WISP Technical Notes

PMU Identification Numbers

Unique 16-Bit Identifiers Assigned to the PMU Registry

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PMU Identification Numbers

During our initial WISP WAN introduction webinar we discussed the PMU registry. One of the functions of the registry is that during the registration of the device (PMU, DFR, PDC, etc.) a unique 16-bit identifier is assigned to the PMU.

A brief discussion of the IEEE C37.118-2005 specification.

The C37.118 data frame format is used to transmit synchrophasor data from a PMU to a PDC and then from the PDC to a RC PDC as was explained in the webinar. The C37.118 data frame contains a header, the phasor data, and ends with an error check (CRC). The header is of particular interest, it contains the device identifier. This identifier is 16 bits long (2 bytes) and in programming terms is known as a 16-bit unsigned integer. This means it can contain a number between 0 and 65,535. No fractions and no negative numbers. The numbers 0 and 65,535 are identified as reserved and so cannot be used. As you can imagine this is not a lot of numbers especially if shared by the entire North American area.

The Data Exchange Work Group (DEWG) has assigned the numbers **34001-36000** (2000 unique IDs)

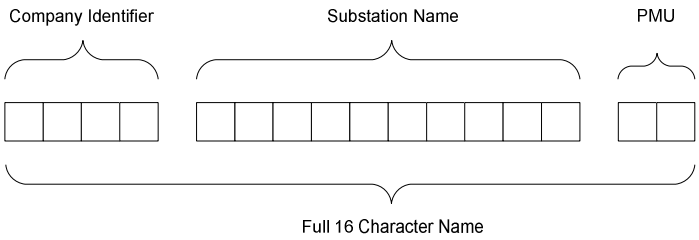
It is important that the IDs of the individual PMUs for each of the participants use a number form this range, and even critical that ID numbers are not duplicated. For example on our first look at real data with only approximately 12 PMUs, three of the PMUs had an ID of 1.

PMU and Signal Names:

Recently I have been circulating spreadsheets that have contained substation, PMU, and signal name information. Another limitation of the C37.118 specification is that there is a 16 character limitation on PMU names and signal names. During the development of the registry we have allowed for the use of much longer more descriptive names for PMUs and Signals. However application vendors have embraced the C37.118 specification and are limiting their applications to the same 16 character limit. As a result would like to adopt the naming convention proposed by PJM and other entities in the Midwest and East Coast.

16-Character PMU Names (a combination of substation and PMU)

/ PJM / MISO specification:



There is already a document which describes a four character Company Identifier:

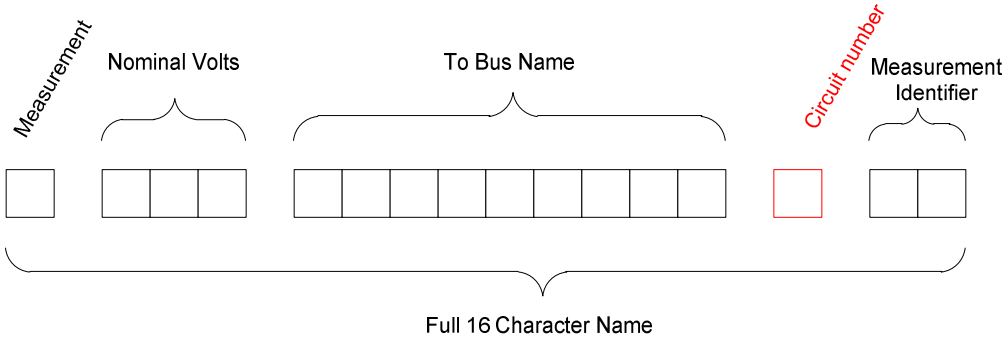
WON OAG_ICCP-WSCC_Utility_Identifiers-from_BPA_1995.PDF

This associates IDs of W001 through W287 for each member. Substation names are a little more controversial and would prefer the names we have in our EMS system for example BOISECSC for Boise Cascade, all the EMS names for substations are 8 characters or fewer, for C37.118 we will right pad with underlines. The last two characters are just the numbers 01 through 99 applied to the order the PMU is in the substation, note this has no relationship the 16-bit ID described on page 3.

For example the ***third*** PMU in the Nevada Energy substation Harry Allen would have a PMU name of

`W017HALLEN__03` since some PDC applications automatically delete spaces from signal and device names we use the underscore character

16-Character Signal Names



1. Asset Measured – 1 character to identify measurement
    a. B - Bus Side phasor
    b. L – Line Side phasor
    c. D – Digital or status i.e. 1 or 0

   d. A – Analog (non-phasor use for frequency and df/dt, or Watts and VARs any single value scalar)
   e. T – Phasor on transformer
   f. G – Phasor on Generator
   g. C – Phasor on Capacitor Bank
   h. R – Phasor on Reactor
2. Nominal Voltage
   a. For phasors nominal voltage kV e.g. 500
   b. For non-phasors leave blank except for frequency and df/dt then include nominal voltage
3. The "To Bus" name has the most complex rule-set (if less than 9 characters pad with the underscore character)
   a. This would be the name of the out-bound substation on the other end of the line or;
      i. For example the phasor from the first PMU at the ALLSTON substation has a PMU identifier of W001ALLSTON___01. The signal on that PMU is measuring line current shown on the one-line diagram as going to the KEELER substation would be labeled L500KEELER___1IP
   b. The bus section identifier
      i. Since the bus section identifier is typically something like North, South, East, West, 1, A, etc. will use NORTH, SOUTH etc. for the "to bus" name. For example:
      ii. The substation ALLSTON has a first PMU identifier of W001ALLSTON___01. The voltage phasor on the South Bus signal name will be B500SOUTH____1VP
      iii. Frequency and Rate of change of Frequency. The consensus is that there should be no "To Bus" identification for frequency and f/ t. For each of these analog values the 9 characters should contain "FREQ_____"
4. Circuit number for parallel lines or transformers on the same To Bus will increment the number in position 14 e.g. if the measured signal is the same and it is being measured by the same PMU the name will follow this convention L500KEELER___1IP and L500KEELER___2IP

5. Measurement Variable identifier
    a. VP, VA, IP, IA, F, R etc. (here the P indicates positive sequence)

VP	Voltage	Positive Sequence
IP	Current	Positive Sequence
VZ	Voltage	Zero Sequence
IZ	Current	Zero Sequence
VN	Voltage	Negative Sequence
IN	Current	Negative Sequence
F_	Frequency	Frequency
R_	df/dt	Frequency rate of change
VA	Voltage	Phase A
VB	Voltage	Phase B
VC	Voltage	Phase C
IA	Current	Phase A
IB	Current	Phase B
IC	Current	Phase C

6. Special consideration for frequency and frequency rate of change
    a. The IEEE C37.118 communication specification does not contain any method for naming the frequency and frequency rate of change measurements. Every PMU measures and transmits these two values in the header section of a data frame. There is no corresponding field in the Config2 frame to name these two signals.
    b. In the registry and in the data archive system these two values are named according to the convention outlined in this document. The values should be named A230FREQ_____1F_.
    c. After discussing with WISP participants it was decide to name the frequency and frequency rate of change measurements to indicate which voltage the measurements are being taken from.

OSIsoft PI naming convention:

The PI naming convention should follow the C37.118 naming convention with the following additions.

The 16 character PMU name and the 16 character signal name should be concatenated using a "." (dot) separator e.g. W073PALVERDE__01.L500HASSYYAM_1IP. Since PI does not have a method for storing phasor values the phasor will have to be split into two scalar values. To accomplish this split a two character suffix will be appended to the 17 character combined PMU.SIGNAL name using the following table to identify the character after the "." (dot)

Polar phasor angle	A
Polar phasor magnitude	M
Rectangular phasor real	R
Rectangular phasor imaginary	I
Frequency	F
Rate of change of Frequency	R

Examples:

SRP Substation Palo Verde

First PMU in the substation

W073PALVERDE__01

This substation happens to have 3 lines connected to the Hassayampa substation. If positive sequence current synchrophasors were being measured for all three lines they would be identified as follows:

L500HASSYYAM_1IP
L500HASSYYAM_2IP
L500HASSYYAM_3IP
Fully qualified signal name for PI would be
W073PALVERDE__01.L500HASSYYAM_1IP.M for magnitude and
W073PALVERDE__01.L500HASSYYAM_1IP.A for angle

Voltage measured at the east bus the signal name would be

B500EAST_____1VP
Fully qualified signal name for PI would be W073PALVERDE__01.
B500EAST_____1VP.M for magnitude and W073PALVERDE__01.B500EAST_____1VP.A for angle

Frequency and rate of change of frequency example same substation and PMU
A500FREQ_____1F_ and A500FREQ_____1R_

Fully qualified PI names
W073PALVERDE__01.A500FREQ_____1F_.F
W073PALVERDE__01.A500FREQ_____1R_.R

SCADA (ISD) names:

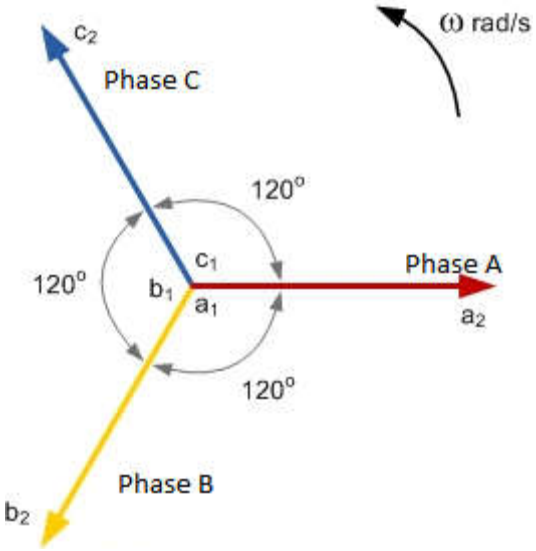
If possible we would like 35 characters for SCADA and the names should follow the same criteria as the PI names. This is under investigation right now to determine if there are any violations in the names allowed for SCADA and if SCADA can accept 35 character names

The WISP program needs latitude and longitude of substation only, the PMU registry will automatically assign to all PMUs and signals inside the substation. In the future for large substations, if required more accurate latitude and longitudes can be measured for the specific CT and PT but this is unlikely

Signal names that can be, will be automatically generated based on the previous criteria

Phasor Measurement

Each PMU or device acting as a PMU always sends a single frequency and frequency rate of change ($f/\ t$) measurement. PMUs can send any number of phasor measurements. This makes it easy to count the total number of PMUs that are in the PMU data set by simply counting the number of frequency signals. Please play close attention to the frequency measurements. In most installations this frequency measurement will be measured from one of the Phase A voltages the PMU is connected to.



Positive sequence synchrophasor measurement is a calculated value that is the vector average of the individual phases with phase B and phase C offset by 120°.

The PMUs installed will be measuring all three phases, usually both voltage and current (I am not aware of any PMUs that measure voltage only) Individual participants may choose to transmit the individual phase phasors internally to their own data centers but only requests the positive sequence phasors

Phase angle offset

Not all participants use the same phase as the reference phase when configuring PMUs to calculate the positive sequence phasor. This results in an apparent shift of plus or minus 120 degrees in phase angle from other participants when used for a wide situational awareness view. In these cases requests that the individual participants modify the phase angles reported to at their individual PDCs by either adding or subtracting 120 degrees from the positive sequence phase angle. The following participants are considered to be using the reference phase of choice for; PG&E, LADWP, SDG&E, BPA, and SCE.

Phasor RMS Magnitude Values

expects the RMS values for the magnitude portion of the phasor to be reported as Phase to Neutral not Phase to Phase, e.g. for a nominal 500kV line the RMS magnitude would be reported as 288,675.135 volts

Appendix: Using PDCs to Rename PMUs and Signals

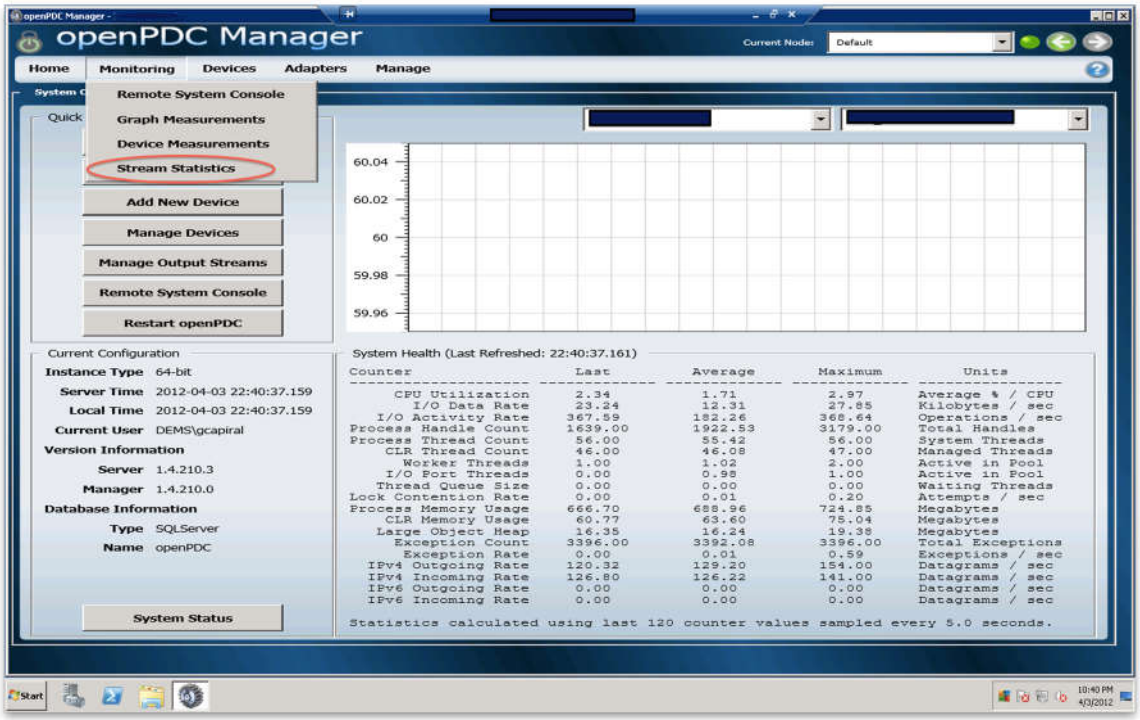
The best technique for compliance with the PMU and synchrophasor naming conventions is to change the configuration of the source PMU directly. When this is not possible the PDC used to transmit the data to the WISP archive can be used to rename the PMU and signals before they are received at the archive. Some example of this is accomplished follow.

Using openPDC to Rename PMUs and Synchrophasor Signals

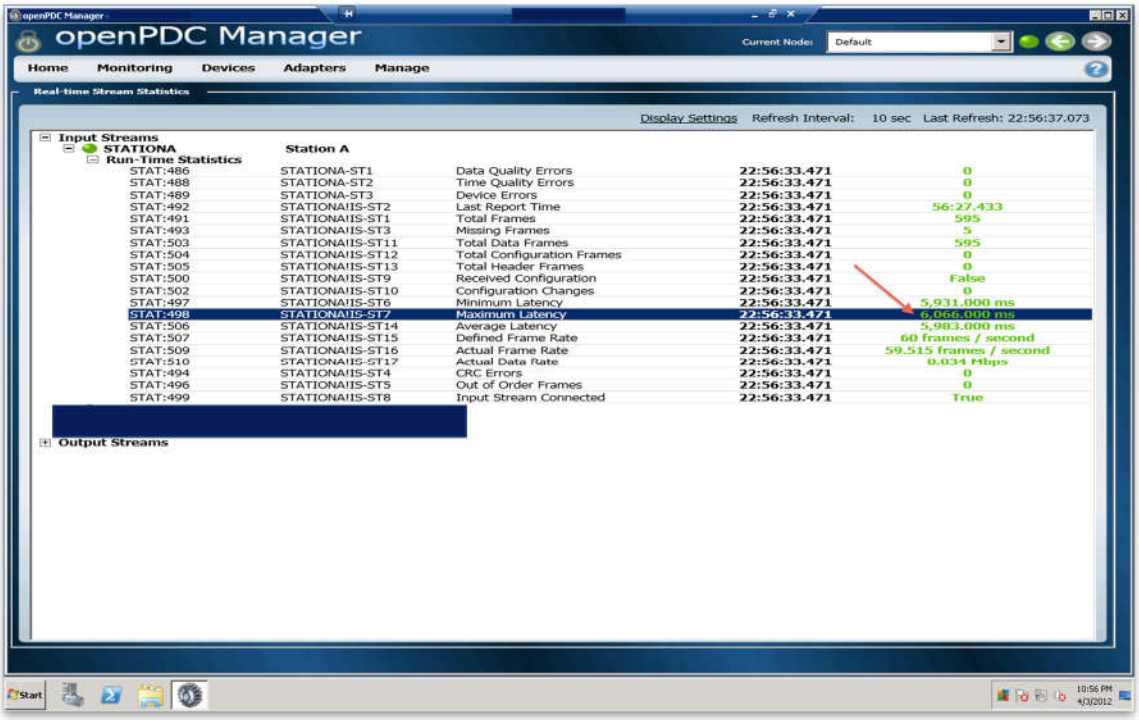
Creating an Output Stream in openPDC

Step 1: Open the openPDC manager.

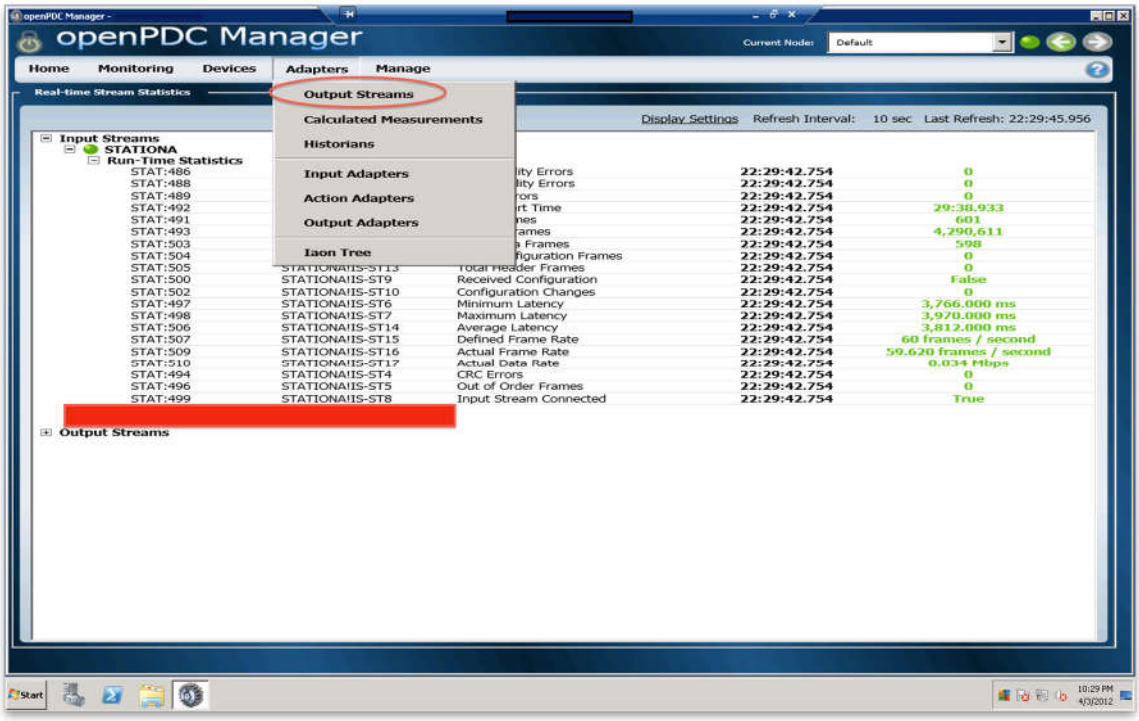
Step 2: On the navigation bar, click on Monitoring -> Stream Statistics.



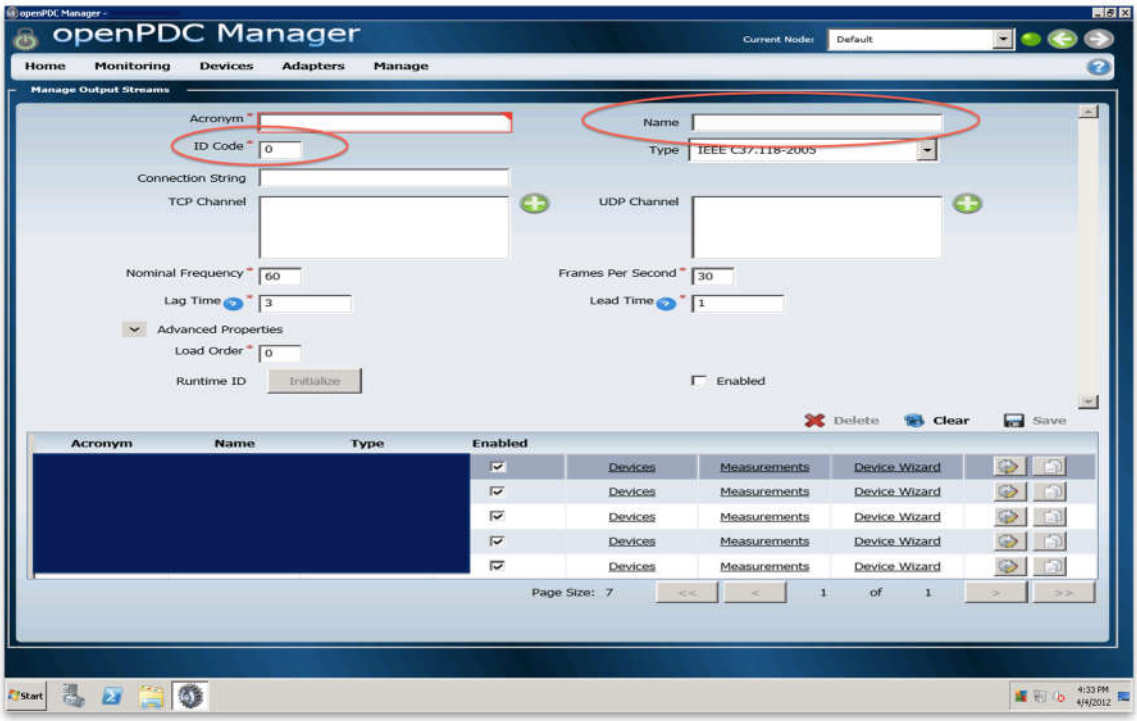
Step 3: Once in this window, take a look at the stream(s) which contain the signals that you will be adding to your output stream. Click on the + sign to view the Run-Time Statistics of the stream. Note the number in the Maximum Latency row as this is an important step in creating the output stream. (If you will be adding signals into your output stream that originate from different input streams, be sure to grab the highest Maximum Latency time between all incoming streams)



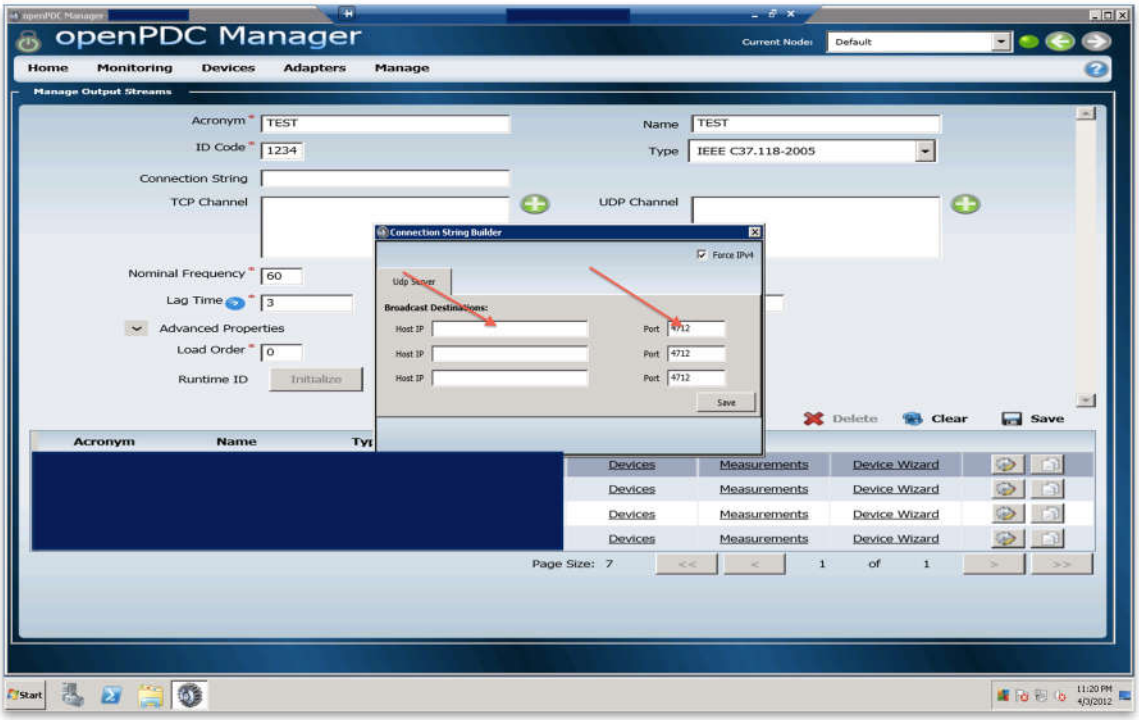
Step 4: On the navigation bar, click on Adapters -> Output Streams



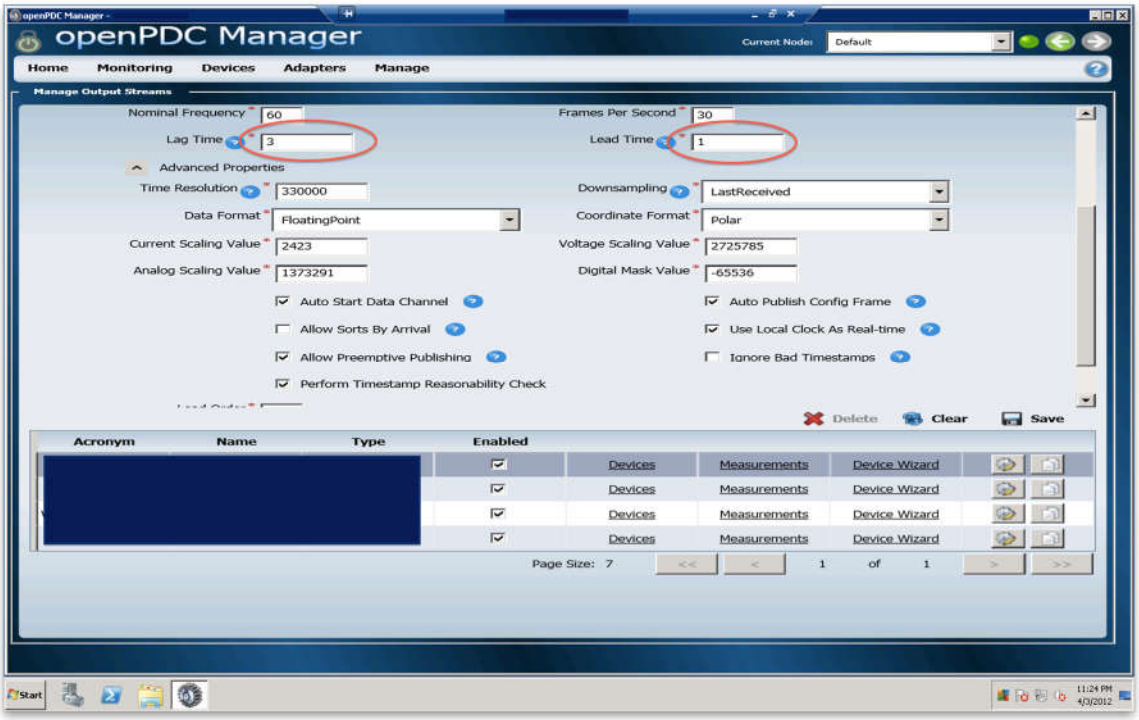
Step 5: To begin creating the output stream, we must first input the acronym, name and the ID code. The name textbox is the PDC name and ID code will be the PDC ID. (The PDC name and ID should conform to the standards for naming and ids WISP has provided).



Step 6: For the purposes of this demo, I will be setting this output stream as UDP ONLY mode sending frames at 30 FPS. Click the green plus button next to the UDP Channel textbox. This will bring up the connection string builder. Fill in the IP address and port of the server you wish to send the data to.



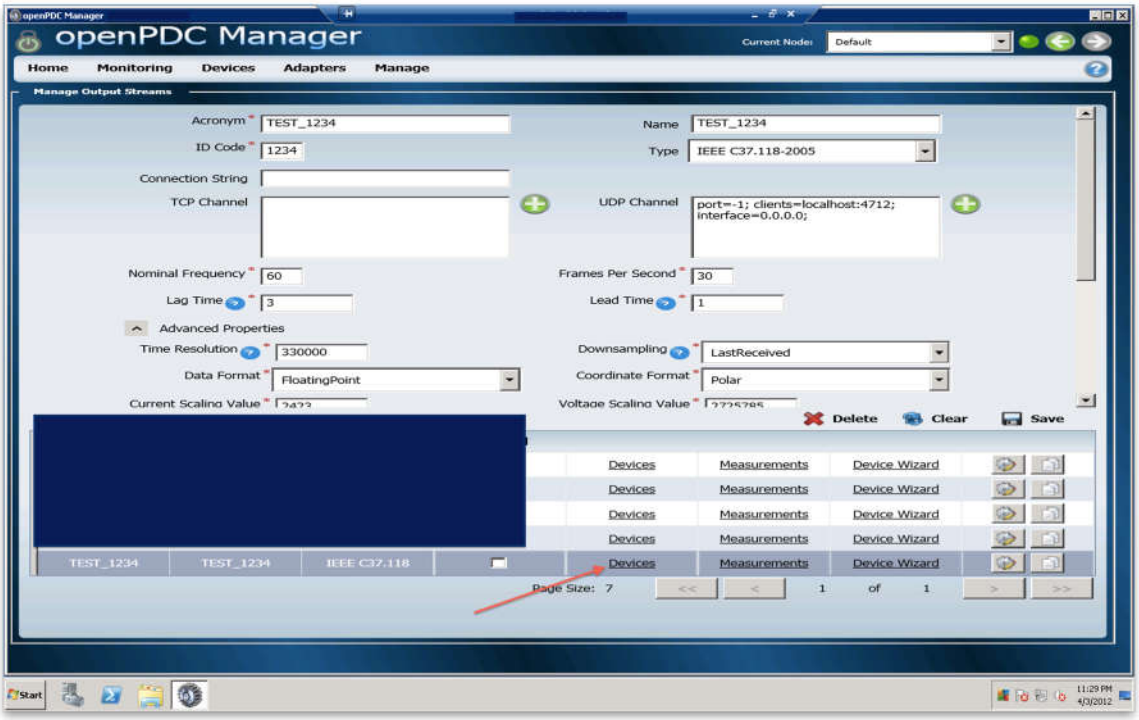
Step 7: At this point, check the value that was derived from the Stream Statistics window. If this number is greater than 3,000 ms (3 seconds), change the value to the Lag Time text box (remember that the value in this textbox is in seconds) to the Maximum Latency value always rounded up to the nearest second (e.g. IF value = 4. 303 THEN textBox value = 5). However, if the value is negative, and the value is less than -1,000 ms, then you will be adjusting the Lead Time text box. (Note: ***Negative lag times or extremely long lag times are indicative of bad clock synchronization between PMU and PDC***.)



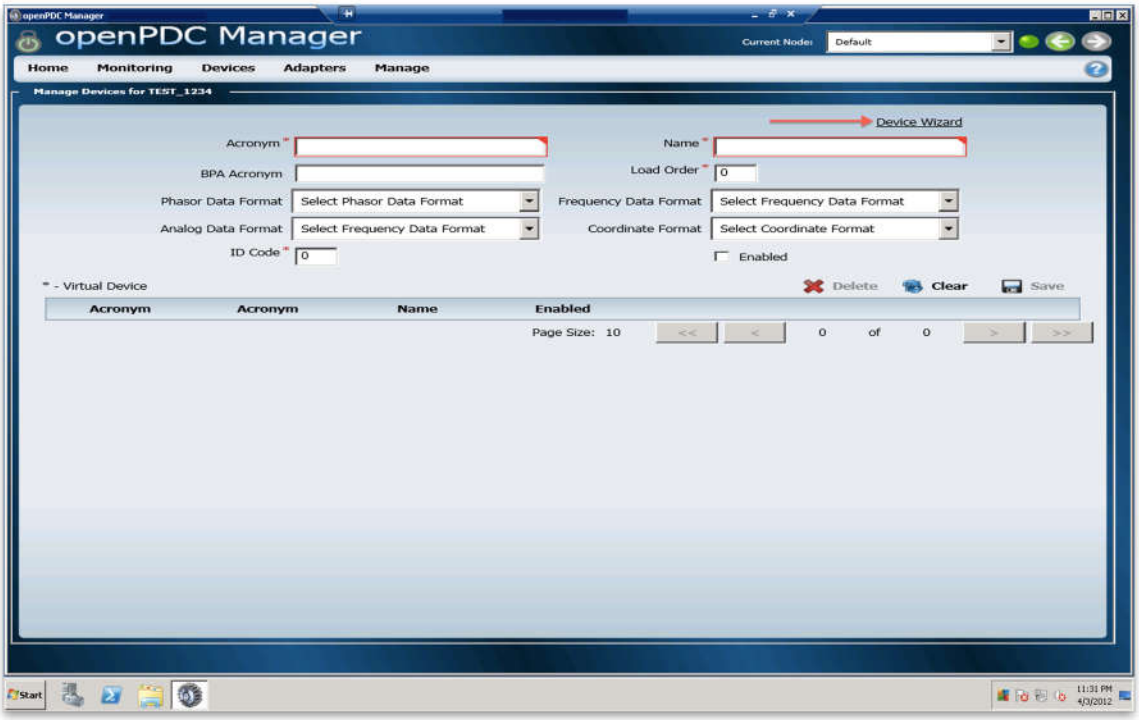
Step 8: Make sure the following check boxes are checked:

Step 9: Click the Save button.

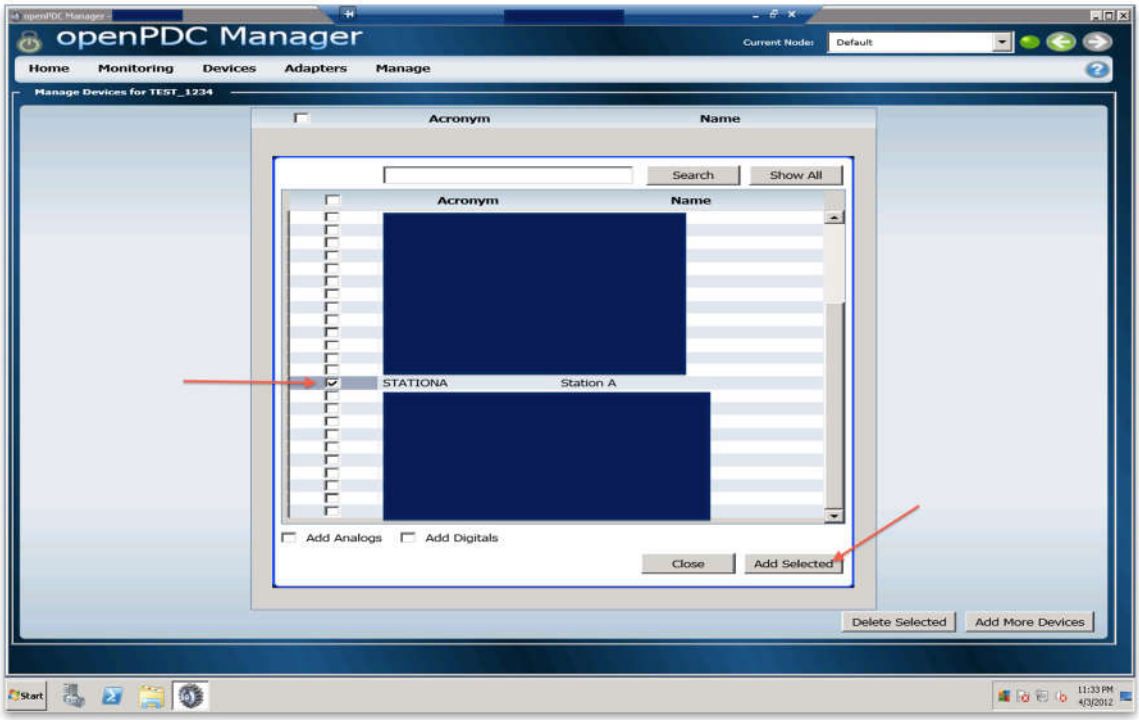
Step 10: The new stream will appear at the bottom of the output stream table. Click on the stream you just created and click on the devices link.



Step 11: Click the Device Wizard Link

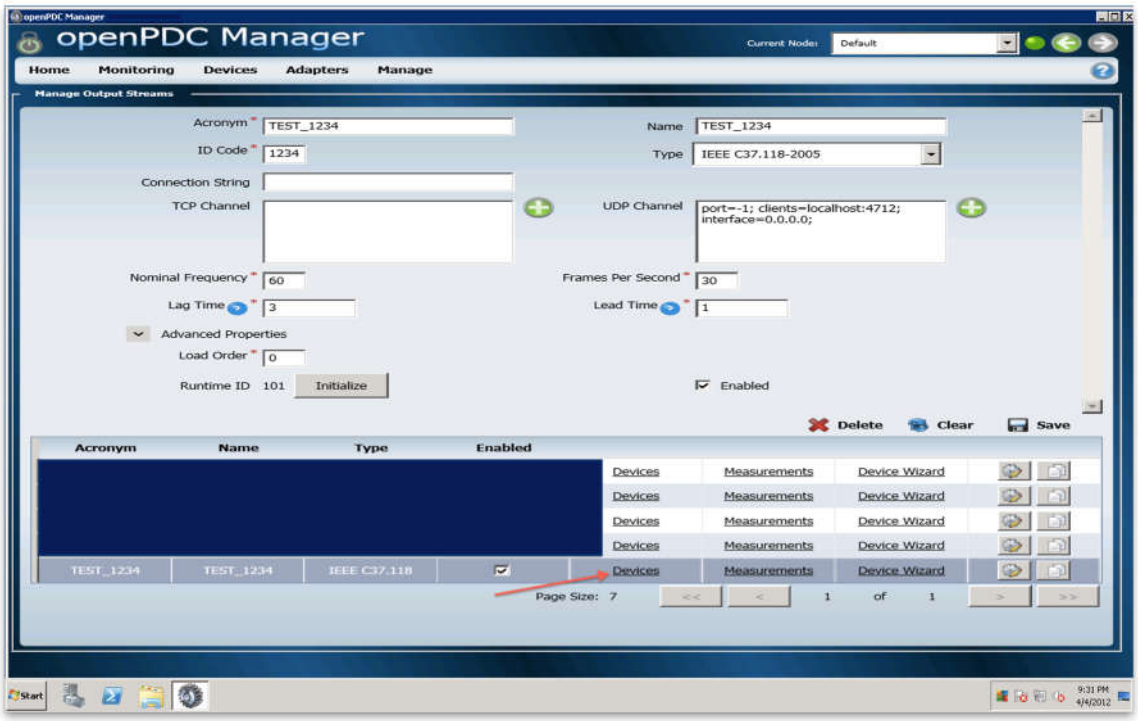


Step 12: Select the PMU you would like to add to the output stream, and then click Add Selected.

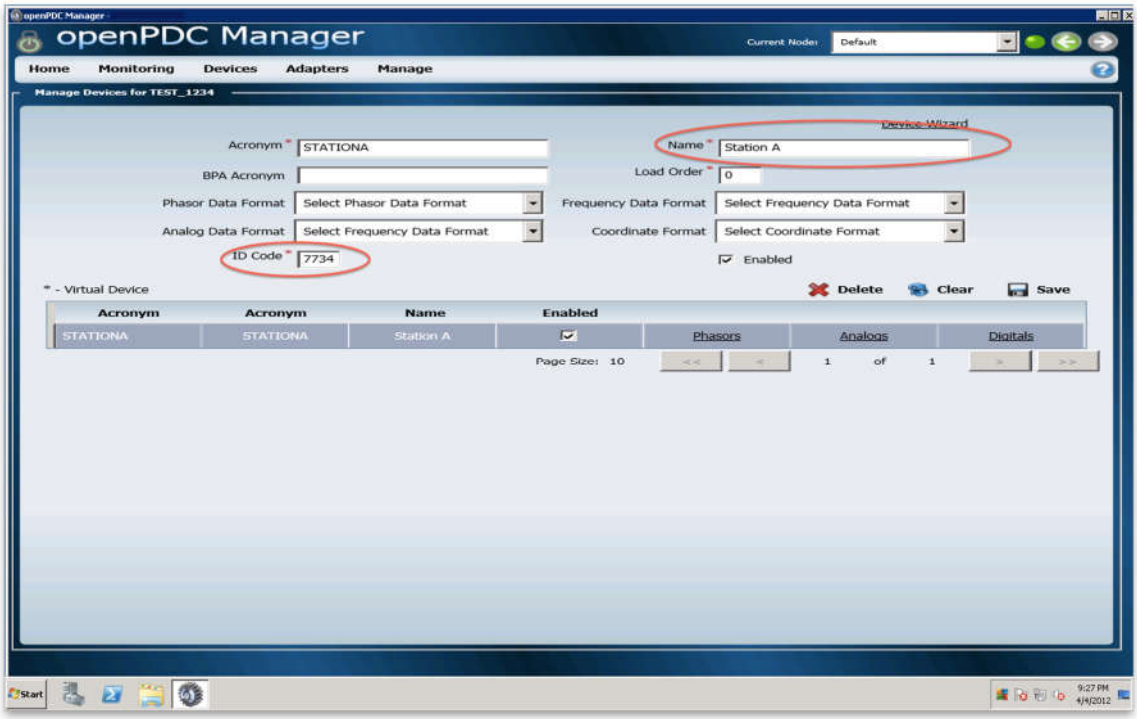


Step 13: Navigate back to the Output Stream window. Adapters -> Output Streams

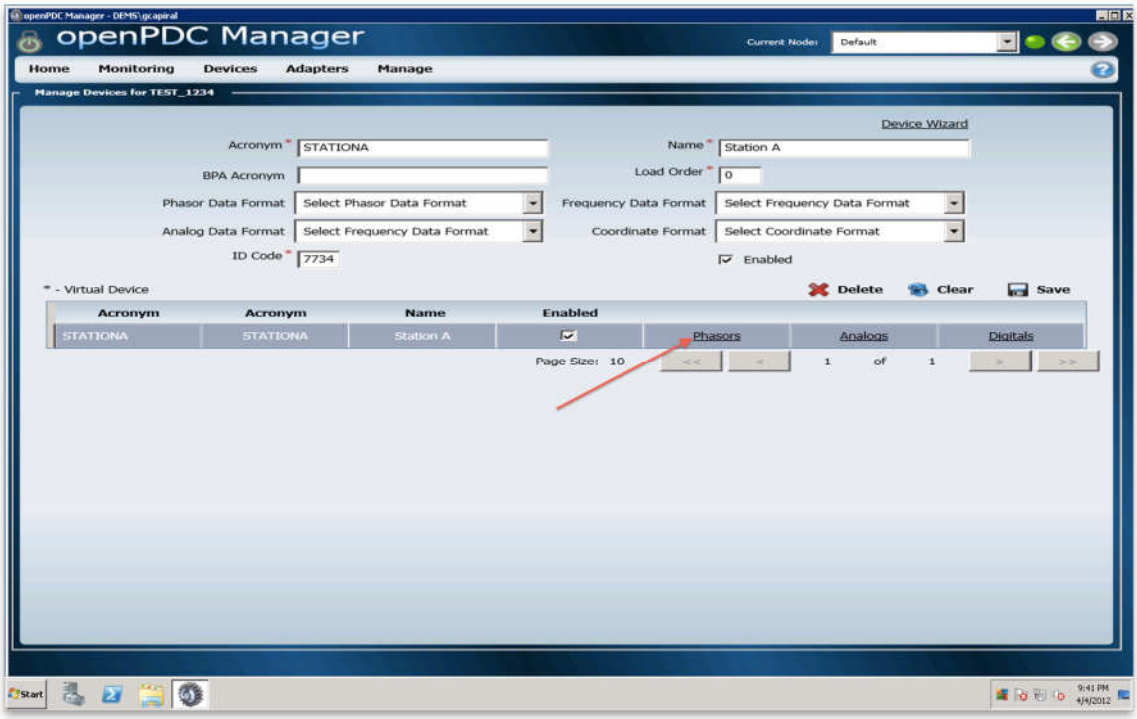
Step 14: At this point, if you would like to rename any of the PMUs or the Signals as well as change IDs this is the time to do so. Once you are back in the Output Streams window, click on the output stream that you created and click the Devices link.



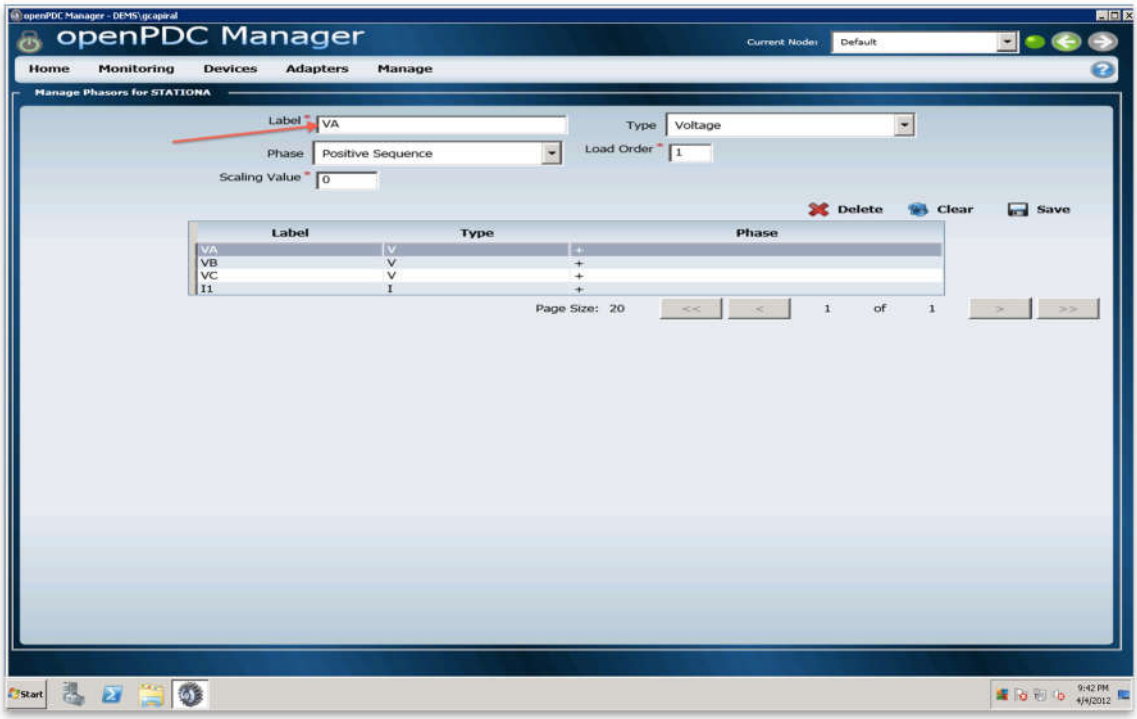
Step 15: This should take you to the Devices window. In this window, you will be able to rename each PMU or change its ID. (The PMU name and ID should conform to the standards for naming and ids WISP has provided).



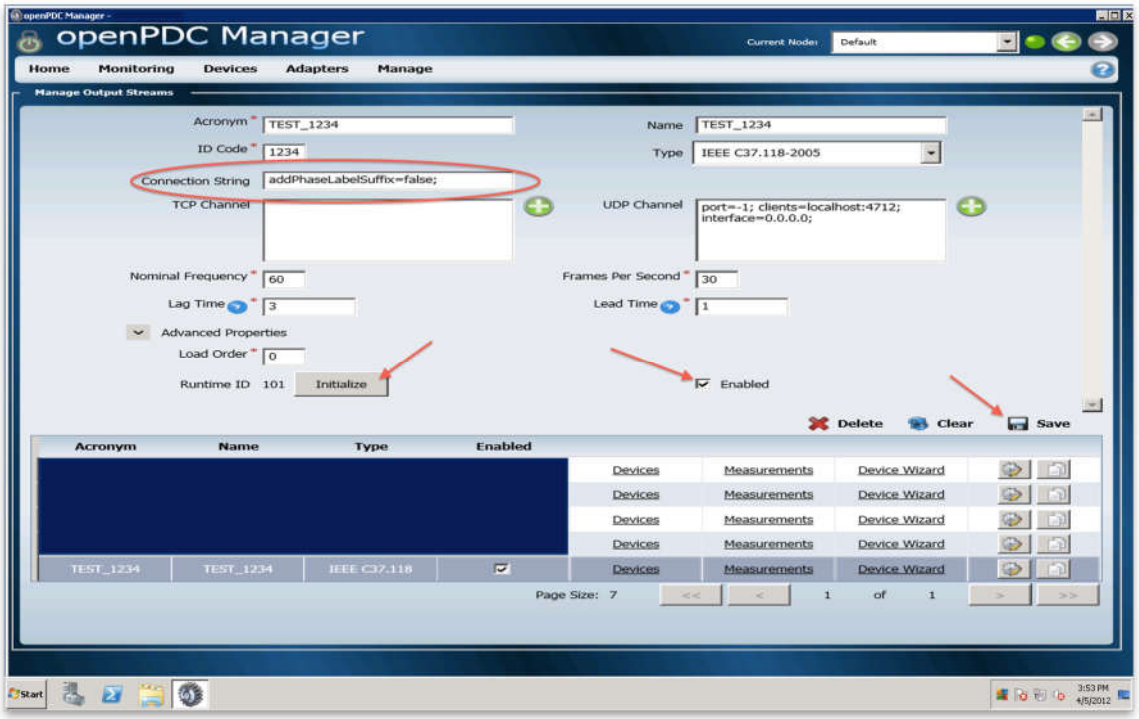
Step 16: Lastly it is also possible to change signal names within each PMU by clicking the Phasors link button located within the PMU of your choice. (The Signal names should conform to the standards for naming WISP has provided). Click save when completed.



Step 17: After clicking on the Phasors link button, you should be taken to the Signals window. By changing the name in the label textbox, you should be able to effectively change the name of the phasor. Click save when completed.



Step 18: When you are all finished, navigate back to the Output Stream window, (Adapters -> Output Streams). openPDC automatically adds a suffix onto each signal name by default. To remove this you must type “addPhaseLabelSuffix=false;” into the Connection String textbox. After this is finished, click the enabled checkbox, the save button, then click the initialize button.



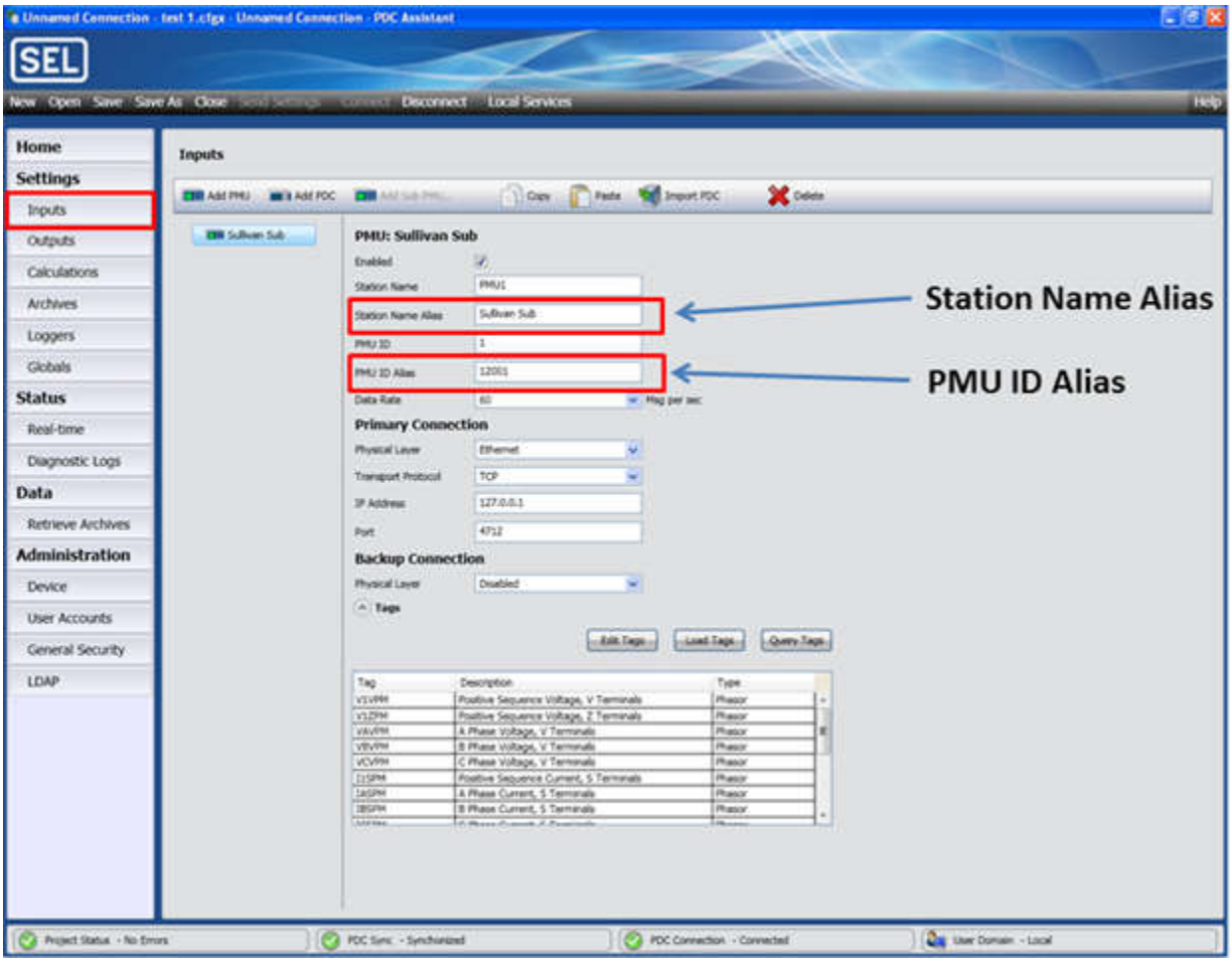
This concludes the instruction for creating an output stream in openPDC.

Using SEL-3373 Station PDC and SEL-5073 Synchrowave PDC to meet WISP PMU Identification Requirements

SEL has worked with the WISP PMO to ensure that the SEL PDCs meet the WISP requirements for PMU identification (in addition to other requirements). Below is a quick summary of how the SEL PDCs can be used to meet these requirements.

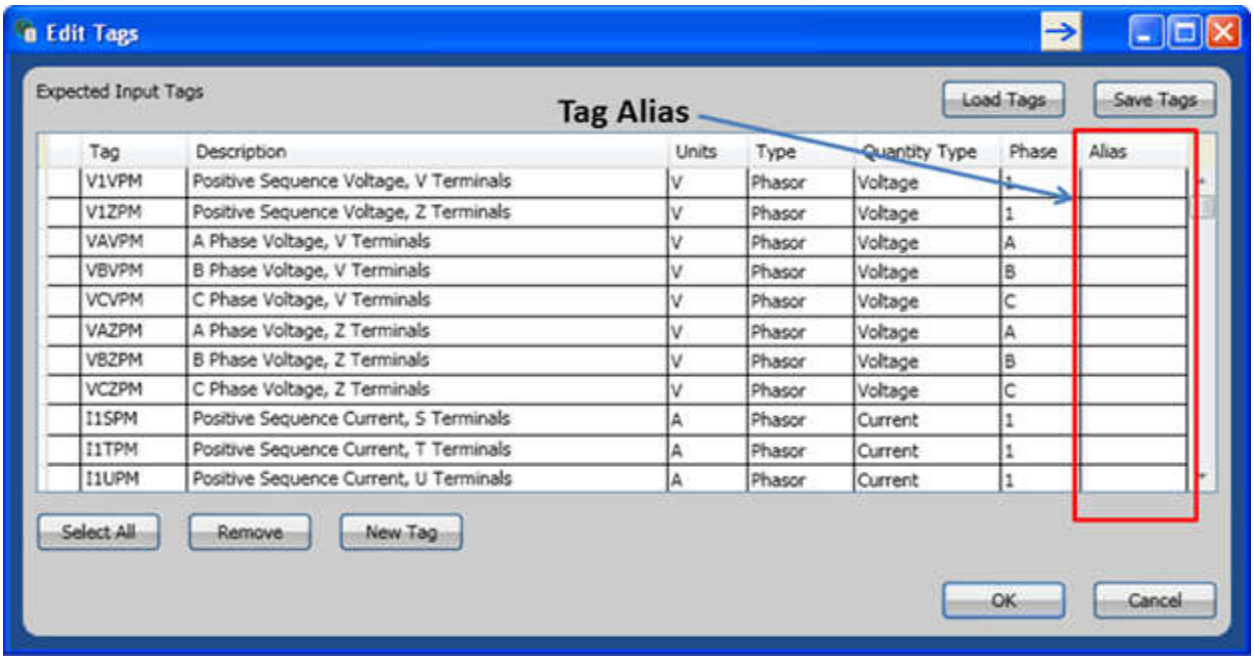
Setting PMU ID and PMU station name using SEL PDCs

The SEL PDCs allow the user to alias these values in the PDC so that no change needs to be made to the PMU. These aliases are set on the following screen of the PDC Assistant



Changing the Tag names using SEL PDCs

The SEL PDCs allow the user to alias all tags in the PDC. These aliases are set by selecting “Edit Tags” button on the above screen of the PDC Assistant.



Additionally, the SEL PDCs allow the user to correct amplitude or angle and calculate power (or other quantities. This allows the user to correct for phase shifting transformers or known errors in the PMU measurements. Contact SEL if you need any help with configuring these for your PDC.

Applying WISP PMU_ID and naming with the ePDC

Change Output PMU Names through Output System Configuration Panel

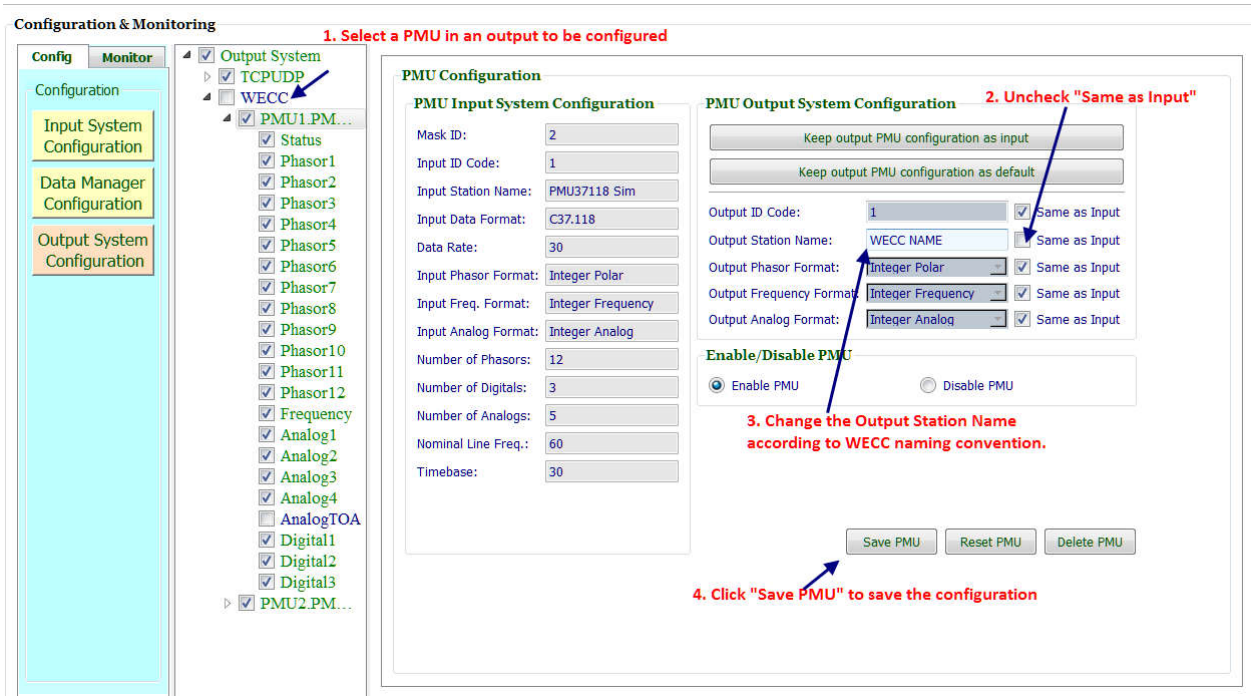
Step 1: Select a PMU in an output to be configured

Step 2: Uncheck “Same as Input” for the Output Station Name

Step 3: Change the PMU name according to WISP naming convention

Step 4: Click “Save PMU” button to confirm the changes

Step 5: Repeat Step 1-4 for other PMUs



Change Output Channel Names through Output System Configuration Panel

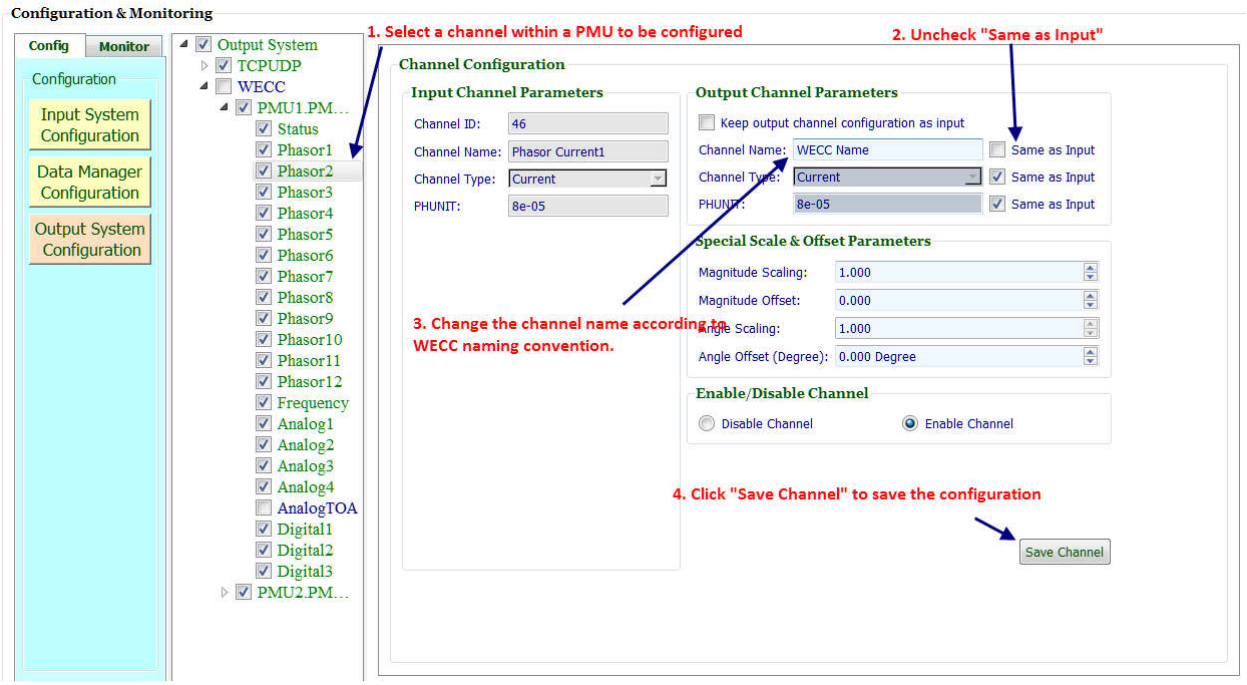
Step 1: Select a channel within a PMU to be configured

Step 2: Uncheck “Same as Input” for the Channel Name

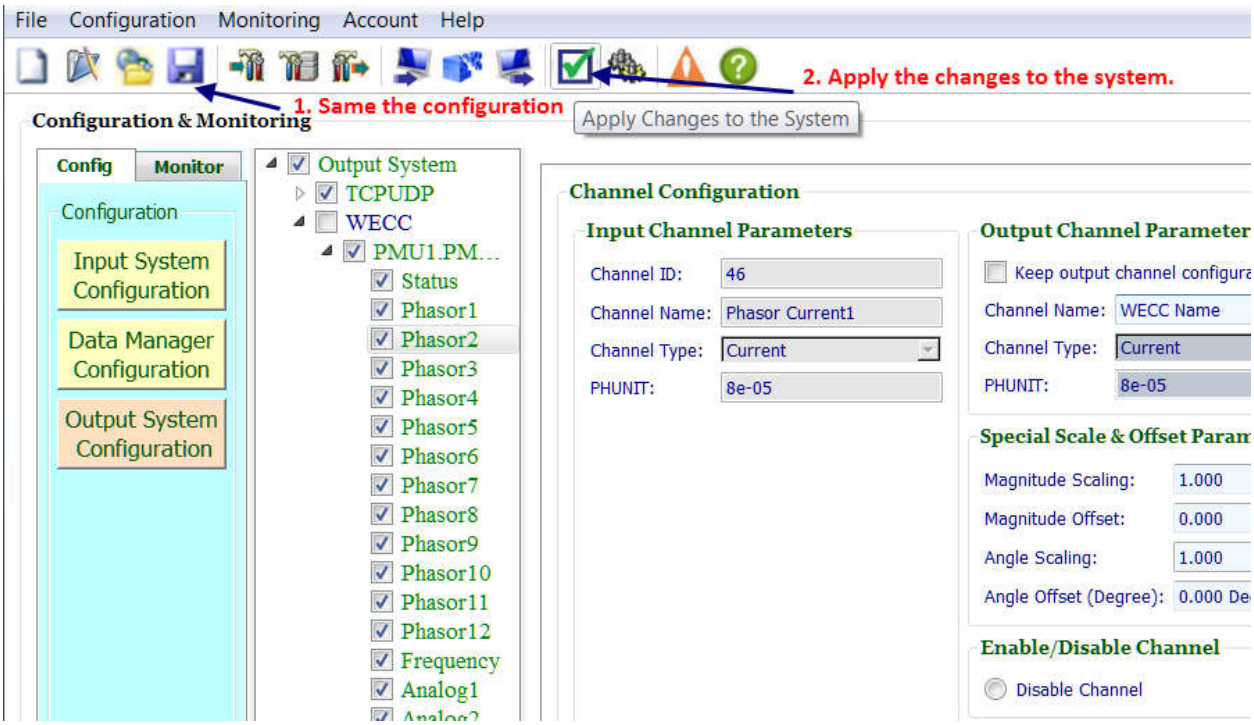
Step 3: Change the channel name according to naming convention

Step 4: Click “Save Channel” button to confirm the changes

Step 5: Repeat Step 1-4 for other channels of all PMUs to be configured



Save the Configuration File and Apply the Changes to System



Appendix: WISP Signal requirements

PMUs are capable of measuring and transmitting Phasors, Frequency, Analog and Digital values. PMUS are capable of measuring and transmitting these values using different data types. Phasors can be represented using either polar or rectangular format, and each format can use either floating point or integer data types. Frequency values can be represented using either floating point or integer data types.

The WISP data archive will only accept phasors using polar format with a data type of floating point. The WISP data archive will only accept frequency values using floating point. does not require, and asks that participants do not transmit analog or digital values.

In summary:

Signal Type	Format	Data Type
Phasor	Polar	Floating Point (Single Precision)
Frequency (and df/dt)	Not Applicable	Floating Point (Single Precision)
Analog	Not Required	Not Required
Digital	Not Required	Not Required

VERSION HISTORY:

Rev.	Date	Action	By	Change Tracking
1.0	01/01/2012	Issued for Use	Dan Brancaccio	Original document
1.1	02/16/2012	Bring in line with MISO specification	Dan Brancaccio	Edited Signal Name specification
1.2	02/21/2012	Add note about circuit number	Dan Brancaccio	Controversy about location of circuit number
2.0	02/25/2012	Review	Mike Gregory	Inclusion into CIP-compliant format for public classification.
2.1	03/09/2012	Remove note about circuit number	Dan Brancaccio	
2.2	03/19/2012	Add details about PI names, SCADA names, and changes to “to bus” for frequency	Dan Brancaccio	
2.3	03/23/2012	Correct some errors in the naming found by BPA	Dan Brancaccio	Some signal names still showed the NE-ISO naming where line number came after nominal voltage
2.4	04/05/2012	Add Appendix A	Dan Brancaccio	Added Appendix A examples for using PDCs to rename Signals
2.5	04/26/2012	Add section for rms values	Dan Brancaccio	Describe expected rms values P-N
2.6	04/27/2102	Add section on SEL PDCs	Dan Brancaccio	Content provided by Bill Flerchinger @ SEL
2.7	05/01/2012	Add Signal Requirements	Dan Brancaccio	Appendix: WISP Signal requirements
2.8	05/03/2012	Add ePDC directions	Dan Brancaccio	Added directions on using ePDC to appendix examples. Content provided by Vivek Bhaman EPG
2.9	07/06/2012	Changed naming convention for frequency and frequency rate of change	Dan Brancaccio	Added section 6
3.0	07/20/2012	Changed “and asks that participants do transmit analog or digital values.” To and asks that participants do ***not*** transmit analog or digital values.	Dan Brancaccio	Text edit
3.1	10/24/12	Minor edits as a result of training	Dan Brancaccio	Text Edit

3.2	11/15/12	Added section to address 120 degree phase offset issue	Dan Brancaccio	New section added
3.3	7/11/14	Cleanup for public availability	Dan Brancaccio	Text Edit

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