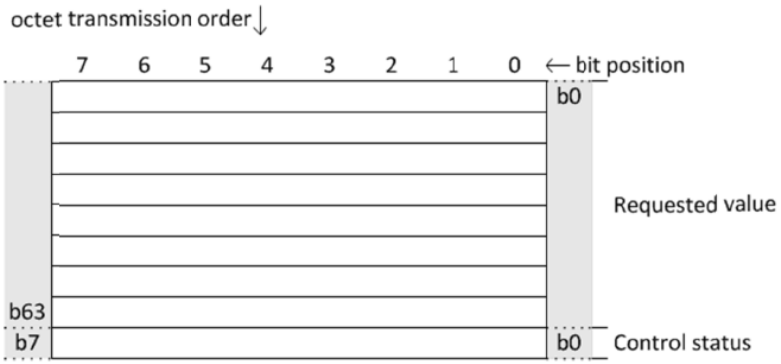
UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

Variation 4 :



A.20.4.2.2 Formal structure

FLT64: Requested value

This is the analog value that is requested; it may be scaled and/or manipulated before a physical or pseudo analog output is set.

Range is approximately -1.7×10^{308} to $+1.7 \times 10^{308}$.

UINT8: Control status.

This value is always 0 in a request message.

In response messages, this value represents the status of the requested control operation. See **Table 11-7** for descriptions of control-related status codes.

Range is 0 to 255.

AOB and FOB are using same DNP3 Address space . it means you couldn't define two tags with same address but different AOB and FOB Type.

AOBF and FOBF concept is exactly like DOBF .

AOBS and FOBS should has same address as AOB and FOB . Look at following sample :

AOB1 , DNP3 Address = 1

AOB2 , DNP3 Address = 2

FOB3 , DNP3 Address = 3

FOB4 , DNP3 Address = 4

AOBS1 , DNP3 Address = 1

FOBS4 , DNP3 Address = 4

If you are not defining AOBS or FOBS tags , pbsFEP will use default setting : Direct operate or Select before Operate (It is depend to configuration and SYS tag 11 and 12) variation 1 for AOB tags and Variation 3 for FOB Tags .

Suppose you want to write analog output 16 bit to RTU , then you need to set AOBS to 2 and after that change AOB Value .

For FOBS you can set it to 3 (Floating point) or 4 (Double Floating Point)