User Manual-v1.3.1

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INTRODUCTION

What is PDC?

Phasor Data Concentrator is a node in a system where phasor data from the number of PMUs or PDCs is correlated and fed out as a single stream to other applications. PDC designed to process streaming time-series data in real-time. Measured data gathered with GPS-time from many hundreds of input sources is time-sorted.

What is iPDC?

i - *Indian Institute of Technology, Bombay*
P - *Phasor*
D - *Data*
C - *Concentrator*

iPDC is a free Phasor Data Concentrator that collects data from Phasor Measurement Units, iPDCs and other vendors PDC those who are compliant with IEEEC37.118 standard. It does the time sequencing and combining of the received data frames as per IEEEC37.118 format and send to other communicating iPDCs and IP based applications. It has the feature to archive received data in the MySQL database on local/remote machine disk. A friendly graphical user interface will enable a user to add or remove new devices (PMU/iPDC) and also send different command frames to the devices from which the data is being received. This version of software is built to work on UNIX and Unix-like platforms.

iPDC act as servers when they are communicating with another iPDC whom they are sending the data/configuration frames. The iPDC receiving data in this case acts as a client. However when the same iPDC sends data to another iPDC, it would act as a server. This pattern will be repeated in the WAMS topology with one peer acting as server and its counterpart a client. When iPDC receives data & configuration frames, it would also direct them to another process called DBServer.

What is PMU Simulator?

P - Phasor
M - Measurement
U - Unit

Phasor Measurement Unit is a device which measures the electrical waves on an electricity grid, using a common time source for synchronization. Time synchronization allows synchronized real-time measurements of multiple remote measurement points on the grid. A PMU can be a dedicated device, or the PMU function can be incorporated into a protective relay or other device.

PMU Simulator is a simulation software for Phasor Measurement Unit. It would act as a server and bind ports for UDP and TCP communication protocol. It would be listening for UDP connections on UDPPORT and for TCP connections on TCPPORT. The PMU Simulator receives the command frames from PDC and sends the configuration frame and data frames to PDC. It has option to configure PMU by adding PMU ID, phasor, analog, and digital channels, data rate, data format, etc. A single PMU Simulator can have multiple PDC client communicating through TCP and UDP.

What is DBserver?

DBServer is the database server module for iPDC. It would run as individual process on local or remote machine. Among the various known open source databases, MySQL has been used for storing the data at the iPDC. The process would have a parser to parse configuration and data frames. After parsing, configuration and data frames entries would be stored in the iPDC MySQL database. The data frames are inserted as they come. This data which is stored in the tables can then be used for later analysis. The data from the database is archived periodically. It will also creating the measurement files in csv format.

Organization of Manual

This user manual covers whole iPDC software suite, containing iPDC, PMUSimulator and DBserver. Organisation of manual is as following

- How to install/run DBserver
- How to install/run PMUSimulator
- How to install/run iPDC

GETTING STARTED

SYSTEM REQUIREMENTS:

- Operating System - Linux
- RAM - 512 MB
- HDD - 1 GB+

DEPENDENCIES:

- gcc
- Mysql-server-5.0
- mysql-client-5.0.
- mysql-common
- libmysqlclient16*
- GTK+2.5
- glade 3.6.7 (optional for development)
- NTP-client (For synchronization of system clock)

TECHNICAL SPECIFICATION:-

- We have mostly used C language to develop the complete software suite.
- Used GTK+ and Glade languages to develop the GUI for complete software suite.
- iPDC is a multithreaded application and we have used POSIX threads library.
- PMU Simulator uses multi-process architecture. One process for continuously communication with PDC and other for user input for PMU Simulator
- We have used MySQL for iPDC database. Changes in the configuration frames and data frames will also be handled dynamically.
- Currently it supports LINUX only, but in near future Windows version would be available

INSTALLATION:-

A complete detail of HOW TO INSTALL is given in README. The installation process varies depends on the flavour of linux system. installation process is given below in generalized and step-by-step method.

- ✓ Dependencies installation: Installation of glade internally installed the GTK+ libraries and there is no need to explicit installation of GTK+. For beginners of Linux, it would be better to go with Glade installation rather then GTK+. NTP is recommended for better and more relevant results for complete iPDC suite.

Here *su/sudo* means root user. If you are using Redhat base system then use *su* (switch user) and if you are using Debian base system then use sudo *means use* su *OR* sudo according to respective environment.

```
su/sudo apt-get update (recommended)
su/sudo apt-get install mysql-server-5.0 (or latest available version)
su/sudo apt-get install mysql-client-5.0 (or latest available version)
su/sudo apt-get install mysql-common
su/sudo apt-get install libmysqlclient16 (or latest available version)
su/sudo apt-get install libmysqlclient16-dev (or latest available)
su/sudo apt-get install glade
su/sudo apt-get install ntp
```

(http://howto.eyeoncomputers.com/ubuntu/install-ntp/)

- ✓ Install DBserver :-

- DBServer can be installed on the same machine or a different machine.
- If DBServer is to be installed on a different machine.
- Then install dependencies mysql-server-5.0, mysql-common, libmysqlclient15off, mysql-client-5.0. Then follow the steps given below.

1. Type *cd/PATH/iPDC.x.y/DBServer.x.y*
2. Type *mysql –uroot –proot <"Db.sql"*
3. Then *su/sudo make*
4. Then *./DBServer* (remember this is accessible only from inside this folder)

- ✓ Install PMUSimulator :-

- ➢ If you need to run simulator on different from iPDC machine then Copy the PMU Simulator on that machine.
- ➢ ONE PMUSimulator installation is sufficient for running multiple simulation on the same machine.

1. Type
   `cd/<path_to_iPDC_folder>/iPDC.x.y/PMUSimulator.x.y`
2. Type `su/sudo make install` (It will be needing root permission to create folder & copying file on them)
3. Run PMU by typing `PMU` via terminal or you can find its shortcut in menu *Applications>Education>PMU Simulator*.

✓ Install iPDC :-

Note: ONE iPDC installation is sufficient for running multiple simulation on the same machine. `x.y` represents version number.

1. First Go to source folder through terminal (using `cd`)
2. Type `Extract iPDC.x.y.tar.gz.`
3. Then type `cd iPDC.x.y/iPDC.x`
4. Now type `su/sudo make install` (It will be needing root permission to create folder & copying file on them)
5. Now to Run -iPDC via terminal type `iPDC` or you can find its shortcut in *Application menu>Education>iPDC.*

UNINSTALL:-

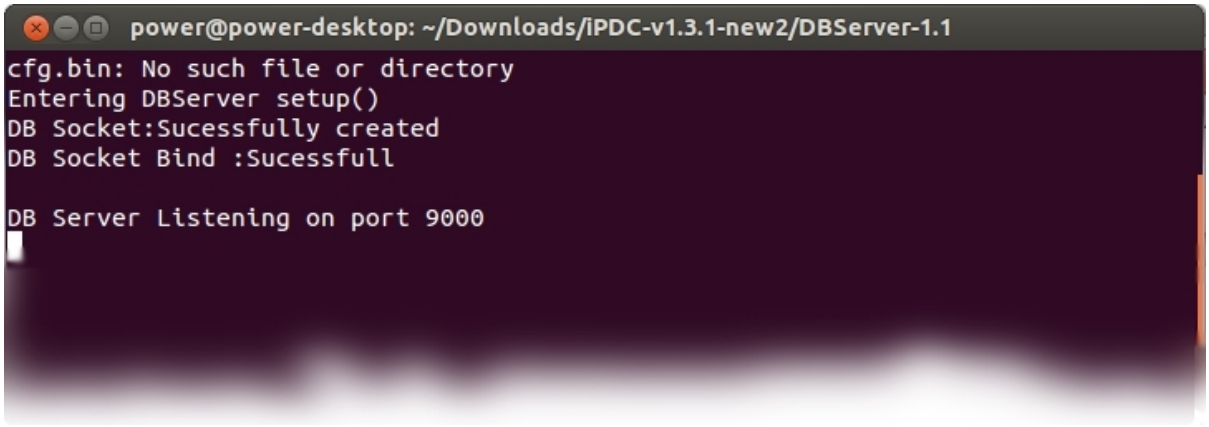
- Uninstall iPDC ->
  `cd iPDC.x.y/iPDC.x/`
  `su/sudo make uninstall` (will be needing root permission)
- Uninstall DBServer ->
  `cd iPDC.x.y/DBServer.x/`
  `make clean` (will also remove the stored configurations file)
- Uninstall PMUSimulator ->
  `cd iPDC.x.y/PMUSimulator.x/`
  `su/sudo make uninstall` (will be needing root permission)

STARTING APPLICATION(S):

iPDC suite can be started in following two ways

✓ For the start up of the setup you can either start with PMUSimulator or DBserver first but for proper functioning it is required that you start DBserver *before* run iPDC, as iPDC is a client of the DBServer.

- ✓ Change directory `cd home/<username>/iPDC.x.y/DBserver.x.y` to DBserver folder, and then type in command `mysql -uroot -proot <Db.sql` and then run `./DBserver.` Once this is done terminal will show you following,

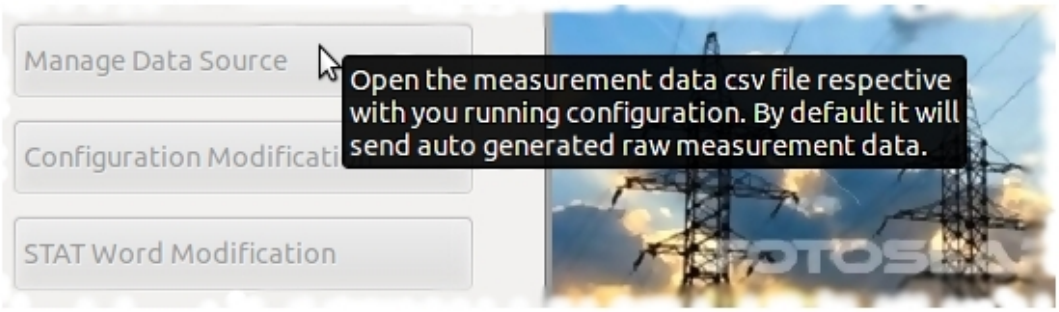


- ✓ To turn on PMU Simulator type `PMU` in terminal and press <*ENTER*>. Other way that you can start it from menu system: Go to Applications> Programming > PMU Simulator.

- ✓ Now to turn ON iPDC type `iPDC` in terminal and press <*ENTER*>. OR Go To Applications>Programming>iPDC.

CONFIGURATION

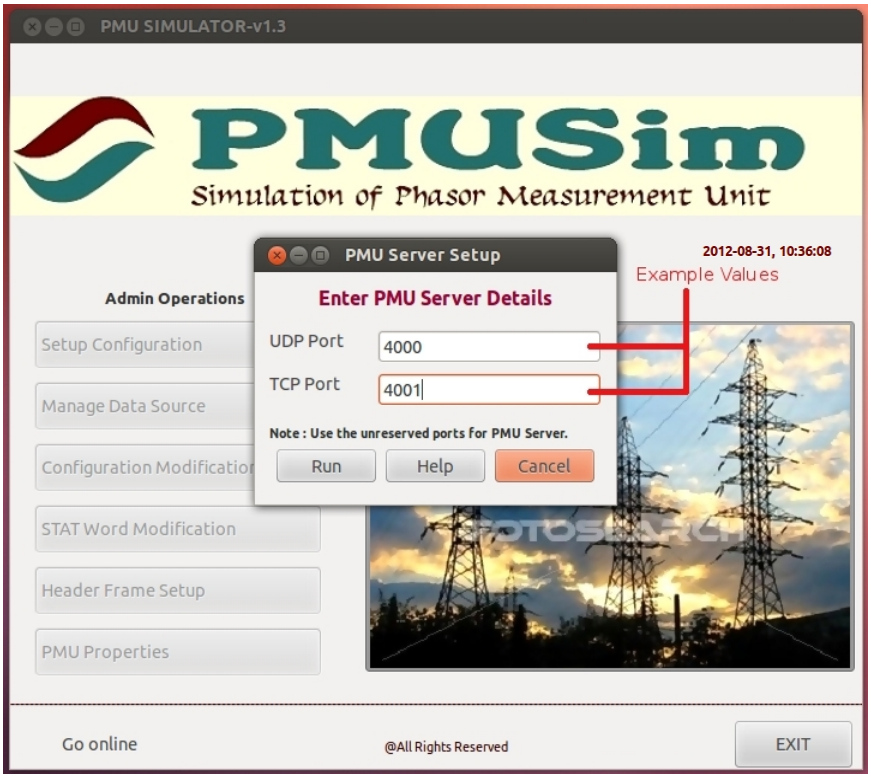
This section will take you through process of "*HOW TO Configure/setup the PMU Simulator and iPDC?*". Designing of Application is done keeping the ease of operation and usability in mind. So, Configuring the PMU Simulator and the iPDC is very easy because each and every function, tab or button is provided with very *descriptive tooltips*, hence the whole interface becomes self explanatory.



So, if incase you get confused, just go over to the option and a tooltip will be at your service. Now with this keeping in mind we will go through a standard PMU Simulator and iPDC setup/configuration procedure...

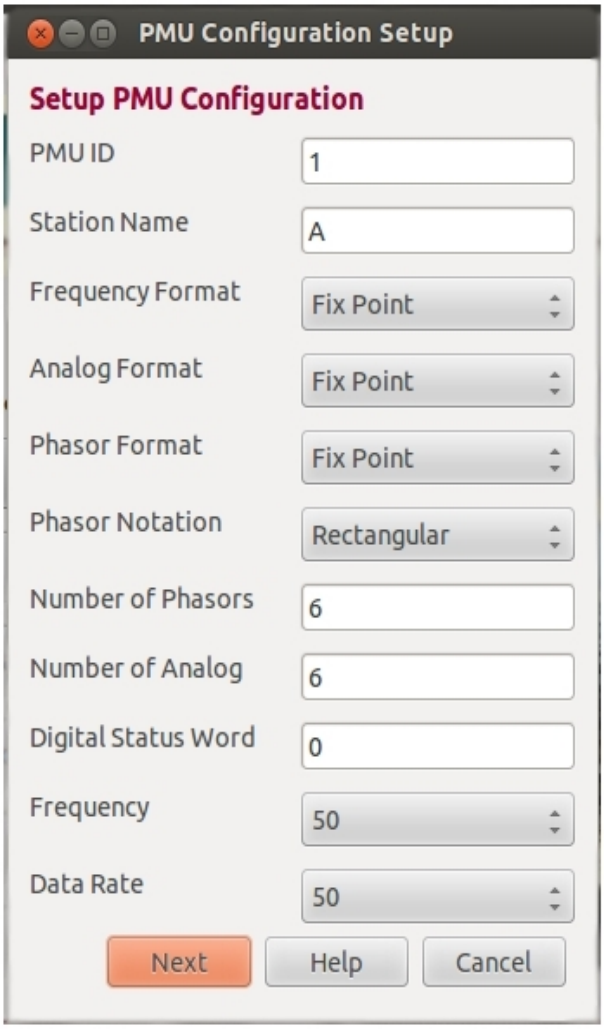
➔ Start *DBserver* **.** (as mentioned above by `./Dbserver`)

➔ Start PMU Simulator. (method shown above in *installation* section)



➔ If your are starting up for the first time it will prompt for UDP and TCP port numbers, input your values as per ur firewall setup and system-configuration. when done click *run*

➔ Then another prompt will ask for PMU ID, Station name, Phasor numbers, etc..



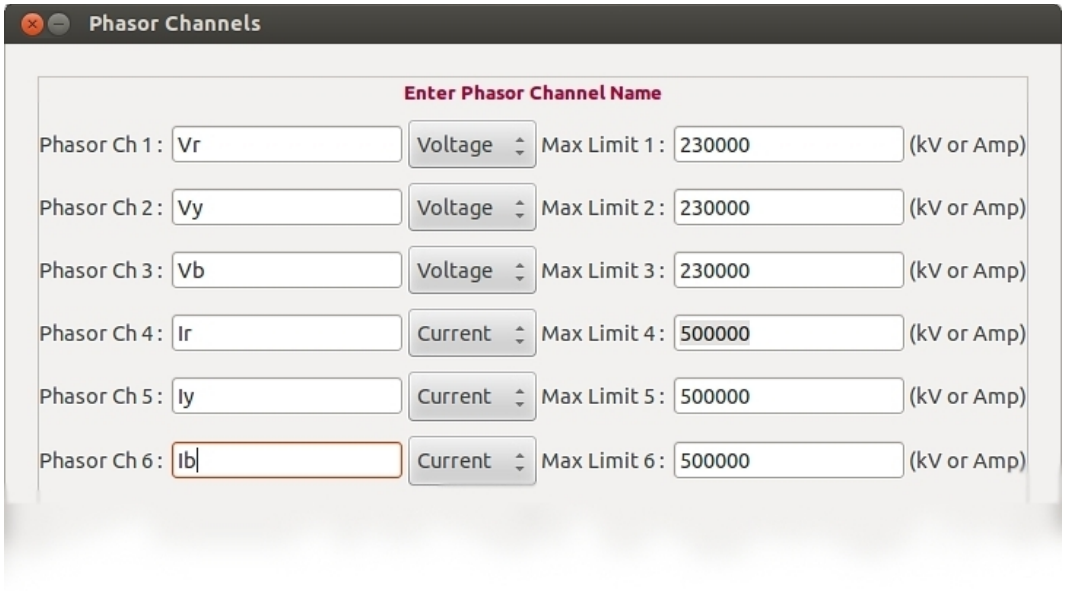
fill in and select the details that you want.

Available options are:

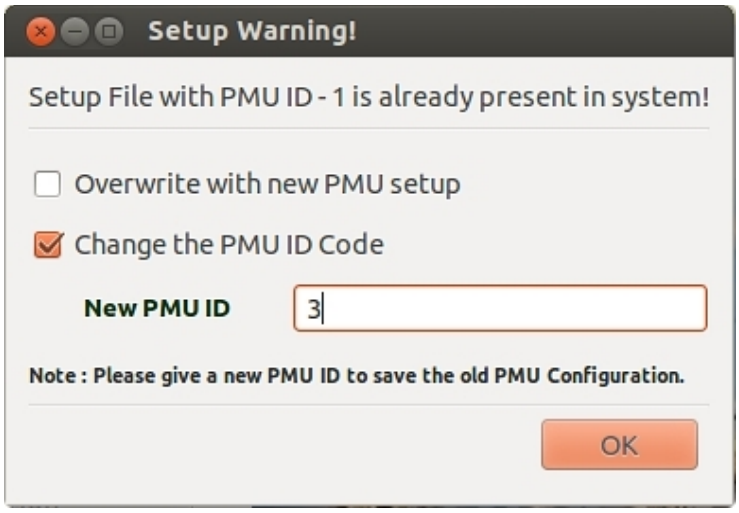
- Freq. Format(Fix/Float)
- Analog Format (Fix/ Float)
- Phasor Format (Fix / Float)
- Phasor Notation (Rec/Pol)
- No. Of Phasor (should be >= 1)
- No. of Analog (should be >= 0)
- Digital Status Word (should be >= 0)
- Frequency (50/60)
- Data Rate= (1/25/30/50/60/100/120)

When you are done click "*NEXT*"

➢ Now enter Channel Names, Unit and Maximm Limit (if Fix point selected) for phasors.as shown below

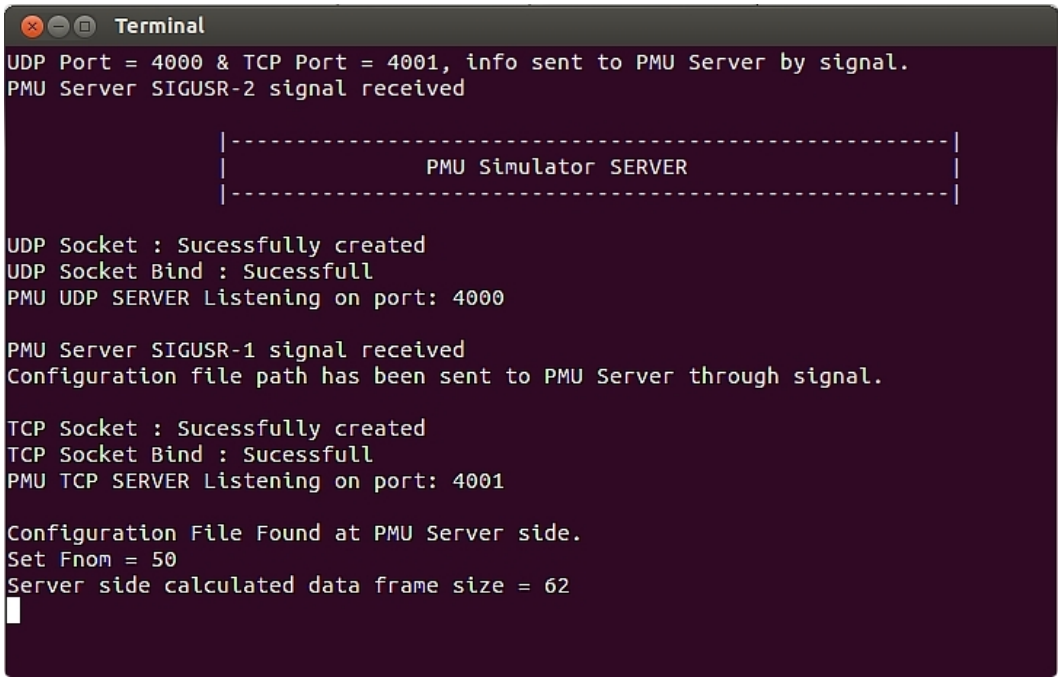


- Similarly a prompt for ANALOG CHANNELS will be next to phasor names, enter the appropriate values according to the requirements and click *NEXT.*
- Now if this is not your first run and a PMU Simulator of similar ID exists then it will ask for a overwrite of the setup file (pmu*.bin), here you can either change the PMU ID or overwrite new configuration.(shown below)



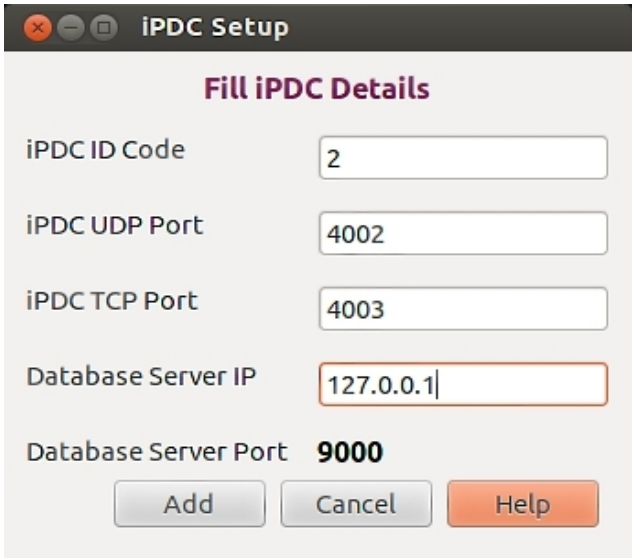
- Once proper input of all fields are done, the main Program window will appear. Where following options and features are available. (shown below)

- The primary setup of PMU Simulator is done, after this The PMU terminal will look something like following screenshot,



- remaining features will be discussed later in the manual. For Now we will set up iPDC.

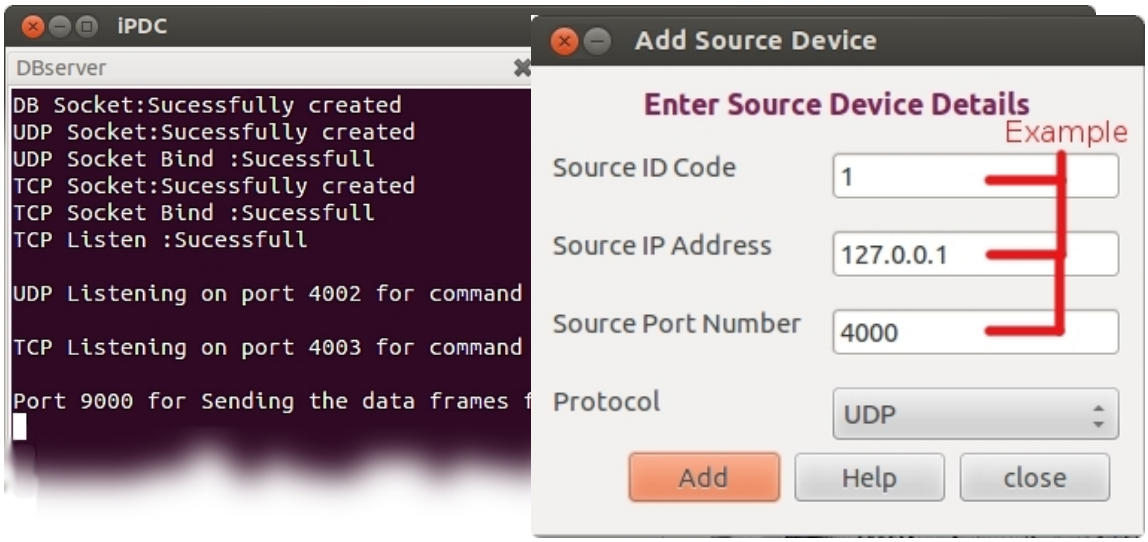
- Start PDC by any of the methods described before. For first time run of iPDC will pop up a prompt shows at right hand side.



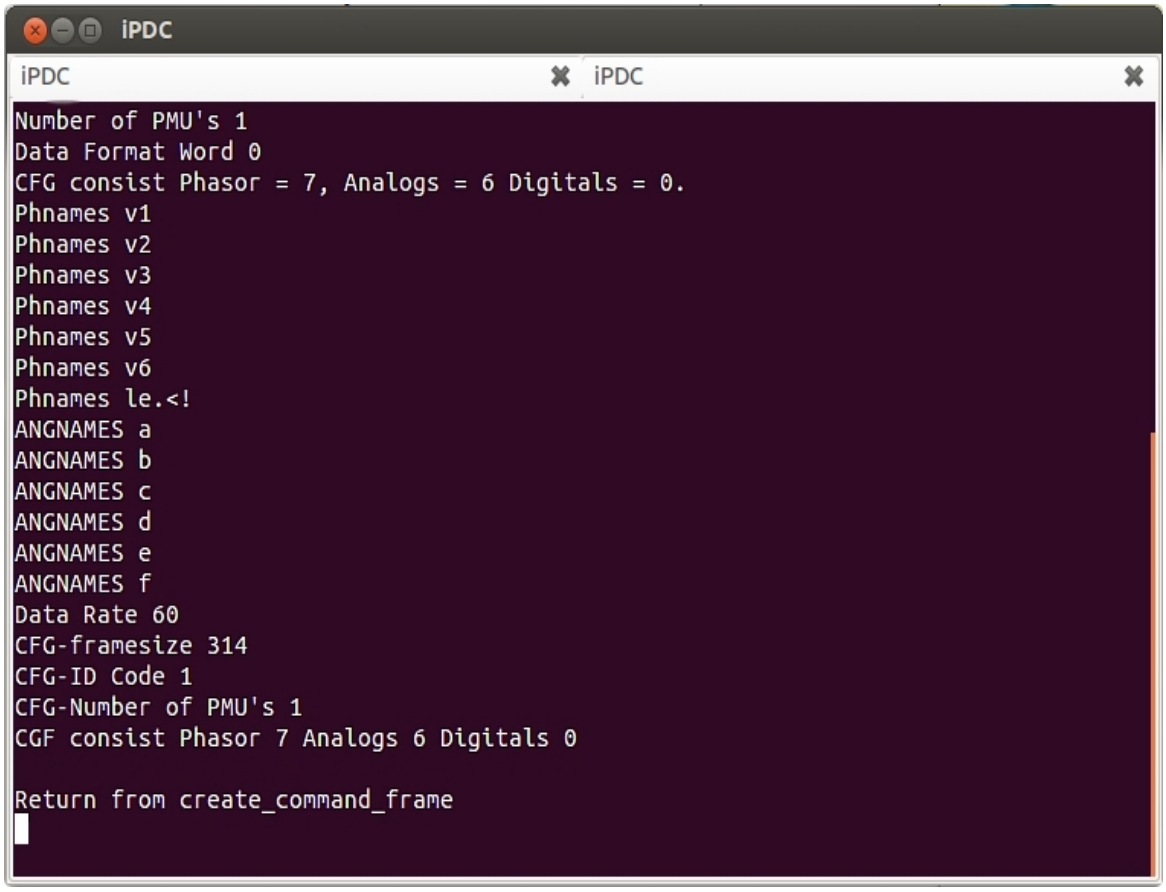
- Fill in proper details, click *add.*

- This will activate all available options on the main window, a screen shot of main window is show below.

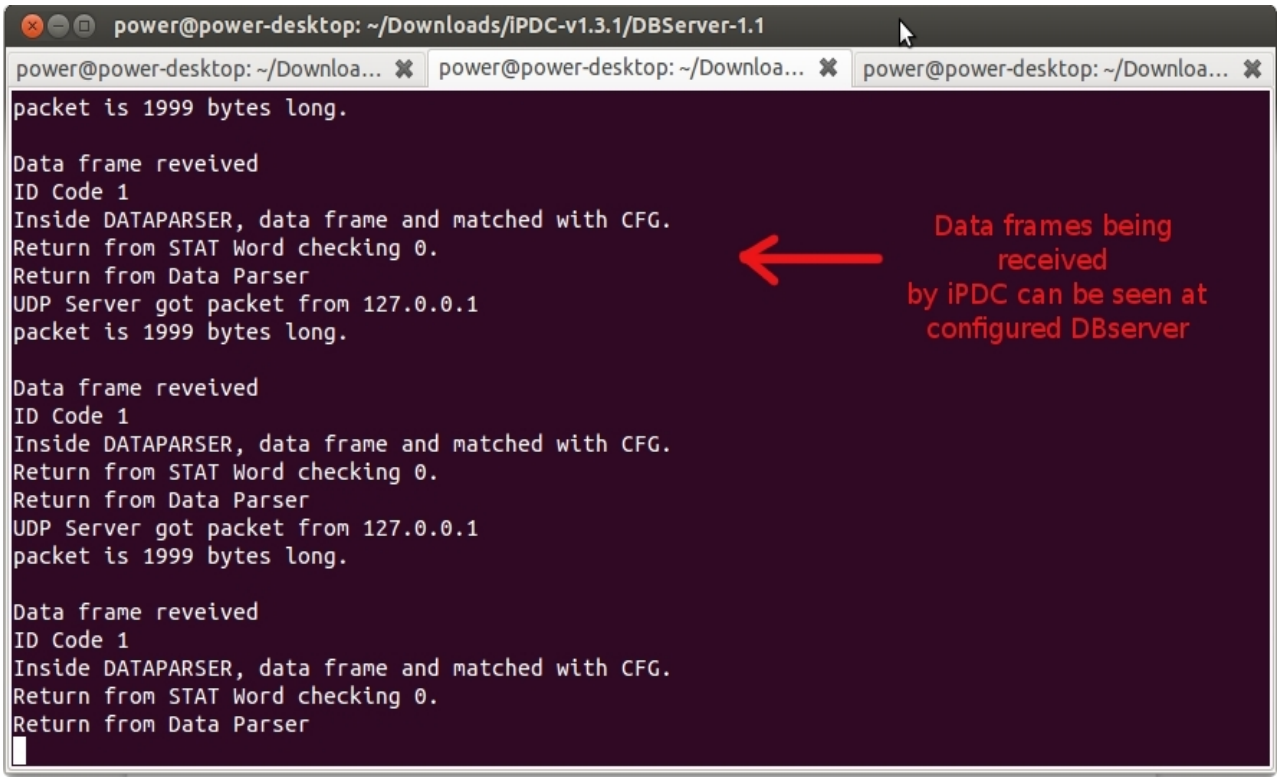
- And screent shot along with this showing the terminal prompt is given below.



- Now, click on "*Add a Source Device*" to add PMU or iPDC. Enter correct IP and port details regarding the source device details (Physical PMU or Simulator).
- Voila..!! Primary configuration is DONE....
- And once a Source Device is configured, CFG and DATA frames are communicated, which can again be seen in terminal as show below.



- Along with this, DBserver starts receiving the data frames following image on the next page shows the data frame received in DBserver terminal.


power@power-desktop: ~/Downloads/iPDC-v1.3.1/DBServer-1.1
power@power-desktop: ~/Downloa...
power@power-desktop: ~/Downloa...
power@power-desktop: ~/Downloa...
packet is 1999 bytes long.
Data frame reveived
ID Code 1
Inside DATAPARSER, data frame and matched with CFG.
Return from STAT Word checking 0.
Return from Data Parser
UDP Server got packet from 127.0.0.1
packet is 1999 bytes long.
Data frame reveived
ID Code 1
Inside DATAPARSER, data frame and matched with CFG.
Return from STAT Word checking 0.
Return from Data Parser
UDP Server got packet from 127.0.0.1
packet is 1999 bytes long.
Data frame reveived
ID Code 1
Inside DATAPARSER, data frame and matched with CFG.
Return from STAT Word checking 0.
Return from Data Parser
Data frames being received by iPDC can be seen at configured DBserver

FEATURES

1. iPDC

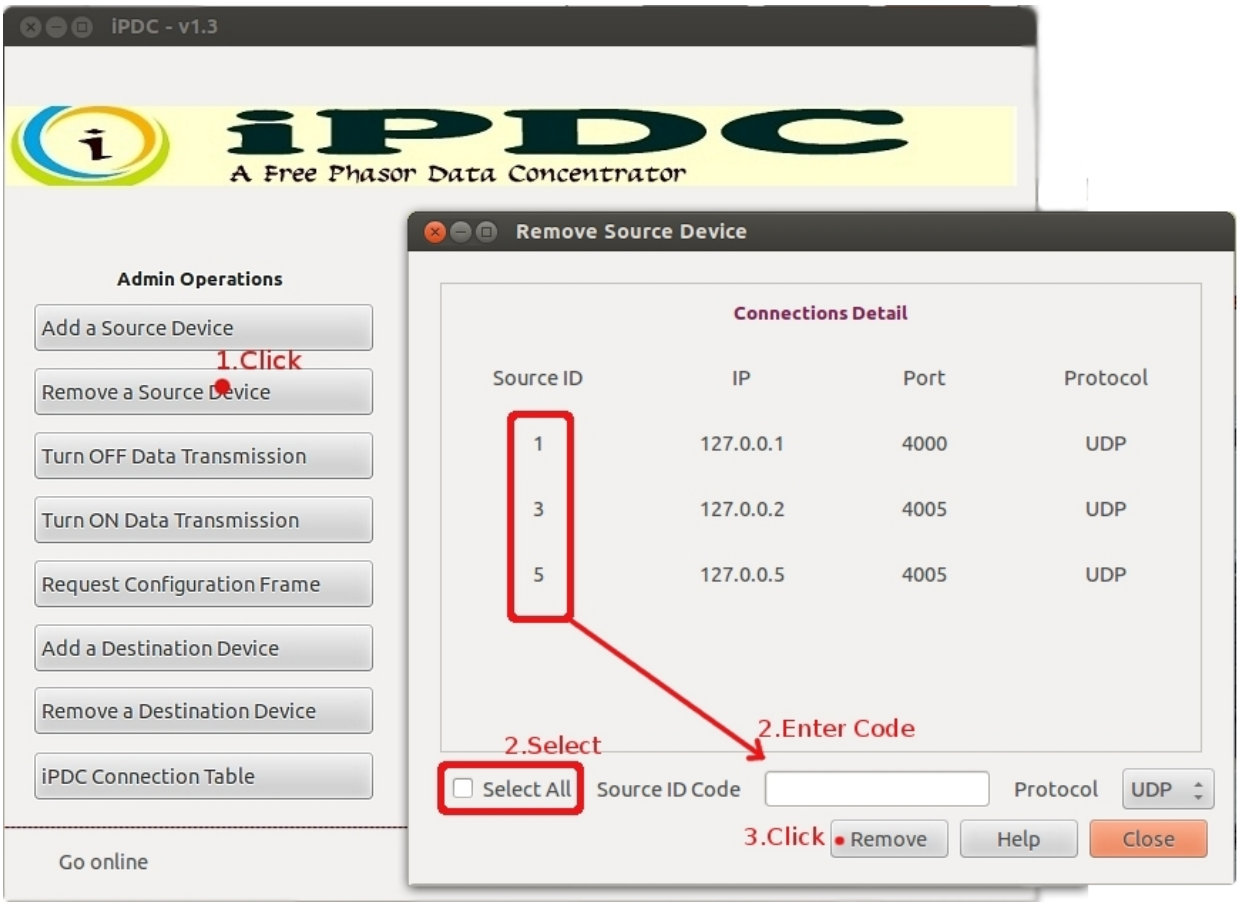
Now we will go through different features provided in the suite.

1.1. Add a source Device:-

- iPDC can handle (theoretically) any number of streaming sources. To add a source device in addition you just have to click "*Add Source Device*" and fill in the details as shown above.

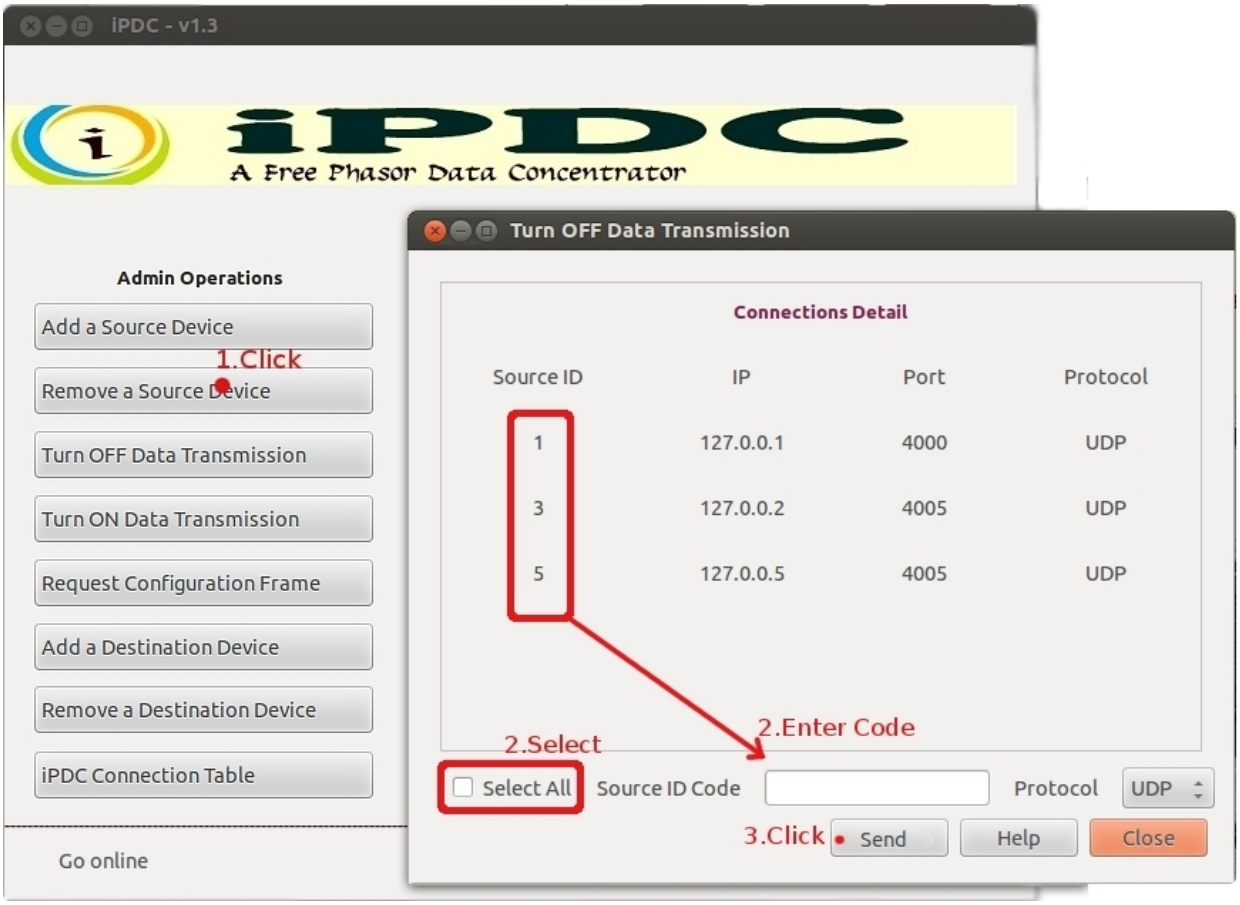
1.2. Remove a Source Device:-

- To remove a source device click "Remove a Source Device", a new window will appear showing all the devices currently connected with the iPDC,



1.3 Turn OFF Data Transmission:-

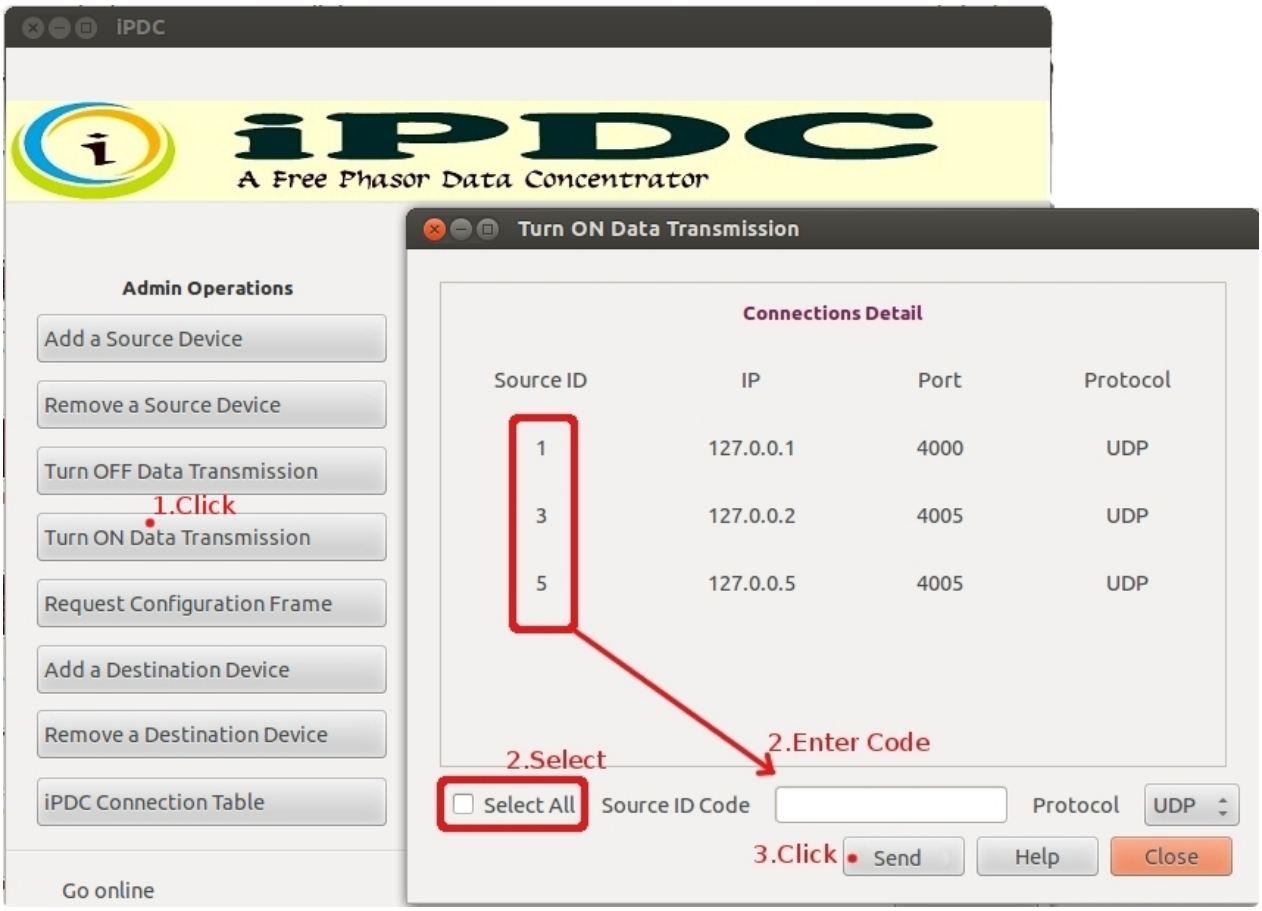
- There is a special feature provided to turn of data streaming from a specific connection(s). To turn OFF follow the steps shown in the figure



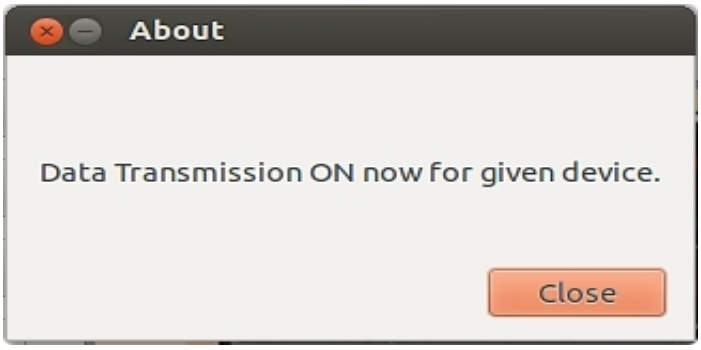
1.4 Turn ON data Transmission:-

- Once the data stream is turned OFF from any device, it can be turned ON again. For Turning it back ON, the process is similar to turning OFF process, it can be very easily assumed and derived from the turning OFF process.

- Click "*Turn ON Data Transmission*" > type in the "*Source ID code*" > click *Send.*



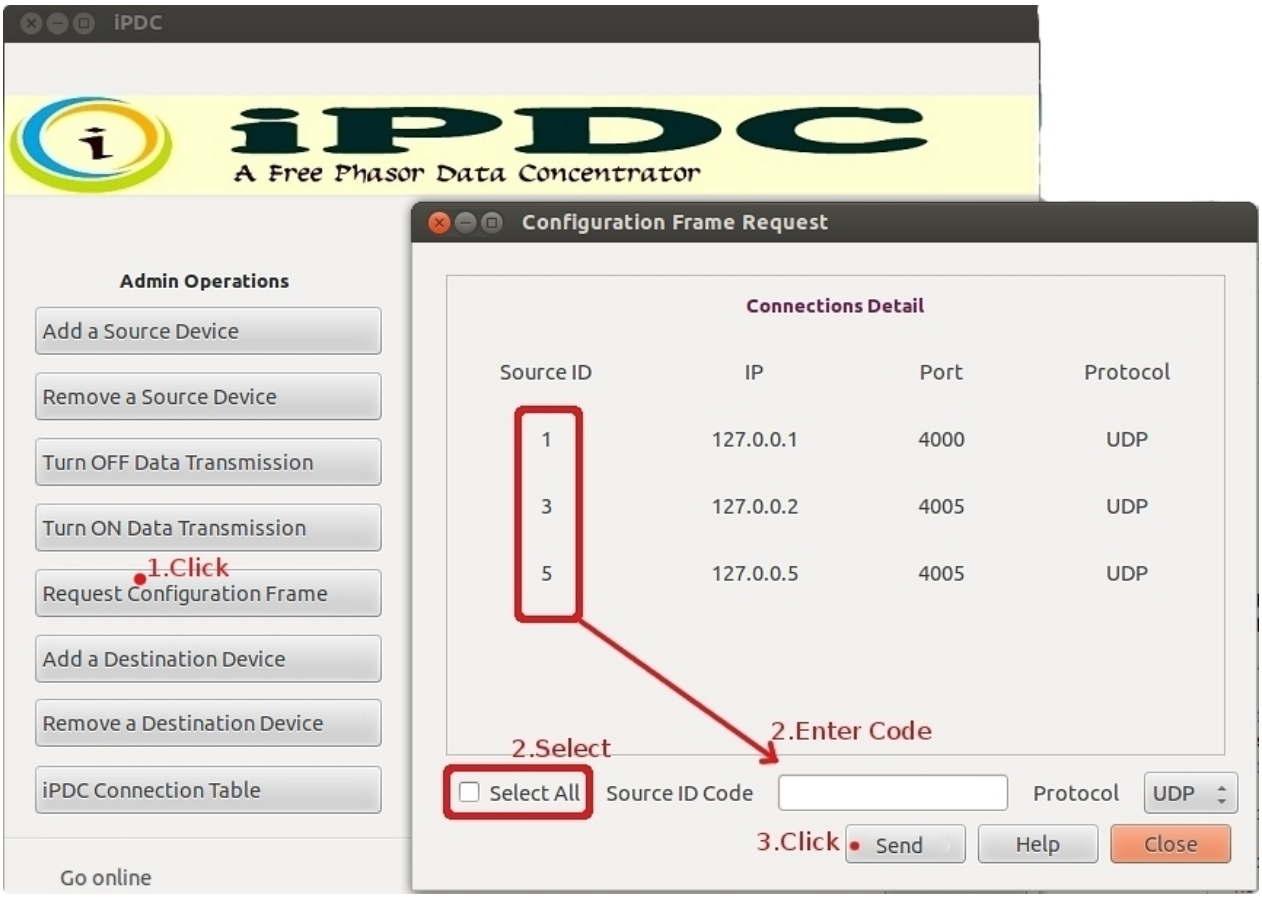
- A *confirmation* will be given.



1.5 Request Configuration Frame:-

- Request to PMU for his configuration frame by sending respective command frame. The standard requires that PMU should be capable of receiving command from the PDC.
- One of the command is 'request PMU for to send his configuration frame'. iPDC implements this through the "*Request Configuration Frame*" button.

- This feature is used to get details regarding the current configuration of the source device. In this process iPDC sends a request to the PMU (simulator/physical device) requesting it's Phasor details, analog details , digital status word etc..



1.6 Add a Destination Device:-

- This feature allows iPDC to be *a node* of a complex, interlinked cascaded network. Through this feature iPDC (previously) being a source device for destination devices.
- It then sends consolidated data received to the upper level PDC/SCADA or any other supervisory system (IP based connection).
- The diagram below shows how you can configure a destination device.

- Theoretically you can add N-numbers of destination device.

1.7 Remove a Destination Device:

- It is used to remove the destination device added by the above method.
- If the removal process succeeded it gives a Confirmation message,as a notification.

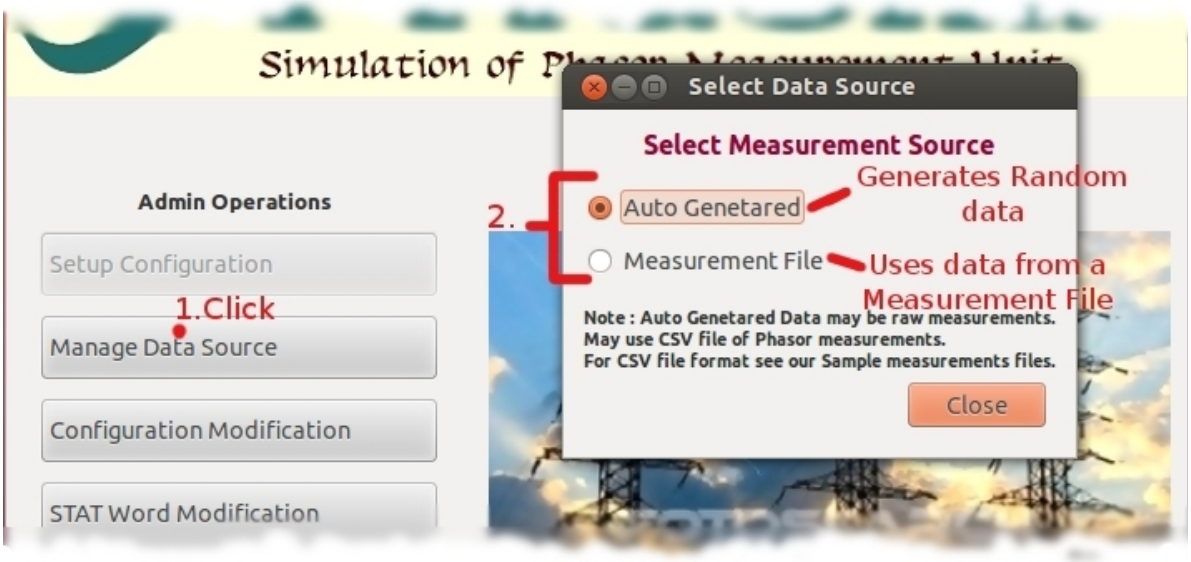
1.8 iPDC Connection Table

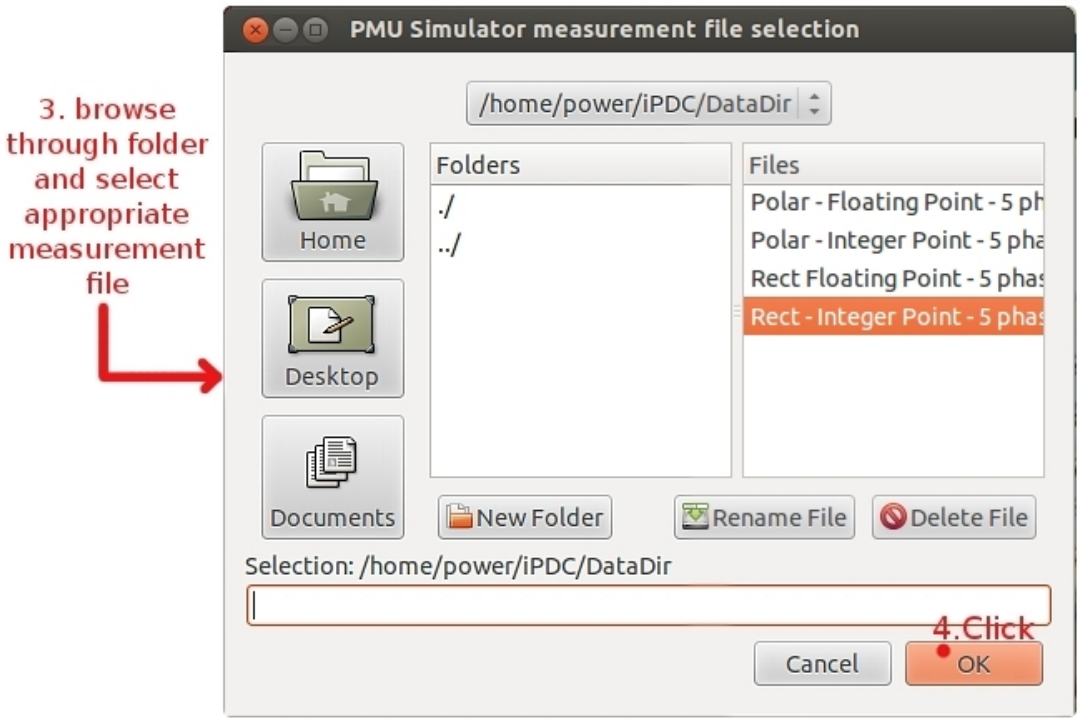
- By clicking this option, iPDC gives the information about connected Source and destination devices connection details. Would be look like as below,

2. PMUsimulator

2.1 Manage Data Source:-

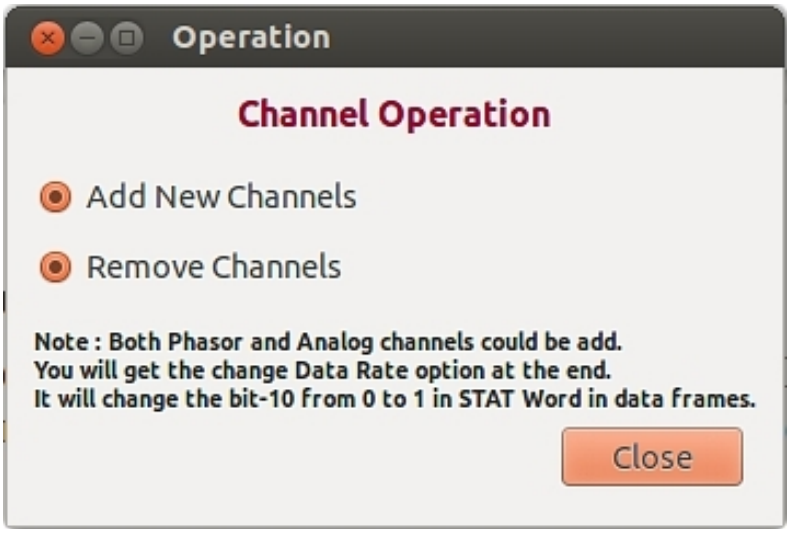
- Two mode of data source are provided,
    1. Auto Generate
    2. Measurement FIle
- Auto-generate, renders random data itself whereas *measurement file* option fetches data from a CSV measurement file. A procedure is show below.
- This option gives a choice for user to send the real world measurement from data file.



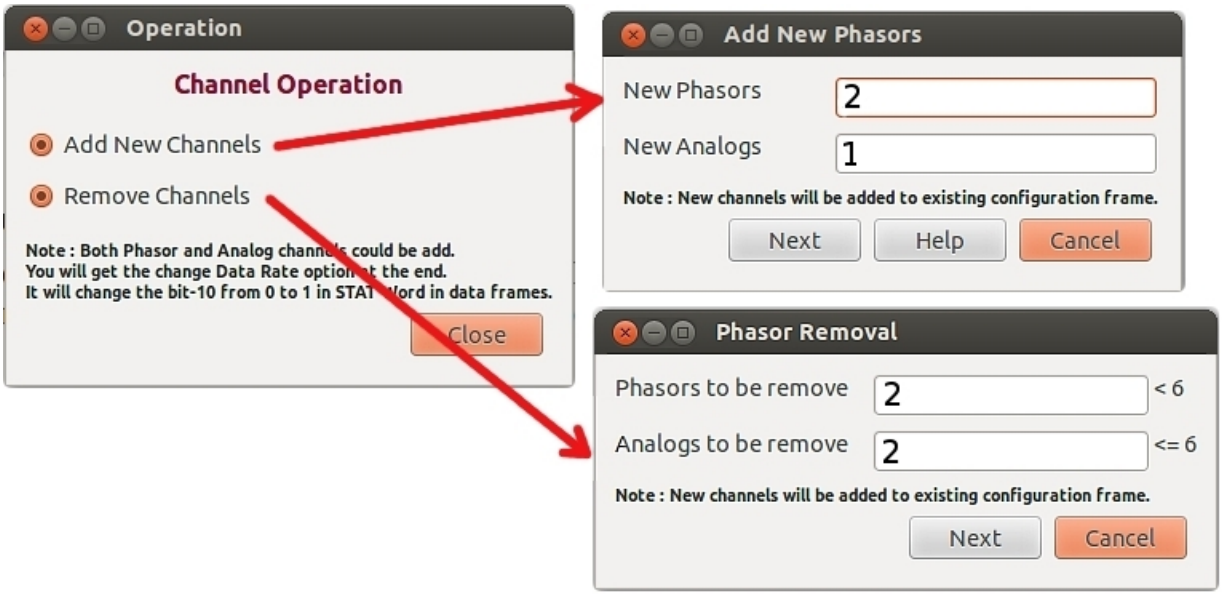


2.2 Configuration Modification:-

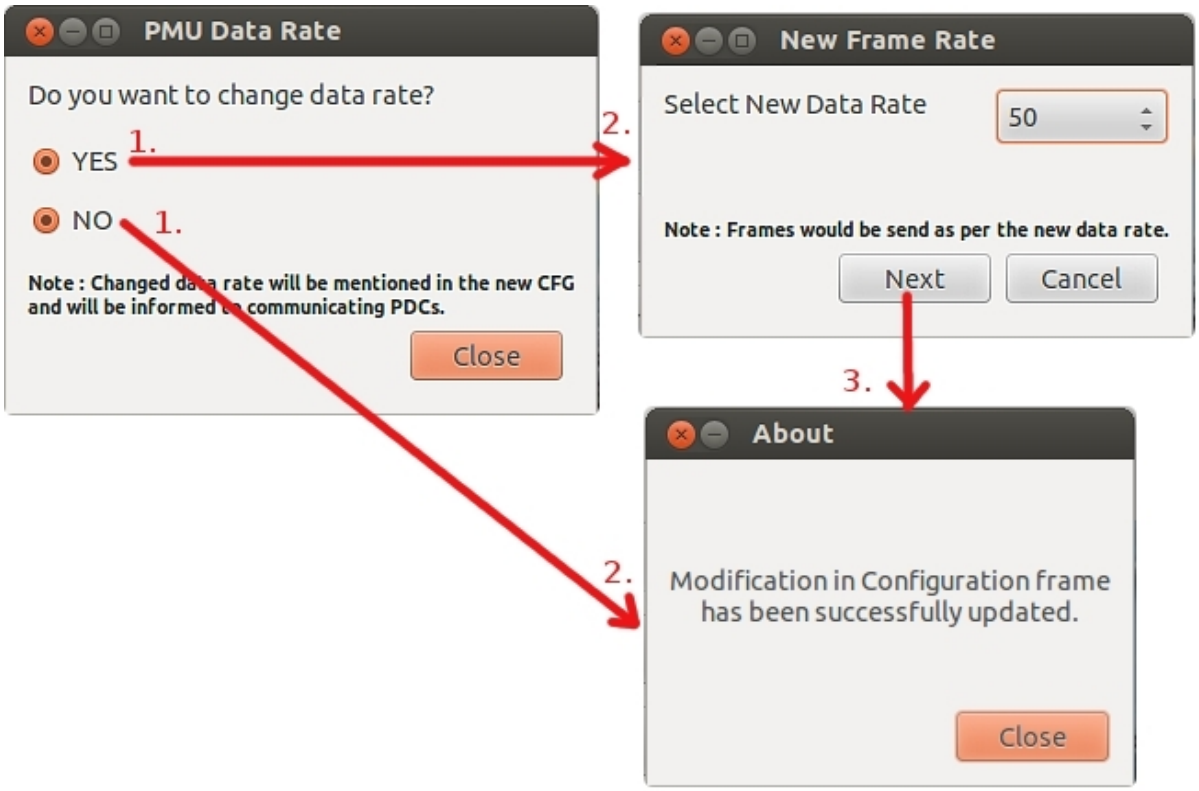
- This option provides facility of adding or Removing a phasor or Analog channel along with option to change data rate.
- By clicking on "*Configuration Modification*" a prompt will pop up



- Select appropriate option, will give you following dialog box.

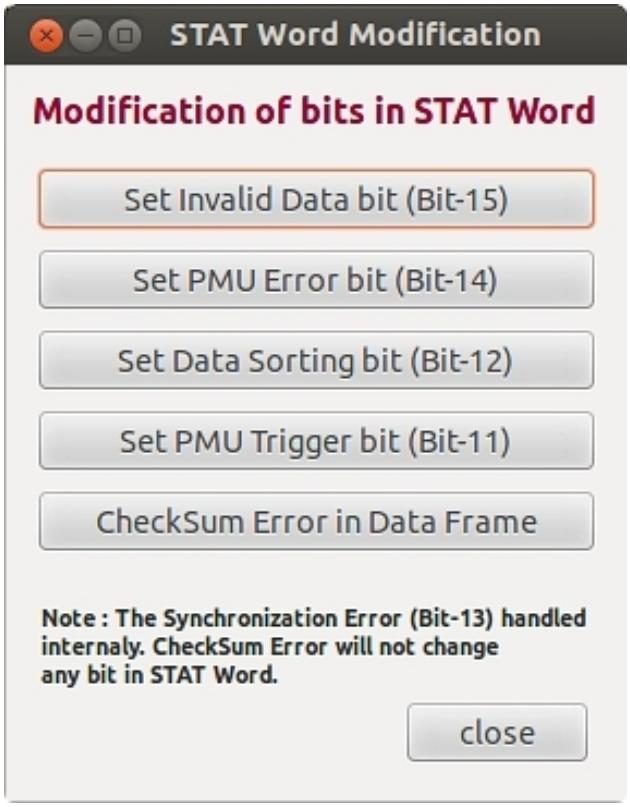


- If A*dd New Channels* option is selected a prompt for adding *New Phasor Details* will be displayed, this window would look same as *Phasor Channel Configuration*, *you saw* during making configuration for PMU Simulator . Fill in the details and click *Next.*
- After that following prompt will be displayed



2.3 STAT Word Modification:-

- This feature of PMU simulator could be used in PDC testing. As this is not an actual PMU, we can/should introduce different status artificially. Detailed explanation about stat word can be found in C37.118 in section '*Explanation for STAT word in the data frame*'.
- It is an imitation of the Actual PMU, it is done automatically in a physical PMU. i.e. If PMU is not in synch with GPS then PMU sends *PMU synch Error,* accordingly other status words are simulated. But only in single data frame.
- It also has option to send invalid Checksum in data frame. Not related to STAT Word.

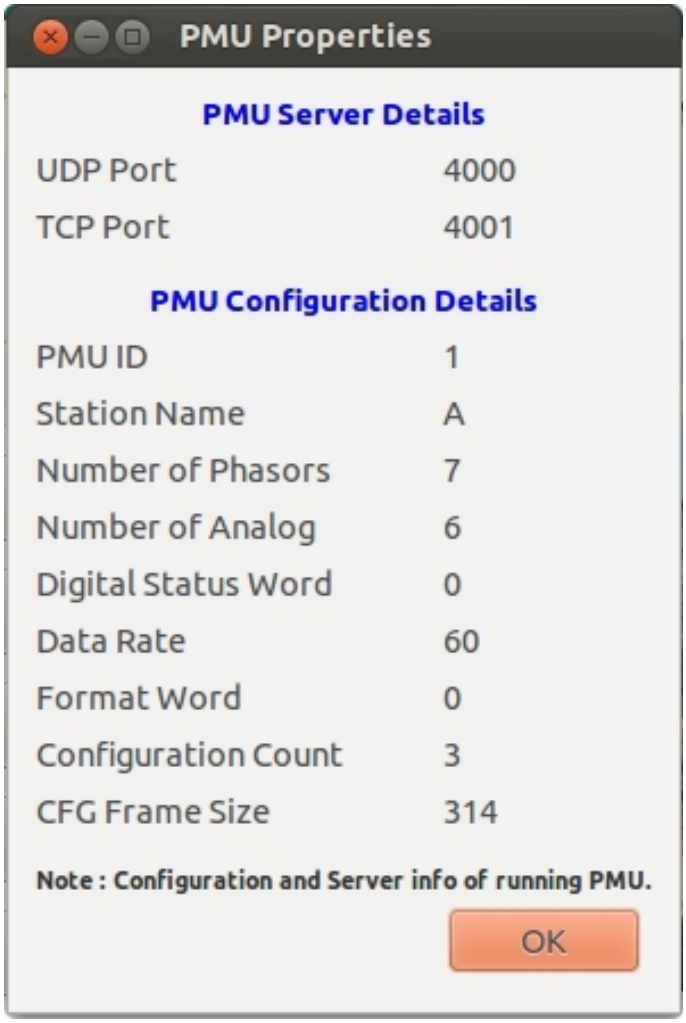


2.4 Header Frame Setup:-

- This frame shall be human-readable information about the PMU, the data sources, scaling, algorithms, filtering, or other related information. The frame has the same SYNC, FRAMESIZE, SOC, FRACSEC, and CHK as the other frames, and is identified by bits 4–6 the SYNC word.
- After clicking the Header Frame option, pop up a prompt with box, in which you can write the information in ASCII-format, Which is saved and sent to PDC when command for sending header frame will received.

2.5 PMU Properties:-

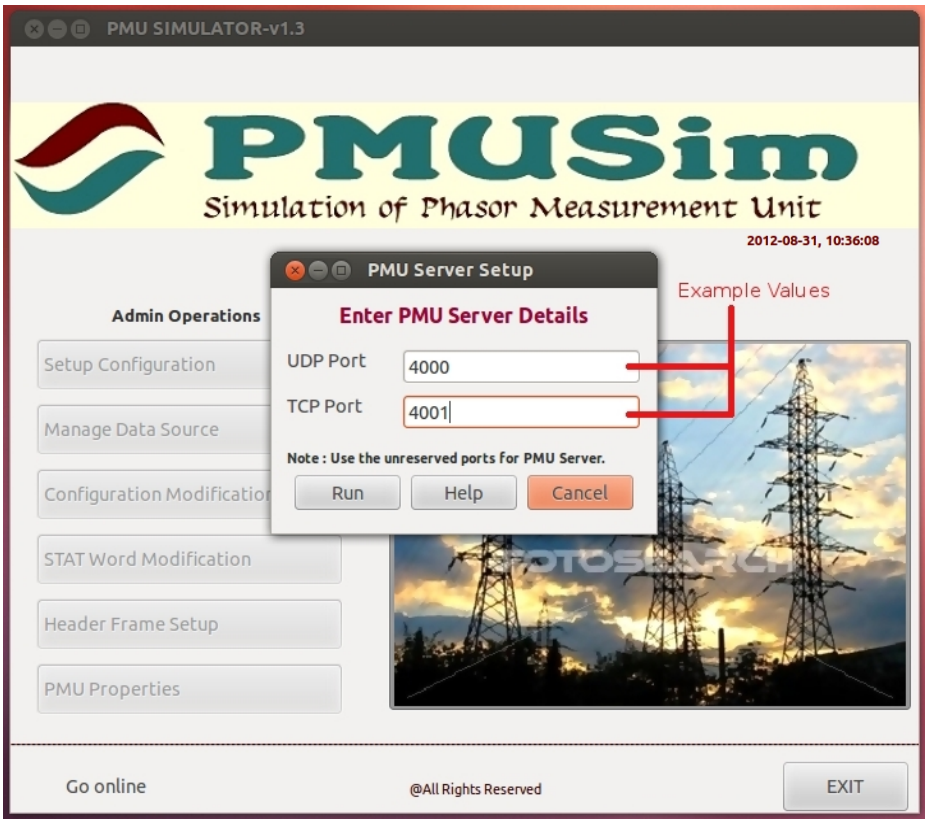
- It provides details regarding the PMU simulator state. (i.e. Server details, No. Of Phasors, No. Of analog signals, Data Rate, etc).
- A sample window is shown over here.



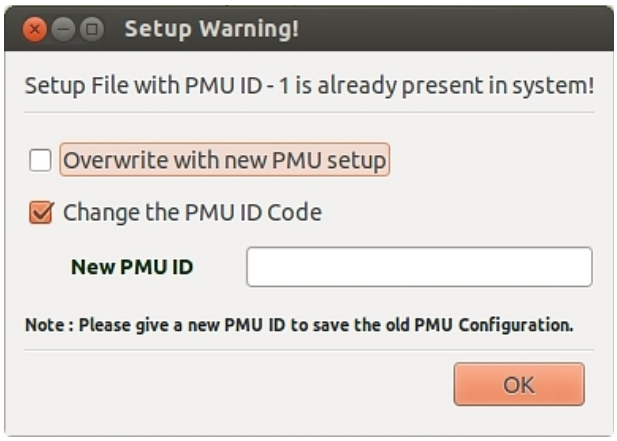
3. General Features

3.1 Saved Configuration:-

- Each and every setup of PMU or iPDC creates a setup file (*.bin) and saves the settings in it. With it's respective PMU/PDC ID value.
- If the PMU/iPDC is running for the first time it will shows a prompt,

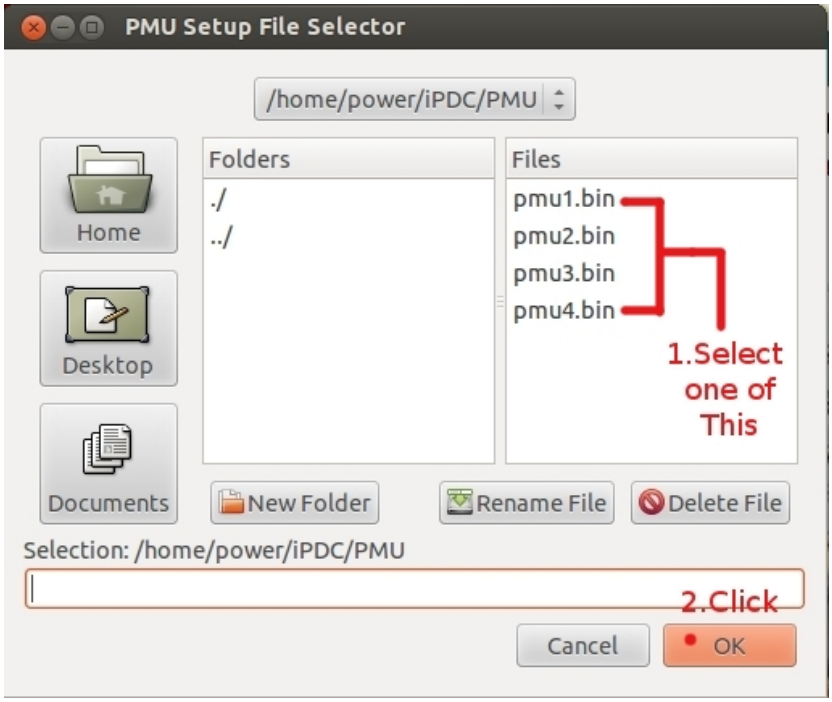


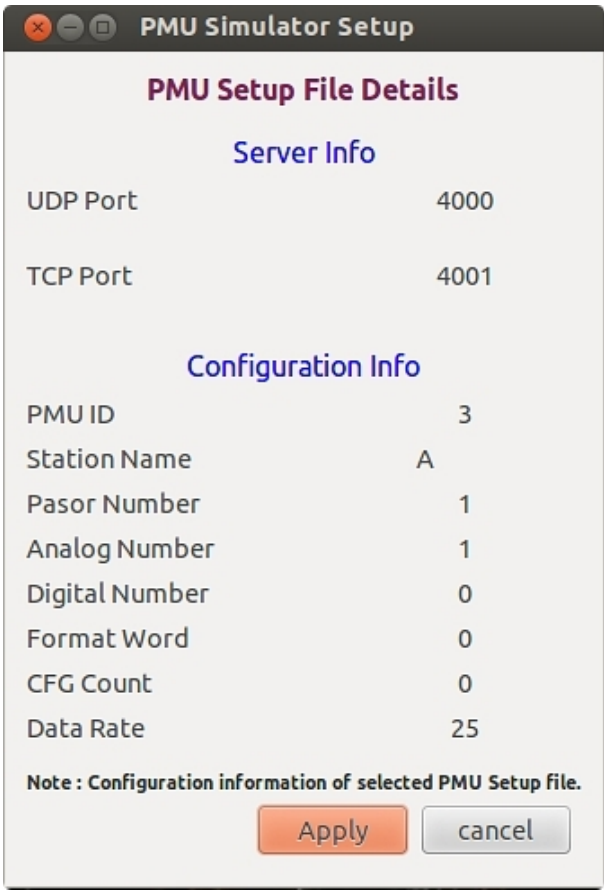
- After this if PMU of same ID exist it will ask for setup that, here if you wish to overwrite then you can overwrite, OR you can save the setting with some other PMU ID.



3.2 Retrieve Previous Configuration:-

- PMUSimulator and iPDC have feature to use old saved setup. In any case if one had to reset the PMU/iPDC setup or is switching the machine then old iPDC/PMU (*.bin) file can be used to recalibrate the installation on the new/formatted system.
- Here is the procedure how it's done, click *FILE* menu> *Open PMU Setup/Open iPDC Setup. T*his will show a following window,

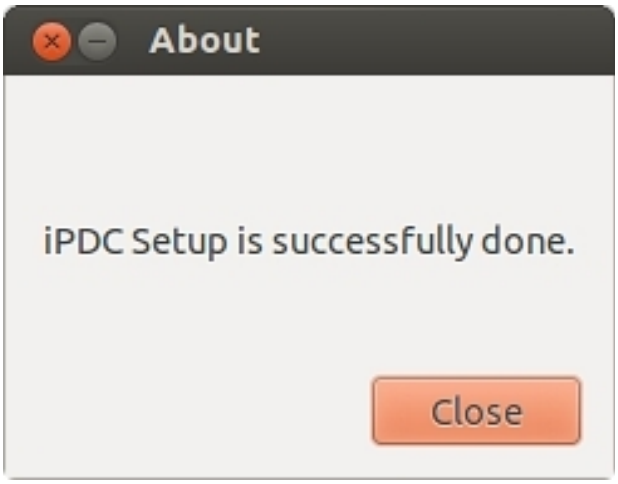




- after selecting *.bin file and clicking OK another prompt will appear showing the property of bin file.

- Same as above is for iPDC,if the iPDC of same ID exist then as soon as you add it will give following dialog box

- Here if u click *YES*, file will get overwritten immediately and following *confirmation message* will appear



- otherwise if you select NO then again *iPDC configuration window* will appear.

Future Planning

- We are having following major Future milestone.
    1. Visualization applications for phasor data.
    2. Porting of complete iPDC software on Windows Environment.
    3. Import/export Data file in comtrade format.
- These are our major thrust area, currently the only way to study the data is in MySQL database, or in DBserver terminal, but it is not sufficient! We intend to develop a interface (something like charting Visualization) in which we can render the data in real time.
- To increase the usability and versatility of the application second objective is also appears to be quite essential due to the popularity of the windows environment.

How Can I HELP?

- Yes, SURE you can help us..!! in fact we really NEED you and will be happy to have your support. We have brought the project up to this level but as all other open source software project this project also needs programmer/developer community's Love, Care & Support.
- So please FEEL FREE to join us - support us – Contact us in any ways you wish...

- Currently you can help us (mainly) in following ways
    - If you are good UI designer (QT, JNI, GTK, Python, etc... anything) then please help us design more user friendly and attractive GUI for iPDC.

    - If you are good (or even rookie will also do, because nobody is a born programmer!!) at Visualization programming like charting API, graphics or any other data rendering methods which can handle large amount of data and possibly in real time using python, C/C++, Perl etc.

    - Apart from above mentioned things, if there is anything else you think needs to be done for improvement (OBVIOUSLY!!) of the project and in that you can help us, please DO CONTACT US. We will be more than happy to have your support.

- If possible please let us know where you are using iPDC software. That really help us,to how to change and improve the software for future.

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