XynetSCADA uCFlow

Flow Calculation User Manual

Ver 2.3, 7th July 2015

REVISION INDEX

No.	Description	Sheets	Rev.	Date	Remarks
1	Issued for Internal Review	All Pages	A	25th Oct 2011	
2	Issued for Internal Review	All Pages	B	24th Dec 2011	.
3	Issued for Internal Review	All Pages	C	11th Jan 2012	
4	Issued for Internal Review	All Pages	D	5th March 2012	
5	Release Ver 2.1	All Pages	E	8th Feb 2013	
6	Release Ver 2.2	All Pages	F	8th Apr 2013	
7	Release Ver 2.3	All Pages	G	7th July 2015	Modify Modbus register

CONTENTS

1. INTRODUCTION 5
1.1. Scope and Purpose 5
1.2. Basis of Design 5
1.3. Definition, Abbreviation and Terminology 6
1.3.1. Definition 6
1.3.2. Abbreviation 7
2. OVERVIEW 9
3. HARDWARE AND SOFTWARE REQUIREMENTS 9
4. SYSTEM OVERVIEW 9
4.1. Motherboard Introduction 9
4.2. Rebooting 10
4.2.1. Reboot LED Sequence 11
5. CONTROLLER SPECIFICATION 11
6. HARDWARE WIRING AND INTERFACE 12
6.1. On-Board Ethernet Port 12
6.2. Wi-Fi Interface 12
6.3. Serial Interface 13
7. COMMUNICATIONS 14
7.1. Modbus TCP 14
7.2. Modbus RTU (RS-232/RS-485) 14
7.3. Wi-Fi Connection 14
7.4. FTP Daemon 15
7.5. Web Server (HTTP Daemon) 15
8. WEB INTERFACE 15
8.1. System Configuration 15
8.1.1. Status Tab 15
8.1.2. Network Tab 18
8.1.3. Service Tab 21
8.1.4. System Tab 24
8.1.5. Graphs Tab 30
8.1.6. Comm Tab 31
8.1.7. Logout Tab 36
8.2. Flow Calculation Configuration 37
8.2.1. Calculation Results 38
8.2.2. General Configuration 40
8.2.3. Gas Composition 42
8.2.4. AGA3 43
8.2.5. AGA7 45
8.2.6. Process Value 45
8.2.7. GPA2172 Value 47
8.2.8. Event 48

8.2.9. Report 50
8.3. Web Interface Security 51

9. FLOW CALCULATION FEATURES 52

9.1. Flow Calculations Algorithms..52
9.2. Flow Parameter Load File (.aga) 53
9.3. Data Persistence and Restore..54
9.4. Error Messages 54

10. FLOW CALCULATION INPUT AND OUTPUT VALUES 55

10.1. Input Values 55
10.2. Input Value Ranges 55
10.2.1. AGA Report Number 3 (Orifice flow metering) Input Value Ranges 55
10.2.2. AGA Report Number 8 (Compressibility) Input Value Ranges....................56
10.3. AGA Report Number 7 (Turbine metering) Input Value Ranges 57
10.4. AGA Report Number 5 (Fuel gas energy metering) Input Value Ranges....................57
10.5. Wafer Cone (Gas and liquid) Input Value Ranges....................57
10.5.1. Linear Coefficient of Thermal Expansion 57
10.6. V- Cone (Gas and liquid) Input Value Ranges 57
10.6.1. Linear Coefficient of Thermal Expansion 57

A. APPENDIX – FLOW PARAMETER LOAD FILE (SAMPLE) 59

B. APPENDIX – EVENT LOG CODE....................61

C. APPENDIX – REPORT AND EVENT COLUMN DEFINIATION 64

D. APPENDIX – MODBUS REG ADDRESSES FOR FULL DEVICE POLL TYPE....................65

E. APPENDIX – MODBUS REG ADDRESSES FOR SHORT DEVICE POLL TYPE 77

F. APPENDIX – MODBUS REG ADDRESSES FOR MODBUS SLAVE....................78

G. APPENDIX – HOT .... ERROR! BOOKMARK NOT DEFINED.

1. INTRODUCTION

1.1. Scope and Purpose

The scope of this document is to provide user information about the flow calculation hardware and software setup for its proper functioning.

This document also covers test data as per Albert Energy and Utility Board (AEUB) Directive 14 document.

1.2. Basis of Design

The documents listed below are common design basis for this specification. Documents occasionally referred by the individual section will be directly listed within the section. Cross references of other deliverable documents will be referred with the document.

#	Document Title	Source
1	American Gas Association Report No. 3	AGA
2	American Gas Association Report No. 8	AGA
3	American Gas Association Report No. 5	AGA
4	American Gas Association Report No. 7	AGA
5	GPA2172-96 Calculation for gross heating value	GPA
6	API Manual Of Petroleum Measurement Standards. Chap 21, Section 1	API
7	Wikipedia. The Free Encyclopaedia	Web

1.3. Definition, Abbreviation and Terminology

1.3.1. Definition

Item	Description
AEUB	Albert Energy and Utility Board
API	American Petroleum Institute
Applet	Programs written in the Java programming language that are included in a web page
Crossover Cable	This is a type of cable wiring schema where the cable will be used to connect the controller to a DTE (for example like a laptop)
CSV format	A format where each record is a single line and each field in the record is indicated by a comma.
DB9	RS232 serial communication connector which uses 9 pin (male or female).
DCE (Data Circuit-terminating Equipment)	A device that sits between the data terminal equipment (DTE) and a data transmission circuit (for example like a router or a hub).
DTE (Data Terminal Equipment)	An end instrument that converts user information into signals or reconverts received signals (for example like a computer or RTU).
Daemon	A daemon is a computer program that runs as a background process, rather than being under the direct control of an interactive user.
Floating point	32 bit real number
Gateway	Node (a router) on a TCP/IP network that serves as an access point to another network.
Human Machine Interface	The user interface, in the industrial design field of human–machine interaction, is the space where interaction between humans and machines occurs.
Hyperlink	Location within the web page where the document can be followed
Intranet	An intranet is a computer network that uses Internet Protocol technology to share information, operational systems, or computing services within an XynetSCADA.
Java	A type of software programming language that allows virtual machine program development
Kernel	Central component of operating system
Meter Run	Flow calculation using a particular algorithm with user defined input
Modbus	Communications protocol (serial and TCP) published by Modicon in 1979 for use with its programmable logic controllers (PLCs)
Operating System	Set of programs that manage computer hardware resources

	and provide common services for application software.
Recommended Standard 232 (RS-232)	Traditional name for a series of standards for serial binary single-ended data and control signals connecting between a DTE (Data Terminal Equipment) and a DCE (Data Circuit-terminating Equipment).
Recommended Standard 485 (RS-485)	A standard that defines the electrical characteristic of driver and receiver for use in balance digital multipoint systems.
Service set identification (SSID)	An SSID is the name of a wireless local area network (WLAN). All wireless devices on a WLAN must employ the same SSID in order to communicate with each other.
Straight Though Cable	This is a type of cable wiring schema where the cable will be used to connect the controller to a DCE (for example like a hub or a switch)
Virtual Machine (Java)	A "completely isolated guest operating system installation within a normal host operating system".
Unix Time	System for describing instances in time, defined as the number of seconds that have elapsed since midnight Coordinated Universal Time (UTC), 1 January 1970, not counting leap seconds.
WEP Key	It is a security algorithm for IEEE 802.11 wireless networks that is adopted by the XynetSCADA for wireless access
Wi-Fi	A mechanism for wirelessly connecting electronic devices
Wi-Fi Ad hoc Connection	Ad hoc connection mode is a method of wireless card in the XynetSCADA to directly communicate with any Wi-Fi enabled devices such as laptop and smart phone
XynetSCADA Intranet Services	These are local intranet daemons that are running on the XynetSCADA that enhances user access to data in the XynetSCADA uCFlow. These are the following services provided by XynetSCADA; webserver, FTP server and NTP server

1.3.2. Abbreviation

AGA	American Gas Association
CSV	Comma-Separated Values
DCE	Data Circuit-terminating Equipment
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name Server
DTE	Data Terminal Equipment
EFM	Electronic Flow Measurement
EGM	Electronic Gas Measurement
HMI	Human Machine Interface
HTTP	Hypertext Transfer Protocol
IP	Internet Protocol
MAC	Media Access Control
OS	Operating System
PLC	Programmable Logic Controller
RAM	Random Access Memory

RS232	Recommended Standard 232
RTU	Remote Terminal Unit
RTD	Resistance Temperature Detector
SSH	Secure Shell
SSID	Service Set Identification
TCP	Transmission Control Protocol
URL	Uniform Resource Locator
USB	Universal Bus Serial
WEP	Wired Equivalent Privacy
WLAN	Wireless Local Area Network

2. OVERVIEW

These are notes relating to the program.

- All calculations done in imperial. If input and/or output values are required in metric, conversion must be done in using the web interface or Modbus communication.

- Differential pressure must be greater than or equal to differential cut-off pressure before calculation can be resumed.

- For the equation to calculate accurate flow values, the input values must fall within the specified ranges (see Section 4.0 of this documentation).

- AGA 3, 8 and 7 has been tested as per Alberta Energy and Utility Board (AEUB) test cases. The flowrate, coefficient of discharge (Cd), expansion factor base on upstream static pressure (Y1), expansion factor base on downstream static pressure (Y2), velocity of approach factor (Ev) and compressibility (Z) falls with the specified percentage of tolerance.

- AGA 8 Gross Calculation has been tested as per AGA Report Number 8 test cases.

3. HARDWARE AND SOFTWARE REQUIREMENTS

Here are the hardware and software requirements to run this controller.

- Hardware
  - Ethernet cable
    - If the controller is going through a DCE (such as hub, industrial switch, Ethernet radio), a straight thought Ethernet cable is required.
    - If the controller is going through a DTC (laptop, server, computer), a cross-over Ethernet cable is required.
  - Serial cable
    - If the controller is going through a DCE (such as hub, industrial switch, Ethernet radio), a straight thought serial cable is required.
    - If the controller is going through a DTC (laptop, server, computer), a cross-over serial cable is required.
  - Power supply 6 to 15 VDC
- Software
  - Web browser
    - Microsoft Internet Explorer 7.0 or greater
    - Mozilla Firefox 7.0
    - Safari 5.1

4. SYSTEM OVERVIEW

4.1. Motherboard Introduction

Much like a computer motherboard, XynetSCADA motherboard comprises of CPU, RAM and multitude of connection ports. The image below identifies all the main components of the XynetSCADA.

Figure 4.1A, Motherboard Layout

0	This is an on-board 10/100BaseT Ethernet port on the XynetSCADA which allows user to access the System Configuration and Flow Parameter Configuration web pages via the local web services. Alternatively, a USB wireless adapter can be used to gain access to the configuration webpages of the XynetSCADA.
1	There are six high speed USB ports (version 2.0) on a XynetSCADA which allows connection of USB-to-serial adapter and USB wireless adapter.
2	These two LEDs are for the motherboard state indications. Red LED • The red LED indicates that the power supply is on and XynetSCADA motherboard is running properly. Green LED • The green LED indicates boot status. • The green LED will turn on and off once during boot and then turn back on when everything is running.
3	This is a warm reboot switch and pressing it will reboot the motherboard. Holding this switch for more than 10 seconds while the power on the XynetSCADA is up will cause the XynetSCADA to go in Factory mode. This essentially means that all System Configurations and Flow Parameters will be lost permanently. End-user should never perform this function. A soft reboot can be performed remotely from the System Configuration webpage
4	Power supply for the XynetSCADA (connector type)
5	Power supply for the XynetSCADA (terminal block)
6	Not used
7	Not used
8	Not used
9	JTAG connector, for internal testing purposes only

4.2. Rebooting

Rebooting is a process by which the running XynetSCADA is either power cycled (hard reboot), reset button pressed on the XynetSCADA (warm reboot) or reboot command issued from the System Configuration webpage (soft reboot). In any of the abovementioned instances, all flow computer daemons and kernels processes will get restarted. However, the flow parameters will not get lost during the reboot sequence as it is stored in the persistence file periodically (every

5 seconds or when a new flow parameter configuration file is uploaded through the webpage). When the XynetSCADA has completed the reboot sequence, the persistence file is loaded into the memory before running the flow calculation daemons.

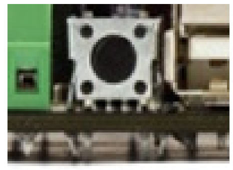


Figure 4.2A, Reset Button

4.2.1. Reboot LED Sequence

When the XynetSCADA is rebooted (hard, warm or soft), both the Ethernet port LEDs (yellow, green) and the green status LED will turn off. This indicates that the XynetSCADA has started the reboot sequence. When the reboot sequence is completed, the green status LED will turn solid green, the yellow LED on the Ethernet port will turn solid yellow and the green LED on the Ethernet port will flash green.

Figure 4.2.1A, On-Board Ethernet Port and Status LEDs

The reboot sequence will take approximately 25 to 30 seconds.

Never hold the reset button more than 10 seconds while the XynetSCADA is powered up. This will cause the system to go to Factory Mode, hence loosing all you're your system configurations and flow configuration parameters.

5. CONTROLLER SPECIFICATION

The table below shows the system specification.

Processor	ARM920T
CPU Speed	400MHz
Solid State Drive	512MB
SDRAM	64MB
USB	6 USB ports
Ethernet	10/100BaseT
Power Input	6 to 15 VDC
Power Consumption	1.2 watt with Ethernet cable 2.5 watt max per additional USB device
OS	Linux

These specifications are available in the web interface.

```
http://<IP ADDRESS>/cg-bin/sc/system-status.sh
```

"<IP ADDRESS>" is the IP address of the controller.

6. HARDWARE WIRING AND INTERFACE

There are three ways to interface to XynetSCADA uCFlow and they are as listed below.

6.1. On-Board Ethernet Port

The XynetSCADA uCFlow has one on-board Ethernet port where it can be connected to access its data. XynetSCADA is a DTE; therefore a hub or a switch will be required when connecting two DTEs. A common setup would be when a connection between XynetSCADA uCFlow and a RTU/PLC is required. The example is as illustrated below.

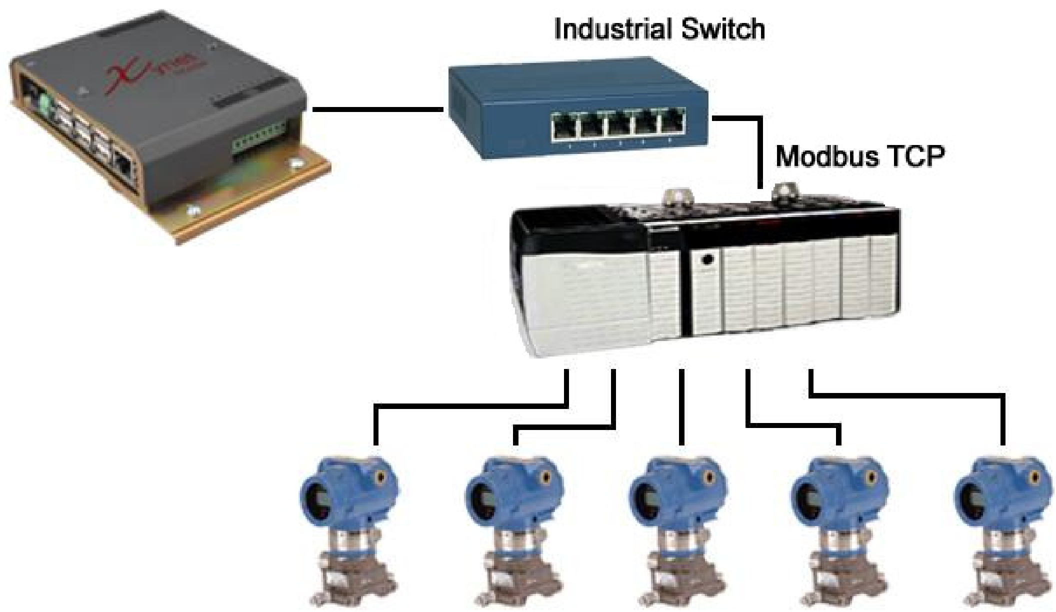


Figure 6.1A, On-Board Ethernet connection

Likewise, if XynetSCADA uCFlow is to be connected with a laptop or a computer, a hub or a switch is required.

The on-board Ethernet connection allows Modbus TCP protocol and any XynetSCADA intranet services (for example webpages, FTP) to be served to the user.

6.2. Wi-Fi Interface

The XynetSCADA uCFlow has a Wi-Fi interface capability which has the same function as the on-board Ethernet port (supports Modbus TCP and XynetSCADA intranet services) except for the requirement of a physical cable connection.

The main purpose of having Wi-Fi is to allow the user to access data on the XynetSCADA uCFlow via mobile device. The diagram below demonstrates this wireless setup.

Figure 6.2A, Wi-Fi connection

Maximum devices a user can connect to the Wi-Fi are 255 wireless devices.

6.3. Serial Interface

XynetSCADA supports both RS-232 and RS-485 connections via USB to serial adapter. There are six USB connections on the XynetSCADA where the user can selectively setup the type of serial connection.

The main purpose of this interface is to serially connect to the RTU/PLC/transmitters or HMI via Modbus RTU. The diagram below illustrates the connection between XynetSCADA and HMI via data radio.

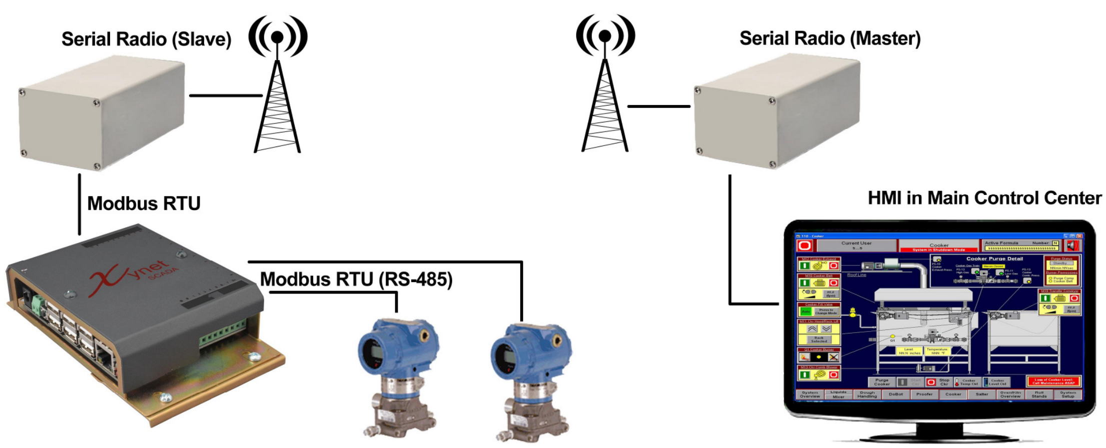


Figure 6.3A, Serial connection

7. COMMUNICATIONS

There are five (5) basic way to communicate with the controller and they are as shown in diagram below.

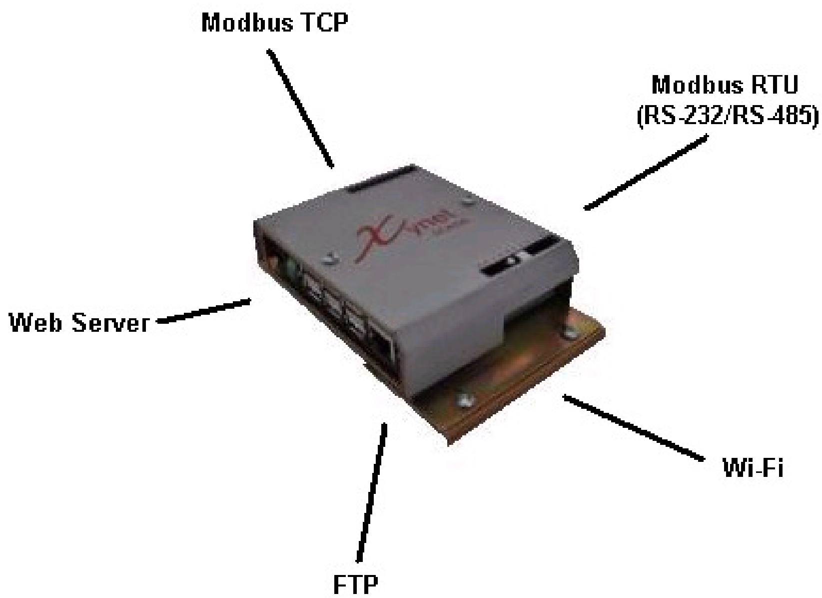


Figure 7A, Communications and Services

7.1. Modbus TCP

Modbus TCP protocol can be used to communicate with the controller either via the on board Ethernet Port or via the Wi-Fi that is available on the controller.

It is a Master Modbus when acquiring data from the RTU, PLC or MVS transmitters for the purpose of flow calculations.

If a HMI is required to be connected to the controller, it will be a Modbus Slave. The complete range of Modbus Slave registers are provided in Appendix B.

7.2. Modbus RTU (RS-232/RS-485)

The controller has six RS 232 or RS-485 communication ports. The configuration of the serial port type will depend on the initial setup of the controller.

These serial ports are used for Modbus RTU communication. It has a full spectrum of serial baud rate and all serial communication is parameters are available for the user to configure.

Like the Modbus TCP that is available on the controller, it is a Master Modbus when acquiring data from the RTU, PLC or MVS transmitters for the purpose of flow calculations. And it performs like a Modbus RTU if a data acquisition software is required to be connected to this controller, like the HMI.

7.3. Wi-Fi Connection

The controller has one Wi-Fi connection which is able to host a Modbus Master function (to acquire flow calculations parameter from RTU, PLC or MVS transmitters for the purpose of flow calculations). Simultaneously, it can perform a function of a gateway to allow user to configure the controller system setup and flow calculation parameters.

7.4. FTP Daemon

An FTP server runs on this controller, hence the user can access all reports and events logs via this web service.

7.5. Web Server (HTTP Daemon)

A light-weight web server is running on this controller which allows the user to access System Configuration and Flow Parameter webpages. Details of these screens are available in the next few sections.

8. WEB INTERFACE

All configuration and setup for the controller and flow parameters can be done using a web browser. The controller has 2 types of web interfaces; System Configuration and Flow Calculation Configuration. The bullet points below shows how to access each of the web interfaces.

- Flow Calculation Configuration Web Interface

  `http://<IP ADDRESS>`
  OR
  `http://<IP ADDRESS>/fc`

- System Configuration Web Interface

  `http://<IP ADDRESS>/sc`

The preferred browser is Microsoft Internet Explorer 8.0

The next few sub section highlights what data is available in each of these web interfaces.

8.1. System Configuration

These web pages allows user to setup and configure all properties and parameters pertaining to the Kernel and hardware. The section below highlights each of the functions in the System Configuration web interface.

8.1.1. Status Tab

The Status Tab shows a read-only version of an overview of the complete system configuration and status.
Generally, all tabs are sub divided into further sub tabs. For the Status Tabs, the following are the sub tabs.

- System
  - Its displays overall hardware information such as type of processor, kernel OS version, MAC Address, on-board user file system and RAM memory space.
- Network
  - Network information is available in this page.
    - Network IP address
    - Network masking

        - Gateway
        - Network mode (DHCP or static IP)
        - Mac address
    - Information available in this section is read-only
- Processes
    - This page shows current running processes in the controller, which can come in handy when debugging the controller.
    - In this page and option is available to spawn or stop the process in the controller.
    - These processes must be running in order for the flow computer to run.
        - uCFlowCalc
            - If there are 10 meter runs, there should be 10 of these processes.
        - [xyberIPC]
        - [xyberIPCModbusSlave]
        - xyberModbusSlave
    - These processes must be running for internet services to run.
        - xyberhttpd
        - xyberftp
- USB
    - Any USB device that is attached to the XynetSCADA will be shown in this list.

Screenshot of each sub tabs are as shown below.

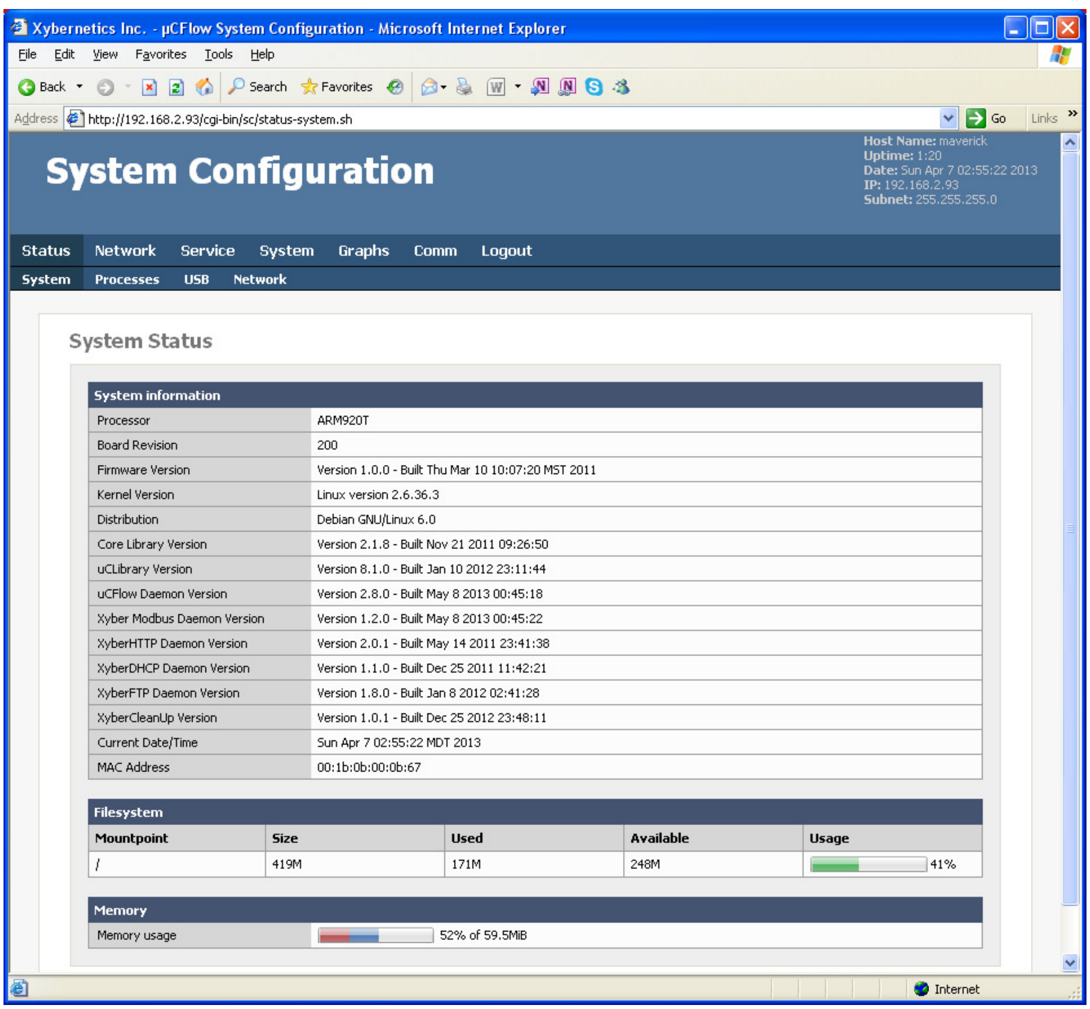


Figure 8.1.1A, Status Tab - System Status

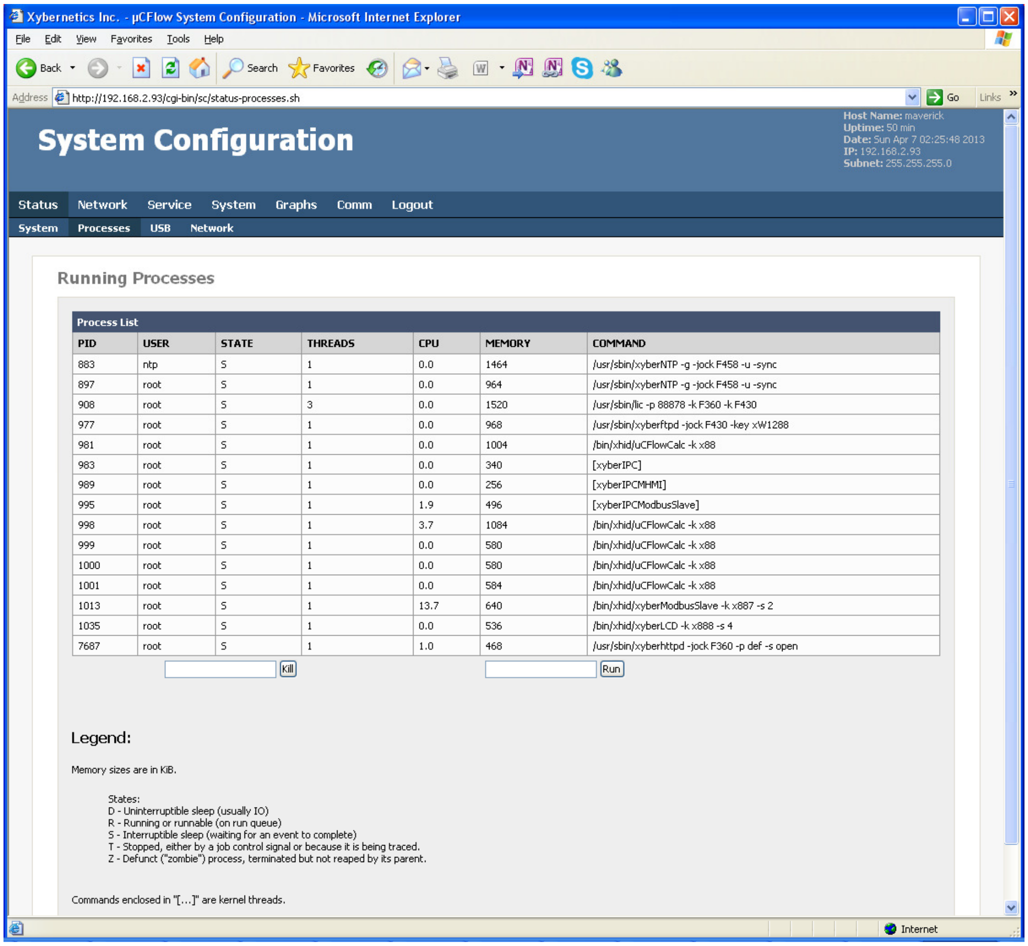


Figure 8.1.1B, Status Tab – Running Process

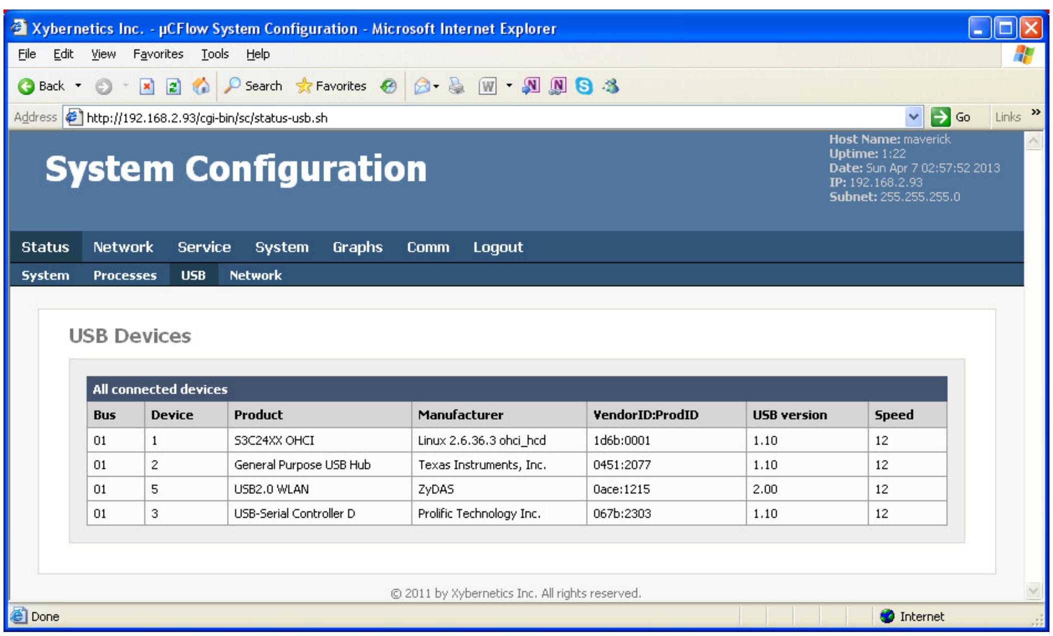


Figure 8.1.1C, Status Tab – USB Device

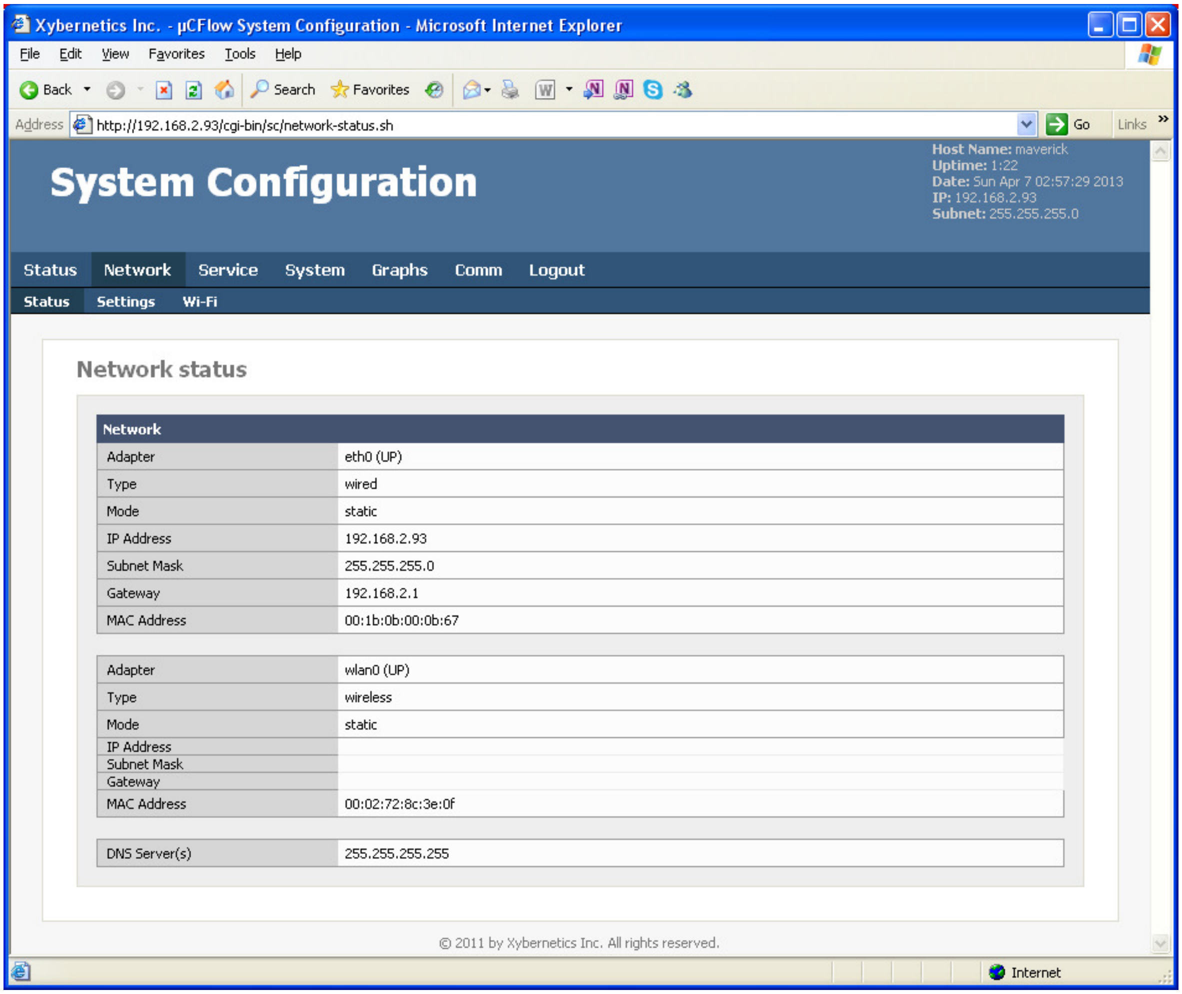


Figure 8.1.1D, Status Tab – Network Status

8.1.2. Network Tab

The Network Tab displays and allows user to configure network parameters. The sub items under this tab are as listed below.

- Status
  - This page displays read-only information about the network parameters
- Settings
  - This page allows user to configure the network parameters as listed below
    - Network Mode (DHCP or static)
    - IP address
    - Network masking
    - Network gateway
    - DNS mode
    - Primary and secondary DNS address
    - SSH Server status
- Wi-Fi Connection
  - This page allows user to configure connection to the controller via wireless connection (Ad Hoc connection).
  - User can change the SSID, the WEP key and the IP address of the wireless card on the controller.

- WEP key must be a hex number of 9 to 10 character long
- The “Reset Wi-Fi Card” button restarts the wireless connection and its associated applications. Hence, it is recommended to click on it when the wireless card is connected when the controller is already powered up. If the “Save Changes” button is click, it also emulates the “Reset Wi-Fi Card” button, therefore it is not necessary to click on the reset button when “Save Changes” button is clicked on after the changes are made.

Screenshot of each sub tabs are as shown below.

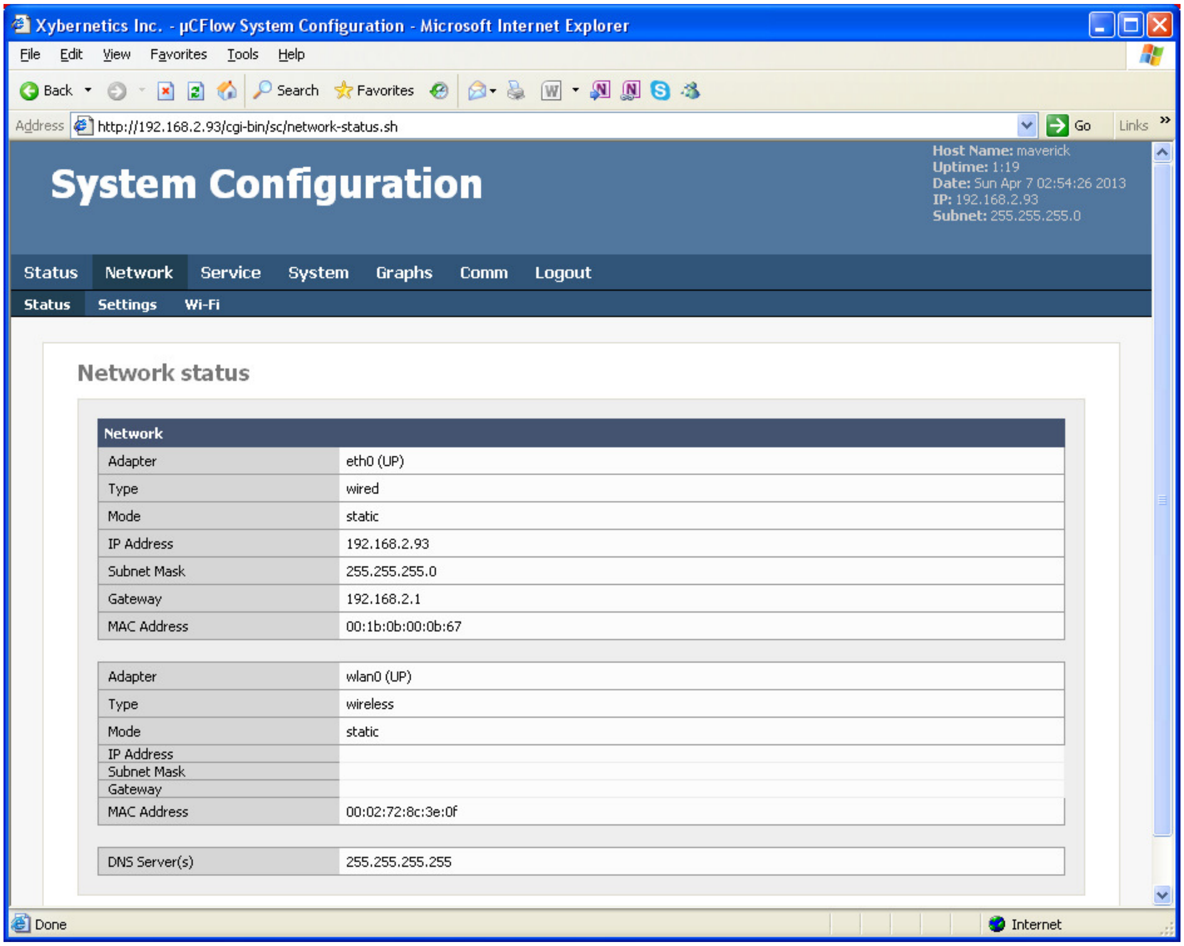


Figure 8.1.2A, Network Tab - Status

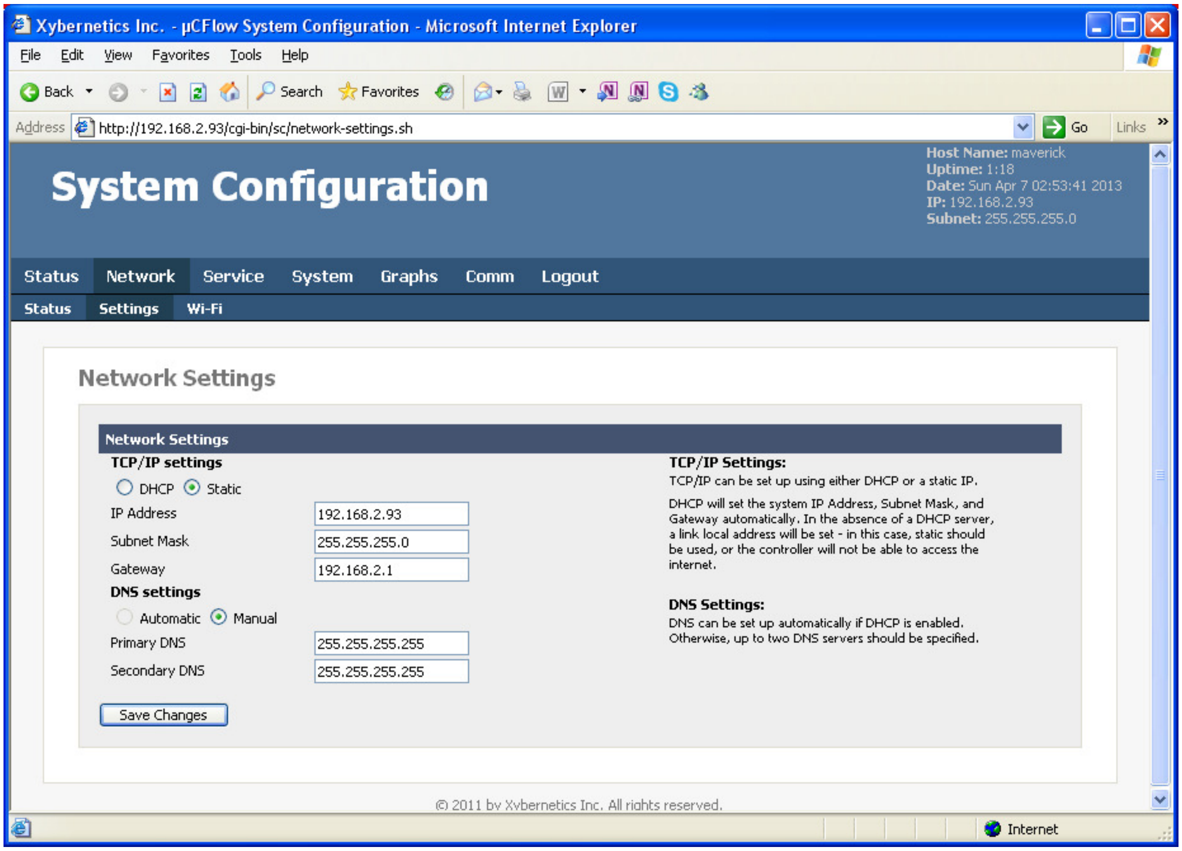


Figure 8.1.2B, Network Tab - Status

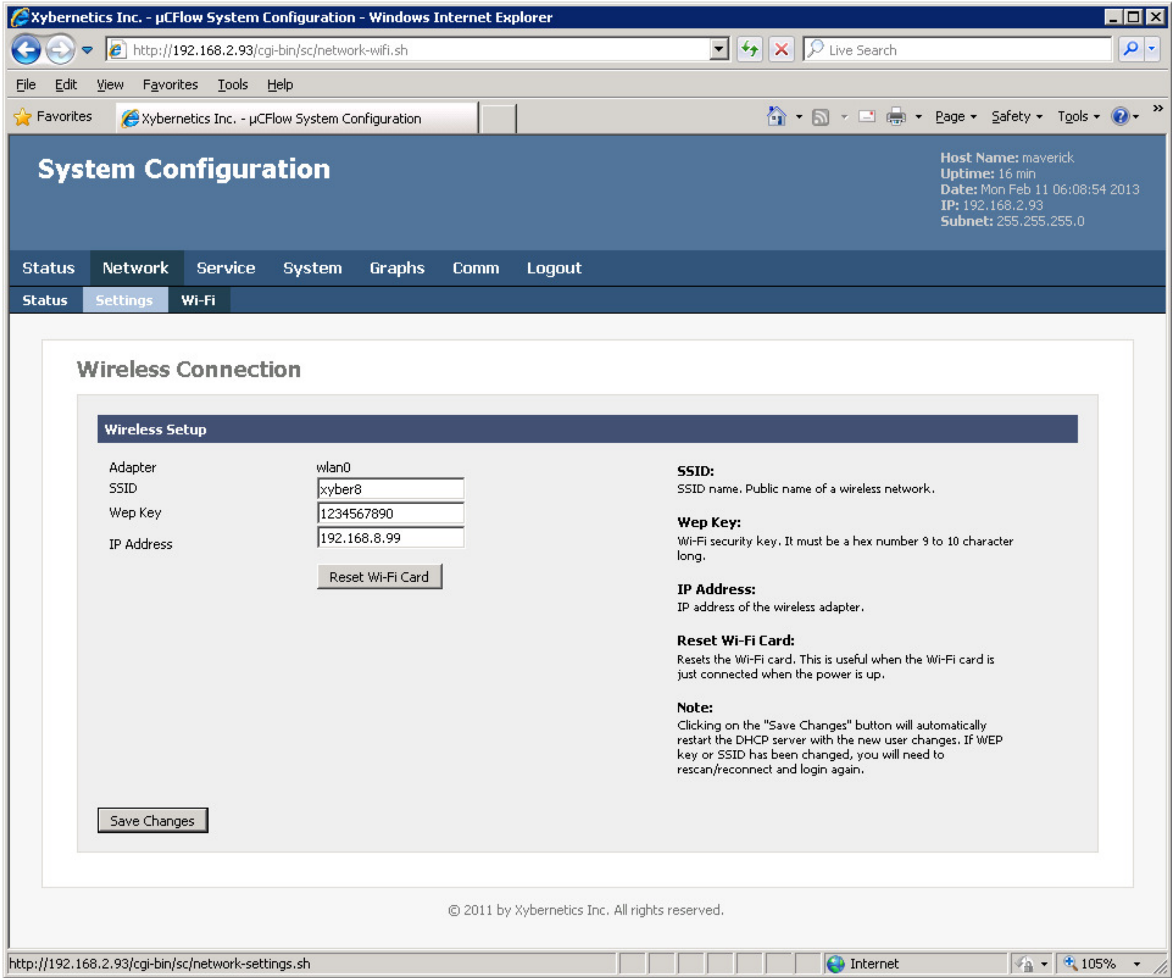


Figure 8.1.2C, Network Tab - Wireless

8.1.3. Service Tab

The Service Tab displays and allows user to configure web service daemon parameters. The following parameters can be configured for the following web services

- Web Server
  - Shows current running status of the server
  - The default port number is 5001. User is able to change this port number.
- DHCP Service
  - Shows current running status of the server
  - The port number is fixed at 68.
  - User is able to restart the DHCP daemon using the “Restart DHCP Server” button.
- FTP Server
  - Shows current running status of the server
  - The port number is fixed at 20.
  - User is able to restart the FTP daemon using the “Restart FTP Server” button.
- Clean Up Service
  - Clean Up service deletes all files that are older than user specified days.
  - This service is an essential task as it ensures that there is sufficient capacity to store future reports, log files and execute all the background application smoothly.

- Clean Up service runs every day at the user specified time. By default the Clean Up service is execute every day at 2359hrs. That is to say, this service does not run all the time in the controller. It runs only when the user define time has expired every day.
- The Report section of this page also allows user to specify the number of days a particular group of report are kept in the controller.
- Maximum allowed number of days is 2920 days (8years).

Screenshot of the service tab is as shown below.

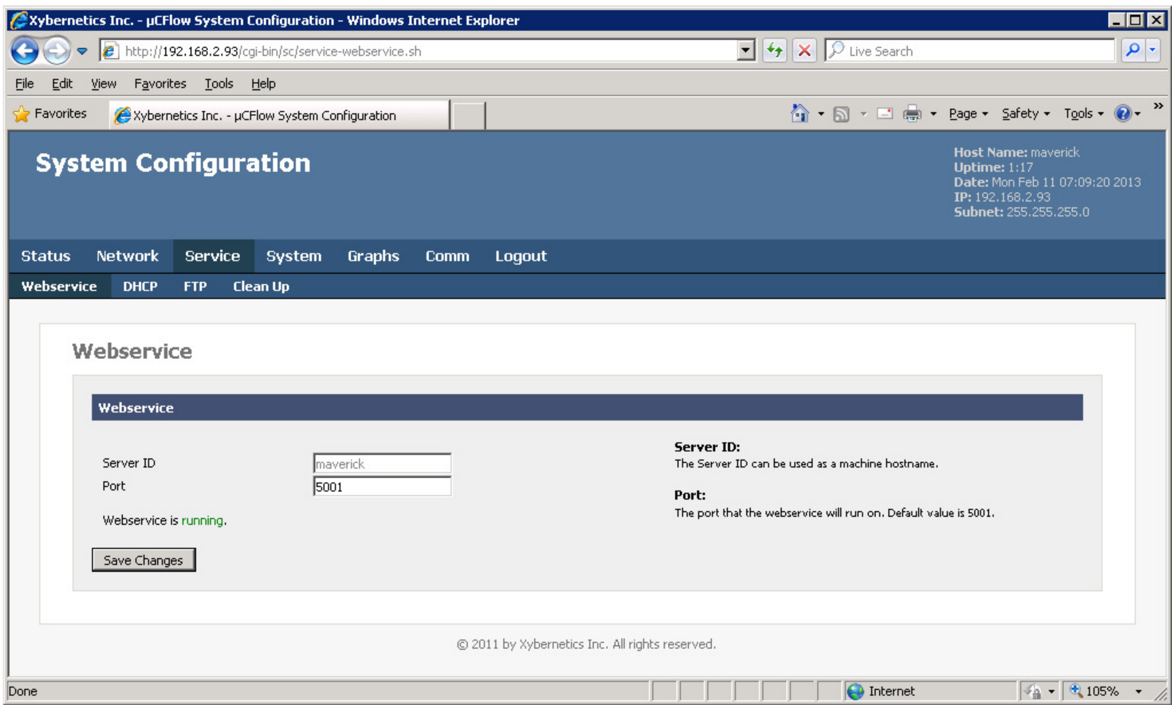


Figure 8.1.3A, Service Tab – Web Server

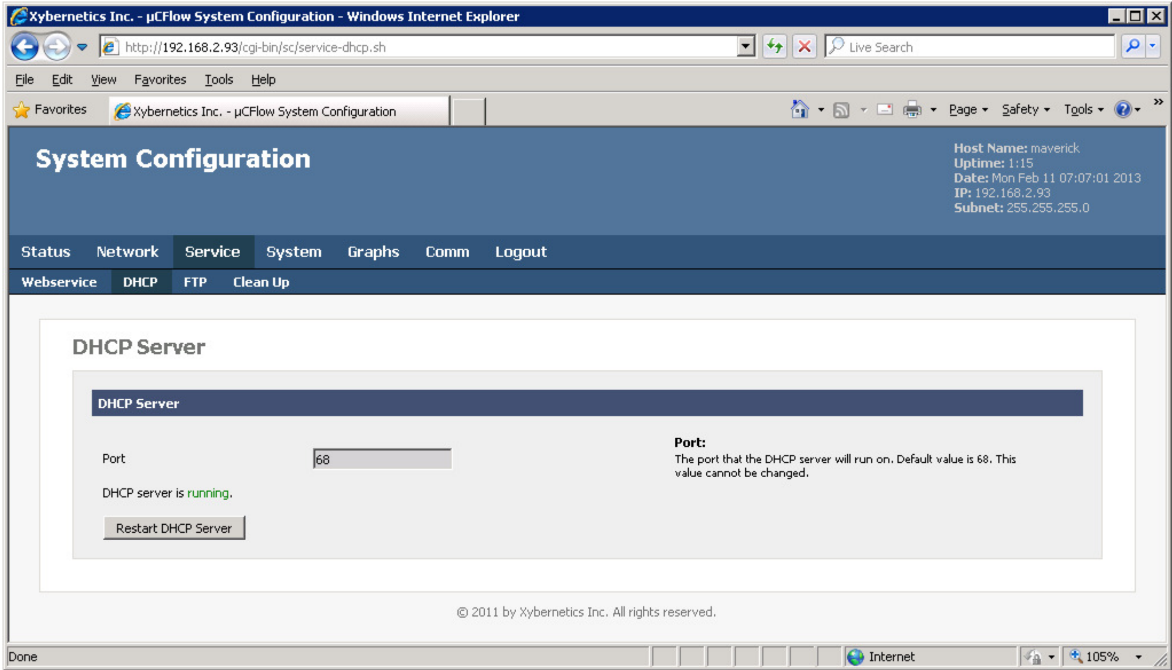


Figure 8.1.3B, Service Tab – DHCP Service

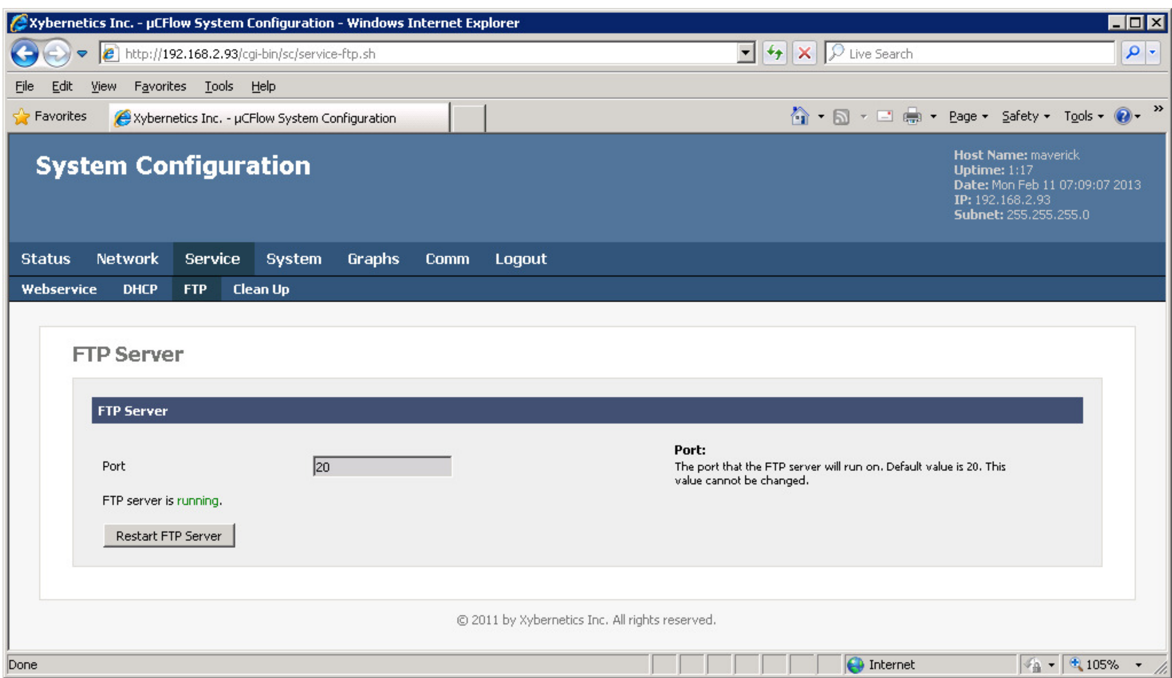


Figure 8.1.3C, Service Tab – FTP Server

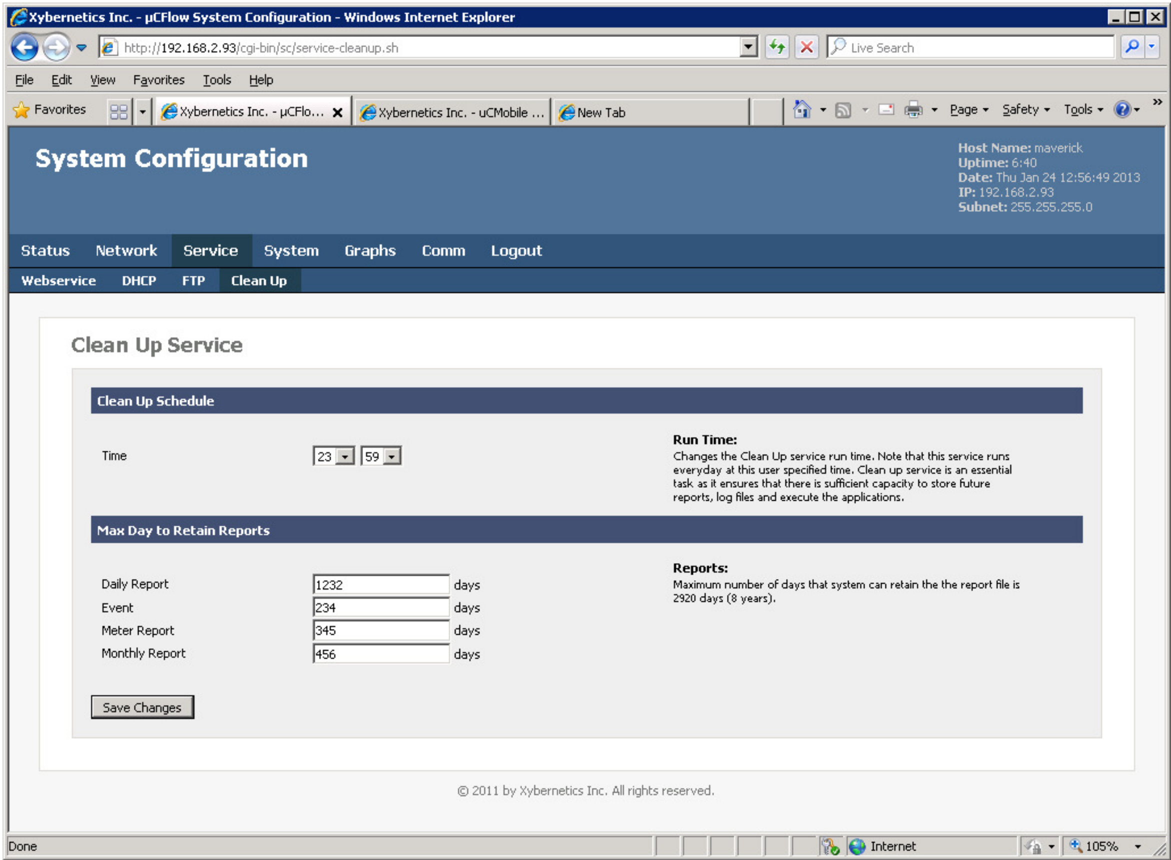


Figure 8.1.3D, Service Tab – Clean Up Service

8.1.4. System Tab

The Service Tab page has all the core controller configuration parameters and the additional controller hardware based functions and commands. The list below highlights all the parameters and functions that can be performed from this page.

- General System Settings
  - Allows user to view and change the following controller parameters
    - Hostname (can be used in the place of IP address when access web interface)
    - Current system date and time. User is able to view and edit current date and time.
    - Time zone. Automatic time adjustment with time zone selection.
- Logs
  - This page allows user to access Kernel log.
  - Also the log files can be filtered based on user defined keywords to allow easy trouble shooting.
- Users
  - This page allows administrators to add user, remove users and modify their password.
  - Adding user here allows user to access the Flow Calculation Parameter Configuration web pages, FTP server access and Wi-Fi connection to the controller. Regular users will not have access to the System Configuration web pages.

  - Only administrators are allowed to edit System Configuration web pages, Flow Calculation Parameter Configuration web pages, FTP server access and Wi-Fi connection to the controller.
  - Administrator user name will always be “admin” (without double quotes) and the admin password can be modified in this tab, however, username “admin” cannot be deleted.
- Persistence
  - This page allows user to manage persistence files for flow calculations. This is a tool for the purpose of backing up the current “snap-shot” of the flow calculation parameter. It should never be used as a tool to update the follow parameters. To update the flow parameter, use the “.aga” file or the Flow Calculation Configuration webpages.
  - Persistence file are used to save all flow calculation parameters in a single binary file for each meter run.
  - In the event of power cycle, he flow calculation software uses the persistence files to retrieve previous setting and continue with normal operation.
  - Persistence file can also be backed up and used on a new controller when the current controller is damaged.
  - Renaming the persistence file and loading it as a different meter run will cause issue to meter run that the file was originally copied from. Therefore, persistence file should never be renamed and uploaded into the controller.
  - The persistence file format is as follows "scPersist#.rag" where "#" is the meter run number.
  - If the communication between RTU/PLC/transmitter is on established, persistence file cannot be generated.
  - Power cycling the controller will also generate a default persistence file, if the persistence file is deleted or does not exist. If the persistence file exists the controller reads the existing persistence file.
  - If the persistence file already exists for a particular meter run, a new persistence file cannot be loaded for the same meter run. The existing persistence in the controller must be deleted before loading it.
  - These are the conditions when the persistence file is generated
    - When any changes to the flow parameters are performed
    - When a new “.aga” file is loaded
- Reboot
  - Allows user to apply soft restart to the controller.

Screenshot of each sub tabs are as shown below.

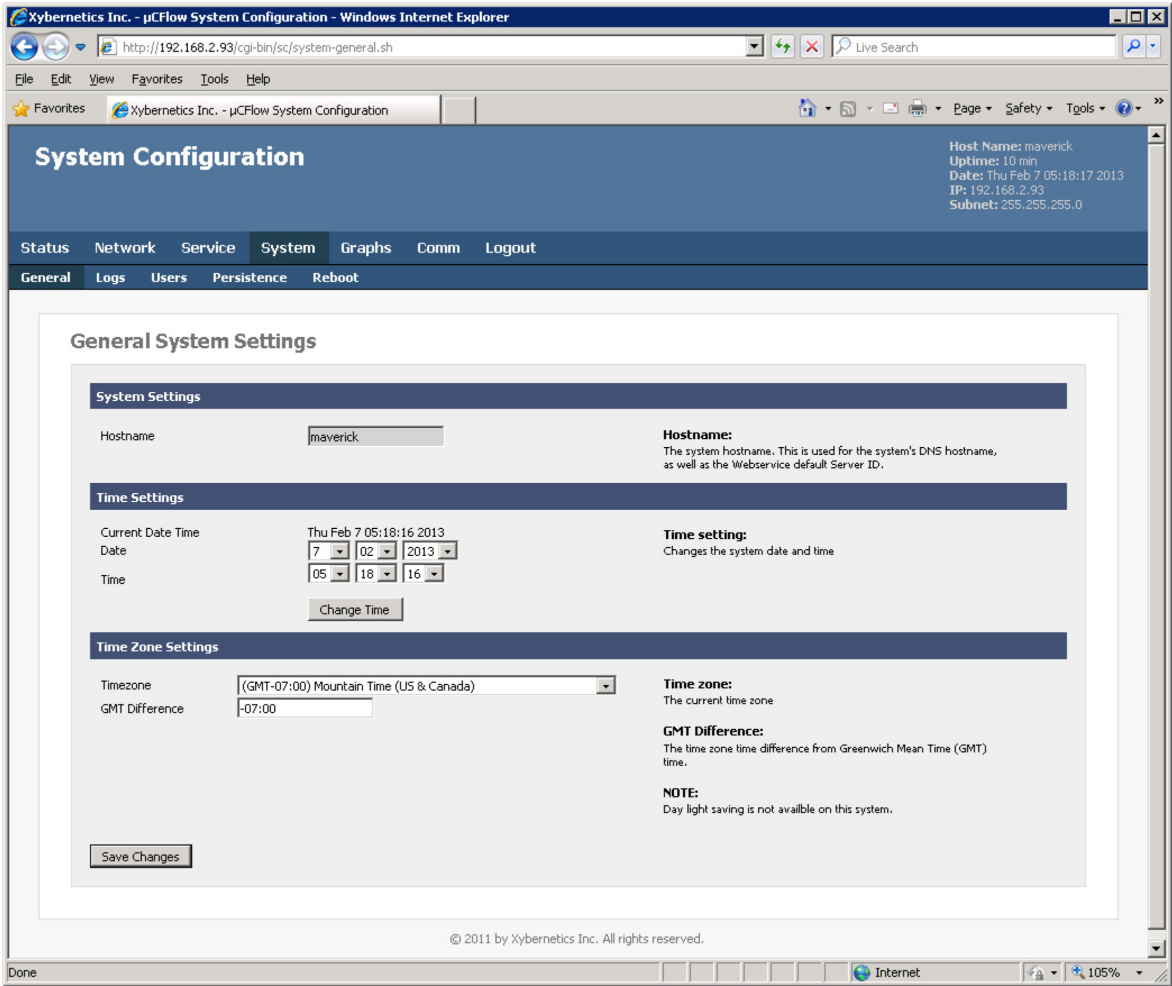


Figure 8.1.4A System Tab – System Tab - General

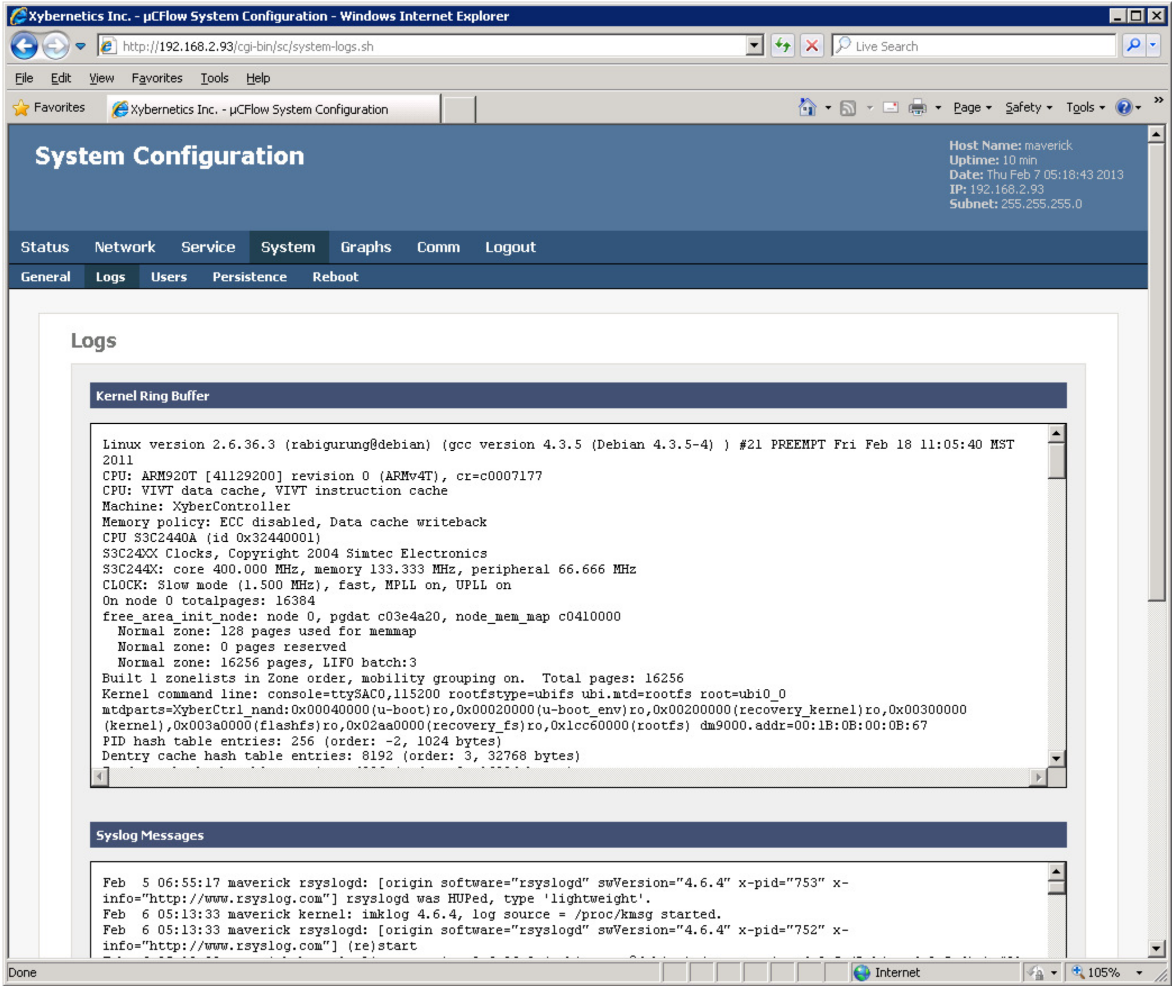


Figure 8.1.4B, System Tab – Log

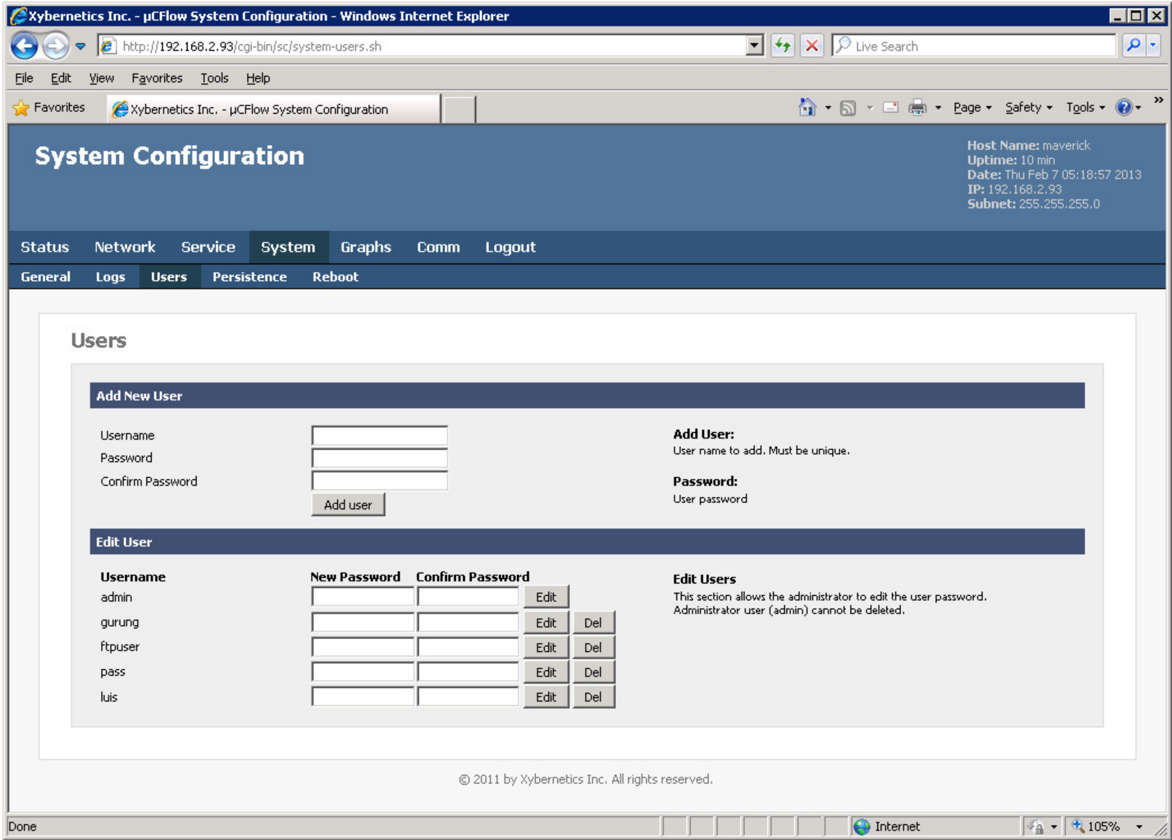


Figure 8.1.4C, System Tab – Users

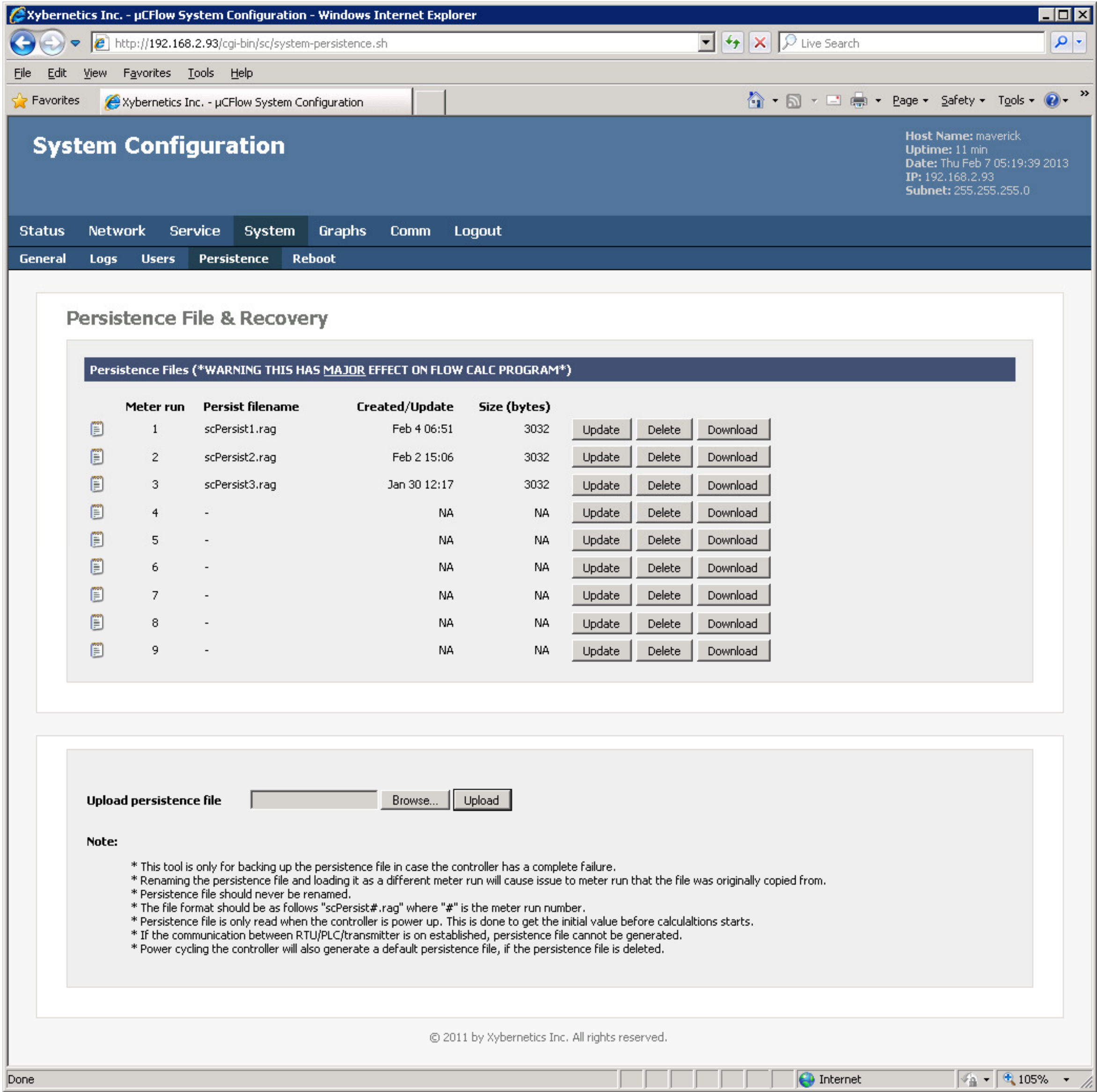


Figure 8.1.4System Tab – Persistence

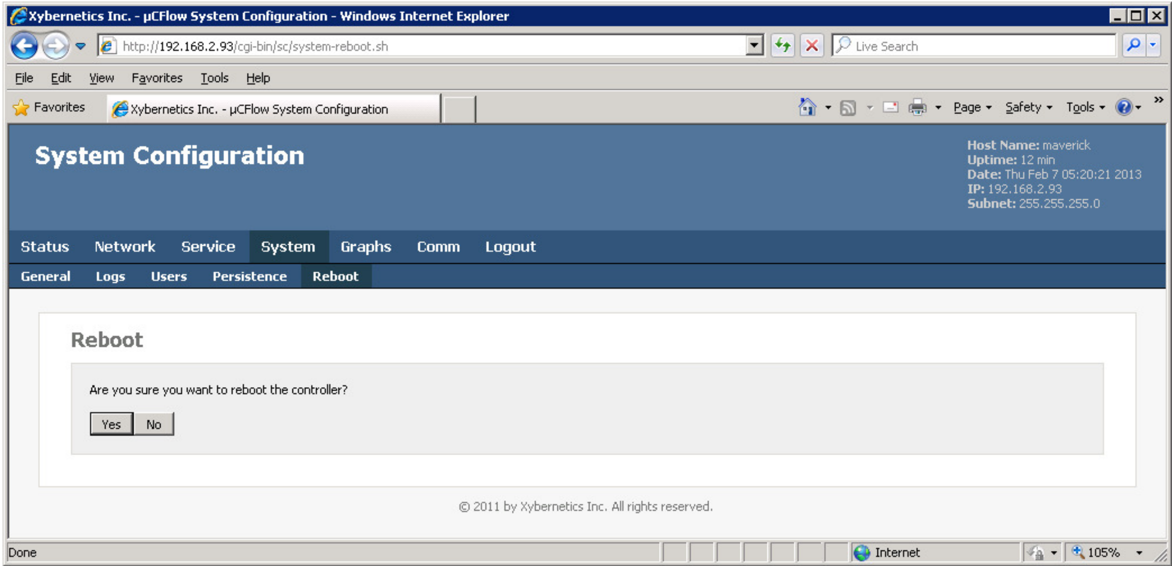


Figure 8.1.4E System Tab – Reboot

8.1.5. Graphs Tab

The Graphs Tab simply shows trending for CPU usage and Ethernet traffic in the Ethernet port. This page requires the user to download and install Adobe SVG Viewer before viewing this page. The viewer can be downloaded from this URL.

http://www.adobe.com/svg/viewer/install/

The screenshot below shows the trending in each tab.

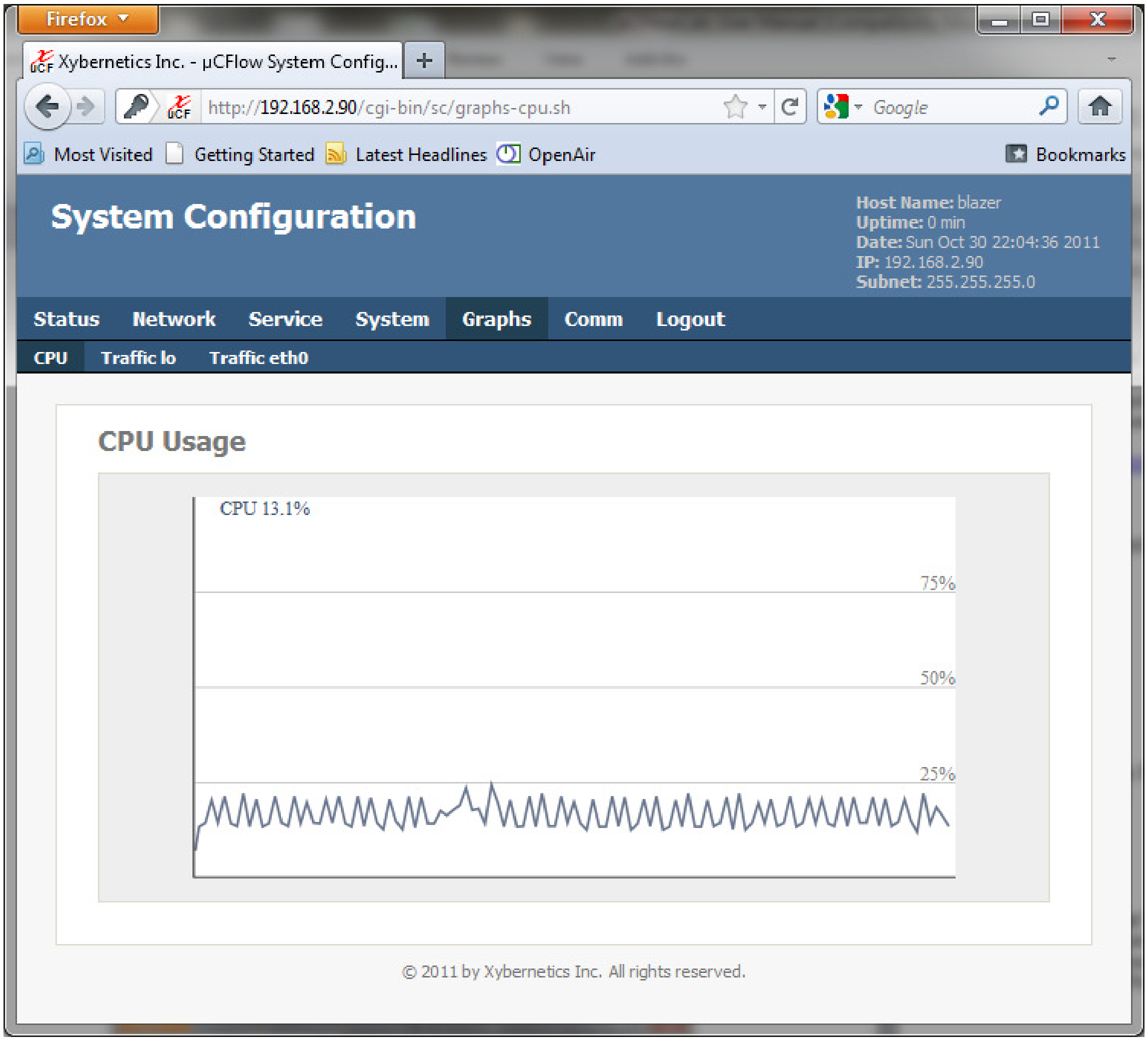


Figure 8.1.5A, Graphs – CPU Usage

8.1.6. Comm Tab

The page allows user to setup both TCP and serial Modbus slave parameters. The following are the slave parameter characteristics and a brief description.

- Modbus End Device Definition
  This section of the configuration handles communication setup between the controller and the RTU, PLC and/or transmitters. The user can setup up to 10 Modbus slave connections, and the slave could be mixture of both Modbus TCP and Modbus RTU (serial).
  - Communication Status
    - Enable or disables the Modbus slave communication channel.
    - If the Modbus slave is not required, it is highly recommended that the slave be disables. This will help reduce CPU usage and free up resources.
    - If the Communication Status is disabled, the communication program will check for the Communication Status change every 60 seconds.
  - Slave number
    - Changing this value will selectively change the communication slave channel and its associated communication parameters

    - The flow computer is set to communicate to ten different communication channels.
- Connection Type
    - There are two type of communication; TCP and serial.
    - Selecting either TCP or serial presents the user with the appropriate communication setup screen. For example TCP will have IP address entry while serial will have baud rate.
    - The serial selection will not be available to the user unless a serial port (either RS-232 or RS-485 cable) is connected to the controller (via USB)
- IP address
    - IP address of the Modbus TCP slave device.
- Port Number
    - Modbus TCP slave network port number
    - Port number 888 has been reserved for internal inter process communications and should not be used.
    - Maximum allowable port number is 65535
- Baudrate
    - Modbus serial communication speed of data transfer.
- Data Bits
    - Modbus serial communication data bits
- Parity
    - Modbus serial communication parity.
- Stop Bits
    - Modbus serial communication stop bits.
- Station
    - Modbus slave station number
    - As per the Modbus communication standard, the range of station number is from 1 to 255 inclusive.
- Timeout
    - Time delay (CPU sleep time) between each retries.
    - Max timeout is 128 seconds.
- Number of Retries
    - Maximum number of retries before it is considered as timeout.
    - Maximum allowable number of retries is 128.
- Poll Delay
    - Time delay between each successful polls (scan rate).
    - Max poll delay is 128 seconds.
- No Respond Timeout
    - Time delay for slave to respond before connection is flagged as failed and retry sequence is performed.
    - Max allowed “No respond timeout” is 128 seconds.
- Device Poll Type
    - There are 2 basic device poll type; Short and Full.
    - “Short” device poll type will poll basic 3 parameter to do flow calculations; static pressure, differential pressure and flow temperature. This setting is useful if the Modbus End Device is a Multi Variable Transmitter (MVS or better known as 3-in-1)
    - Selecting “Short” device poll type will allow user to enter Modbus register addresses for the 3 parameters; static pressure, differential pressure and flow temperature.
    - “Full” device poll type will poll the full 322 registers (See Appendix B) in the user specified holding register starting with register specified in the “Start Register”. This is useful in situation where the end device has all the parameters stored in the end device but is not able to do flow

calculations. For example, a RTU or PLC without flow calculations capabilities.

- Start Register
  - This allows user to specify the first Modbus register for the slave.
  - All registers must be holding registers (40000)
  - One poll block of Modbus register has a total of 139 registers in total. Hence, with 322 Modbus registers for "Full" device poll type, one meter run will require 2 Modbus polls.
- Register 1, Register 2 and Register 3
  - This is Modbus address for instantaneous value
  - This option is available when the user selects "Short" device poll type.
  - An option is also available for the user to specify the type of holding register; 16bits or 32bit register.
  - These are the array of instantaneous values for different flow calculation types

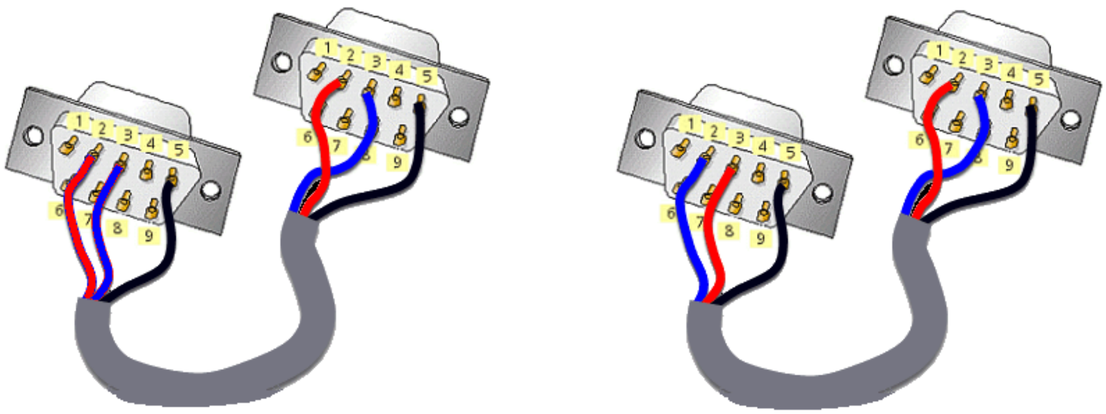
	AGA3	**AGA 7**	**Cone**
Register 1	Static Pressure	Static Pressure	Static Pressure
Register 2	Differential Pressure	Flow Temperature	Differential Pressure
Register 3	Flow Temperature	Turbine Frequency	Flow Temperature

- XynetSCADA needs to be power cycle if new changes are to be applied.

- Modbus Slave Definition
  This part of the communication configuration is for communication between controller and any Modbus Master that he user might want to connect to the controller. The controller will be a Modbus slave for that matter of fact; and it can be either Modbus TCP or Modbus RTU (serial).
  - Communication Status
    - Enable or disables the Modbus slave communication channel.
    - If the Modbus slave is not required, it is highly recommended that the slave be disables. This will help reduce CPU usage and free up resources.
    - If the Communication Status is disabled, the communication program will check for the Communication Status change every 60 seconds.
  - Connection Type
    - There are two type of communication; TCP and serial.
    - Selecting either TCP or serial presents the user with the appropriate communication setup screen. For example TCP will have IP address entry while serial will have baud rate.
    - The serial selection will not be available to the user unless a serial port (either RS-232 or RS-485 cable) is connected to the controller (via USB)
  - Port Number
    - Modbus TCP slave network port number
    - Port number 888 has been reserved for internal inter process communications and should not be used.
    - Maximum allowable port number is 65535
  - Station
    - Modbus slave station number
    - As per the Modbus communication standard, the range of station number is from 1 to 255 inclusive.
  - Restart Modbus Slave
    -

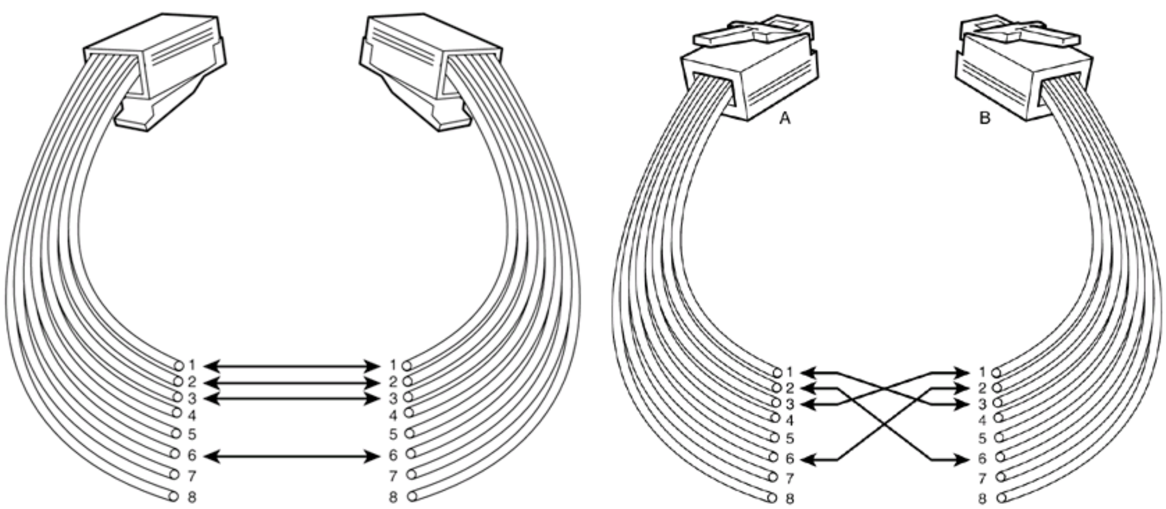
- This button restarts the Modbus slave process (
-
-) in the XynetSCADA, hence applying the new changes in the Modbus slave setting.
- The other way of applying the new Modbus slave setting is to power cycle or reboot the XynetSCADA.

The serial communication does not use “Flow Control”, hence it uses three-wired RS232 serial DB9 wiring schema. The diagram below shows pin out for both serial and Ethernet able.



Straight though **Crossover**

Figure 8.1.6A, DB 9 Cable Straight Though and Crossover Wiring Schema



Straight though **Crossover**

Figure 8.1.6B, Ethernet Cable Straight Though and Crossover Wiring Schema

If controller is connected directly to a computer or a laptop, a null modem cable is required. That is pin 2 and 3 must be crossed. For all other communication setup, a straight though cable can be used.

If this Modbus connection parameters are changed and would like to re-apply the new Modbus parameter without cycling the power, the user must do the following steps. Power down or stop the Modbus slave that is currently connected to and wait for retry delay (that is number of retries * no response timeout). Then start your new Modbus slave.

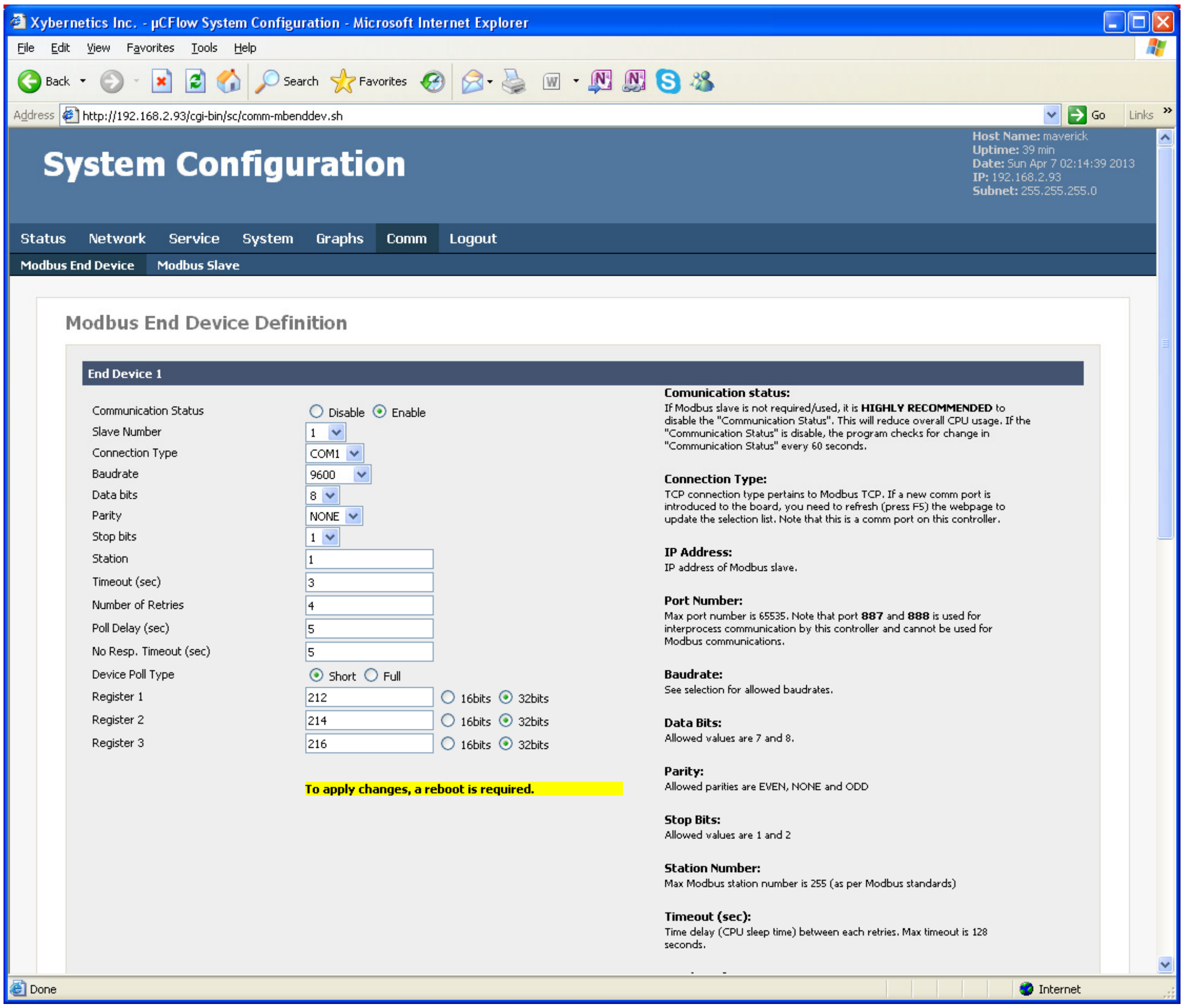


Figure 8.1.6C, Comm Tab – Modbus End Device

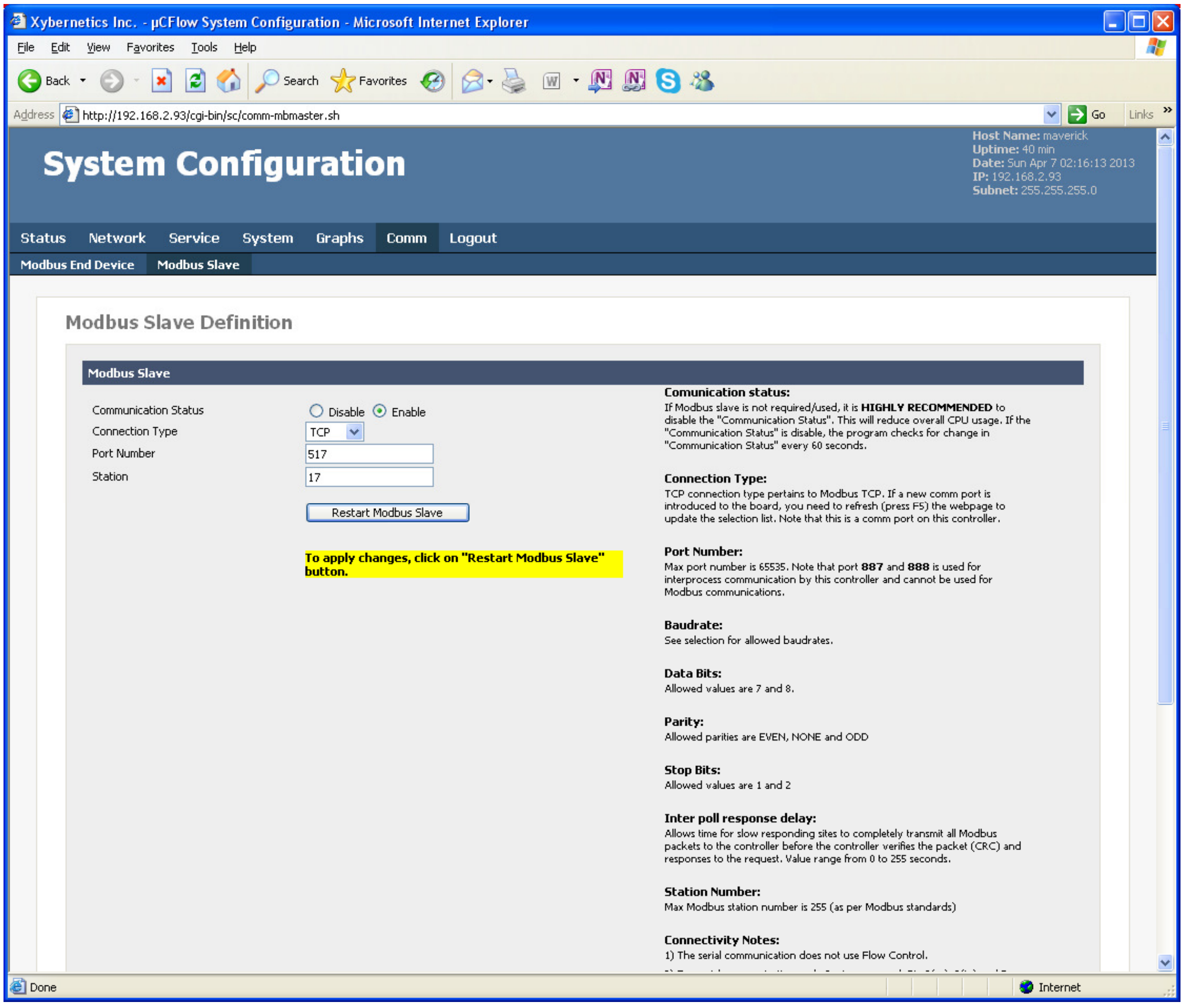


Figure 8.1.6D, Comm Tab – Modbus Slave

8.1.7. Logout Tab

All user login are maintained on the computer session variable. The user must logout before closing the browser to prevent unauthorized users from viewing and changing the system parameters. This page allows users to logout form the session variable.

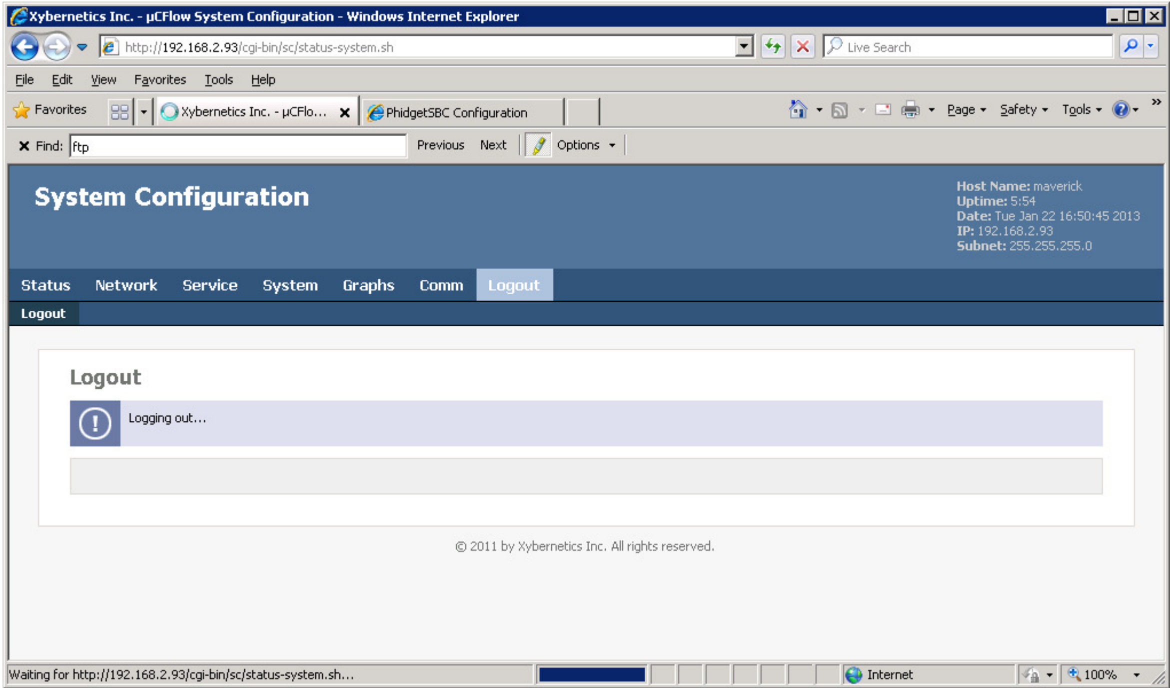


Figure 8.1.7A, Logout Tab

8.2. Flow Calculation Configuration

A typical flow calculation has several inputs and outputs parameters. This section covers configuration of these parameters.

The top section of the webpage is the tab menu which allows users to navigate through all the flow calculation parameters. Some of the tabs will be changed based on the modification of the user entry parameters. For example, if AGA7 was selected as a flow calculation method, AGA7 tab will be displayed and AGA3 will be hidden.

The flow calculation program has been designed to handle ten meter runs. The sidebar (as shown in figure below) allows the user to move from the current meter run to the desired meter run. The text below "Calc Results" tab verifies that the meter run number has been changed and proper flow calculation parameters has been loaded into the Flow Calculation Configuration web interface.

Currently logged in username is shown on the top left-hand side of the webpage (next to logout hyperlink). Once the user is done with the configuration, the login session can be terminated using the logout hyperlink on the top right-hand side of the web page.

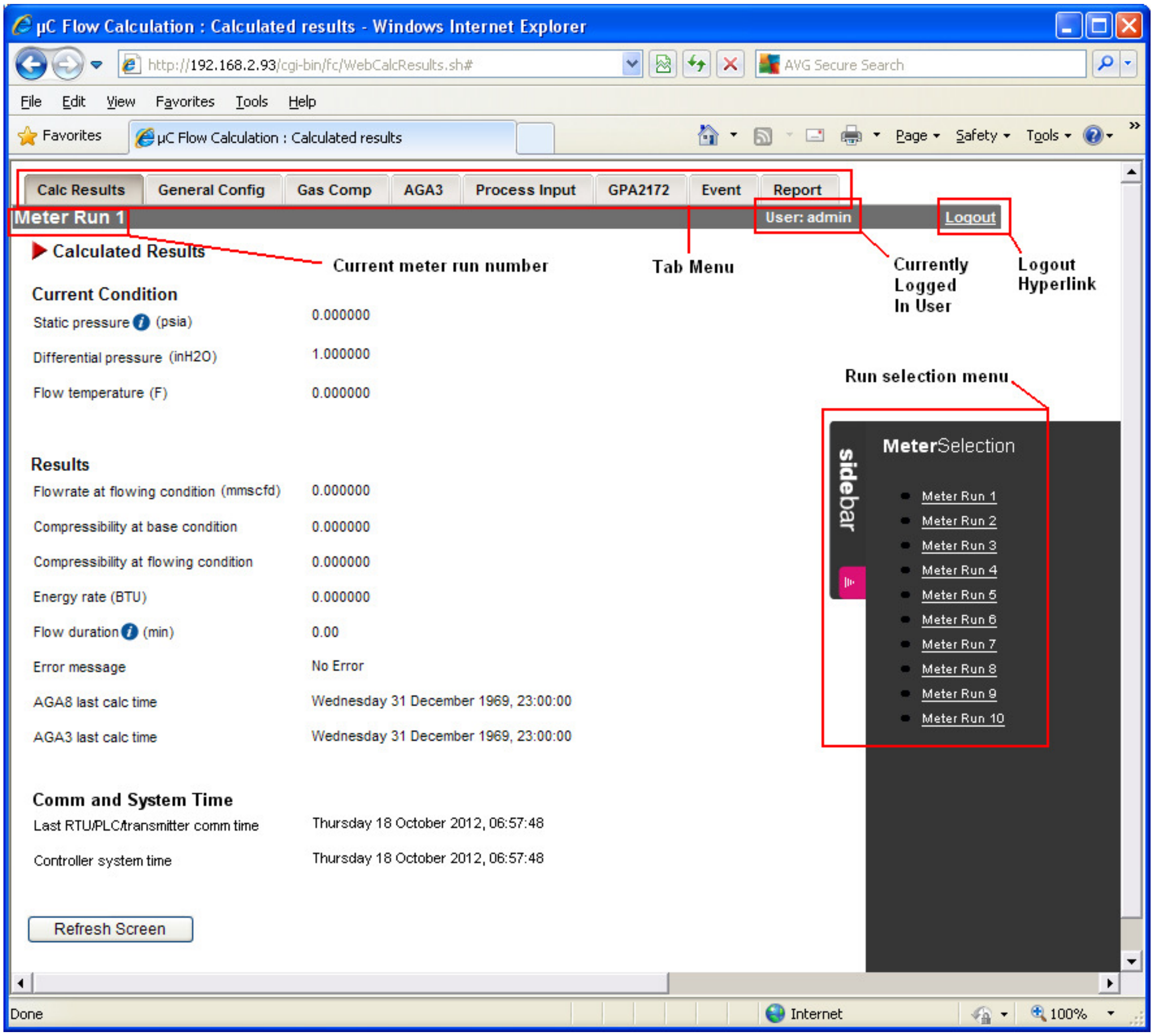


Figure 8.2A, Flow Calculation Configuration

The flow calculation parameters have been grouped into different tabs based on flow calculation method and its functions.

8.2.1. Calculation Results

This page displays the calculated results of the flow calculation depending on the type of flow calculation selected. The following are the available flow calculation methods.

- AGA3
- AGA7
- Wafer Cone
- V-Cone

The following information is available in this web page.

- Current Condition (general input)
  - AGA3
    - Static pressure
    - Differential pressure
    - Flow temperature

  - AGA7
    - Static pressure
    - Flow temperature
  - Wafer Cone and V-Cone
    - Static pressure
    - Differential pressure
    - Flow temperature
- Results (output) For AGA3
  - Flowrate
  - Compressibility (base and flowing condition)
  - Energy rate
  - Flow duration
    - Flow duration will not start if the input values are in debug mode. For example for AGA3 if the static pressure, differential pressure or flow temperature is enabled (checked) in "Process Value" tab, the flow duration will not increase.
  - Error message
    - See Appendix B for Error messages
  - AGA8 last calculation time
  - AGA3 Last calculation time
- Results (output) For AGA7
  - Flowrate
  - Energy rate
  - Flow duration
    - Flow duration will not start if the input values are in debug mode. For example for AGA3 if the static pressure, differential pressure or flow temperature is enabled (checked) in "Process Value" tab, the flow duration will not increase.
  - Error message
    - See Appendix B for Error messages
- Results (output) For Wafer and V-Cone
  - Flowrate
  - Compressibility (base and flowing condition)
  - Energy rate
  - Flow duration
    - Flow duration will not start if the input values are in debug mode. For example for AGA3 if the static pressure, differential pressure or flow temperature is enabled (checked) in "Process Value" tab, the flow duration will not increase.
  - Error message
    - See Appendix B for Error messages
- Historical
  - Total flow today
  - Total flow yesterday
  - Total flow current month
  - Total flow previous month
- Communication and System Time
  - Last RTU/PLC/transmitter communication time
    - A red background text will be visible if the communication to the PLC is lost, and the "Last RTU/PLC/transmitter comm time" entry will be at the frozen state. The red tab is as shown below.

  - Controller system time

- Controller system time can be changed though Modbus (see Appendix B) or though System Configuration webpage (see System Tab->General)
  - Next contract hour time
  - Next month trigger time
  - Next hourly trigger time

The engineering units will be changed dynamically based on the “Input eng unit” and/or “Output eng unit” pull down box(es) in the “General Config” tab.

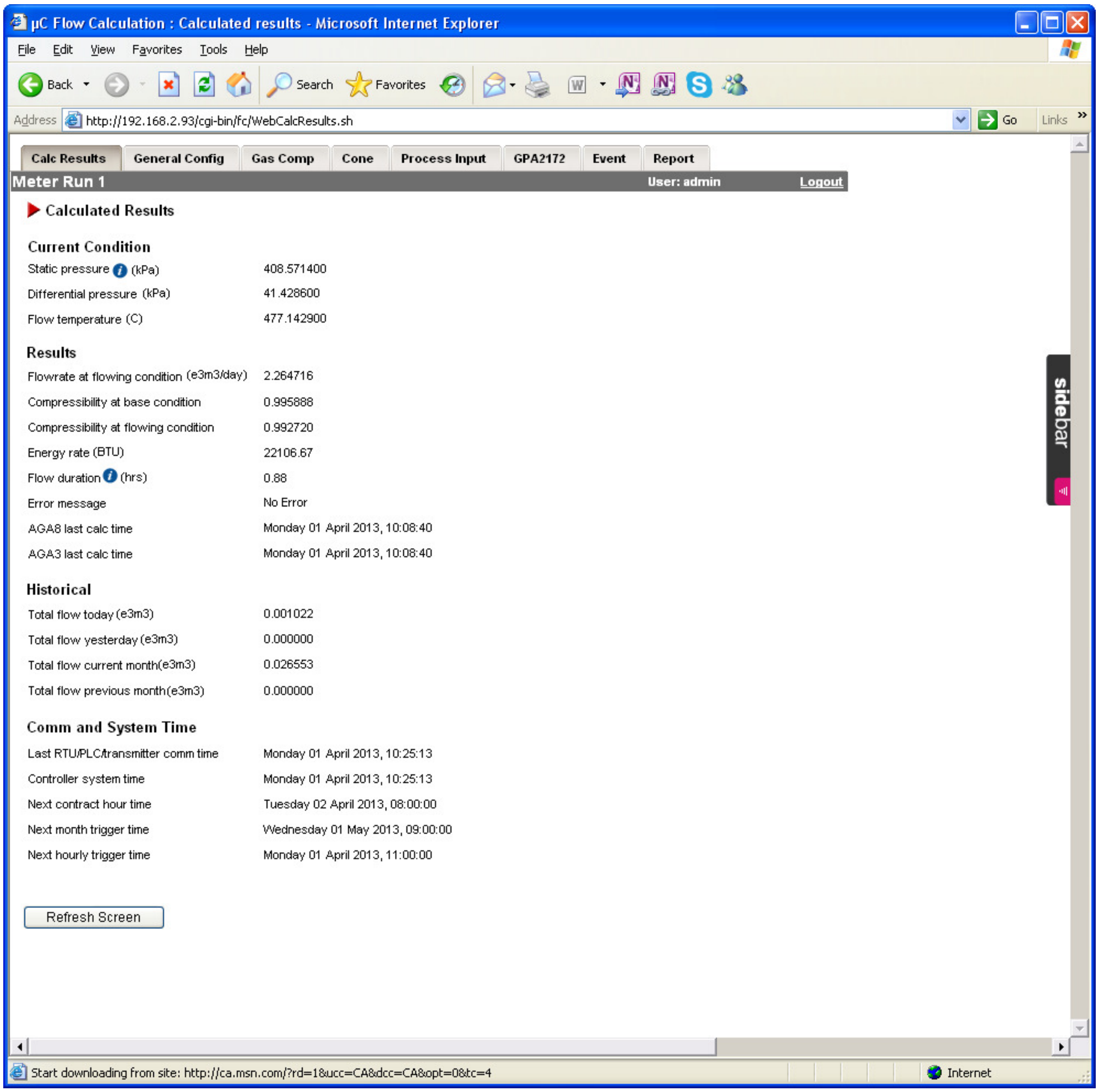


Figure 8.2.1A, Calculation Results Tab

8.2.2. General Configuration

In this screen of the Flow Calculation Configuration, the user is allowed to make typical flow calculation parameter changes. The following are the flow parameter that can be modified from this screen.

- Meter name
    - This name will be part of the report filename. For example, the Daily Report name for this run will be "201208_Test_Meter_DlyRpt.csv". This meter name effects Daily, Monthly and Meter Report.
    - Maximum of 32 characters allowed.
    - Only alphanumeric characters are allowed.
    - Space is allowed.
    - First character can be number
- Flow calculation method
    - Selecting the appropriate flow calculation method will make appropriate tab visible. For example, if "AGA3" is selected, the "AGA3" tab will be visible. And if "AGA7 is selected, "AGA7" tab will be visible.
- Compressor calculation method
- Compressor gross method
    - This selection is not selectable (greyed out) when "AGA8 Detail" is chosen in "Compressor calculation method".
- Heating value calculation method
- Contract hour
    - This value has to be entered in 24-hours clock format; 0 to 23 hours.
- Input engineering unit
    - If the input values are entered in matrix or imperial, this is where the changes are to be made.
    - This effect instantaneous and non-instantaneous (such as gas composition) value.
- Output engineering unit
    - If the output values are preferred in matrix or imperial, this is where the changes are to be made
    - This change effect only the final output/calculated value.
- Base temperature
- Base pressure
- Static pressure type
    - This entry allows user to specify the static pressure reading type; absolute ot gauge pressure.
- Atmospheric pressure mode
    - The flow calculation software has the capability to calculate atmospheric pressure. If "Calculated" is selected for this entry, user must ensure that altitude and latitude is entered correctly.
- Latitude
    - Used for the calculation of atmospheric pressure if "Atmospheric pressure mode" is in "Calculated" mode.
- Altitude
    - Used for the calculation of atmospheric pressure if "Atmospheric pressure mode" is in "Calculated" mode.
- Atmospheric pressure
    - This atmospheric pressure is used if the "Atmospheric pressure mode" is selected as "Manual".

All the Flow Parameters Load File can be saved and loaded from this tab through the "Config File" entry section. After loading the Flow Parameter Load File, the live flow calculation parameters are updated and the new flow parameters are applied to the calculation in 1 to 2 minutes (maximum). The load file is saved as ".aga" file and can be opened using any text editor. A sample of the Flow Parameters Load File can be found in Appendix A or in the following Xybernetics webpage under "Download" tab.

http://www.xybernetics.com/solutions-uCFlowCal.html

The current flow parameters can also be exported to a ".aga' file. The user has to initially click on "Generate Config File" button which will create Flow Parameter Load File with the latest flow configuration. Upon clicking the button, a link "Config File Read for Download" will be available, where the user can click on it and retrieve the ".aga" file.

The engineering units will be changed dynamically based on the "Input eng unit" pull down box.

The General Configuration screen is as shown below.

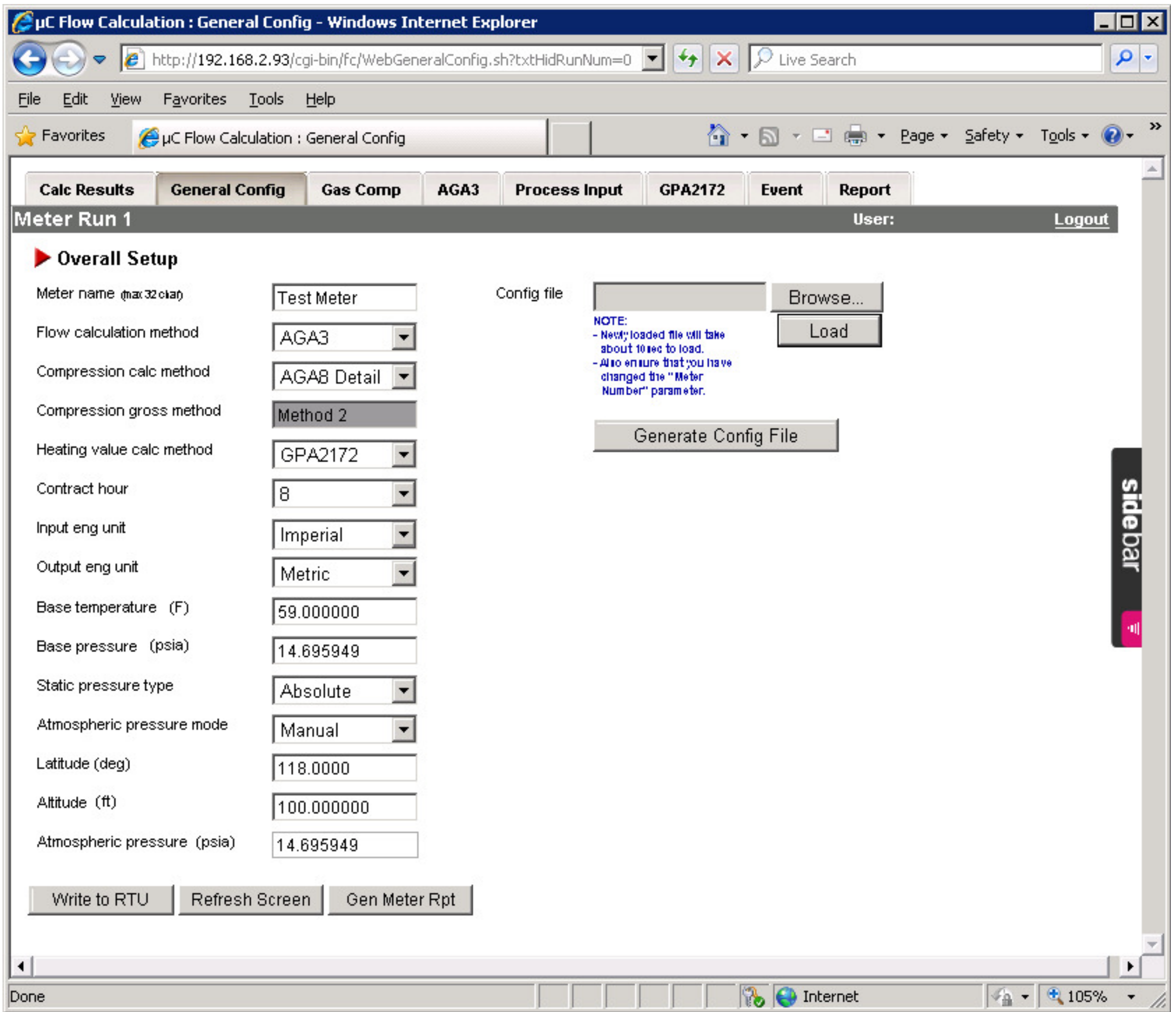


Figure 8.2.2A, General Config Tab

8.2.3. Gas Composition

In this tab, the user has the capability to modify all the twenty one (21) gas compositions and the specific gravity of the medium.

Before the gas composition is incorporated into flow calculation software, verification is done to ensure that the gas composition sums up to one (1). If it does not sum up to one (1), the "Total gas composition" is highlighted in red and the total is shown (as per user entry). The acceptable value of the total gas composition should be greater than or equal to 0.999995 and less than or equal to 1.000005.

If the “Specific gravity method” is set to “Calculated”, the user entry specific gravity will be disabled (grey out, not used for flow calculation algorithm) and the program will calculate the specific gravity based on user entered flow parameters.

The Gas Composition screen is as shown below.

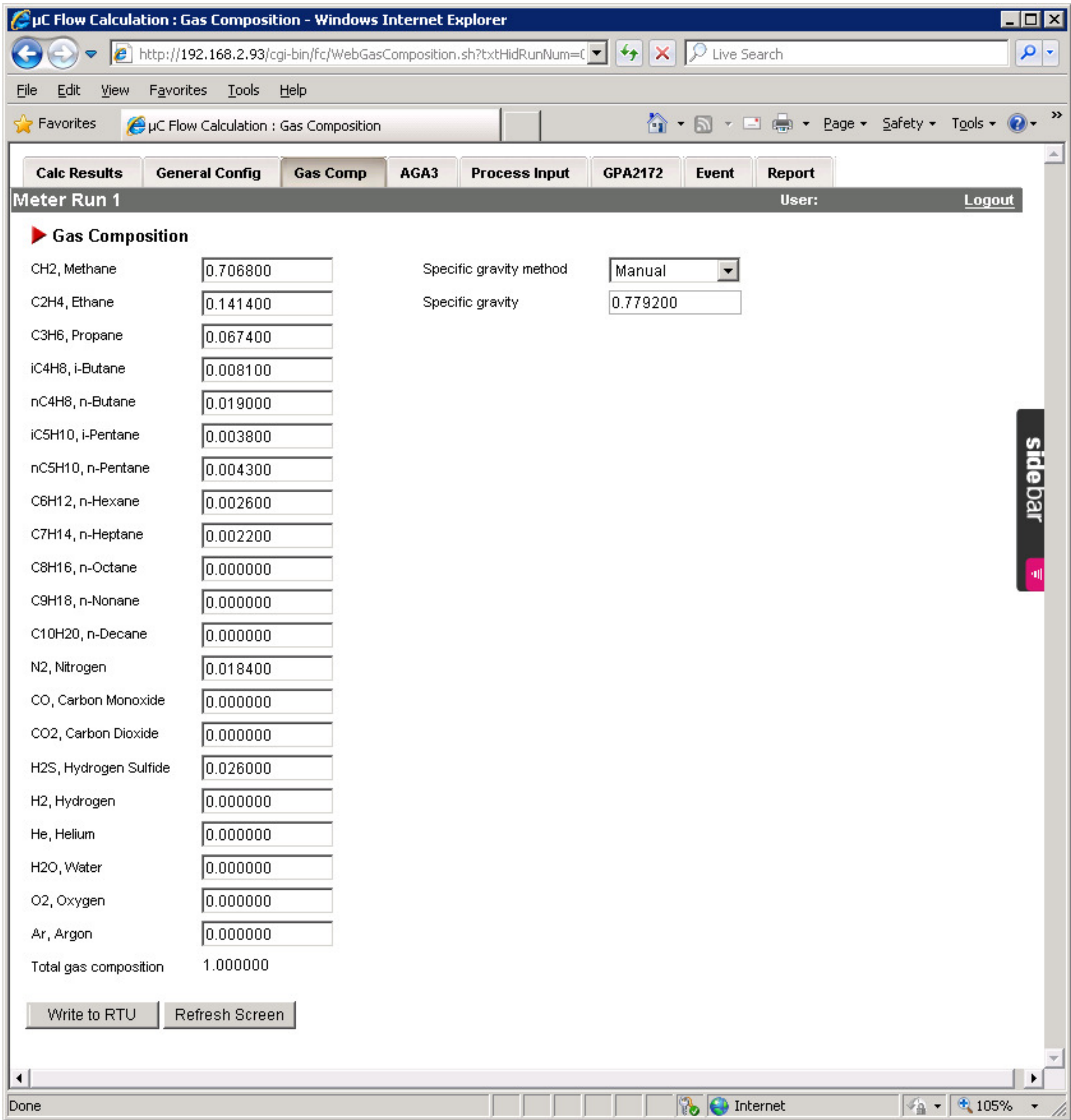


Figure 8.2.3A, Gas Composition Tab

8.2.4. AGA3

This tab is visible when the user has selected “AGA3” in the “Flow Calculation method” on the “General Config” tab.

If orifice plate is adopted as the flow meter, this tab will be available for the user to select. In this tab, the user is able to make modification to parameters pertaining to AGA3 flow calculation parameters.

The following AGA3 parameters can be modified.

- Orifice plate bore diameter
- Orifice plate material
- ipe internal diameter
- Pipe material
- Ref temp for plate and pipe
- Static tap location
- Isentropic
- Viscosity
- DP cutoff
- Correction factor

The engineering units will be changed dynamically based on the “Input eng unit” pull down box in the “General Config” tab.

The AGA3 screen is as shown below.

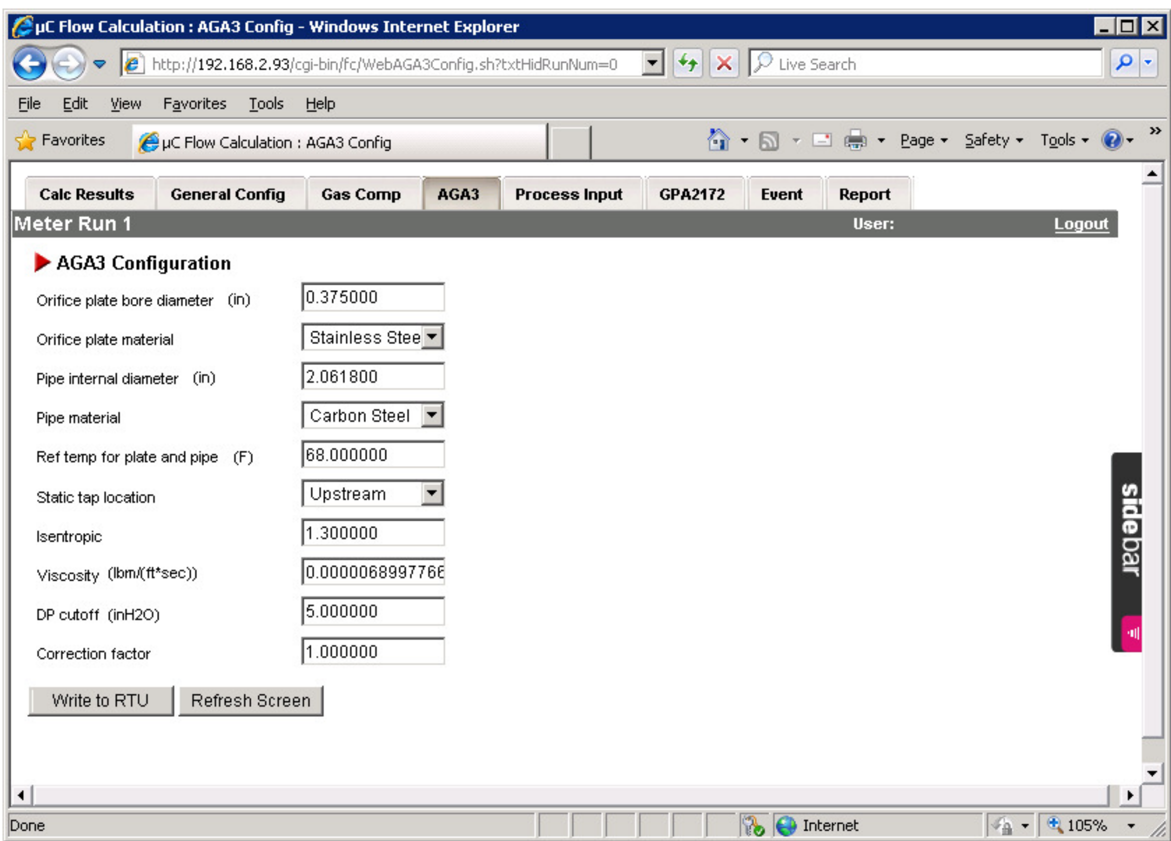


Figure 8.2.4A, AGA3 Tab

8.2.5. AGA7

This tab is visible when the user has selected “AGA7” in the “Flow Calculation method” on the “General Config” tab.

If turbine meter is adopted as the flow meter, this tab will be available for the user to select. In this tab, the user is able to make modification to parameters pertaining to AGA7 flow calculation parameters.

The following AGA7 parameters can be modified.

- k-factor
- Unit time

The engineering units will be changed dynamically based on the “Input eng unit” pull down box in the “General Config” tab.

The AGA7 screen is as shown below.

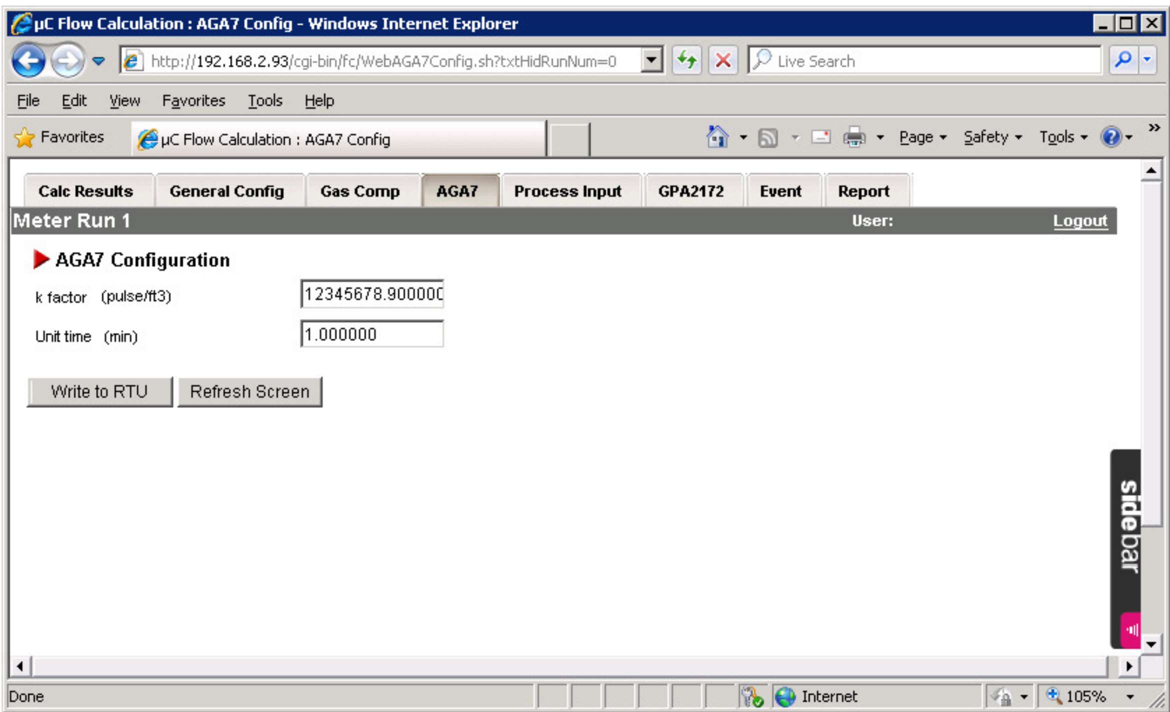


Figure 8.2.5A, AGA7 Tab

8.2.6. Process Value

This section of the Flow Calculation Configuration allows the user to put the controller into debugging mode and enables the user to force a value to the instantaneous values; such as static pressure, differential pressure and flow temperature.

This tool is useful during the commissioning process where the user can for a value to the abovementioned instantaneous value and simulate flow. It is also valuable when performing bench test of communication interface between the controller and a HMI, without needing the actual transmitters.

Here are some of the key pointers to be aware if you put the instantaneous value(s) in debugging mode.

- If any of the instantaneous values are in debugging mode, a red banner will appear above the Flow Configuration screen. Also in the “Calc Results” tab, a yellow banner next to the instantaneous value will highlight which one is in debugging mode.
- If any of the input values are in debug mode, the regular poll to acquire static pressure, differential pressure and flow temperature is temporarily disabled.

In this section, the user can also enter deadband and calibration ranges for the instantaneous values such as static pressure, differential pressure and flow temperature.

The engineering units will be changed dynamically based on the “Input eng unit” pull down box in the “General Config” tab.

The Process Value screen is as shown below.

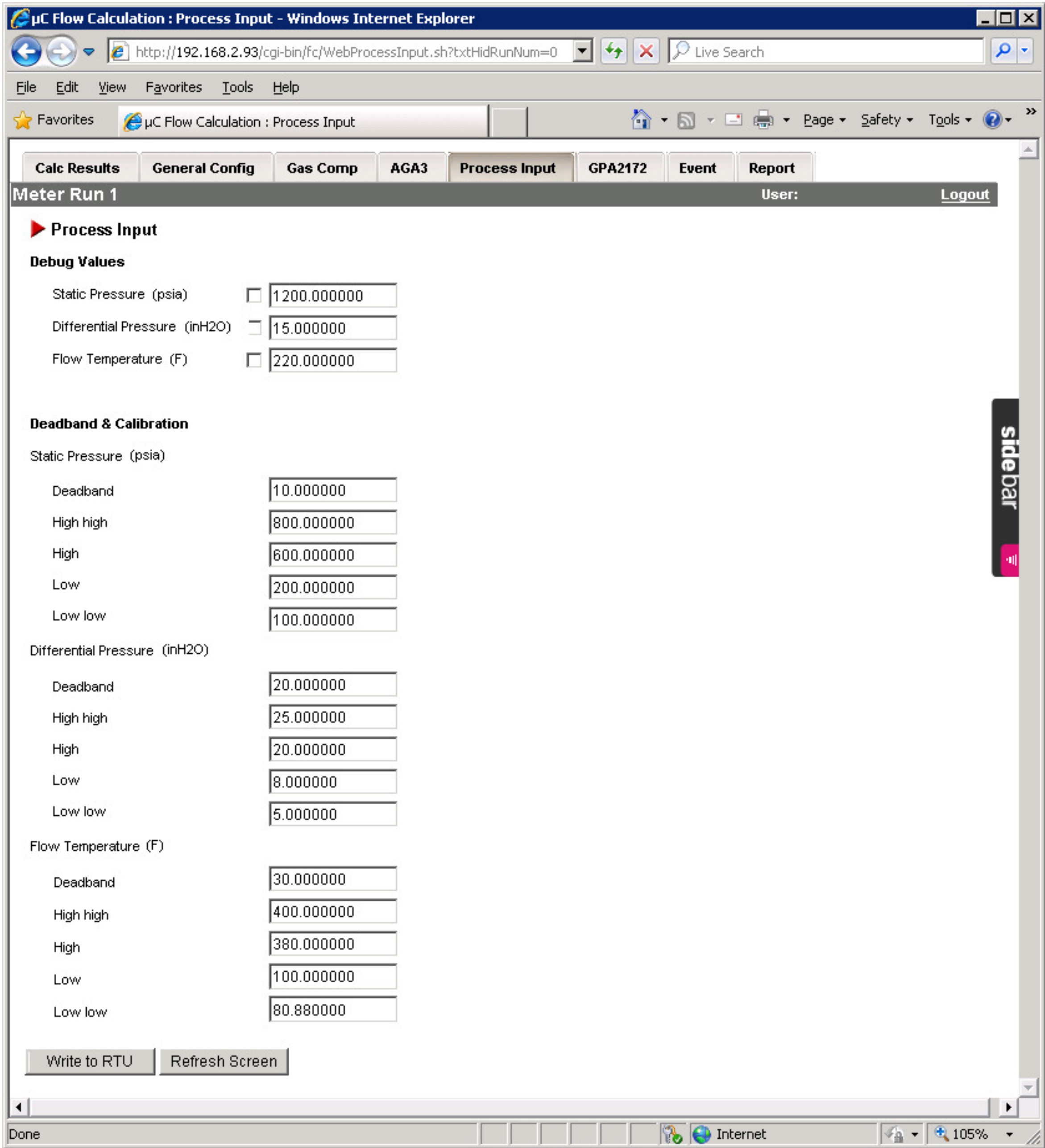


Figure 8.2.6A, Process Input Tab

8.2.7. GPA2172 Value

If the user were to select the “Heating Value Calculation Method” as GPA2172, this tab will be visible.

The engineering units will be changed dynamically based on the “Input eng unit” pull down box in the “General Config” tab.

The GPA2172 Value screen is as shown below.

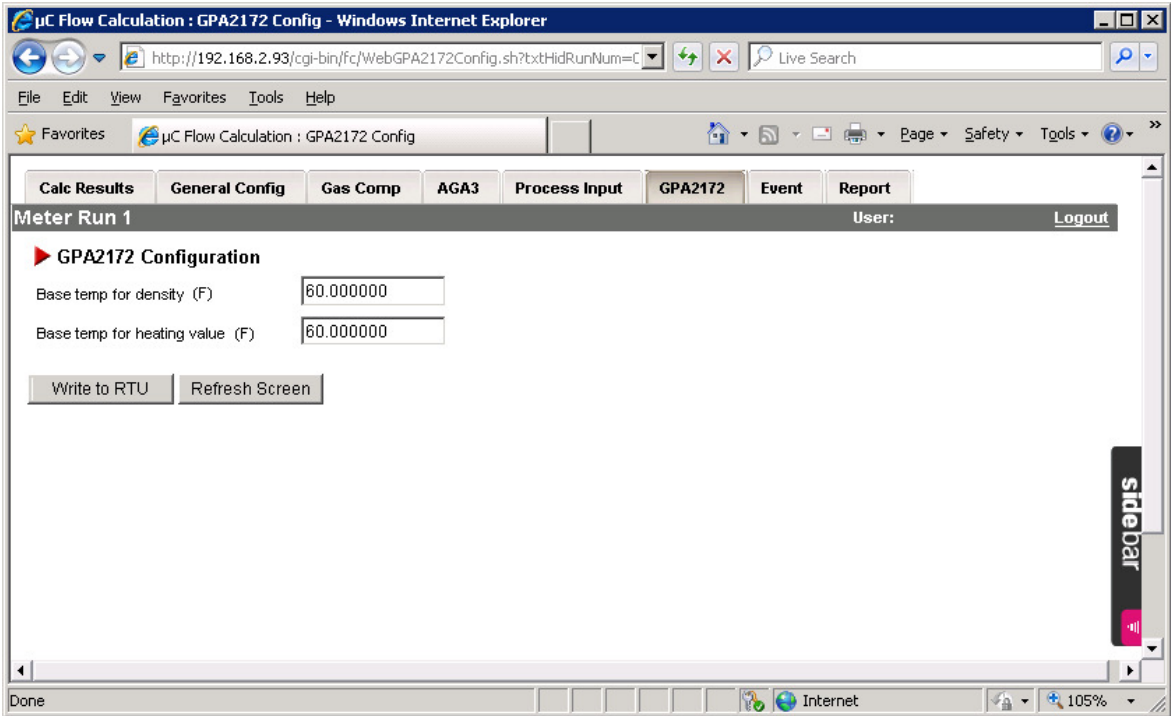


Figure 8.2.7A, GPA2172 Tab

8.2.8. Event

The Event log will display all actions that were performed in the controller with username associated to the action.

There are several purposes of this log and they are as listed below

- For the purpose of future appraisal and record keeping
- Identify what changes were made
- For the purpose of auditing by the local governing body

The event log captures the following events.

- Power cycle of controller
- Communication loss and establishment of the Modbus master and slave
- Disconnection and reconnection of the Ethernet cable
- System time change
- Any flow calculation parameter changes from Flow Calculation Configuration webpage
- Any flow calculation parameter changes from “Config file” upload

The event logs shown in the web page are based on meter run. If the user wants to watch another meter run event log, the user can change the “Event log file” pull down box (as shown below). A new event log file will be generated when the month changes.

The Event screen is as shown below.

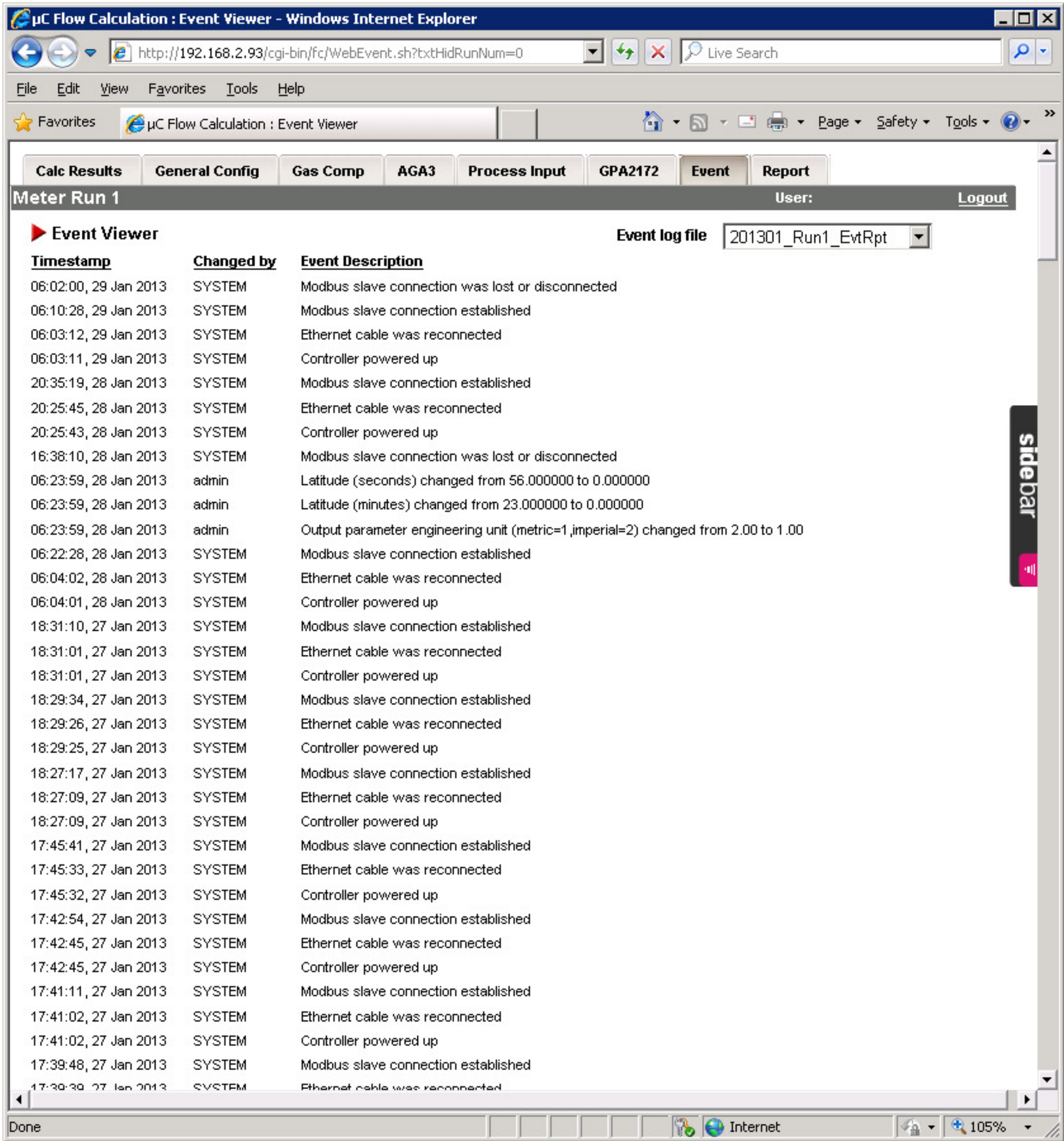


Figure 8.2.8A, Event Tab

The event log is a CSV file and can be opened using Microsoft Excel or any text editor. This CSV file can be downloaded from the “Report” tab and by selecting “Event Log” from the “Report Type” pull down box. The downloading of the event log and reports are discussed further in the next section.

An example of a typical log file is as shown below.

```
1350974108.000000,1.00,2.00,5,admin
1350972886.000000,56.000000,0.000000,42,admin
1350972886.000000,23.000000,0.000000,41,admin
1350972886.000000,2.00,1.00,5,admin
1350972855.000000,0,0,2004,SYSTEM
1350972082.000000,0,0,2001,SYSTEM
```

```
1350972081.000000,0,0,2002,SYSTEM
1350911233.000000,56.000000,0.000000,42,admin
1350911233.000000,23.000000,0.000000,41,admin
1350889811.000000,0,0,2001,SYSTEM
1350889810.000000,0,0,2002,SYSTEM
1350543503.000000,56.000000,0.000000,42,admin
1350543503.000000,23.000000,0.000000,41,admin
1350543503.000000,Test Meter,Test Meter23423234hy3w41,1,admin
1350543412.000000,0,0,2004,SYSTEM
1350543359.000000,0,0,2001,SYSTEM
1350543358.000000,0,0,2002,SYSTEM
1350459220.000000,0,0,2001,SYSTEM
1350459138.000000,0,0,2002,SYSTEM
1350373623.000000,0,0,2001,SYSTEM
1350373620.000000,0,0,2000,SYSTEM
1350370738.000000,0,0,2001,SYSTEM
1350370738.000000,0,0,2002,SYSTEM
1349723473.000000,0,0,2001,SYSTEM
1349723473.000000,0,0,2002,SYSTEM
1349642014.000000,0,0,2001,SYSTEM
1349642014.000000,0,0,2002,SYSTEM
1349633708.000000,0,0,2001,SYSTEM
1349633708.000000,0,0,2002,SYSTEM
1349632228.000000,0,0,2001,SYSTEM
1349632228.000000,0,0,2002,SYSTEM
1349629238.000000,0,0,2001,SYSTEM
1349629237.000000,0,0,2002,SYSTEM
[END]
```

The denotation of each row is shown in Appendix D Report and Event Column Definition.

8.2.9. Report

The following reports that are downloadable from the controller are as listed below.

- Daily report
  - A file is generated on the first day of the month at contract hour.
  - Every day at the expiration of the contract hour, a row is added to this file.
  - Every meter will have its own file
  - In CSV file format
- Monthly report
  - A file is generated on the first day of the year at contract hour
  - On the every first day of the month at the contract hour, a row is added to this file on the first of the next month at the expiration of the contract hour.
  - Every meter will have its own file
  - In CSV file format
- Meter report
  - A file is generated when a change to the flow calculation parameter is made
  - Every meter will have its own file
  - In CSV file format
- Event log
  - If an appropriate event occurs after the first day of the month after 0000hrs, a new file is generated, and any event occurring in that month is logged in this file.
  - Every meter will have its own file
  - In CSV file format

The format of the column for each file type is listed in Appendix D Report and Event Column Definition.

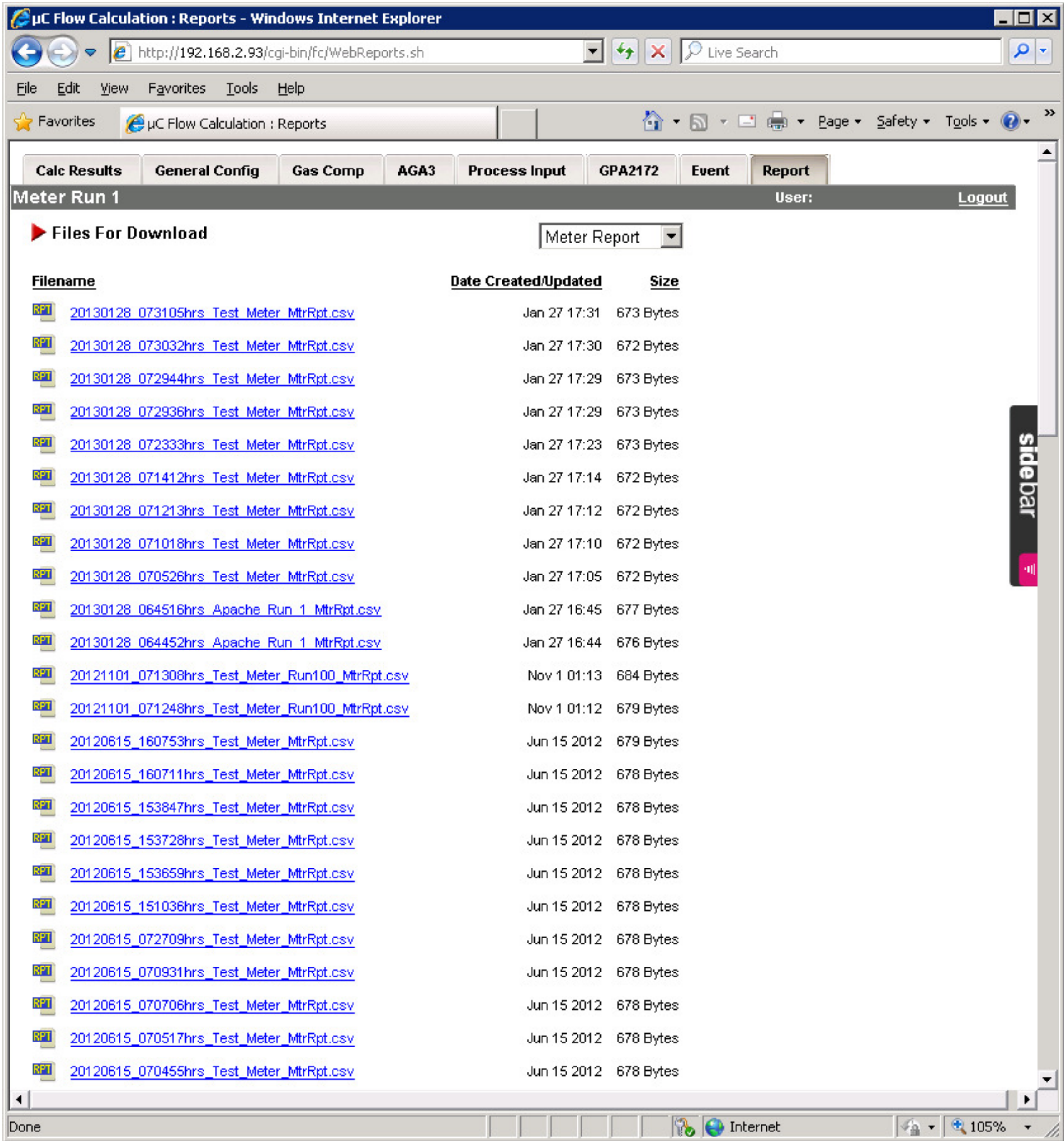


Figure 8.2.9A, Report Tab

8.3. Web Interface Security

A layer security is present when the user wants to access the web interface pages (System Configuration or Flow Calculation Configuration). System Configuration and Flow Calculation Configuration maintains its own login session. That is, if the user logins into System Configuration and if the user wants to view the Flow Calculation Configuration, he/she will have login to Flow Calculation Configuration.

Since System Configuration and Flow Calculation Configuration maintain its own login session, when the user logs out of the System Configuration, the login session in Flow Calculation Configuration web interface is not lost. Likewise, if the user logs out of Flow Calculation Configuration, the login session to System Configuration is not lost.

The figure below shows System Configuration login windows.

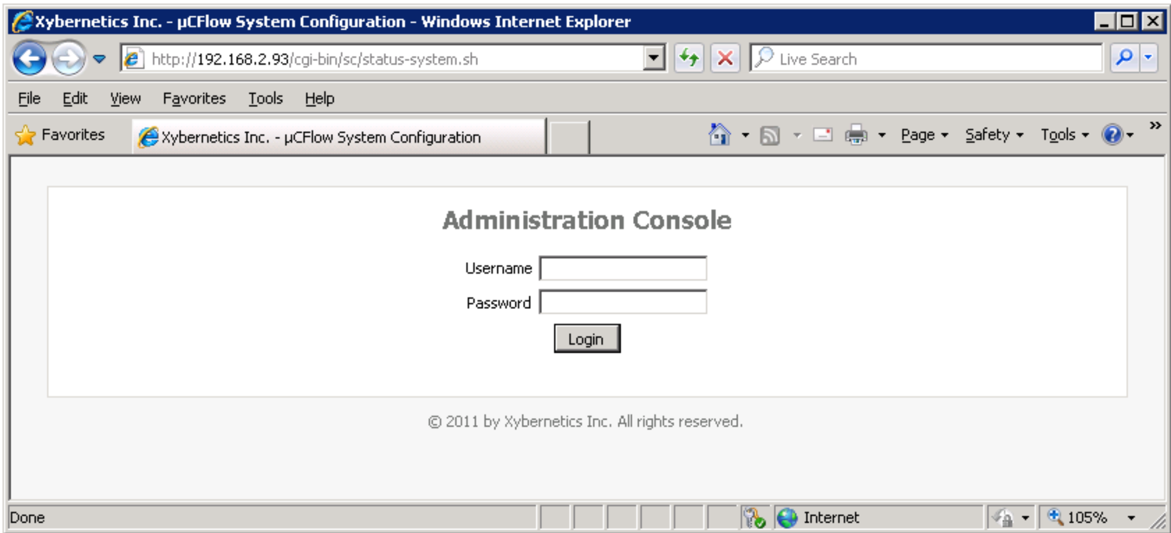


Figure 8.3A, System Configuration Login

9. FLOW CALCULATION FEATURES

This section highlights all function and features that is available in the uCFlowCalc controller.

9.1. Flow Calculations Algorithms

The following algorithms to calculate flow for natural gases are covered in the controller.

- AGA Report Number 3, 1990 (Orifice flow metering)
- AGA Report Number 7, 1985 (Measurement of gas by turbine meter)
- AGA Report Number 8, 1992 (Compressibility factor of natural gas and other related hydrocarbon gases; Detail Characterization Method)
- AGA Report Number 8, 1992 (Compressibility factor of natural gas and other related hydrocarbon gases; Gross Characterization Method 1 and 2)
- AGA Report Number 5, 1985 (Fuel gas energy metering; Gas volume to energy conversion method)
- V-Cone flow calculation (gas and liquid)
- Wafer-Cone flow calculation (gas and liquid)
- AGA Report Number 9, 1998 (Measurement of Gas by Multipath Ultrasonic Meters)
- AGA Report Number 10, 1998 (Speed of Sound in Natural Gas and Other Related hydrocarbon Gases)

The flow calculation selection can be made through web interface or though Modbus communication

9.2. Flow Parameter Load File (.aga)

There are two ways to configure the flow calculation parameter. The conventional way is to use the Flow Calculation web interface and enter every flow parameters. The other way is to use a predefined flow parameter file and upload it into the controller, which essentially speed up configuration time to sites with similar settings.
The flow parameter is a text file which can be easily edited using any text editor if further customisation is required.

To load the flow parameter file go to the Flow Calculation web interface. Select "General Config" tab and upload the file into the controller using the "Config File" textbox. See figure shown below.

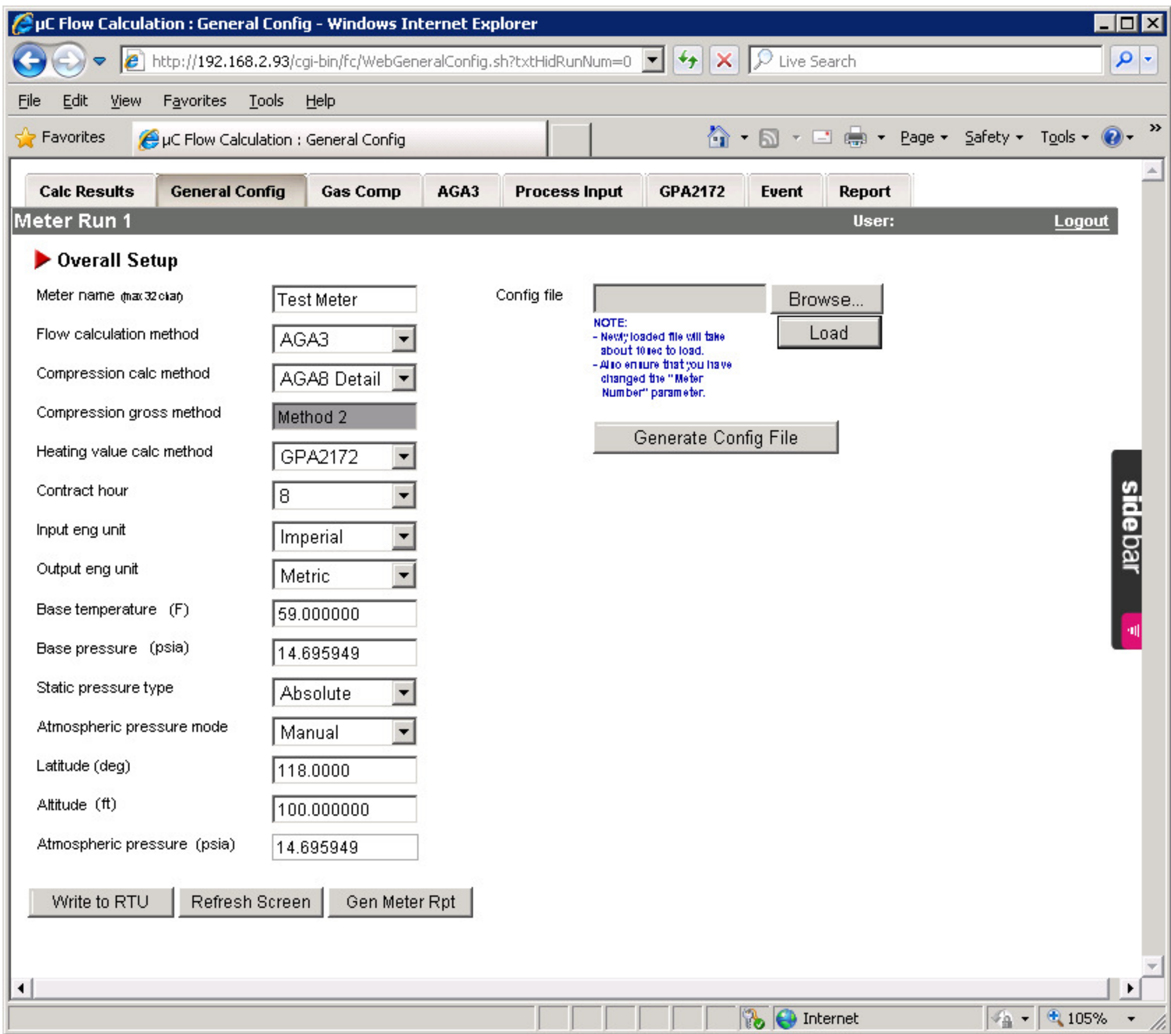


Figure 9.2A, System Configuration Login

Once the flow parameter file is loaded, it will require 30 seconds for the program to verify and upload the new configuration into the currently running flow calculation. The user is required to refresh (by pressing F5 or the "Refresh" button) the web page to view the newly uploaded flow parameters in the web interface.

Power cycle of the controller is not required to apply these changes.

A sample of the flow parameter load file can be found in Appendix A of this document. Here are the characteristics of the file.

- [config] denotes section header and it should **not** be edited
- The delimiter is a pound character "#"
- Anything before the delimiter is title header and it should **not** be edited. The title header gives the user some insight of what value they are configuring. If a fixed value is expected from the use (for example "Flow calculation algorithm selection"), the title header provides options that are available for the user.
- Anything after the delimiter is the value. These values can be edited as per user requirements and preference. It is to be noted that some value can be an integer and other can be real numbers.
- The order of the flow calculation parameter file should not be changed. When the flow calculation program reads the configuration file it is, expecting the input values in that order as shown in Appendix A. Changing the order will result in inaccurate flow calculation and potentially program to crash due to numeric over flow (as integer was expected and a floating point was provided)
- "Meter Number" parameter must be changed according to which meter run this ".aga" file is for. For example, if the configuration file is for meter run number 8, "Meter Number" parameter in the file must be changed to "`Meter Number#8`" before loading the file to the controller through the webpage. The valid entry is an integer number from 1 to 10.
- The data get loaded every 10 seconds. That is to say that if you load the configuration file using the web page, the program will take as long as 10 seconds before loading it to the runtime flow calculation parameters.

A sample of the Flow Parameters Load File can be found in Appendix A or in the following Xybernetics webpage under "Download" tab.

http://www.xybernetics.com/solutions-uCFlowCal.html

9.3. Data Persistence and Restore

When ever a user makes any changes to the flow calculation parameters, the complete flow parameter configurations for that particular meter run is saved to a persistence file. During the event of power loss or if the user decides to reset the controller, the persistence file helps in reinstating the previous flow parameter before the power loss or user reset.

9.4. Error Messages

This section covers error messages that are issued by the flow calculation program and what is its significance.

- AGA8 Detail : Gas composition not within range (0.999995<=GC<=1.000005)
  a. This error message is issued when the total gas composition does not adds to greater than or equal to 0.999995 and less than or equal to 1.000005
  b. Gas composition is required to be reviewed again to rectify this issue
  c. This message is represented as -1 in Modbus register. For Modbus register number refer to Appendix B
- AGA3 : Incorrect static tap location
- AGA8 : Flow temp and/or static pressure is out of range (-200<=T<=760 & 0<=P<=40000)
- AGA3 : Pressure ratio out of range

- AGA3 : Temperature ratio out of range
- AGA3 : Division by zero (check diameter and specific gravity)
- AGA7 : Division by zero (check k factor and time span)
- Cone : Division by zero (check diameter and specific gravity)
- Invalid calculation selection
- Invalid atmospheric pressure selection
- Invalid specific gravity selection
- AGA3 : Invalid orifice plate material
- AGA3 : Invalid pipe material
- AGA3 : Invalid static pressure tap location
- Cone : Invalid pipe material
- Cone : Invalid cone material
- Cone : Invalid state of fluid
- AGA5 : Division by zero
- AGA8 DCM : Division by zero
- AGA3 : Orifice plate diameter >= pipe diameter
- Cone : Cone diameter >= pipe diameter
- AGA8 : Invalid compressibility calculation selection
- AGA8 Gross : Heating value <= 0.00
- AGA8 Gross : Ref temperature for heating value <= zero
- AGA8 Gross : N2, CO2, H2 and/or CO is zero
- AGA8 Gross : N2, CO2, H2 and/or CO is < zero
- AGA8 Gross : Specific gravity <= zero
- AGA8 Gross : Ref temperature for specific gravity <= zero
- AGA8 Gross : Ref pressure for specific gravity <= zero
- AGA3 : Flowrate is negative
- Controller date and time has not been updated or report file cannot be created/appended/open.

10. FLOW CALCULATION INPUT AND OUTPUT VALUES

This section discusses what values can be input to the controller and what will be the output from the controller.

10.1. Input Values

The following are the required input values required for the AGA program to function properly.

10.2. Input Value Ranges

The flow calculation equation for medium type has a validity range, of which it directly dictates it accuracy. If the input value(s) starts to go off the specified range, the result of the AGA published equations starts to deteriorate and enter a section of the trend call uncertainty value range.
The sections bellow outlines the range of each equation before the calculated value starts to get into the uncertainty range.

10.2.1. AGA Report Number 3 (Orifice flow metering) Input Value Ranges

The followings are the conditions that must satisfy before implementing AGA3 calculations. Any input values out of this range will fall under uncertainty condition.

10.2.1.1. Linear Coefficient of Thermal Expansion

- Constant for SUS304/316 is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Monel is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Carbon Steel is valid for temperature range from -7°F to 154°F (-21°C to 67.77°C)
- Reference temperature is assumed to be 68°F (see AGA3, Part3, pg8)

10.2.1.2. Upstream/Downstream Expansion Factor

- The pressure ratio (diff. pressure/abs static at upstream) must be from 0 to 0.2
- The pressure ratio (abs static at downstream/abs static at upstream) must be from 0.8 to 1.0
- Beta ratio (orifice diameter at flowing temp/meter diameter at flowing temp) must be from 0.10 to 0.75
- Also meter and orifice plate temperature range must be met (see section 4.1.1)

10.2.1.3. Coefficient of Discharge

- Initial coefficient of discharge is assumed to be 0.06 (as per AGA3 Part2, pg 57, recommendation).

10.2.1.4. Reynolds Number

- Base temperature is assumed to be 60°F, 519.67R (see AGA3, Part3, pg11)
- Base pressure is assumed to be 14.73psi (see AGA3, Part3, pg11)
- Compressibility of air at base pressure is assumed to be 0.999590 (see AGA3, Part3, pg11)

10.2.2. AGA Report Number 8 (Compressibility) Input Value Ranges

The followings are the conditions that must satisfy before implementing AGA8 calculations. Any input values out of this range will fall under uncertainty condition.

10.2.2.1. Pressures

Pressure must range between 0 to 40000psia.

10.2.2.2. Temperature

Temperature must range between -200°F to 760°F.

10.2.2.3. Gas Composition

- Methane composition fraction must be within 0.45 to 1.00.
- Nitrogen composition fraction must be within 0.00 to 0.50.
- Carbon dioxide composition fraction must be within 0.00 to 0.30.
- Ethane composition fraction must be within 0.00 to 0.10.
- Propane composition fraction must be within 0.00 to 0.04.
- Water composition fraction must be within 0.00 to 0.0005.
- Hydrogen sulphide composition fraction must be within 0.00 to 0.0002.
- Hydrogen composition fraction must be within 0.00 to 0.10.
- Carbon monoxide composition fraction must be within 0.00 to 0.03.
- Oxygen composition fraction must be within 0.00 to 1.00.
- i-Butane composition fraction must be within 0.00 to 0.01.
- n-Butane composition fraction must be within 0.00 to 0.01.
- i-Pentane composition fraction must be within 0.00 to 0.003.
- n-Pentane composition fraction must be within 0.00 to 0.003.

- n-Hexane composition fraction must be within 0.00 to 0.002.
- n-Heptane composition fraction must be within 0.00 to 1.00.
- n-Octane composition fraction must be within 0.00 to 1.00.
- n-Nonane composition fraction must be within 0.00 to 1.00.
- n-Decane composition fraction must be within 0.00 to 1.00.
- Helium composition fraction must be within 0.00 to 0.002.
- Argon composition fraction must be within 0.00 to 1.00.

10.3. AGA Report Number 7 (Turbine metering) Input Value Ranges

User specified “Unit Time” will dictate the rate of flow unit. For example, if the “Unit Time” is in hours, the calculated flow will be in ft3/hr. Or if the “Unit Time” is in minutes, the calculated flow will be in ft3/min.

10.4. AGA Report Number 5 (Fuel gas energy metering) Input Value Ranges

4.4.1 General equation
Gas volume to energy conversion only applies to volume units under a pressure of 14.73psi and 60°F
4.4.2 Energy volume ratio
a) Energy-volume ratio is at 14.73psi and 60°F
b) AGA5 uses volumetric flow equation to calculate the gas energy. The other way to calculate gas energy is using mass flowrate (not in this program).

10.5. Wafer Cone (Gas and liquid) Input Value Ranges

The followings are the conditions that must satisfy before implementing wafer cone calculation. Any input values out of this range will fall under uncertainty condition.

10.5.1. Linear Coefficient of Thermal Expansion

- Constant for SUS304/316 is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Monel is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Carbon Steel is valid for temperature range from -7°F to 154°F (-21°C to 67.77°C)
- Reference temperature is assumed to be 68°F (see AGA3, Part3, pg8)
- If operating temperature is <560 Rankin (<100F, <38C), material thermal expansion factor (Fa) will be excluded from the calculation. That is, all this ranges will not apply at all.

10.6. V- Cone (Gas and liquid) Input Value Ranges

The followings are the conditions that must satisfy before implementing v-cone calculation. Any input values out of this range will fall under uncertainty condition.

10.6.1. Linear Coefficient of Thermal Expansion

- Constant for SUS304/316 is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Monel is valid for temperature range from -100°F to 300°F (-73.33°C to 148°C)
- Constant for Carbon Steel is valid for temperature range from -7°F to 154°F (-21°C to 67.77°C)
- Reference temperature is assumed to be 68°F (see AGA3, Part3, pg8)

- If operating temperature is <560 Rankin (<100F, <38C), material thermal expansion factor (Fa) will be excluded from the calculation. That is, all this ranges will not apply at all.

A. APPENDIX – FLOW PARAMETER LOAD FILE (SAMPLE)

```
[config]
Meter number#1
Meter name#Test Meter Run100
Flow calculation algorithm selection (AGA3=1, AGA7=2, VCone=3, WaferCone=4)#1
Compression calculation algorithm selection (AGA8 Detail=1, AGA8 Gross=2)#1
AGA8 Gross method selection (Method 1=1, Method 2=2)#1
Heating value calculation method (AGA5=1, GPA2172=2)#2
Atmospheric pressure calculation selection (Calculated=1, Manual=2)#2
Specific gravity calculation selection (Calculated=1, Manual=2)#2
Correction factor for AGA 3 (0.0000 to 1.0000 inclusive)#1
Contract hour#8
Input parameter engineering unit (metric=1,imperial=2)#2
Output parameter engineering unit (metric=1,imperial=2)#2
Methane, CH4#0.7068
Nitrogen, N2#0.0184
Carbon dioxide, C02#0.0000
Ethane, C2H6#0.1414
Propane, C3H8#0.0674
Water, H2O#0.0000
Hydrogen sulphide, H2S#0.0260
Hydrogen, H2#0.0000
Carbon monoxide, CO#0.0000
Oxygen, O2#0.0000
i-Butane, IC4H10#0.0081
n-Butane, NC4H10#0.0190
i-Pentane, IC5H12#0.0038
n-Pentane, NC5H12#0.0043
n-Hexane, C6H14#0.0026
n-Heptane, C7H16#0.0022
n-Octane, C8H18#0.0000
n-Nonane, C9H20#0.0000
n-Decane, C10H22#0.0000
Helium, He#0.0000
Argon, Ar#0.0000
Atmospheric pressure in psia#13.5
Orifice plate and tube diameter measurement reference temperature in F#68.00
Static pressure type (absolute=1,gauge=2)#1
Differential pressure cutoff in inH2O#2.0
Upstream static pressure deadband in psia#2.0
Differential pressure deadband in inH2O#3.0
Flow temperature deadband in °F#4.0
AGA7 pulse deadband in Hz#6.0
Latitude (degrees)#118
Latitude (minutes)#23
Latitude (seconds)#56
Altitude in ft#100.0
Base temperature in °F#59.0
Base pressure in psia#14.695948804
Orifice diameter at reference temperature in inches#0.375
Meter diameter at reference temperature#2.0618
Orifice plate material (stainless steel=1,monel=2,carbon steel=3)#1
Meter tube material (stainless steel=1,monel=2,carbon steel=3)#3
Static pressure tap location (upstream=1,downstream=2)#1
Isentropic expansion, as per EUB Dir 17#1.3
Viscosity in lbm/ftsec#0.0000068997766652
Specific gravity#0.7792
AGA7, K, pulses per cubic foot#246810.0
AGA7, Unit time#1.0
Cone, Pipe inside diameter (inches)#2.0
Cone, Cone diameter (inches)#0.5
Cone, Flowmeter coefficient (CD)#0.8
Cone, Pipe material (stainless steel=1,monel=2,carbon steel=3)#1
Cone, Cone material (stainless steel=1,monel=2,carbon steel=3)#2
Cone, Reference specific gravity at 60°F, 14.696psia#0.824
Cone, State of fluid (liquid=2, gases and vapours=1)#1
AGA8 Gross, Gross calorific heating value for gas mixture in BTU/ft³#1034.85
AGA8 Gross, Reference temperature for heating value in °F#60.0
AGA8 Gross, Reference temperature for molar density in °F#60.0
AGA8 Gross, Reference temperature for relative density in F#60.0
AGA8 Gross, Reference pressure for molar density in psi#14.73
AGA8 Gross, Reference pressure for relative density in psi#14.73
AGA9 Average velocity in ft/hr#0.0
AGA9 Low-flow velocity threshold in ft/hr#0.0
AGA9 Enable CPSM (0=off, 1=on)#0
```

```
AGA9 Enable CTSM (0=off, 1=on)#0
AGA9 Enable profile correction factor (0=off, 1=on)#0
AGA9 CPSM state (Calculated=1, Manual=2)#1
AGA9 CTSM state (Calculated=1, Manual=2)#1
AGA9 Profile correction factor state (Calculated=1, Manual=2)#1
AGA9 Pipe outside diameter in ft#0.0
AGA9 Pipe inside diameter in ft#0.0
AGA9 Poisson's ratio#0.0
AGA9 Young's modulus of elasticity in psia#0.0
AGA9 Reference pressure in psia#0.0
AGA9 Reference temperature in °F#0.0
AGA9 Pipe linear expansion coefficient due to temperature in/in-°F#0.0
AGA9 Wall roughness in ft#0.0
AGA9 Path factor (0.94=Juniorsonic, 1.00=Seniorsonic)#1.0
AGA9 Dynamic viscousity in lbm/ft.sec#0.0
AGA9 Manual CPSM entry#0.0
AGA9 Manual CTSM entry#0.0
AGA9 Manual profile correction factor entry#0.0
GPA2172 Base temperature for density in °F#60.0
GPA2172 Base temperature for heating value in °F#60.0
Put static pressure in debug mode (enable=1,disable=2)#2
Put differential pressure in debug mode (enable=1,disable=2)#2
Put flow temperature in debug mode (enable=1,disable=2)#2
Put AGA7 pulse in debug mode (enable=1,disable=2)#2
Mock static pressure (must be in debug mode)#408.73
Mock differential pressure (must be in debug mode)#40.9897
Mock flow temperature (must be in debug mode)#134.6
Mock AGA7 pulse (must be in debug mode)#246810.0
Static pressure calibration value, high high in psi#800.0
Static pressure calibration value, high in psi#600.0
Static pressure calibration value, low in psi#200.0
Static pressure calibration value, low low in psi#100.0
Differential pressure calibration value, high high in inH2O#25.0
Differential pressure calibration value, high in inH2O#20.0
Differential pressure calibration value, low in inH2O#8.0
Differential pressure calibration value, low low in inH2O#5.0
Flow temperature calibration value, high high in °F#400.0
Flow temperature calibration value, high in °F#380.0
Flow temperature calibration value, low in °F#100.0
Flow temperature calibration value, low low in °F#80.0
```

Note:

- "Meter Number" parameter <u>must</u> be changed according to where this aga file is to be loaded. For example, it is for meter run number 8; "Meter Number" parameter in the file must be changed to "`Meter Number#8`" before loading the file to the controller through the webpage.
- The data get loaded every <u>1 to 2 minutes</u>. That is to say that if you load the configuration file using the web page, the program will take as long as 1 to 2 minutes before loading it to the runtime flow calculation parameters.
- Maximum number of characters allowed in one line of data must be 80 characters or less.
- Sequence of the parameters in this file must not be changed. User should only change the value after # character as per site requirements.
- Anything before the # character is ignored by the program as it is only for user guideline only but it should never be changed nevertheless to maintain consistency.
- The user is encouraged to enter a minimum of 8 decimal places for real/floating number to get high resolution of accuracy.

B. APPENDIX – EVENT LOG CODE

This appendix highlights the Event Log Code.

Event Log Code	Event log denotation
1	Meter name changed
2	Flow calculation algorithm selection (AGA3=1, AGA7=2, VCone=3, WaferCone=4) changed
3	Compression calculation algorithm selection (AGA8 Detail=1, AGA8 Gross=2) changed
4	AGA8 Gross method selection (Method 1=1, Method 2=2) changed
5	Heating value calculation method (AGA5=1, GPA2172=2) changed
6	Atmospheric pressure calculation selection (Calculated=1, Manual=2) changed
7	Specific gravity calculation selection (Calculated=1, Manual=2) changed
8	Correction factor for AGA 3 (0.0000 to 1.0000 inclusive) changed
9	Contract hour changed
10	Input parameter engineering unit (metric=1,imperial=2) changed
11	Output parameter engineering unit (metric=1,imperial=2) changed
12	Methane, CH4 changed
13	Nitrogen, N2 changed
14	Carbon dioxide, C02 changed
15	Ethane, C2H6 changed
16	Propane, C3H8 changed
17	Water, H2O changed
18	Hydrogen sulphide, H2S changed
19	Hydrogen, H2 changed
20	Carbon monoxide, CO changed
21	Oxygen, O2 changed
22	i-Butane, IC4H10 changed
23	n-Butane, NC4H10 changed
24	i-Pentane, IC5H12 changed
25	n-Pentane, NC5H12 changed
26	n-Hexane, C6H14 changed
27	n-Heptane, C7H16 changed
28	n-Octane, C8H18 changed
29	n-Nonane, C9H20 changed
30	n-Decane, C10H22 changed
31	Helium, He changed
32	Argon, Ar changed
33	Atmospheric pressure changed
34	Orifice plate and tube diameter measurement reference temperature in deg F changed
35	Static pressure type (absolute=1,gauge=2) changed
36	Differential pressure cutoff changed
37	Upstream static pressure deadband changed
38	Differential pressure deadband changed
39	Flow temperature deadband changed
40	AGA7 pulse deadband changed
41	Latitude (degrees) changed
42	Latitude (minutes) changed
43	Latitude (seconds) changed

44	Altitude changed
45	Base temperature changed
46	Base pressure changed
47	Orifice diameter at reference temperature changed
48	Meter diameter at reference temperature changed
49	Orifice plate material (stainless steel=1,monel=2,carbon steel=3) changed
50	Meter tube material (stainless steel=1,monel=2,carbon steel=3) changed
51	Static pressure tap location (upstream=1,downstream=2) changed
52	Isentropic expansion changed
53	Viscosity changed
54	Specific gravity changed
55	AGA7, k-factor changed
56	AGA7, unit time changed
57	Cone, pipe inside diameter changed
58	Cone, cone diameter changed
59	Cone, flowmeter coefficient (CD) changed
60	Cone, pipe material (stainless steel=1,monel=2,carbon steel=3) changed
61	Cone, cone material (stainless steel=1,monel=2,carbon steel=3) changed
62	Cone, reference specific gravity at 60F, 14.696psia changed
63	Cone, state of fluid (liquid=1, gases and vapours=0) changed
64	AGA8 Gross, gross calorific heating value for gas mixture in changed
65	AGA8 Gross, reference temperature for heating value changed
66	AGA8 Gross, reference temperature for molar density changed
67	AGA8 Gross, reference temperature for relative density changed
68	AGA8 Gross, reference pressure for molar density changed
69	AGA8 Gross, reference pressure for relative density changed
70	AGA9, average velocity changed
71	AGA9, low-flow velocity threshold changed
72	AGA9, enable CPSM (0=off, 1=on) changed
73	AGA9, enable CTSM (0=off, 1=on) changed
74	AGA9, enable profile correction factor (0=off, 1=on) changed
75	AGA9, CPSM state (Calculated=1, Manual=2) changed
76	AGA9, CTSM state (Calculated=1, Manual=2) changed
77	AGA9, profile correction factor state (Calculated=1, Manual=2) changed
78	AGA9, pipe outside diameter changed
79	AGA9, pipe inside diameter changed
80	AGA9, Poisson's ratio changed
81	AGA9, Young's modulus of elasticity changed
82	AGA9, reference pressure changed
83	AGA9, reference temperature changed
84	AGA9, pipe linear expansion coefficient due to temperature changed
85	AGA9, wall roughness changed
86	AGA9, path factor (0.94=Juniorsonic, 1.00=Seniorsonic) changed
87	AGA9, dynamic viscosity changed
88	AGA9, manual CPSM entry changed
89	AGA9, manual CTSM entry changed
90	AGA9, manual profile correction factor entry changed
91	GPA2172, base temperature for density changed
92	GPA2172, base temperature for heating value changed
93	Put static pressure in debug mode (enable=1,disable=2) changed
94	Put differential pressure in debug mode (enable=1,disable=2) changed
95	Put flow temperature in debug mode (enable=1,disable=2) changed
96	Put AGA7 pulse in debug mode (enable=1,disable=2) changed

97	Mock static pressure changed
98	Mock differential pressure changed
99	Mock flow temperature changed
100	Mock AGA7 pulse changed
101	Static pressure calibration value, high high changed
102	Static pressure calibration value, high changed
103	Static pressure calibration value, low changed
104	Static pressure calibration value, low low changed
105	Differential pressure calibration value, high high changed
106	Differential pressure calibration value, high changed
107	Differential pressure calibration value, low changed
108	Differential pressure calibration value, low low changed
109	Flow temperature calibration value, high high changed
110	Flow temperature calibration value, high changed
111	Flow temperature calibration value, low changed
112	Flow temperature calibration value, low low changed
2000	Ethernet cable disconnected
2001	Ethernet cable was reconnected
2002	Controller powered up
2003	Modbus slave connection was lost or disconnected
2004	Modbus slave connection established

C. APPENDIX – REPORT AND EVENT COLUMN DEFINIATION

- **Daily report**
  The following are the title header for Daily report.

```
Correction Flag,Time Stamp,Meter Name,Total Flow,Total Flow
(Corrected),Total Flow Time,Avg SP,Avg DP,Avg FTemp
```

- **Monthly report**
  The following are the title header for Monthly report.

```
Correction Flag,Time Stamp,Meter Name,Total Flow Last Month,Total
Flow Last Month (Corrected),Total Flow Time
```

- **Meter report**
  The following are the title header for Meter report.

```
Time Stamp,Meter Name,Inst Flowrate,Inst SP,Inst DP,Inst Flow
Temp,SG,Comp at Base,Comp at Flow,Contract Hour,Atmospheric
Press,Base Press,Base Temp,Meter Dia, Orifice Dia,Static Tap
Location,Orifice Material,Pipe Material,SP Hi Hi,SP Hi,SP Lo,SP
Lo Lo,DP Hi Hi,DP Hi,DP Lo,DP Lo Lo,FTemp Hi Hi,FTemp Hi,FTemp
Lo,FTemp Lo Lo,DP Cutoff,Correction Factor,Cd,Y1,Ev
```

- **Event log**
  The Event log does not have a header but the section below outlines what each column of data represents.

```
<Unix time>,<old value>,<new value>,<event code>,<username>
```

Where

<Unix time>	Seconds since 1st Jan 2970
<old value>	Value before change
<new value>	Value after change
<event code>	Event log code. Detail of each event code can be found in Appendix B Event Log Code
<username>	Username who made the change. If the user name is "SYSTEM", it means that the event is performed by the controller. This applies to events such as controller power cycle.

D. APPENDIX – MODBUS REG ADDRESSES FOR FULL DEVICE POLL TYPE

These set of Modbus registers are for application where the end devices have a full set of registers available for XynetSCADA uCFlow to read and write. A typical setup will be where the site has a RTU or PLC which is acquiring instantaneous values (such as static pressure, differential pressure, flow temperature or turbine speed) from the field device. The diagram below illustrates the setup for “Full Device Poll Type”.

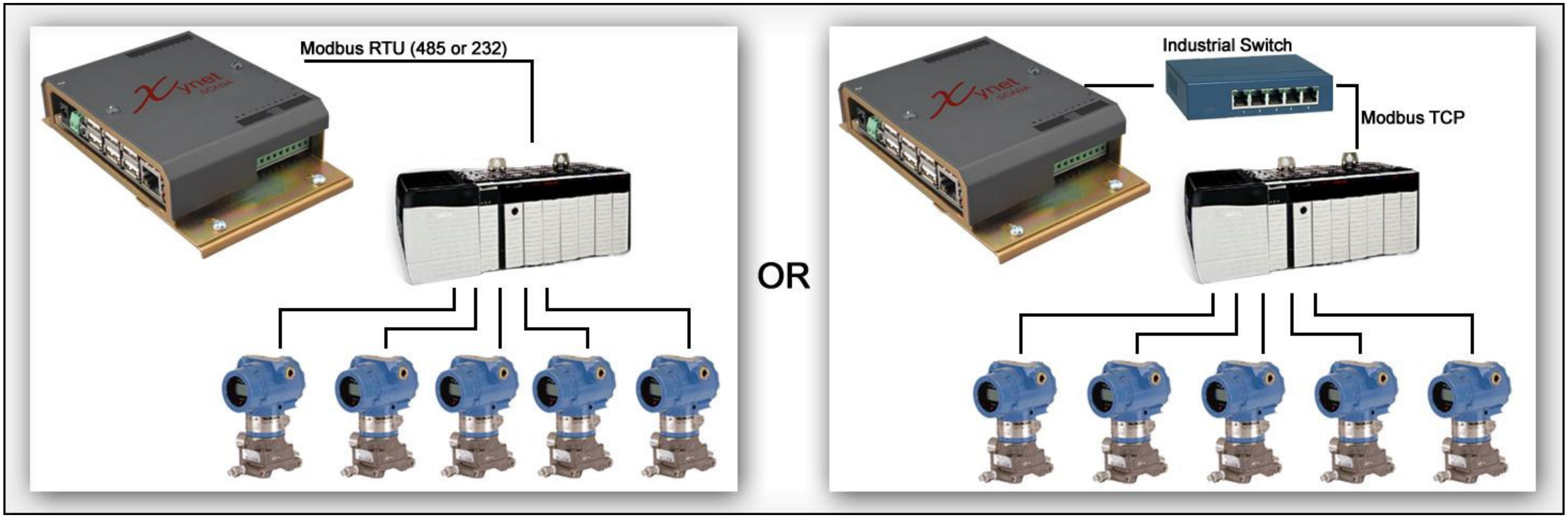


Figure AppD1, Full Device Poll Type Connections

- **Input Values**
  The table below gives a detail overview of all input values for the controller. The Modbus Offset Register is a number that is to be added to the Start Modbus Register defined in the System Configuration web interface. For example, if the Start Register defined in the System Configuration is 810, the Modbus register address of “Flow Calculation Algorithm” will be 40811. It is to be noted that integer refers to 16 bit number and float is a 32 bit number. Therefore, the Modbus address of Methane would be 40812 and Nitrogen would be 40814.
  The input values engineering unit is in imperial (as shown in table below) as all calculations are done in imperial; however, the user has the option of having the input value as metric. This engineering unit change can be done in Flow Calculation web interface.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
1	Flow calculation algorithm selection	-	integer	AGA3=1 AGA7=2 V-Cone=3 Wafer Cone=4
2	Compression calculation algorithm selection	-	integer	AGA8 Detail=1 AGA8 Gross=2
3	AGA8 Gross method selection	-	integer	Method 1=1 Method 2=2
4	Heating value calculation method	-	integer	AGA5=1 GPA2172=2
5	Atmospheric pressure calculation selection	-	integer	Calculated=1 Manual=2
6	Specific gravity calculation selection	-	integer	Calculated=1 Manual=2
7	Correction factor for AGA 3 (0.0000 to 1.0000 inclusive)	-	float	Corrected flow = Calc Flow * Correction Factor
9	Contract hour	hour	integer	Valid number are from 0 to 23
10	Input parameter engineering unit	-	integer	Metric=1 Imperial=2
11	Output parameter engineering unit	-	integer	Metric=1 Imperial=2
12	Methane, CH4	fraction 0 to 1	float	
14	Nitrogen, N2	fraction 0 to 1	float	
16	Carbon dioxide, C02	fraction 0 to 1	float	
18	Ethane, C2H6	fraction 0 to 1	float	
20	Propane, C3H8	fraction 0 to 1	float	
22	Water, H2O	fraction 0 to 1	float	
24	Hydrogen sulphide, H2S	fraction 0 to 1	float	
26	Hydrogen, H2	fraction 0 to 1	float	
28	Carbon monoxide, CO	fraction 0 to 1	float	
30	Oxygen, O2	fraction 0 to 1	float	

32	i-Butane, IC4H10	fraction 0 to 1	float	
34	n-Butane, NC4H10	fraction 0 to 1	float	
36	i-Pentane, IC5H12	fraction 0 to 1	float	
38	n-Pentane, NC5H12	fraction 0 to 1	float	
40	n-Hexane, C6H14	fraction 0 to 1	float	
42	n-Heptane, C7H16	fraction 0 to 1	float	
44	n-Octane, C8H18	fraction 0 to 1	float	
46	n-Nonane, C9H20	fraction 0 to 1	float	
48	n-Decane, C10H22	fraction 0 to 1	float	
50	Helium, He	fraction 0 to 1	float	
52	Argon, Ar	fraction 0 to 1	float	
54	Atmospheric pressure	psia	float	
56	Orifice plate and tube diameter measurement ref temperature	°F	float	
58	Static pressure type	-	integer	Absolute=1 Gauge=2
59	Differential pressure cutoff	inH2O	float	
61	Upstream static pressure deadband	psia	float	
63	Differential pressure deadband	inH2O	float	
65	Flow temperature deadband	°F	float	
67	AGA7 pulse deadband in pulse	pulse	float	
69	Latitude	degrees	float	
71	Latitude	minutes	float	
73	Latitude	seconds	float	
75	Altitude	ft	float	
77	Base temperature	°F	float	
79	Base pressure	psia	float	
81	Orifice diameter at reference temperature	in	float	
83	Meter diameter at reference temperature	in	float	
85	Orifice plate material	-	integer	Stainless steel=1 Monel=2 Carbon steel=3

86	Meter tube material	-	integer	Stainless steel=1 Monel=2 Carbon steel=3
87	Static pressure tap location	-	integer	Upstream=1 Downstream=2
88	Isentropic expansion, as per API AGA Report 3	-	float	
90	Viscosity	lnm/ft.sec	float	
92	Specific gravity	-	float	
94	AGA7, K factor	pulse/ft³	float	
96	AGA7, Unit time	see note	float	
98	Cone, Pipe inside diameter	in	float	
100	Cone, Cone diameter	in	float	
102	Cone, Flowmeter coefficient (CD)	-	float	
104	Cone, Pipe material	-	integer	Stainless steel=1 Monel=2 Carbon steel=3
105	Cone, Cone material	-	integer	Stainless steel=1 Monel=2 Carbon steel=3
106	Cone, Reference specific gravity at 60°F, 14.696psia	-	float	
108	Cone, State of fluid	-	integer	Liquid=2 Gases and vapors=1
109	AGA8 Gross, Gross calorific heating value for gas mixture	BTU/ft³	float	
111	AGA8 Gross, Reference temperature for heating value	°F	float	
113	AGA8 Gross, Reference temperature for molar density	°F	float	
115	AGA8 Gross, Reference temperature for relative density	°F	float	
117	AGA8 Gross, Reference pressure for molar density	psi	float	
119	AGA8 Gross, Reference pressure for relative density	psi	float	
121	AGA9 Average velocity	ft/hr	float	
123	AGA9 Low-flow velocity threshold	ft/hr	float	To acquire full flow calculation parameters from the controller, 2 Modbus polls is required. From this register 2nd poll starts.

125	AGA9 Enable CPSM	-	integer	Off=0 On=1
126	AGA9 Enable CTSM	-	integer	Off=0 On=1
127	AGA9 Enable profile correction factor	-	integer	Off=0 On=1
128	AGA9 CPSM state	-	integer	Calculated=1 Manual=2
129	AGA9 CTSM state	-	integer	Calculated=1 Manual=2
130	AGA9 Profile correction factor state	-	integer	Calculated=1 Manual=2
131	AGA9 Pipe outside diameter	ft	float	
133	AGA9 Pipe inside diameter	ft	float	
135	AGA9 Poisson's ratio	-	float	
137	AGA9 Young's modulus of elasticity	psia	float	
139	AGA9 Reference pressure	psia	float	
141	AGA9 Reference temperature	°F	float	
143	AGA9 Pipe linear expansion coefficient due to temperature	in/in.°F	float	
145	AGA9 Wall roughness	ft	float	
147	AGA9 Path factor	-	float	Junior sonic=0.94 Senior sonic=1.00
149	AGA9 Dynamic viscosity	lbm/ft.sec	float	
151	AGA9 Manual CPSM entry	-	float	
153	AGA9 Manual CTSM entry	-	float	
155	AGA9 Manual profile correction factor entry	-	float	
157	GPA2172 Base temperature for density	°F	float	
159	GPA2172 Base temperature for heating value	°F	float	
161	Put static pressure in debug mode	-	integer	Enable=1 Disable=2
162	Put differential pressure in debug mode	-	integer	Enable=1 Disable=2
163	Put flow temperature in debug mode	-	integer	Enable=1 Disable=2

164	Put AGA7 pulse in debug mode	-	integer	Enable=1 Disable=2
165	Mock static pressure	psia	float	Must be in debug mode
167	Mock differential pressure	inH2o	float	Must be in debug mode
169	Mock flow temperature	°F	float	Must be in debug mode
171	Mock AGA7 pulse	Hz	float	Must be in debug mode
173	Static pressure calibration value, high high	psia	float	
175	Static pressure calibration value, high	psia	float	
177	Static pressure calibration value, low	psia	float	
179	Static pressure calibration value, low low	psia	float	
181	Differential pressure calibration value, high high	inH2o	float	
183	Differential pressure calibration value, high	inH2o	float	
185	Differential pressure calibration value, low	inH2o	float	
187	Differential pressure calibration value, low low	inH2o	float	
189	Flow temperature calibration value, high high	°F	float	
191	Flow temperature calibration value, high	°F	float	
193	Flow temperature calibration value, low	°F	float	
195	Flow temperature calibration value, low low	°F	float	

- **Output Values**
  The table below gives a detail overview of all output values from the controller. The Modbus Offset Register is a number that is to be added to the Start Modbus Register defined in the System Configuration web interface. For example, if the Start Register defined in the System Configuration is 810, the Modbus register address of “Compressibility at base condition” will be 40810+192 = 41002. It is to be noted that floating point is a 32 bit number and therefore requiring 2 Modbus registers.
  The output values engineering unit is in imperial (as shown in table below) as all calculations are done in imperial; however, the user has the option of having the output value in metric. This engineering unit change can be done in Flow Calculation web interface.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
197	Compressibility at base condition	-	float	
199	Molar density at base condition	moles/dm³	float	
201	Mass density at base condition	kg/m³	float	

203	Compressibility at flowing condition	-	float	
205	Molar density at flowing condition	moles/dm^3	float	
207	Mass density at flowing condition	kg/m^3	float	
209	AGA3 calculated flowrate	ft^3/hr	float	
211	AGA3 calculated flowrate	mmscfd	float	
213	AGA7 calculated flowrate	ft^3/xxx (Input AGA7, Unit time)	float	
215	AGA5 calculated energy	BTU/min	float	
217	Wafer and V-cone flowrate	ft^3/sec	float	
219	Calculated specific gravity	-	float	
221	Heating value	BTU/ft^3	float	
223	Calculated/User input atmospheric pressure	psi	float	
225	AGA10 calculated speed of sound	m/s	float	
227	AGA9 calculated flowrate	ft^3/hr	float	
229	GPA2172 Gross heating value	BTU/lb	float	
231	GPA2172 Gross heating value	BTU/Ideal CF	float	
233	GPA2172 Gross heating value	BTU/Real CF	float	
235	Flow calculation duration	second	long	
237	Error code	-	integer	-1: Not used -2: Not used -3: AGA8 Detail : Gas composition not within range (0.999995<=GC<=1.000005) -4: AGA3 : Incorrect static tap location -5: AGA8 : Flow temp and/or sp is out of range (-200<=T<=760 & 0<=P<=40000) -6: AGA3 : Pressure ratio out of range -7: AGA3 : Temperature ratio out of range -8: Not used -9: AGA3 : Division by zero (check diameter and specific gravity) -10: AGA7 : Division by zero (check k factor and time span) -11: Cone : Division by zero (check

				diameter and specific gravity) -12: Invalid calc selection -13: Invalid atmospheric pressure selection -14: Invalid specific gravity selection -15: AGA3 : Invalid orifice plate material -16: AGA3 : Invalid pipe material -17: AGA3 : Invalid static pressure tap location -18: Cone : Invalid pipe material -19: Cone : Invalid cone material -20: Cone : Invalid state of fluid -21: AGA5 : Division by zero -22: AGA8 DCM : Division by zero -23: AGA3 : Orifice plate diameter >= pipe diameter -24: Cone : Cone diameter >= pipe diameter -25: AGA8 : Invalid compressibility calculation selection -26: AGA8 Gross : Heating value <= 0.00 -27: AGA8 Gross : Ref temperature for heating value <= zero -28: AGA8 Gross : N2, CO2, H2 and/or CO is zero -29: AGA8 Gross : N2, CO2, H2 and/or CO is < zero -30: AGA8 Gross : Specific gravity <= zero -31: AGA8 Gross : Ref temperature for specific gravity <= zero -32: AGA8 Gross : Ref pressure for specific gravity <= zero -33: AGA3 : Flowrate is negative -34: Unable to run TimeController() function. Report trigger, report generation,

				average calculator and total calculator has failed
238	AGA 8 last calculation time	Unix time	long	
240	AGA 3 last calculation time	Unix time	long	
242	AGA 7 last calculation time	Unix time	long	
244	Cone last calculation time	Unix time	long	

- **Reports Values**
  The table below gives a detail overview of all reporting values from and to the controller.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
246	Today - Hourly average static pressure	psia	float	
248	Today - Hourly average differential pressure	inH2O	float	
250	Today - Hourly average flow temperature	°F	float	
252	Today - Hourly average flowrate	mmscfd	float	
254	Today - Accumulated flow	mmscf	float	
256	Today - Accumulated flow (corrected by user)	mmscf	float	
258	Yesterday - Daily average static pressure	psia	float	
260	Yesterday - Daily average differential pressure	inH2O	float	
262	Yesterday - Daily average flow temperature	°F	float	
264	Yesterday - Daily average flowrate	mmscfd	float	
266	Yesterday - Accumulated flow	mmscf	float	
268	Yesterday - Accumulated flow (corrected by user)	mmscf	float	
270	Yesterday - Total flow time	seconds	float	
272	Current month - Accumulated flow	mmscf	float	
274	Current month - Accumulated flow time	seconds	float	
276	Current month - Accumulated flow (corrected by user)	mmscf	float	
278	Previous month - Accumulated flow	mmscf	float	

280	Previous month - Accumulated flow time	seconds	float	
282	Previous month - Accumulated flow (corrected by user)	mmscf	float	
284	Today - Corrected total flow flag	-	integer	Correction=1 No correction=2
285	Yesterday - Corrected total flow	-	integer	Correction=1 No correction=2
286	Current month - Corrected total flow	-	integer	Correction=1 No correction=2
287	Previous month - Corrected total flow flag	-	integer	Correction=1 No correction=2
288	Report trigger - Unix time of next month report	Unix time	long	
290	Contract hr trigger - Unix time of next contract hour	Unix time	long	
292	Hourly trigger - Unix time of next hour	Unix time	long	

- **System Date and Time**
  The table below is a list of Modbus table for system time and date; read and write registers.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
294	Current controller time (read)	Unix time	long	
296	Current hour (read)	hour	integer	
297	Current minute (read)	min	integer	
298	Current second (read)	second	integer	
299	Current day (read)	day	integer	
300	Current month (read)	month	integer	
301	Current year (read)	year	integer	
302	Current controller time (read)	Unix time	long	
304	Current hour (write)	hour	integer	Write current hour to controller
305	Current minute (write)	min	integer	Write current minute to controller
306	Current second (write)	second	integer	Write current second to controller
307	Current day (write)	day	integer	Write current day to controller
308	Current month (write)	month	integer	Write current month to controller

309	Current year (write)	year	integer	Write current year to controller

- **Instantaneous Values**
  The table below highlights Modbus registers for all instantaneous value for flow calculations.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
310	Instantaneous static pressure	psia	float	
312	Instantaneous differential pressure	inH2O	float	
314	Instantaneous flow temperature	°F	float	
316	Instantaneous turbine frequency	Hz	float	

- **Trigger Values**
  The table below gives a detail overview of all triggering values from and to the controller. The Modbus Offset Register is a number that is to be added to the Start Modbus Register defined in the System Configuration web interface. For example, if the Start Register defined in the System Configuration is 810, the Modbus register address of “Flow Calculation Duration” will be 40810+220 = 41030. It is to be noted that floating point is a 32 bit number and therefore requiring 2 Modbus registers, and an integer is a 16 bit number requiring 1 Modbus register.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
318	Trigger flow calculation	-	integer	
319	Command from RTU to read from controller	-	integer	Trigger read command=1 Normal=0
320	Command from RTU to write to controller	-	integer	Trigger write command=1 Normal=0
321	Command to generate meter report	-	integer	Generate meter report=1 Normal=0
322	Command to write to persistence file	-	integer	Trigger write persistence file=1 Normal=0
323	Command to update date and time	-	integer	Update date and time=1 Normal=0

- **RTU/PLC Communication Status**
  The table below summaries the Modbus table for RTU/PLC communication status.

Modbus Register Offset	Description	Eng. Unit	Data Type	Note
324	RTU/PLC/transmitter last communication time calculation time	Unix time	long	
326	Modbus slave connection status	-	integer	Modbus slave is connected=1 Modbus slave disconnected=0

Note

- All units shown in the tables are in imperial. In order to change the unit to matrix, change the “Input parameter engineering unit” and/or “Input parameter engineering unit” appropriately.
- Integers are 16 bit number
- Float and long is a 32 bit number

E. APPENDIX – MODBUS REG ADDRESSES FOR SHORT DEVICE POLL TYPE

A "Short Device Poll Type" is a classification of poll in XynetSCADA where only the instantaneous value Modbus registers are polled. For example if the user were to select AGA3 as flow calculation algorithm, only six holding registers are polled (32 bit number); static pressure, differential pressure and flow temperature. While on the other hand, if AGA7 were to be selected as flow calculation algorithm; only two holding registers are polled for turbine speed.

A typical setup would be XynetSCADA uCFlow communicating directly to the 3-in-1 transmitter via Modbus RTU (RS-485). This example is as illustrated below.

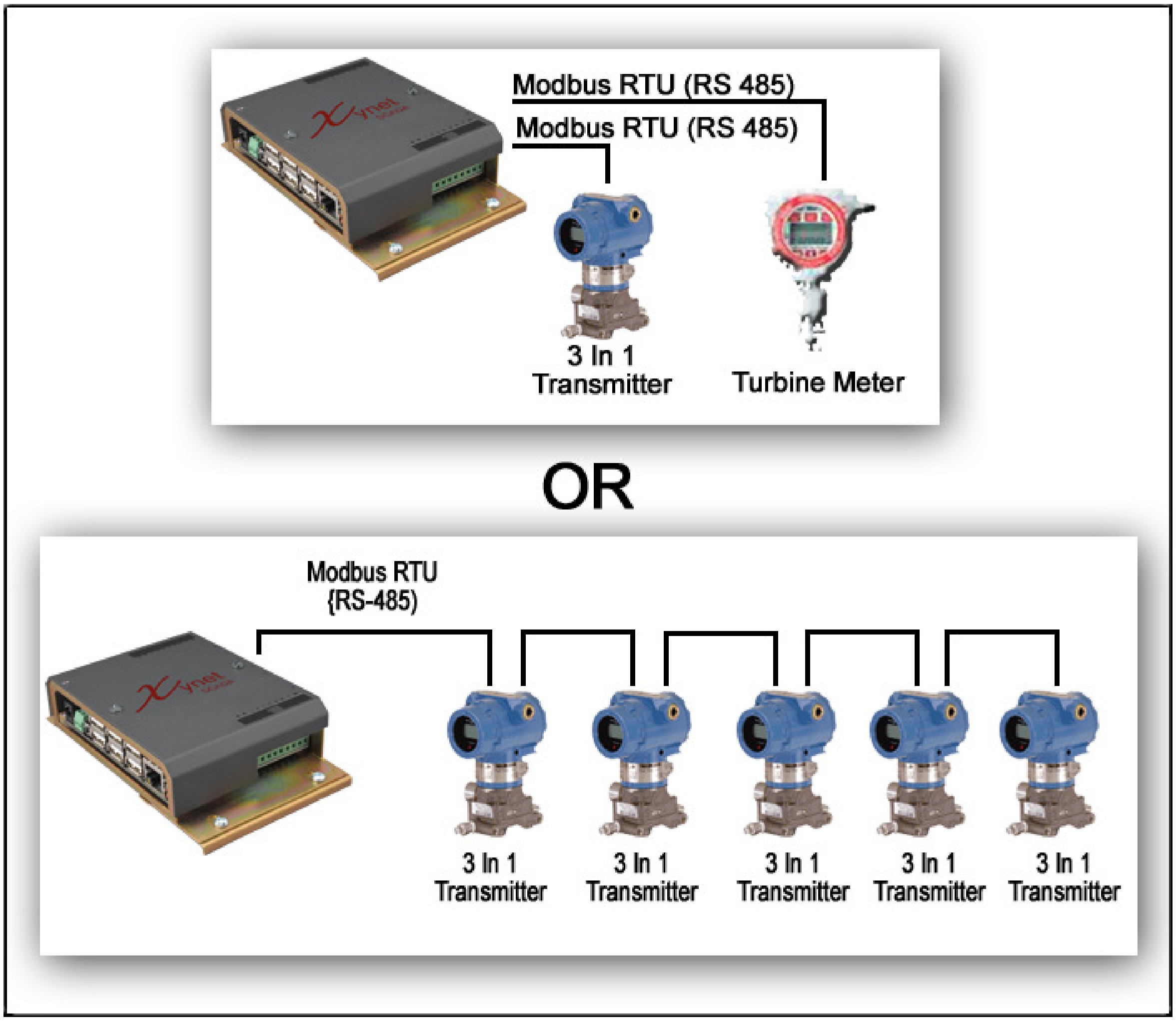


Figure AppE1, Short Device Poll Type Connections

Configuration of end device Modbus setup and configuration can be done in the System Configuration webpages under the tab of "Comm->Modbus End Device".

F. APPENDIX – MODBUS REG ADDRESSES FOR MODBUS SLAVE

The XynetSCADA has a Modbus Slave which is always running on the background to allow and device or HMI to query for the flow data. Typically, a HMI system will be querying the XynetSCADA Modbus Slave for data so that it can be shown graphically in the HMI. The diagram below shows a typical connection between XynetSCADA uCFlow and a HMI System.

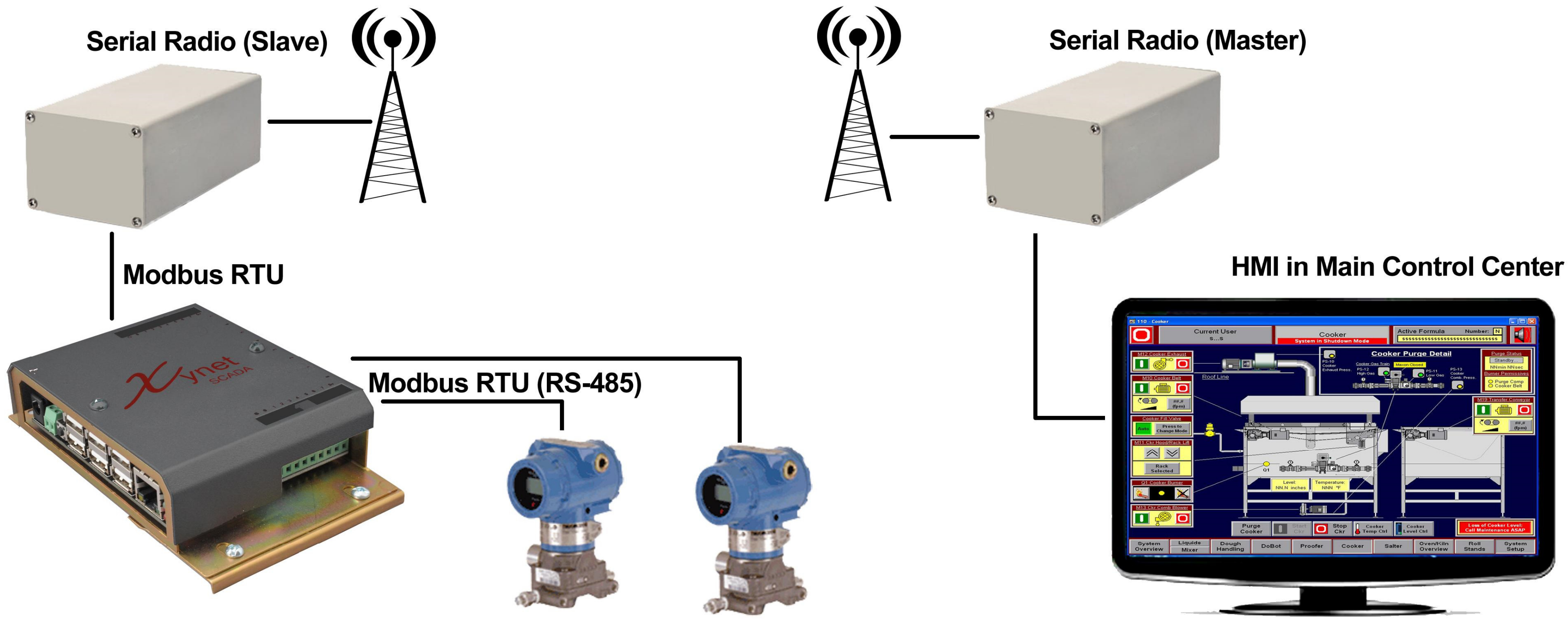


Figure AppF1, Modbus Slave Connection

The Modbus Slave has been structure in a block of 500 Modbus registers per meter run. The table below shows how the blocks are distributed among all meters runs.

Meter Run Number	Modbus Register Range
1	40000 to 40499
2	40500 to 40999
3	41000 to 41499
4	41500 to 41999
5	42000 to 42499
6	42500 to 42999
7	43000 to 43499
8	43500 to 43999
9	44000 to 44499
10	44500 to 44999

The table below outlines the location of all flow parameters.

END OF DOCUMENT