

## Monitoring and Analysis Plan for UTC Power Fuel Cell at the Hilton Towers

*Monitoring System Commissioned Revision September 19,2007*

CDH Energy was on site September 17 to perform verification and commissioning of the monitoring system. This document has been updated to include the final wiring configuration of the monitoring system on the fuel cell skid, as well as provide initial data verification of the readings.

This document describes the measurements, sensors, and data logging equipment proposed to quantify the performance of the UTC Power fuel cell unit installed at the Hilton Towers located at 1330 Avenue of the Americas in Manhattan. The fuel cell is a 200 kW unit that operates on natural gas. Heat will be recovered from the operation of the fuel cell via a glycol loop and plate frame heat exchanger and used to heat domestic hot water loads at the hotel.

Figure 1 displays the fuel cell unit during installation. The equipment are located on the 4<sup>th</sup> floor mezzanine roof, and consist of the fuel cell unit itself, the fuel gas booster, and the dry cooler (dump radiator). All other equipment (heat exchangers, pumps, etc) are located in the mechanical space directly below the skid.



*UTC Power Fuel Cell and Gas Booster*



*UTC Power Fuel Cell and Dry Cooler*

**Figure 1. UTC Power Fuel Cell , Fuel Gas Booster, and Dry Cooler**

Figure 2 displays the main piping interconnection connecting the fuel cell glycol loop to the building DHW loop via the plate frame HX, located in the mechanical room.



Figure 2. Plate Frame HX, Glycol and DHW Piping

### **Description of Monitored Data Points**

Table 1 lists the monitored points required to characterize the performance of the fuel cell. Each point is accompanied by the respective sensor and engineering unit measured.

**Table 1. Data Point List**

No.	Data Point	Description	Units	Sensor	Channel
1	TGL	Glycol HR Loop Temperature Leaving Fuel Cell	F	Mamac TE211-Z-CA1B1E7 50-200 F	EXP1-A1
2	TGE	Glycol HR Loop Temperature Entering Fuel Cell	F	Mamac TE211-Z-CA1B1E7 50-200 F	EXP1-A2
3	FG	Glycol HR Flowrate	gpm	Onicon F1111 4-20 mA	EXP1-A3
4	FMW	Makeup Water Flow	gallons	Omega FTB 4107A-P	EXP1-P1
5	TRL	Dry Cooler Temperature Leaving Fuel Cell	F	Mamac TE211-Z-CA1B1E7 50-200 F	EXP2-A1
6	TRE	Dry Cooler Temperature Entering Fuel Cell	F	Mamac TE211-Z-CA1B1E7 50-200 F	EXP2-A2
7	FR	Dry Cooler Flow Rate	gpm	Onicon F1111 4-20 mA	EXP2-A3
8	FGFC	Fuel Cell Gas Consumption	cuft	Roots 3M175-TD w/ SSP	D/A1
9	IFGB	Fuel Gas Booster Current	Amps	Veris H921 4-20 mA	D/A2
10	TAO	Ambient Temperature	F	Mamac TE211-Z-OAWP-1E3	D/A3
11	IR	Dry Cooler Current	Amps	Veris H921 4-20 mA	D/A5
12	WFC	Fuel Cell Energy Produced	kWh	Veris H8036-400-3	MBUS
13	WFC_KW	Fuel Cell Instantaneous Output	kW		
14	WFC_kVAR	Fuel Cell Reactive Power	kVAR		
15	WFC_kVA	Fuel Cell Apparent Power	kVA		
16	WFC_PF	Fuel Cell Power Factor	-		
17	WFC_VLL	Fuel Cell Voltage - Line to Line	V		
18	WFC_VLN	Fuel Cell Voltage - Line to Neutral	V		
19	WFC_I	Fuel Cell Current	Amps		
20	WFC_KW1	Fuel Cell Real Power - Phase A	kW		
21	WFC_KW2	Fuel Cell Real Power - Phase B	kW		
22	WFC_KW3	Fuel Cell Real Power - Phase C	kW		
23	WFC_PF1	Fuel Cell Power Factor - Phase A	-		
24	WFC_PF2	Fuel Cell Power Factor - Phase B	-		
25	WFC_PF3	Fuel Cell Power Factor - Phase C	-		
26	WFC_VAB	Fuel Cell Voltage - Phase A to B	V		
27	WFC_VBC	Fuel Cell Voltage - Phase B to C	V		
28	WFC_VAC	Fuel Cell Voltage - Phase C to A	V		
29	WFC_VAN	Fuel Cell Voltage - Phase A to N	V		
30	WFC_VBN	Fuel Cell Voltage - Phase B to N	V		
31	WFC_VCN	Fuel Cell Voltage - Phase C to N	V		
32	WFC_KWAV	Fuel Cell Average Demand	kW		
33	WFC_KWMN	Fuel Cell Minimum Demand	kW		
34	WFC_KWMX	Fuel Cell Maximum Demand	kW		

Figure 3 displays a schematic of the location of monitored data points.

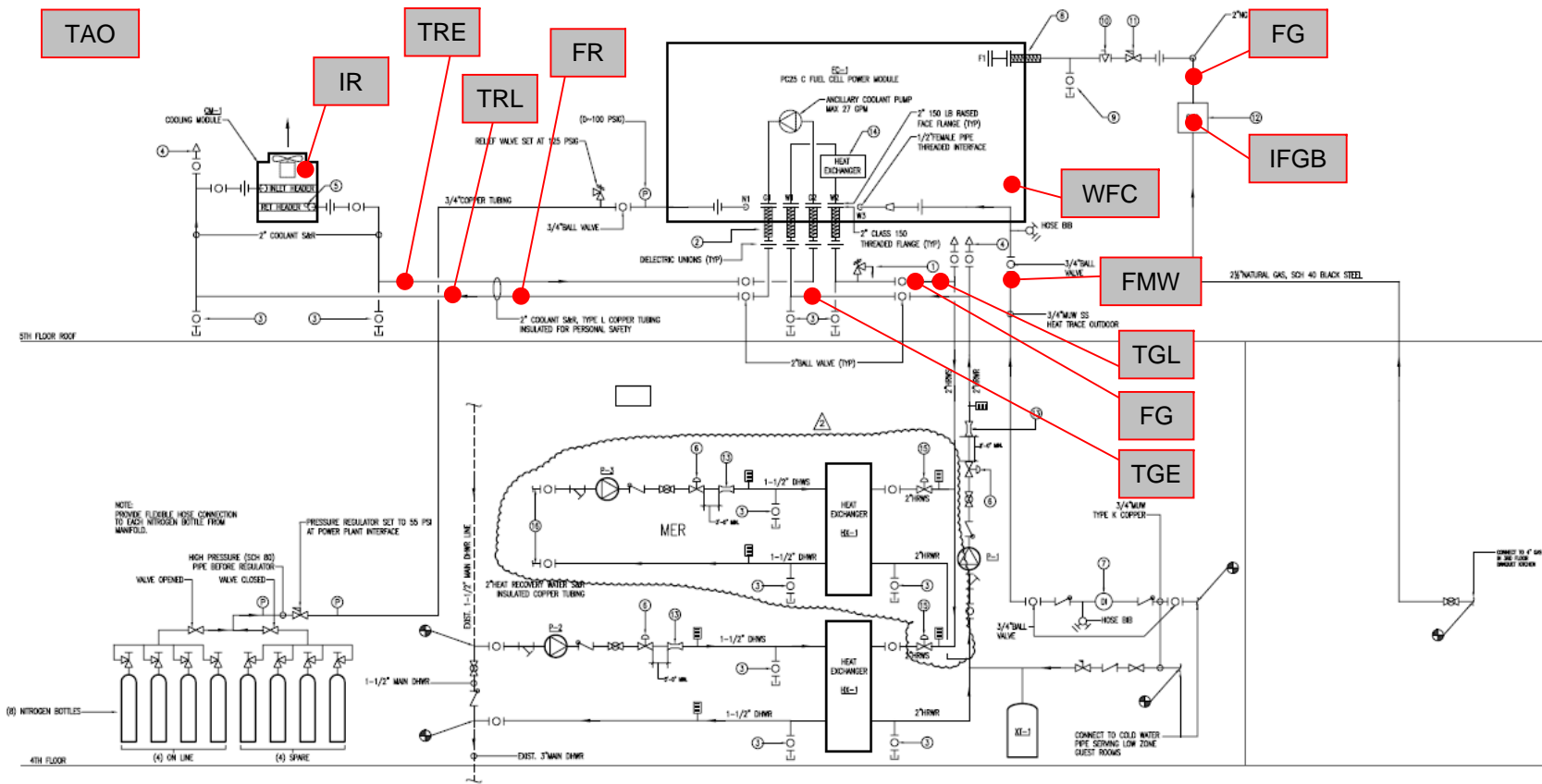


Figure 3. Location of Monitored Points on M-4 PID Drawing

### **Temperature Sensors (TGE, TGL, TRE, TRL, TAO)**

The temperature sensors are installed in 6-inch thermowells. The system glycol temperature readings will be measured with two sets of RTDs equipped with onboard 4-20 ma transmitters. Each pair of RTDs are calibrated to the resistors located on the expansion boards, resulting in a highly accurate, repeatable temperature difference measurement. Based on the nominal operation of the fuel cell unit, the transmitters are factory calibrated with a temperature sensing range of 50°F to 200°F. The ambient temperature sensor is located directly below the fuel cell skid, out of the influence of solar radiation.

### **Glycol Flowmeters (FG, FR)**

The glycol flowmeters are placed in a 2" x 1" Tee and 1-inch ball valve assembly. The flow meter tees are located in a clear run of horizontal pipe 10-pipe diameters (20-inches) away upstream and downstream from any fittings, including the CDH supplied thermowells. Flow readings for the two glycol temperature loops will be measured using a low-pressure drop, insertion style turbine meter with a 4-20 ma output.

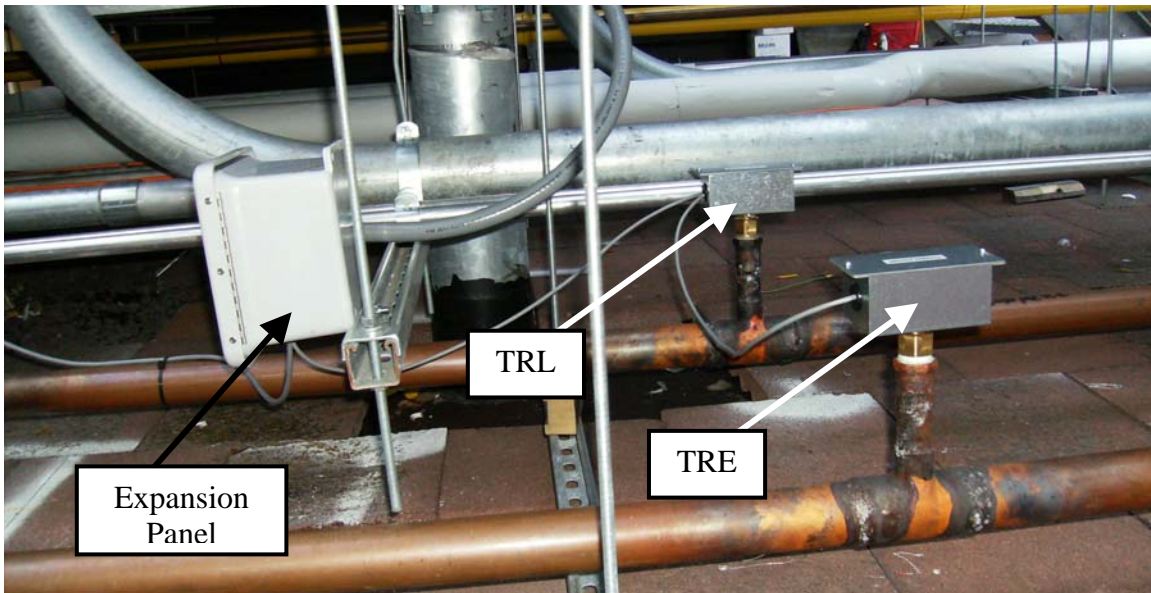


Figure 4. TRE, TRL sensors on 2-inch lines to Dry Cooler

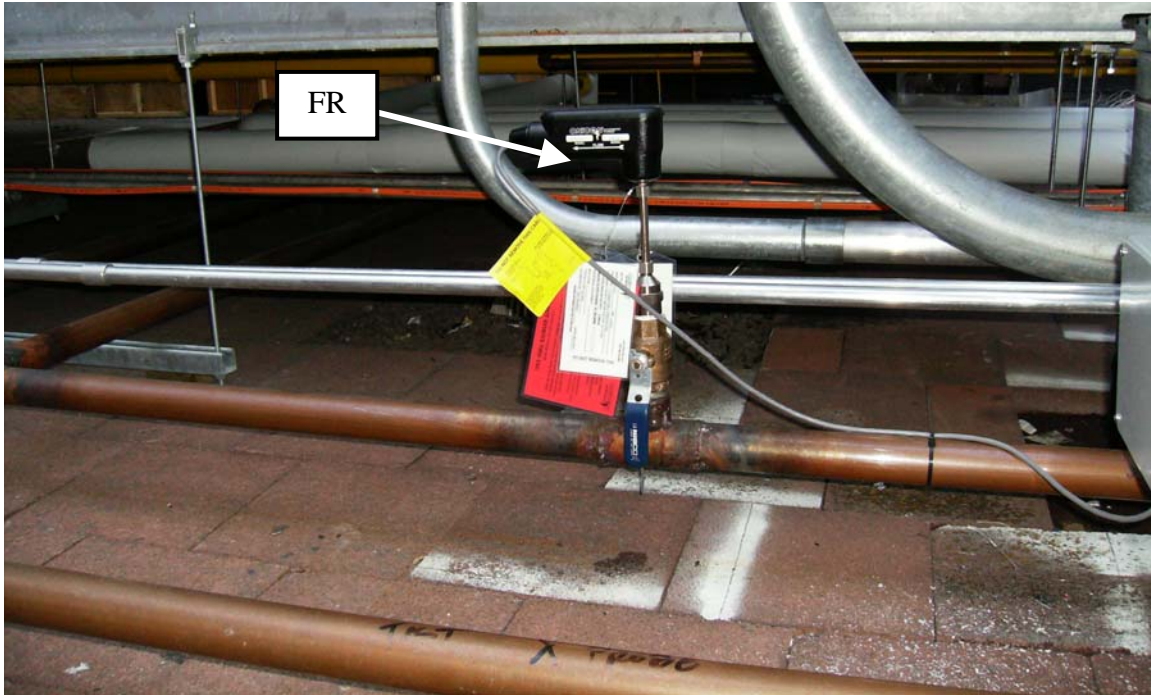


Figure 5. FR sensor on 2-inch lines to Dry Cooler

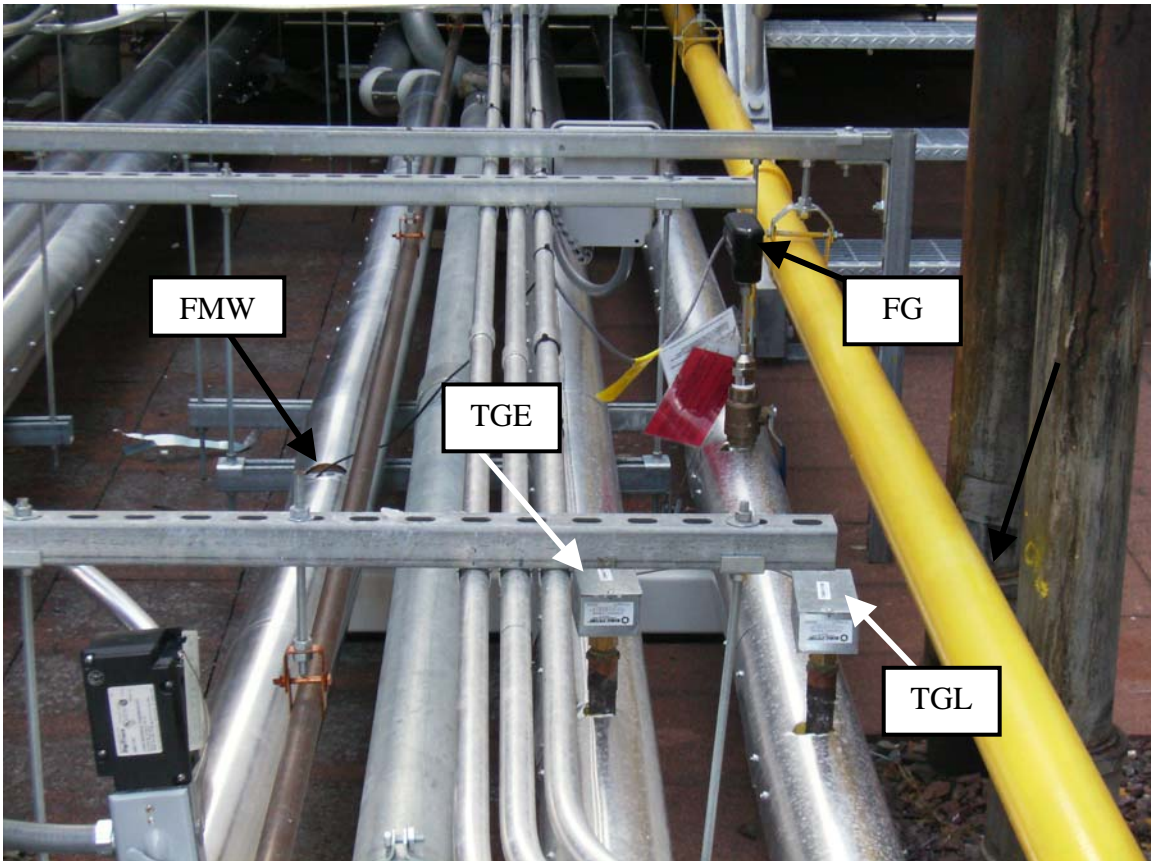


Figure 6. TGE, TGL, FG, and FMW sensors

### **Fuel Cell Power Output (WFC)**

The electrical output of the fuel cell is monitored by a power transducer installed on the lower half of the 400-amp disconnect located on the fuel cell unit itself. This will allow metering of either the utility-dependant, or utility independent loads met by the fuel cell unit.



**Figure 7. Power Transducer Located at Fuel Cell Unit 400-amp Disconnect**

### **Fuel Cell Gas Input (FGFC)**

A Roots style gas meter was installed on the 2-inch high pressure line leaving the fuel gas booster. The meter is equipped with a pulse output head, which delivers 1 pulse/10 cu ft. of natural gas consumption. The meter is uncompensated, but will be calibrated to the monthly utility billing data.



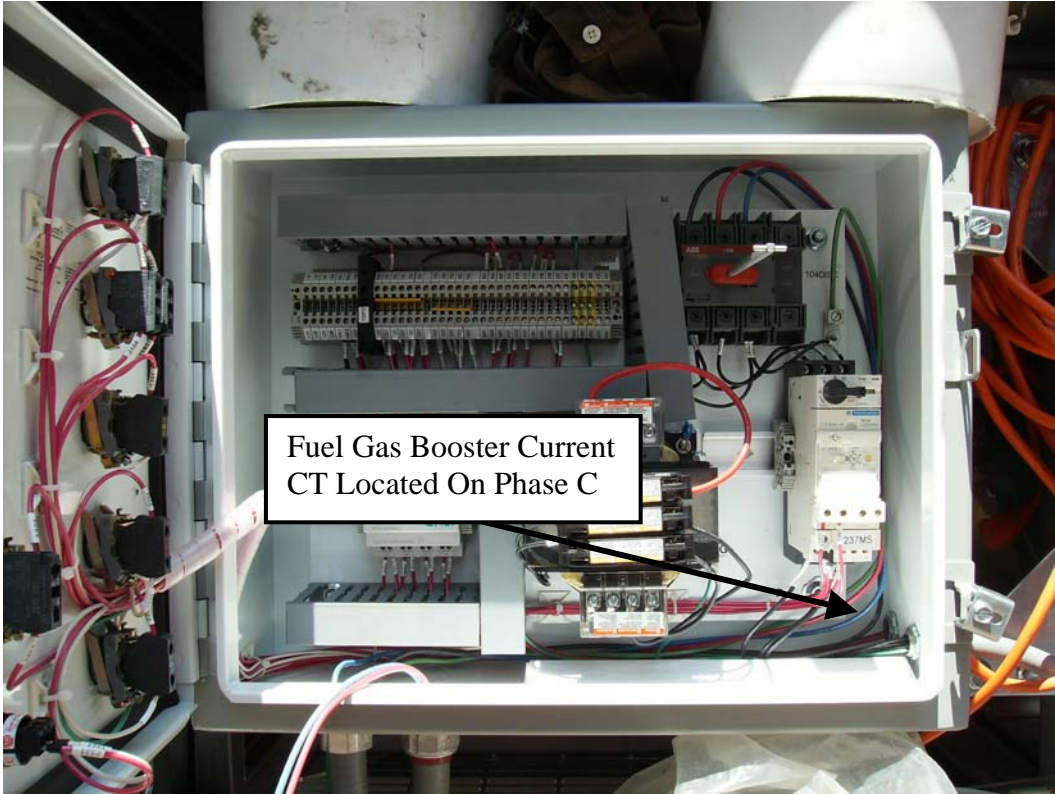
**Figure 8. Fuel Cell Natural Gas Meter on 2-inch High Pressure Line**

### **Ancillary Loads (IFGB, IR)**

The primary ancillary loads for the fuel cell system are the fuel gas compressor, the dry-cooler dump radiator fans, and the glycol circulating pump (P1). Of these three loads, the glycol pump is expected to be constant, and will be measured using a one-time power reading. Operation of this pump is expected to be either constant, or coincident with the fuel cell operation. Based on the observed operating status, we will apply the appropriate annual runtime for this parasitic load. Also, the electricity consumption of these ancillary loads are primarily met by the fuel cell unit, meaning that the power data already has the parasitic energy removed.

For the other two loads, a measurement of the electrical consumption will be performed using a current transducer (CT), and correlated to one-time power measurements at various loading levels.





**Figure 9. Fuel Gas Booster Current Sensor Located In FGB Control Panel**



**Figure 10. Dry Cooler Current Sensor Located in Fuel Cell Electrical Section**

### **Data Logging Equipment**

The data logging system will be based around the Obvius AcquiSuite A8812 data logger. The logger has eight analog or digital input on the main board, and monitoring capabilities can be extended using expansion boards. The primary sensor connection configuration for the logger is a two-wire twisted pair network, that reduces the number of low voltage sensor wire runs. The logger has 32 MB of onboard RAM for data retention, which can be expanded via a USB memory key. The logger is equipped with both a 10/100 LAN port and an analog phone modem for remote data retrieval. We are utilizing one of the two analog phone lines supplied to the fuel cell unit.



**Figure 11. Obvius AcquiSuite Datalogger**

Each night we poll the logger via telephone, and collect the data recorded across the day. Data are automatically loaded into the database system here at CDH Energy, where a number of automated data verification routines will identify any suspect data. Verification routines will consist of range checks, where the data are compared to a preset range of value, and data exceeding these values will be flagged; and/or relational checks, where the data are compared to the operational state of the unit for validity, such as “Is the fuel cell consuming gas while producing power?” Data that fails the verification routines will be checked manually by CDH personnel on a daily basis, and corrupt data will be removed from the database. We will endeavor to address data collection issues such as data logging hardware or sensor failures within 48-hours of the failure being identified.

All sensors are scanned on the order of once per second, and these samples will be combined into 15-minute averages (for analog data) and totals (for digital data). The

logger has sufficient memory to hold up to 65-days of data without overwriting the logger memory.

All data logging equipment is installed in a fiberglass NEMA Type 1 enclosure to be mounted inside the fuel cell unit. The data logging panel will be located to the left hand side of the Beckwith Power System Protection panel display.



Figure 12. Interior of Data Logging Panel



Figure 13. Location of Data Logging Panel

The data logging panel is fed with a single 15 amp circuit tied into CB18 (SPARE) on the fuel cell unit 120/240 VAC distribution panel.

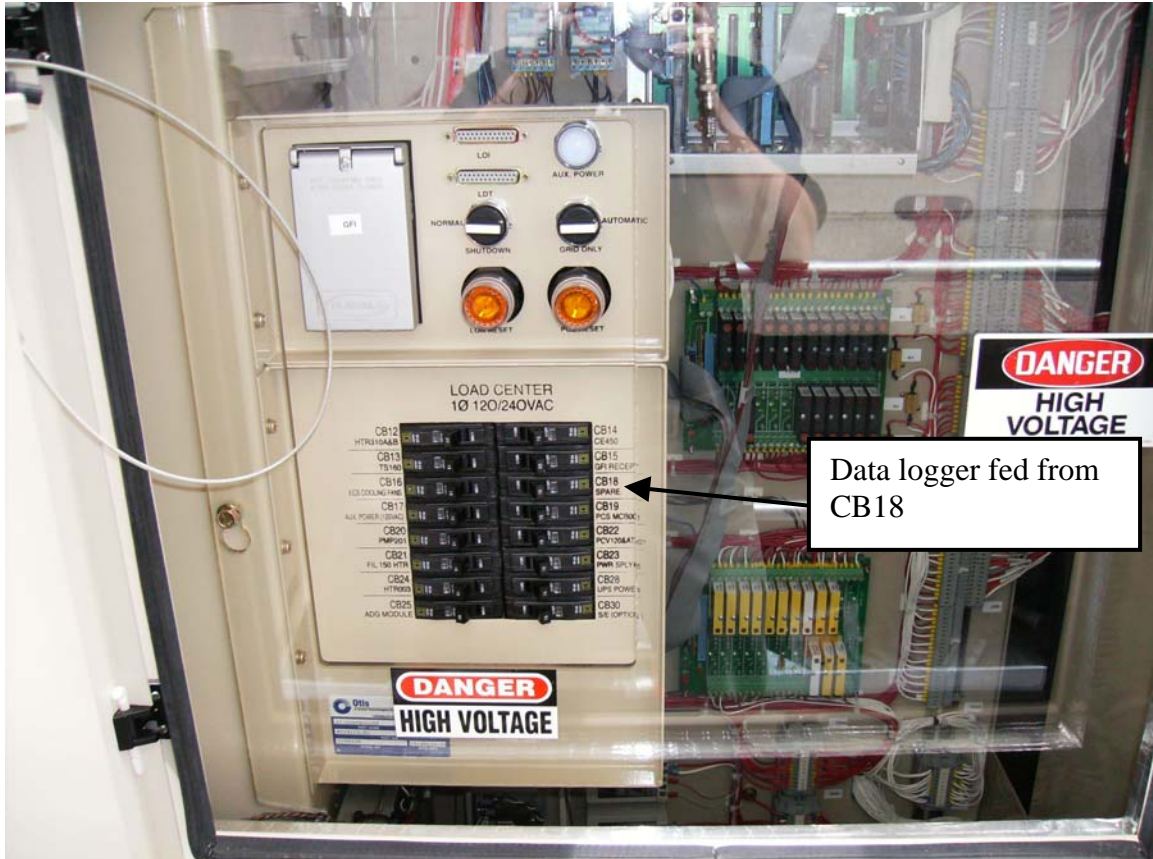


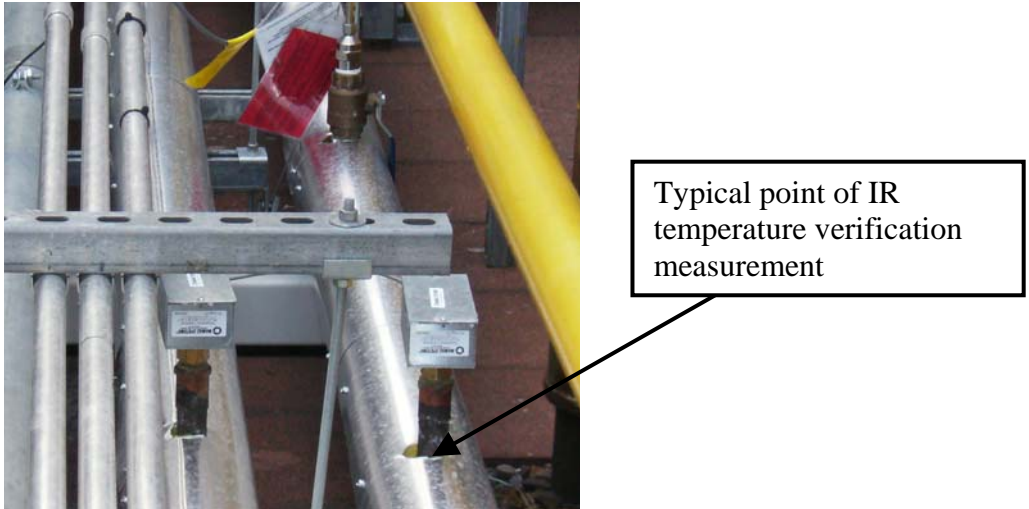
Figure 14. Fuel Cell 120/240 VAC Control Distribution Panel

### **Sensor Selection**

Cut sheets for the data logging equipment and sensors are attached.

### **Sensor Verification**

Field measurements using an independent handheld meter were performed to verify if the DAS system was returning a correct measurement for each sensor. To verify temperature readings an Extech 42545 Infrared Thermometer was used. The non-contact temperature reading was performed at the top of each thermowell tee, on the exposed pipe section (Figure 15).



**Figure 15. Typical Location of IR Temperature Measurement**

Table 2 lists the temperature values recorded by the DAS, and the corresponding IR temperature measurements. Typically the temperature measurements on the DAS were within 1-2°F of the measurement from the IR temperature probe, with the IR typically higher than the DAS. This difference is acceptable as the IR temperature probe is susceptible to local variations in emissivity of the surface. Bench testing prior to installation indicated the maximum temperature difference between the sensors in free air was on the order of 0.5°F.

**Table 2. Comparing DAS Temperatures to Handheld Readings**

<b>Data Point</b>	<b>DAS Reading (°F)</b>	<b>Extech IR Reading (°F – EMS @ 0.8)</b>
TGL	179.34°F	181.3°F
TGE	163.08°F	164.6°F
TRL	161.25°F	161.2°F
TRE	87.07°F	89.2°F
TAO	69.70°F	70.5°F

One time power readings on the main disconnect for the fuel cell were also performed using a Fluke 39 Power Quality Analyzer. The power transducer was initially installed with the Phase B & C current transducers on the incorrect legs, resulting in an inaccurate power measurement on the DAS. The CTs were oriented properly, and the power measurement from the DAS agreed well with the Fluke meter.

**Table 3. Comparing DAS and Fluke Handheld Power Measurements – 2 of 3 CT Reversed**

<b>Data Point</b>	<b>DAS Reading</b>	<b>Fluke 39 Reading</b>
Phase A V→N (VAC)	279.7 VAC	279.4 VAC
Phase B V→N (VAC)	279.3 VAC	279.5 VAC
Phase C V→N (VAC)	278.7 VAC	279.1 VAC
Current Phase A (amps)	246 amps	241 amps
Current Phase B (amps)	240 amps	244 amps
Current Phase C (amps)	245 amps	244 amps
Power Phase A→N (kW)	35.5 kW	101 kW (A→B)
Power Phase B→N (kW)	69.9 kW	104 kW (B→C)
Power Phase C→N (kW)	33.7 kW	
<b>Total Power (kW)</b>	<b>136.2 kW</b>	<b>205 kW</b>

**Table 4. Comparing DAS and Fluke Handheld Power Measurements – CTs Correct**

<b>Data Point</b>	<b>DAS Reading</b>	<b>Fluke 39 Reading</b>
Phase A V→N (VAC)	279.7 VAC	279.4 VAC
Phase B V→N (VAC)	279.3 VAC	279.5 VAC
Phase C V→N (VAC)	278.7 VAC	279.1 VAC
Current Phase A (amps)	245 amps	248 amps
Current Phase B (amps)	241 amps	243 amps
Current Phase C (amps)	245 amps	247 amps
<b>Total Power (kW)</b>	<b>203.1 kW</b>	<b>205 kW</b>

The current draw of the dry-cooler fans was also calibrated to a one-time power measurement. The current CT for this point is located on the load side of a VSD inverter. Future measurement of this point will be repeated to fully correlate current to power for this sensor.

**Table 5. Comparing DAS and Fluke Handheld Power Measurements – Dry Cooler Fan**

<b>Data Point</b>	<b>DAS Reading</b>	<b>Fluke 39 Reading</b>
Phase A V→B (VAC)	N/A	265 VAC
Phase B A→C (VAC)	N/A	265 VAC
<b>Current Phase A (amps)</b>	<b>3.2 amps</b>	<b>3.3 amps</b>
Current Phase B (amps)	N/A	3.4 amps
Current Phase C (amps)	N/A	3.2 amps
<b>Total Power (kW)</b>	<b>N/A</b>	<b>1.15 kW (48 Hz)</b>

The current draw of the fuel gas booster was also calibrated to a one-time power measurement. The current CT for this point is located on the line side of the service to the booster. Repeat measurements will be necessary after gas booster operation is observed.

**Table 6. Comparing DAS and Fluke Handheld Power Measurements – Fuel Gas Booster (idle)**

Data Point	DAS Reading	Fluke 39 Reading
Phase A V→B (VAC)	N/A	208 VAC
Phase B A→C (VAC)	N/A	208 VAC
Current Phase A (amps)	N/A	0.37 amps
Current Phase B (amps)	N/A	0.06 amps
Current Phase C (amps)	0.234 amps	0.37 amps
Total Power (kW)	N/A	33 W (60 Hz)

Finally the gas volume flow through the gas meter was verified by observing the rotation of the 10-foot dial on the odometer for 100 cubic feet of gas flow, and comparing the incremental gas use on the data logger. The data logger showed a 1:1 correlation in gas pulses to the rotation of the 10-foot dial. Table 7 summarizes the observed gas flow parameters.

**Table 7. Verifying Gas Meter Operation**

Gas Flow Parameter	Reading
Time for 100 CF through gas meter	3 minutes 11 seconds (191 seconds)
Corresponding DAS gas pulses	10 pulses, 10 cf/pulse
Average gas flow rate	1,885 cf/h

The gas meter is served using “regulated” pressure gas, ranging between 4 and 14 inches of water column (IWC). During the time of testing the gas pressure was 4.2 IWC (Figure 16. Gas Pressure Entering Fuel Cell).



**Figure 16. Gas Pressure Entering Fuel Cell**

A slight pressure correction is required for the fuel cell gas consumption measurement. Each cubic foot of natural gas measured by the meter needs to be corrected back to standard conditions (14.7 psia, 60°F). Based on a minimum operating pressure of 4 IWC, the minimum correction for the gas pulses is 1.0% (each pulse is equal to 10.101 cf). If the fuel gas booster operates at 14 IWC, then the correction rises to 3.5% (each pulse is equal to 10.354 cf). Based on the idle state of the fuel gas booster, operation at 4 IWC is assumed to be constant, unless indicted by an increase in the fuel gas booster operation.

**System Energy Flows**

Using data from the first day of monitored operation (9/18/2007), an energy balance was performed on the fuel cell. The following performance is based on an 11-hour data set spanning from Midnight to 11:00 AM on 9/18/2007.

**Figure 17. Fuel Cell Performance Summary 9/18/07 Midnight – 11:00 AM**

	Measurement	Min	Max	Average	Total
[1]	Electricity Produced (kWh/h), (kWh)	202.80	203.20	202.82	2,231
[2]	Fuel Consumed (MBtu/h), (MBtu)	1,872.72	1,955.96	1,903.94	20,943
[3]	Heat Recovered to DHW (MBtu/h), (MBtu)	151.25	293.90	213.86	2,352
[4]	Heat Rejected to Dry Cooler (MBtu/h), (MBtu)	526.13	788.73	653.50	7,188
[5]	Electrical Efficiency (HHV) (%)	35.4%	37.0%	36.4%	36.4%
[6]	CHP Efficiency (HHV) (%)	44.2%	50.4%	47.6%	47.6%

The first two lines (electricity produced and fuel consumption) are directly measured by the power transducer and gas meter. The gas has been adjusted to standard cubic feet and is converted to Btus by using a Higher Heating Value of 1,030 Btu/cf.

Line three is the heat recovered to the building DHW system, which is calculated by the following measurements:

$$Q = 0.480 \times FG \times (TGL - TGE)$$

Where :

$Q$  = Heat recovered to DHW (MBtu/h)

$$0.480 = \text{Heat Capacity of Glycol} \left( \frac{\text{MBtu}}{\text{gallon } ^\circ\text{F}} \times \frac{60 \text{ min}}{\text{hour}} \right)$$

$FG$  = Glycol loop flowrate (gpm)

$TGL$  = Temperature of glycol loop leaving fuel cell (°F)

$TGE$  = Temperature of glycol loop entering fuel cell (°F)

The heat recovery flow rate is converted to Btu/interval by multiplying the rate by 0.25 hours (one 15-minute data record).



Line four is the heat rejected to ambient by the dry cooler, which is calculated by the following measurements:

$$QR = 0.480 \times FR \times (TRL - TRE)$$

Where :

$QR$  = Heat rejected by dry cooler (MBtu/h)

0.480 = Heat Capacity of Glycol ( $\frac{\text{MBtu}}{\text{gallon } ^\circ\text{F}} \times \frac{60 \text{ min}}{\text{hour}}$ )

$FR$  = Dry cooler loop flowrate (gpm)

$TRL$  = Temperature of dry cooler loop leaving fuel cell ( $^\circ\text{F}$ )

$TRE$  = Temperature of dry cooler loop entering fuel cell ( $^\circ\text{F}$ )

The heat recovery flow rate is converted to Btu/interval by multiplying the rate by 0.25 hours (one 15-minute data record).

Lines five and six are the electrical and CHP efficiency of the fuel cell unit on a HHV basis. Electrical efficiency is determined by:

$$EFF_{elec} = \frac{WFC \times 3.413}{FGFC}$$

Where :

$EFF_{elec}$  = Electrical efficiency of fuel cell unit (% HHV)

$WFC$  = Electricity produced (kWh)

3.413 = Conversion from kWh to MBtu

$FGFC$  = Fuel cell gas consumption @ 1,030 Btu/cu ft HHV (MBtu)

CHP efficiency is determined by:

$$EFF_{CHP} = \frac{WFC \times 3.413 + Q}{FGFC}$$

Where :

$EFF_{CHP}$  = Electrical efficiency of fuel cell unit (% HHV)

$WFC$  = Electricity produced (kWh)

3.413 = Conversion from kWh to MBtu

$Q$  = Useful heat recovered to DHW (MBtu)

$FGFC$  = Fuel cell gas consumption @ 1,030 Btu/cu ft HHV (MBtu)

Over the initial 11-hour data collection period the fuel cell unit has an average CHP efficiency of 47% HHV. If the heat rejected by the dry cooler is included, the monitoring system is presently accounting for 82% of the fuel utilization of the system, with the balance of 18% being lost to exhaust streams and radiation, both of which are not and can not be measured by the DAS.

The following four plots display the limited data collected so far. A more comprehensive analysis of the startup data will be prepared after 300-hours of system operation have been recorded.

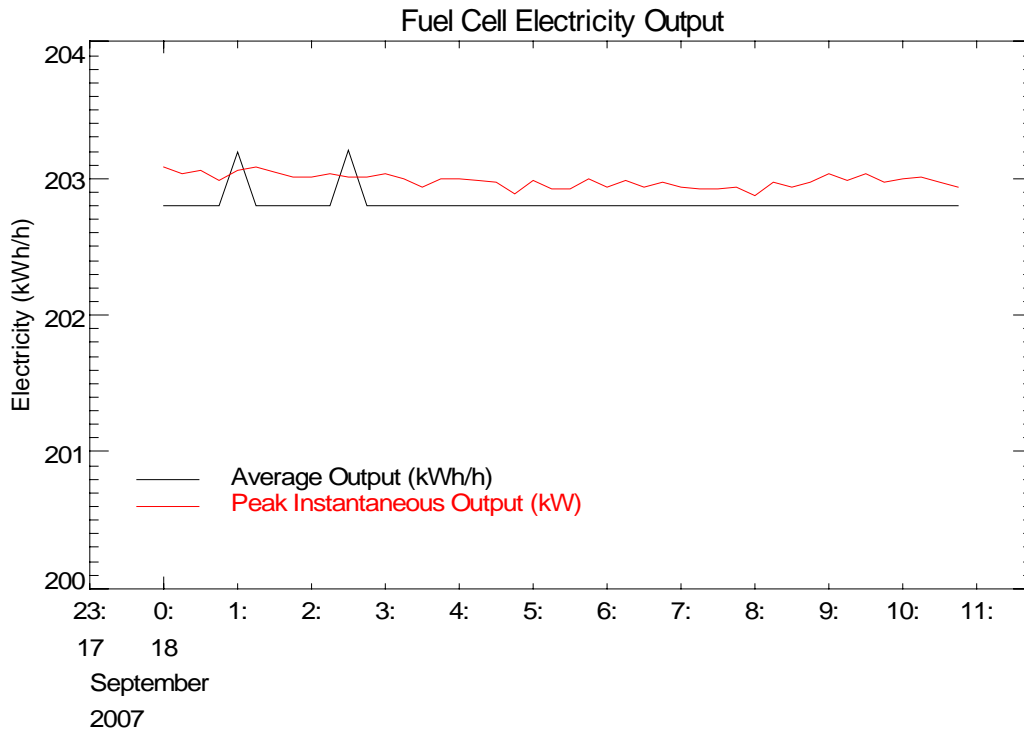


Figure 18. Fuel Cell Electricity Output Trends

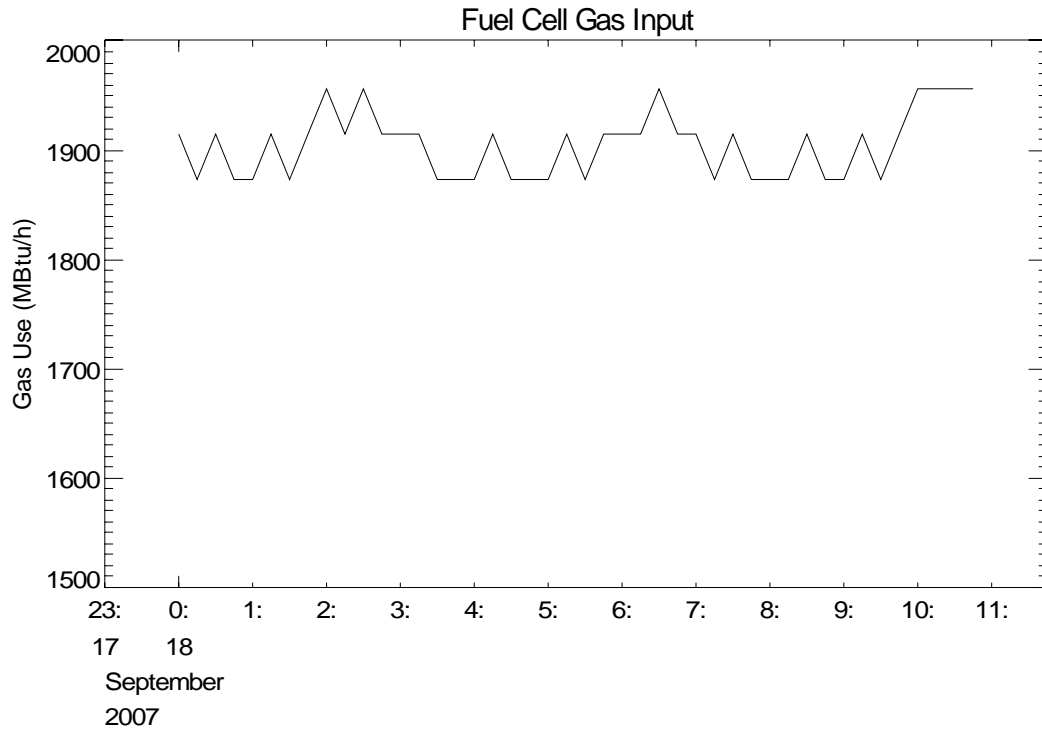


Figure 19. Fuel Cell Gas Input Trends

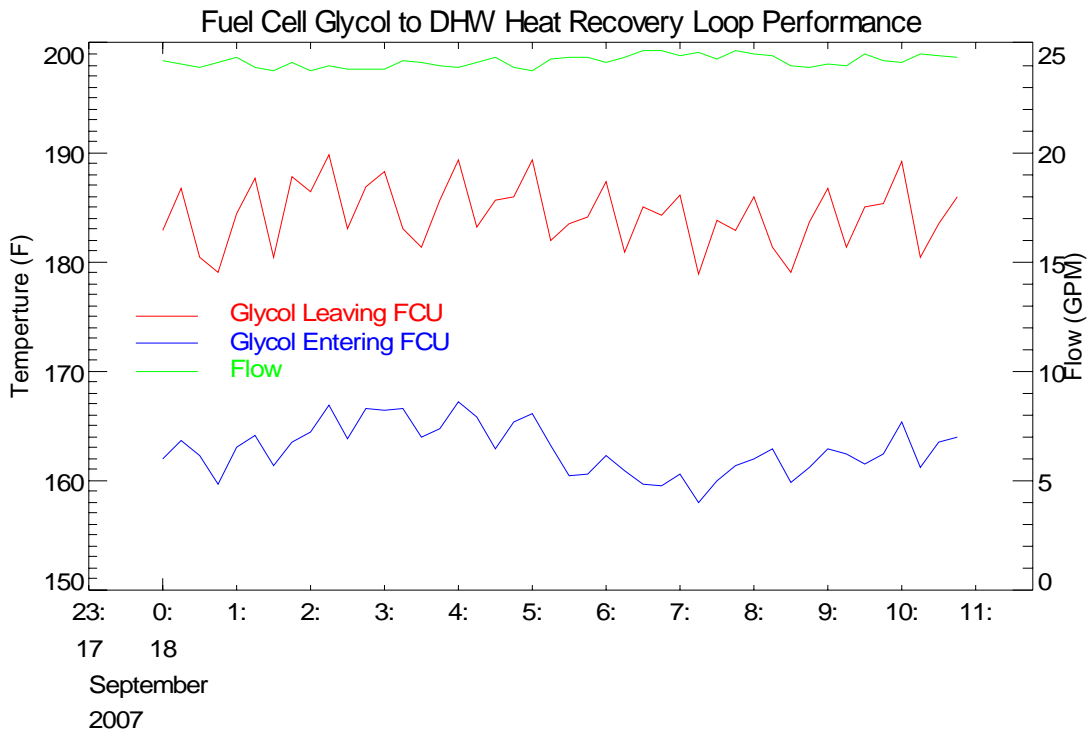


Figure 20. Fuel Cell Useful Heat Recovery Trends

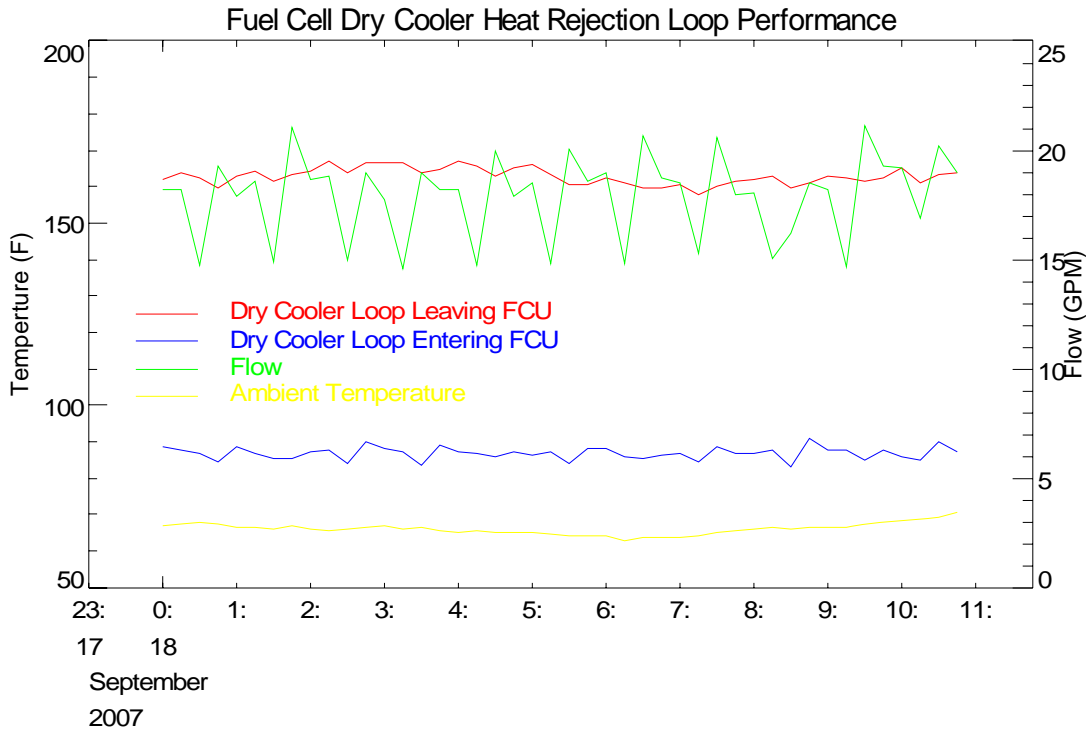


Figure 21. Fuel Cell Dry Cooler Heat Rejection Trends

**Data Collection Status**

The following issues were identified and corrected during the commissioning of the monitoring system:

- DAS system date was initially set to the default system time of 8/17/1963 5:26 AM PDT when the local time was actually 9/17/2007 2:41 PM EDT. The DAS clock was set to the correct time.
- Dial in phone communications were established and verified
- The power transducer for WFC was found to have two CTs oriented incorrectly. These CTs were moved to the proper conductors and proper power measurement was verified.
- The gas meter pulse output was mis-wired on the DAS faceplate. The meter was terminated correctly and gas data is now being collected.
- Data collection on the system officially began at 9/17/2007 5:00 PM. The system startup time according to the DAS was 9/13/2007 2:00 PM.
- Data are currently being collected on the performance of the system on a nightly basis.

## **APPENDIX A – Sensor Cut Sheets**

# A8812 AcquiSuite DR™ Data Acquisition Server



## Description

Obvius, the leader in cost effective data acquisition and wireless metering solutions introduces the all-new A8812-x AcquiSuite DR™ data acquisition server, providing high performance and low cost for:

- Demand response programs
- Benchmarking building operations performance
- Verification of energy savings and utility costs
- Cost allocation to departments or tenants
- Internet based supervisory control outputs

The system combines the flexibility of choosing LAN, modem or cellular communication paths with the lowest total installed cost for logging building data such as:

- Electrical, gas and water usage and costs
- Indoor and outdoor temperatures
- Pressure, humidity, CO2
- Industry standard pulse or analog inputs

AcquiSuite™ brings “plug and play” capability to the data acquisition market, dramatically reducing the time and training required to put a typical building on line. In most applications, the installation can be done by the building engineer or contractor in less than 2 hours. The system automatically detects and configures Modbus devices in just seconds reducing installation time and costs.

## Applications

- Demand response program control and reporting
- Cost allocation to tenants and third parties
- Measurement & verification of energy savings
- Data center branch circuit monitoring
- Monitoring performance of building systems (e.g., chillers, boilers, fans)

## Easy installation saves time and money

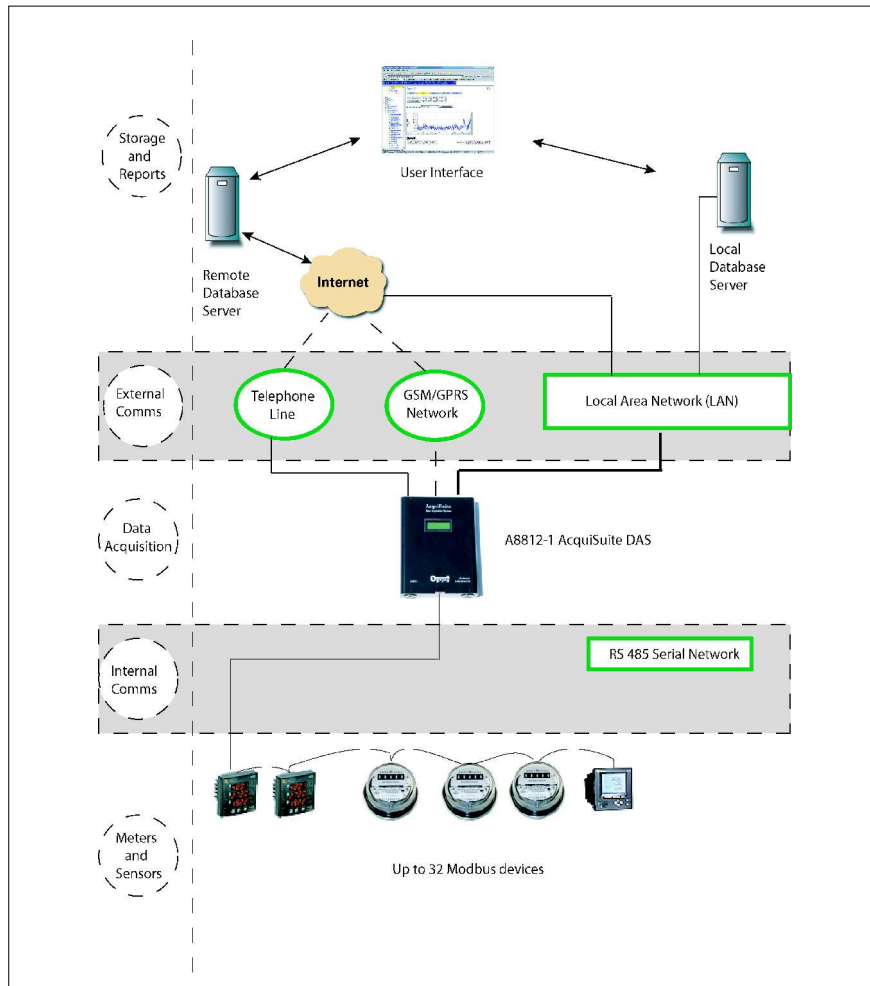
- Simple “plug and play” connectivity to standard Modbus meters minimizes installation time and costs
- “Flex” I/O inputs provide easy connections for analog, pulse and resistance sensors
- Acquisuite hardware and software is designed to provide data in flexible, industry standard formats for databases, spreadsheets, etc.
- A8812 provides onboard plug in for R9120 ModHopper to allow wireless RS 485 communications
- Integrated relay outputs allow supervisory control from any location for load shedding or local generation
- Integrated web server provides setup and configuration using any industry standard web browser (i.e., Netscape™ or Internet Explorer™)

## Internet display of key building parameters

- Buildingmanageronline.com™ allows authorized users to see building performance data in an easy to use graphical format
- BMO site provides storage, display and downloads of historical data in a secure SQL database
- Users can be notified of alarm conditions in any or all monitored points
- Open protocols provide connectivity to any energy management or building automation software

## Flexible communications and wireless connectivity

- All data is stored at the site in nonvolatile memory, insuring protection of valuable information in the event of power loss
- Optional on-board ModHopper (R9120-x) for wireless RS 485 communications (consult factory)
- A8812-1 provides two communication options: Local Area Network (LAN) or phone line
- A8812-GSM replaces the standard phone modem with a GSM/GPRS modem for cellular data transfer



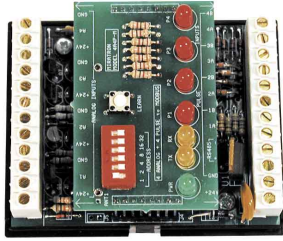
## SPECIFICATIONS

Processor	Main processor: ARM 9 ; I/O co-processor: ARM 7
Operating System	Linux 2.6
Flash ROM	16 MB NOR Flash (expandable with USB memory device)
Memory	32 MB RAM
LED	8x pulse input, 4 modem activity, Modbus TX/RX, power status
Console	2 x 16 LCD character, two buttons
LAN	10/100, Auto crossover detection
Modem (phone)	V.34 bis, 33,600 bps <b>(Part number A8812-1)</b>
Modem (cellular)	GSM/GPRS Class10, 85 kbps <b>(Part number A8812-GSM)</b>
Protocols	Modbus/RTU, Modbus/TCP, TCP/IP, PPP, HTTP/HTML, FTP,SNMP, SMTP, XML
Power Supply	24 VDC, included
Serial Port	RS-485 Modbus
Approvals	CE; FCC Part 15, Class A
USB port	USB memory expansion port
Power Requirement	110-120VAC
Interval recording	User selectable 1-60 minutes. Default 15 minute interval.
Outputs	2x, Dry contact 30 VDC, 150 mA max
Inputs	8x, user selectable: <ul style="list-style-type: none"> <li>• 0-10 V - Min/Max/Ave/Instantaneous</li> <li>• 4-20 mA - Min/Max/Ave/Instantaneous</li> <li>• Pulse - Consumption, Rate</li> <li>• Resistance - Min/Max/Ave/Instantaneous</li> <li>• Runtime - Runtime, Status</li> </ul>



# A8923-4

## AcquiSuite I/O Module



### DESCRIPTION

The A8923-4 I/O Module provides a convenient way to add standard pulse and analog sensors to the AcquiSuite acquisition system network. With it up to 8 standard sensor types, 4 analog (0-10 VDC or 4-20mA), and 4 pulse devices, are easily integrated to a network of other critical energy sensors such as Veris Enercept power meters to provide a solution for comprehensive energy monitoring.

#### Installing and commissioning the A8923-4 is a snap!

- Simply connect the sensors to it and press the sensor input auto detect button to automatically identify the analog sensor input type, 0-10 VDC or 4-20mA.
- The onboard dipswitch sets the Modbus address.
- All configuration information and pulse input data is stored in non-volatile memory to prevent data loss in the event of power failure.

After installation, data from the connected devices is time stamped and stored in nonvolatile memory on user selected intervals. This interval data is stored at the local site until the next scheduled upload to the SQL database server. Using the built-in modem or Ethernet ports, data is sent via either the network or phone lines to the Building Manager Online™ server.

At the BMO site, the newly gathered data is combined with historical information that is available to authorized users from anywhere in the world using standard browsers and the Internet. No additional software is required to develop customized views of operational and energy data from one or more buildings.

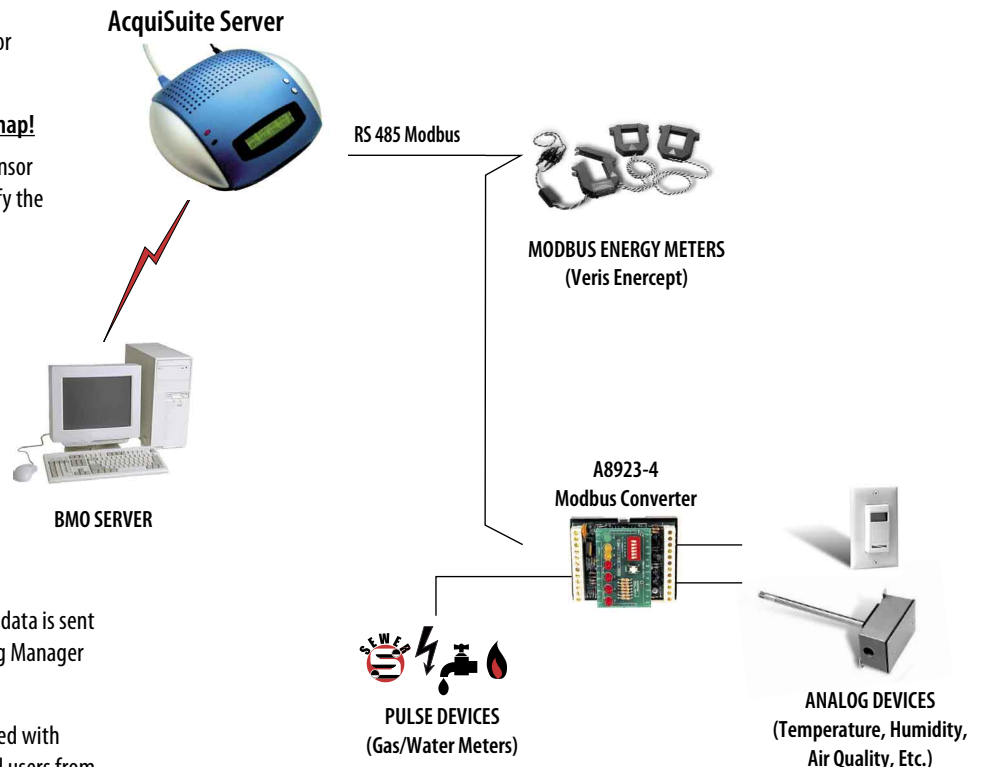
### Network up to 4 analog and 4 pulse sensors to AcquiSuite data acquisition system networks!

- Universal analog inputs simplify setup. Just connect sensors and press button to auto-detect 4-20mA or 0-10v input type!
- Check device status at a glance. LED indicators for fast indication!
- Field selectable address DIP switch. No software or PC configuration required!
- High reliability. Nonvolatile memory retains configuration and pulse data during power failures.

### Simple Comprehensive Data Acquisition

- Enercept meters and I/O sensors with Eservers enable monitoring of essential building parameters...one source for all your energy monitoring needs

ENERGY DATA ACQUISITION



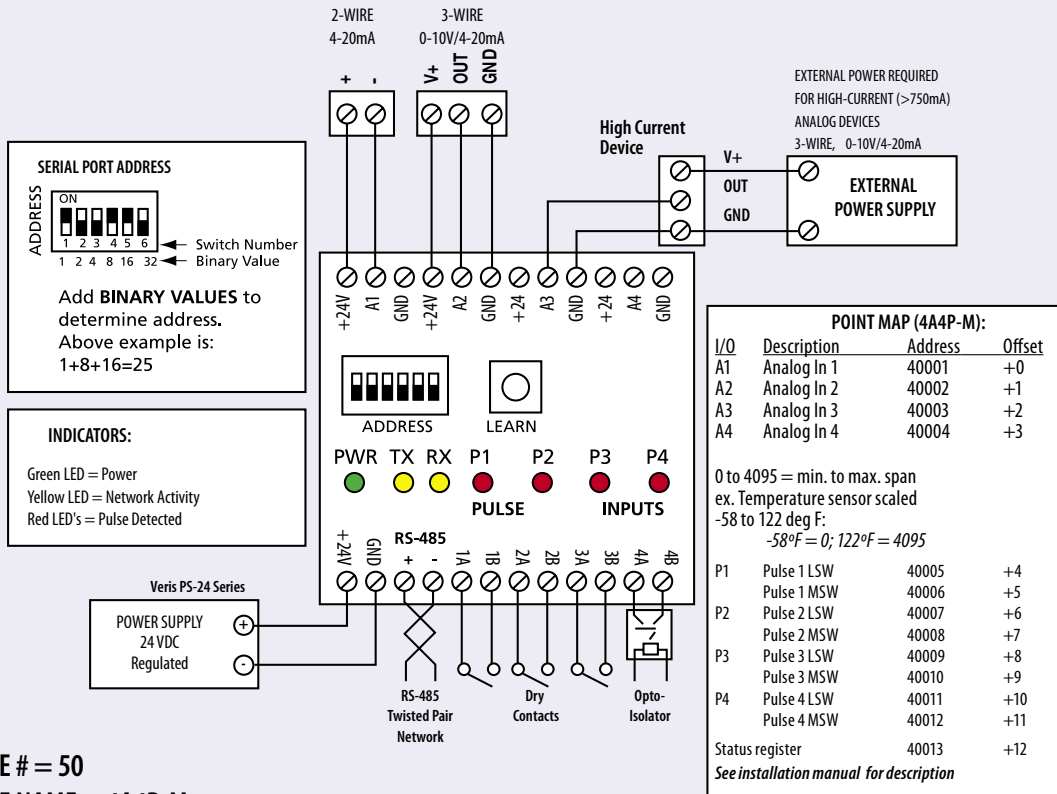
### Ordering INFORMATION

MODEL	DESCRIPTION
A8923-4	AcquiSuite I/O Module

\* Analog inputs are universal 4-20mA or 0-10V



## APPLICATIONS/WIRING EXAMPLE:



## SPECIFICATIONS

### Inputs

Power ..... 24vdc, 50mA + converter powered analog devices  
 Analog ..... 4-20mA or 0-10v auto-detected (ranges and units set in master device)  
 0-10v Input impedance = 10k ohms; 4-20mA  
 Input Impedance = 250 ohms  
 Pulse ..... Dry contact, 250Hz max.  
 Accuracy ..... +/- 0.25% F.S. (Analog Input)

### Output

Hardware ..... RS-485, 2-wire, non-isolated  
 Protocol ..... Modbus RTU Protocol  
 Latency ..... 5mS

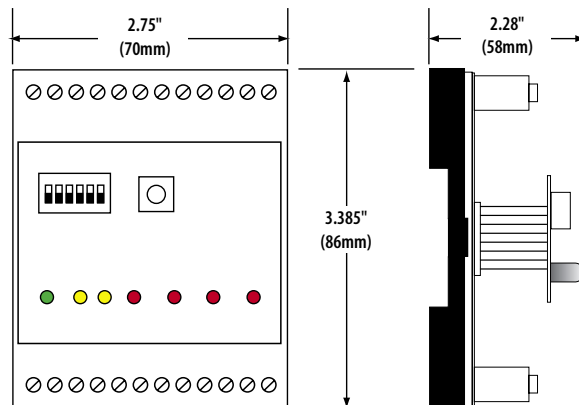
### Configuration

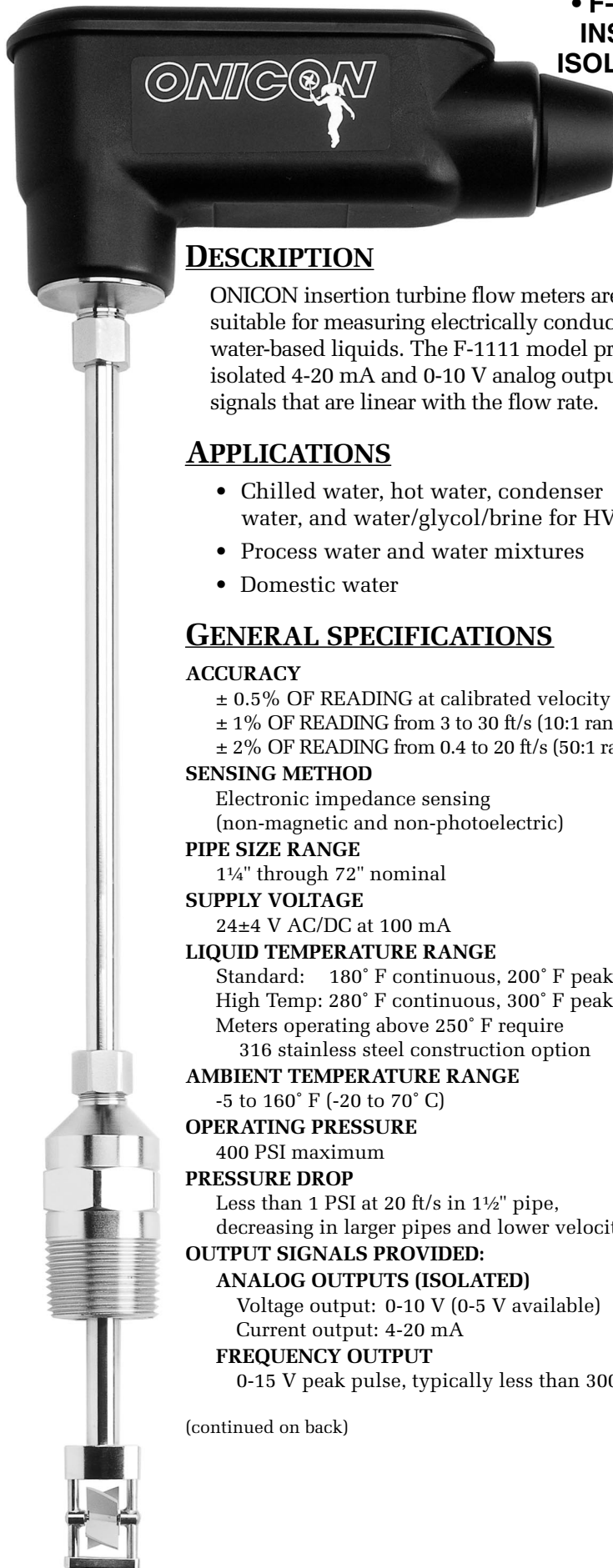
Address ..... 6-position DIP switch, 63 addresses  
 Analog Input ..... Auto-detecting 0-10v or 4-20mA (ranges and units set in master device)

### General

Dimensions ..... 4A4P-M: 4-module, 70mm x 86mm x 58mm(h)  
 Material ..... Base part: Black Noryl UL94-V0; PCB material: FR-4  
 Mounting ..... M36 DIN-RAIL (EN50022)  
 Operating Envir. .... 0 to 50°C, 0 to 95%RH non-condensing

## DIMENSIONS





• F-1111 SINGLE TURBINE •  
 INSERTION FLOW METER  
 ISOLATED ANALOG OUTPUT



Made in the USA

**DESCRIPTION**

ONICON insertion turbine flow meters are suitable for measuring electrically conductive water-based liquids. The F-1111 model provides isolated 4-20 mA and 0-10 V analog output signals that are linear with the flow rate.

**APPLICATIONS**

- Chilled water, hot water, condenser water, and water/glycol/brine for HVAC
- Process water and water mixtures
- Domestic water

**GENERAL SPECIFICATIONS**

**ACCURACY**

- ± 0.5% OF READING at calibrated velocity
- ± 1% OF READING from 3 to 30 ft/s (10:1 range)
- ± 2% OF READING from 0.4 to 20 ft/s (50:1 range)

**SENSING METHOD**

Electronic impedance sensing  
 (non-magnetic and non-photoelectric)

**PIPE SIZE RANGE**

1¼" through 72" nominal

**SUPPLY VOLTAGE**

24±4 V AC/DC at 100 mA

**LIQUID TEMPERATURE RANGE**

Standard: 180° F continuous, 200° F peak  
 High Temp: 280° F continuous, 300° F peak  
 Meters operating above 250° F require  
 316 stainless steel construction option

**AMBIENT TEMPERATURE RANGE**

-5 to 160° F (-20 to 70° C)

**OPERATING PRESSURE**

400 PSI maximum

**PRESSURE DROP**

Less than 1 PSI at 20 ft/s in 1½" pipe,  
 decreasing in larger pipes and lower velocities

**OUTPUT SIGNALS PROVIDED:**

**ANALOG OUTPUTS (ISOLATED)**

Voltage output: 0-10 V (0-5 V available)  
 Current output: 4-20 mA

**FREQUENCY OUTPUT**

0-15 V peak pulse, typically less than 300 Hz

(continued on back)

**CALIBRATION**

Every ONICON flow meter is wet-calibrated in our flow laboratory against primary volumetric standards directly traceable to NIST. Certification of calibration is included with every meter.

**FEATURES**

**Unmatched Price vs. Performance** - Custom calibrated, highly accurate instrumentation at very competitive prices.

**Excellent Long-term Reliability** - Patented electronic sensing is resistant to scale and particulate matter. Low mass turbines with engineered jewel bearing systems provide a mechanical system that virtually does not wear.

**Industry Leading Two-year "No-fault" Warranty** - Reduces start-up costs with extended coverage to include accidental installation damage (miswiring, etc.). Certain exclusions apply; see our complete warranty statement for details.

**Simplified Hot Tap Insertion Design** - Standard on every insertion flow meter. Allows for insertion and removal by hand without system shutdown.

OPERATING RANGE FOR COMMON PIPE SIZES 0.17 TO 20 ft/s ± 2% accuracy begins at 0.4 ft/s	
Pipe Size (Inches)	Flow Rate (GPM)
1¼	0.8 - 95
1½	1 - 130
2	2 - 210
2½	2.5 - 230
3	4 - 460
4	8 - 800
6	15 - 1800
8	26 - 3100
10	42 - 4900
12	60 - 7050
14	72 - 8600
16	98 - 11,400
18	120 - 14,600
20	150 - 18,100
24	230 - 26,500
30	360 - 41,900
36	510 - 60,900

# F-1111 SPECIFICATIONS cont.

## MATERIAL

- Wetted metal components
- Standard: Electroless nickel plated brass
- Optional: 316 stainless steel

## ELECTRONICS ENCLOSURE

- Standard: Weathertight aluminum enclosure
- Optional: Submersible enclosure

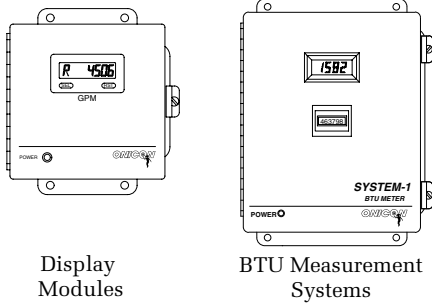
## ELECTRICAL CONNECTIONS

- 4-wire minimum for 4-20 mA or 0-10 V Output
- Second analog output and/or frequency output requires additional wires
- Standard: 10' of cable with 1/2" NPT conduit connection
- Optional: Indoor DIN connector with 10' of plenum rated cable

# F-1111 Wiring Information

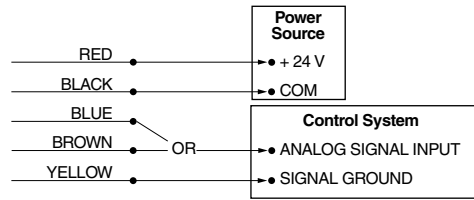
WIRE COLOR CODE		NOTES
RED	(+) 24 V AC/DC supply voltage, 100 mA	Connect to power supply positive
BLACK	(-) Common ground (Common with pipe ground)	Connect to power supply negative
GREEN	(+) Frequency output signal: 0-15 V peak pulse	Required when meter is connected to local display or BTU meter
BLUE	(+) Analog signal: 4-20 mA (isolated)	Use yellow wire as (-) for these signals. Both signals may be used independently.
BROWN	(+) Analog signal: 0-10 V (isolated)	
YELLOW	(-) Isolated ground	Use for analog signals only

## ALSO AVAILABLE



## F-1111 Wiring Diagram

Flow Meter into Control System (No Display or BTU Meter)

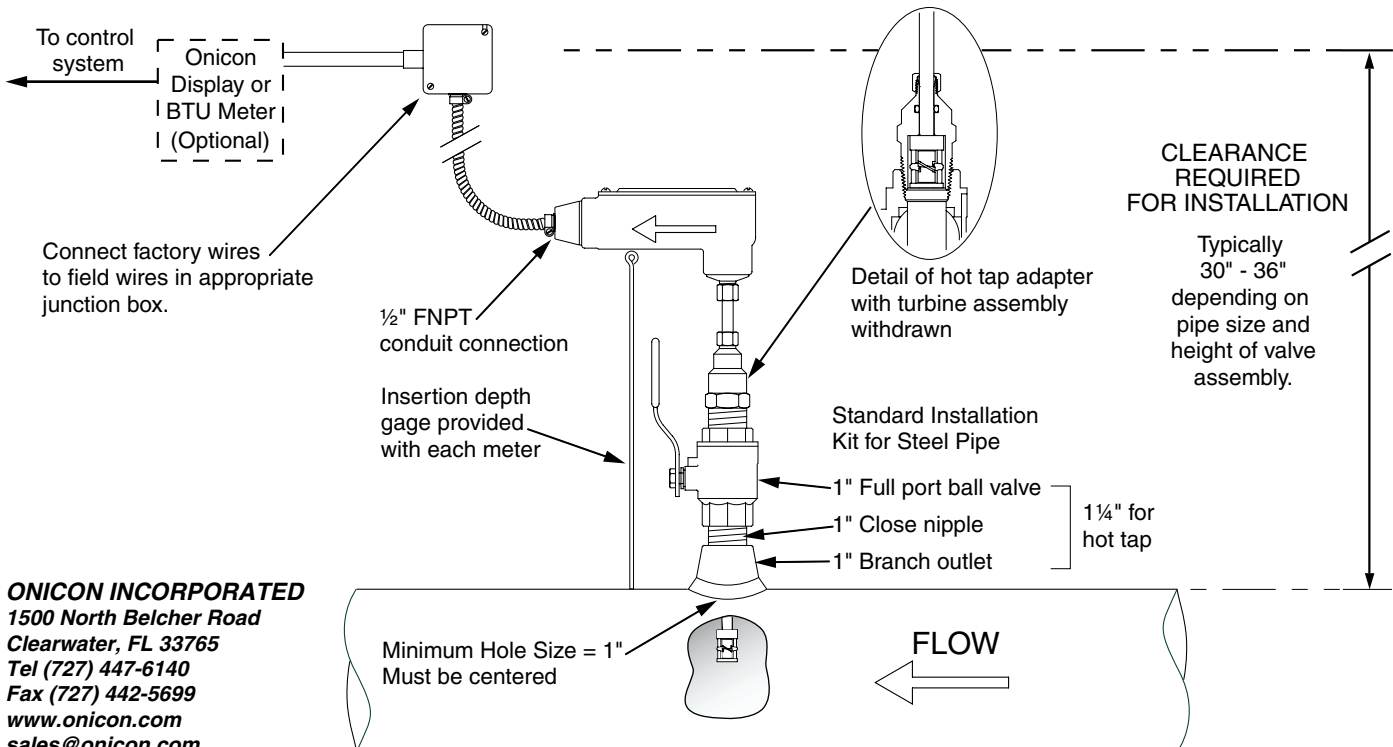


- NOTE: 1. Black wire is common with the pipe ground (typically earth ground).  
 2. Frequency output required for ONICON display module or BTU meter, refer to wiring diagram for peripheral device.

## Typical Meter Installation

(New construction or scheduled shutdown)

- Acceptable to install in vertical pipe
- Position meter anywhere in upper 180° for horizontal pipe



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 Clearwater, FL 33765  
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 Fax (727) 442-5699  
 www.onicon.com  
 sales@onicon.com

Note: Installation kits vary based on pipe material and application. For installations in pressurized (live) systems, use "Hot tap" 1 1/4 inch installation kit and drill hole using a 1 inch wet tap drill.

# Temperature Transducers

## Model TE-211Y, TE-211Z, TE-213

### TE-211Y, Z

- Temperature transducer utilizing 100  $\Omega$  Platinum RTD and 1,000  $\Omega$  Platinum RTD
- 24 VDC power input, 4-20 mA two wire loop signal output

### TE-213

- Temperature transducer utilizing Integrated Circuit
- 12, 24 VDC power input, 0-5, 0-10 VDC, and 4-20 mA signal output available
- Supports four (4) wire power, signal configuration

### GENERAL INFORMATION MAMAC SYSTEMS TEMPERATURE TRANSDUCERS

All sensing elements manufactured by MAMAC Systems, Inc. for the TE-211 and TE-213 are protected against moisture and other contaminants by means of a conformal coating process. The conformal coat is applied to the sensor and a portion of the lead wires creating a moisture proof seal. In addition to coating the sensor, the same urethane compound is used to seal the end of the probe where sensor lead wires exit, resulting in another barrier against harmful moisture. Without this protection, sensors may fail in a short condition due to condensation and other sources of moisture.

The TE-211 and TE-213 are available in different housings to cover applications of Space, Duct, Immersion, Duct Averaging, Outside Air and Strap-On.

**Space Temperature:** Polystyrene enclosure with internal wall separating the sensing element from the electronic circuit board.

**Duct/Immersion Temperature:** Sturdy NEMA-1 16 AWG steel enclosure houses the electronic circuit board. Available with 4", 6", 8" or 12" aluminum or series 300 stainless probe. Probe protrudes from the bottom of the enclosure and is affixed to the enclosure with a brass compression fitting. The bottom of the duct enclosure is gasketed for a tight seal to the duct work. The immersion sensor is equipped with a 1/4" NPT or 1/2" NPT thermowell fitting that can be screwed directly into the A-500 thermowell providing a rigid support to the transducer.

**Duct Averaging:** NEMA-1 16 AWG steel enclosure with 6 ft., 12 ft. or 24 ft. bendable aluminum 3/8" OD probe for averaging duct air temperature. The probe incorporates numerous encapsulated at equal distances across the length of the probe. The complete assembly acts as a single sensor and temperature change is averaged across the sensors. The probe can be easily bent to fit any size duct.

**Outside Air:** A weather proof enclosure with suitable sun shield can be easily screwed onto 1/2" conduit.

**Strap-On:** A NEMA-1 16 AWG steel enclosure is provided with 6 ft. of 18 AWG twisted shielded cable. The sensing element is housed in a 2" aluminum or stainless steel probe at the end of the cable suitable for being strapped onto a pipe or used in a remote application.



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® Registered trademark MAMAC SYSTEMS, Inc.

## TE-211Y, TE-211Z, TE-213

### MORE ABOUT TE -211Y, -211Z

The RTD and transmitter are matched and calibrated as a complete assembly in a temperature chamber against a NIST traceability calibrated standard. The final accuracy is verified with a three (3) point calibration check against the standard over the specified temperature range. The transmitter is equipped with non-interacting zero and span adjustment trimmers for site calibration and is reverse polarity protected against accidental mis-wiring. The transmitter assembly conforms to a ANSI S50.1 Type 2 Class U circuit.

### MORE ABOUT THE TE-213

Signal conditioning is performed by industrial quality integrated circuits to provide a true linear output. The circuit is factory calibrated but zero and span trimmers are provided to adjust the output if necessary. Output accuracy is not affected by long wire runs or electrical noise. The TE-213 provides an analog output linear and proportional to the calibrated temperature range. The integrated circuit and transmitter are calibrated as a complete assembly in a temperature chamber using a NIST traceable calibrated standard. The final accuracy of  $\pm 0.5^{\circ}\text{F}$  is verified with a three (3) point check against the standard over the specified temperature range.

### ORDERING INFORMATION - TE-211

MODEL	ENCLOSURE	PROBE LENGTH	PROBE MATERIAL	WELL FITTING	VOLTAGE IN	SIGNAL OUTPUT	RANGE
TE-211-Y for 100 $\Omega$ Sensor	(A) Space (B) Duct (C) Immersion (D) Duct Ave	(A) 4 Inches (B) 6 Inches (C) 8 Inches (D) 12 Inches	(1) Aluminum (2) Stainless Steel (3) Custom	(A) Brass 1/4" NPT (B) Brass 1/2" NPT (C) Custom	(1) 24 VDC	(E) 4-20 MA 2 wire	(1) 50 T 85F (2) 40 T 140F (3) -30 T 130F (4) 0 T 100F (5) 100 T 250F (6) 0 T 250F (7) Custom
TE-211-Z for 1,000 $\Omega$ Sensor	(E) Remote Probe Strap On (F) Outdoor (G) Custom	(E) 2 Inches (F) 6 Feet (G) 12 Feet (H) 24 Feet (I) Custom					
USE THIS NUMBER TO ORDER:					<b>1</b>	<b>E</b>	

### ORDERING INFORMATION - TE-213

MODEL	ENCLOSURE	PROBE LENGTH	PROBE MATERIAL	WELL FITTING	VOLTAGE IN	SIGNAL OUTPUT	RANGE
	(A) Space (B) Duct (C) Immersion (D) Duct Ave (E) Remote Probe Strap On (F) Outdoor	(A) 4 Inches (B) 6 Inches (C) 8 Inches (D) 12 Inches (E) 2 Inches (F) 6 Feet (G) 12 Feet (H) 24 Feet	(1) Aluminum (2) Stainless Steel (3) Custom	(A) Brass 1/4" NPT (B) Brass 1/2" NPT (C) Custom	(1) 24 VDC  (2) 24 VAC  (4) 12 VDC  (5) Custom	(A) 0-1 VDC (B) 0-5 VDC (C) 0-10 VDC (G) Custom (H) 4-10 MA 2  (D) 4-20 MA (G) Custom  (A) 0-1 VDC (B) 0-5 VDC (G) Custom	(1) 50 T 85F (2) 40 T 140F (3) -30 T 130F (4) 0 T 100F (5) 100 T 250F (6) 0 T 250F (7) Custom
USE THIS NUMBER TO ORDER:							
<b>TE-213</b>							

# TE-211Y, TE-211Z, TE-213

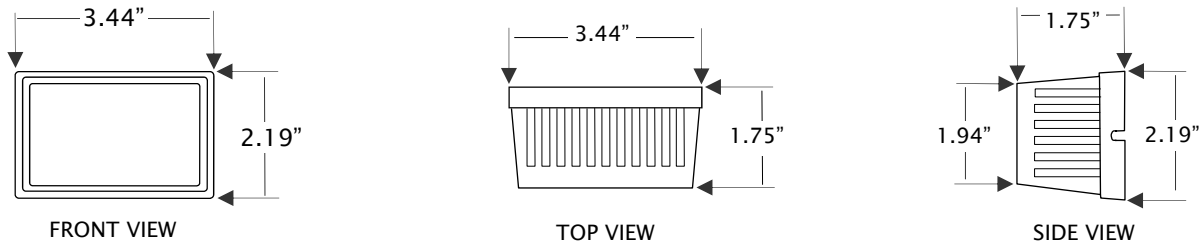
## SPECIFICATIONS:

- Accuracy: Accuracy\*:  $\pm 0.50^\circ$  F FS; Linearity:  $\pm 0.05^\circ$  F; Repeatability:  $\pm 0.01^\circ$  F; Transmitter Error: better than  $\pm 0.01\%$  span.
- Environmental: Ambient Temperature:  $-30^\circ$  F to  $250^\circ$  F; Humidity: (10-95%) Non-condensing; Maximum Temperature Span:  $250^\circ$  F; Minimum Temperature Span:  $35^\circ$  F
- Stability: Stability Factor Over T (rates of drift): better than 10,000 hours @400C; Sensor Stability: .07 ohms per 10,000 hours @ 400C
- Supply Voltage: **TE-211:** 13 to 28 VDC. Can go down to 12 VDC, but max input impedance is 250 ohms (250 ohms x 20 mA = 5 VDC). **TE-213:** 18 VAC, VDC or greater; 24 VDC, 24 VAC, 115 VAC, 12 VDC\* (maximum input impedance 250 $\Omega$ )
- Output: **TE-211:** 4 to 20 mA (proportional to range) **TE-213:** 0-1 VDC, 0-5 VDC, 0-10 VDC, 4-20 MA, 4-10 MA 2 wire, 1-50HKz AFCP
- Current Draw: 50 mA

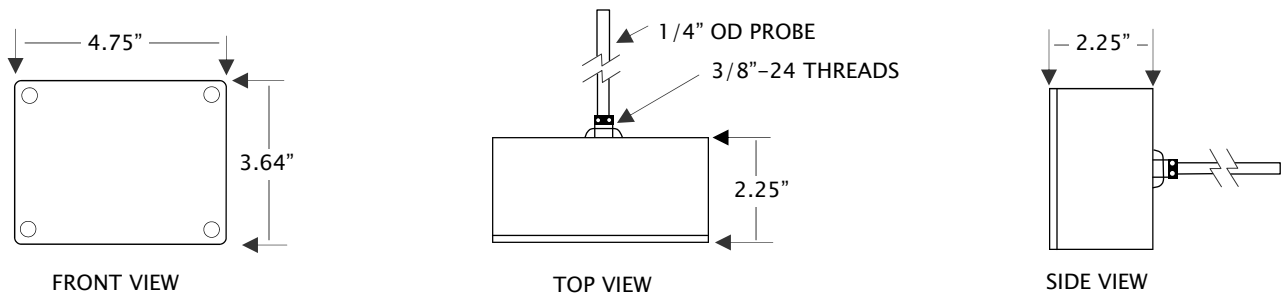
\* Accuracy of Duct Averaging Transducer is  $\pm 3F$

## DIMENSIONS:

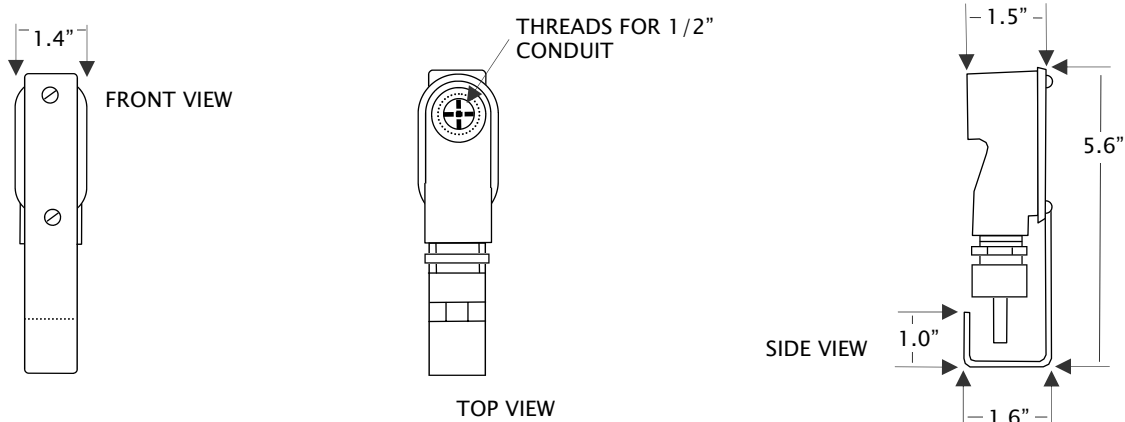
### Space Temperature Enclosure Dimensions:



### Duct, Immersion, Duct Averaging Enclosure Dimensions:



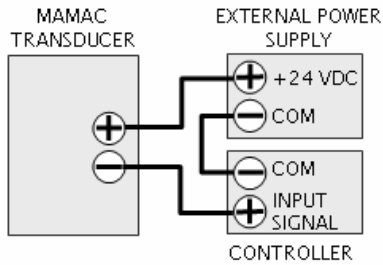
### Outdoor Air Enclosure Dimensions:



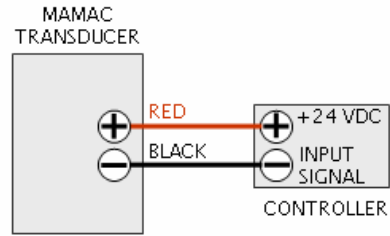
# TE-211Y, TE-211Z, TE-213

## WIRING AND CALIBRATION, TE-211:

### External 12-28 VDC Power Supply



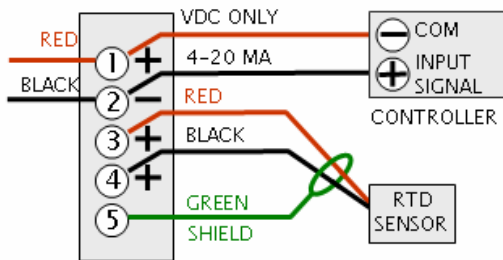
### Internal 12-28 VDC Power Supply



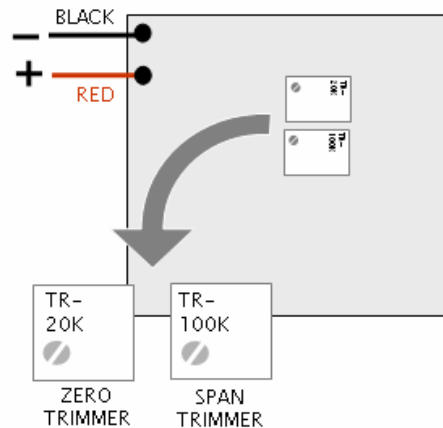
## QUICK CHECKOUT PROCEDURE

- (1) Connect ammeter in series to terminal + or -
- (2) At the low end of the range, the reading should be 4 milliamps. If you don't read this value, a) recheck wiring, b) refer to specific data sheet for the product you are installing, c) call MAMAC Systems for further technical assistance.

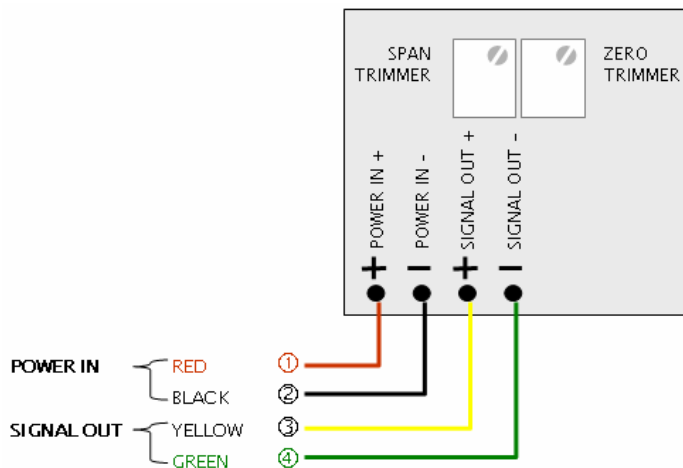
## Sensor Termination Schedule



## TE-211 Trimmer Location



## WIRING AND CALIBRATION, TE-213:



# Thermowell

## Model A-500



- 4", 6", 8" and 12" lengths
- Brass or stainless steel material
- Machined from a single piece
- Withstands up to 3000 psig pressure
- 3/4" external with 1/2" internal or 1/2" external with 1/4" internal thread options
- A-505 Thermal Compound eliminates condensation
- Excellent thermal conductive synthetic paste
- No particle migration or fluid separation
- High working temperature with no evaporation or hardening

The A-500 Thermowell is machined from a single piece of brass or stainless steel to provide a rugged and leak proof well for MAMAC temperature sensors. Each A-500 Thermowell is precisely machined to 0.255" bore to provide a tight fit for our standard 1/4" O.D. probe. This feature also significantly enhances the thermal transfer from the media to the temperature sensor.

The external and internal threads are machined to meet published specifications exactly, and each well is individually inspected to insure thread integrity. Hexagon wrench flats are provided to assist in installing the well in the pipe. Other thermowells that incorporate dissimilar metals like brass and copper which are welded/soldered together are susceptible to leaks caused by thermal shock. In HVAC applications, the temperature of the media may change rapidly and due to different coefficient of thermal expansion, a welded/soldered thermowell may leak. The A-500 Thermowell has a single piece construction and, as a result, is immune to leaks which may be caused by thermal shock or weak welds.

The MAMAC A-500 Thermowell is available in 4", 6", 8" and 12" lengths to handle pipe diameters from 4" to 24". The Thermowell has an industry standard 3/4" NPT external with a 1/2" NPT internal thread or a 1/2" NPT external with a 1/4" NPT internal thread.

With more than four length options, brass and stainless steel

material choices, two external thread and two internal thread options, solid leak proof one piece construction, and precision machining enable the A-500 Thermowell to reliably accommodate all HVAC immersion temperature sensing applications.

In order to improve thermal transfer and to eliminate condensation forming within the Thermowell, MAMAC Systems offers a high grade Thermal Compound for the A-500 series Thermowell. The A-505 Thermal Compound is a synthetic, ester based white homogeneous paste, filled with heat conductive metal oxides, providing efficient thermal conductivity with negligible bleed and evaporation loss even at high working temperatures. A-505 exhibits no particle migration, fluid separation or hardening. Unlike silver oxide thermal compounds which may react with the temperature sensor probe in the presence of contaminants, the A-505 is totally inert and does not exhibit catalytic behavior between the probe material and the Thermowell.

The A-505 Thermal Compound has a specific gravity of 2.9 at 77°F, service temperature of - 40°F to 392°F, and thermal conductivity exceeds  $19.0 \times 10^{-4}$  (calories/ cm<sup>2</sup>/° C/sec/cm). The A-505 Thermal Compound is available in conveniently packaged 1 oz. syringes. We highly recommend using the Thermal Compound with the A-500 Thermowell to insure that there is no condensation within the Thermowell and to improve the heat transfer from the media to the temperature sensor.



# MAMAC SYSTEMS®

MONITOR • DECISION • CONTROL

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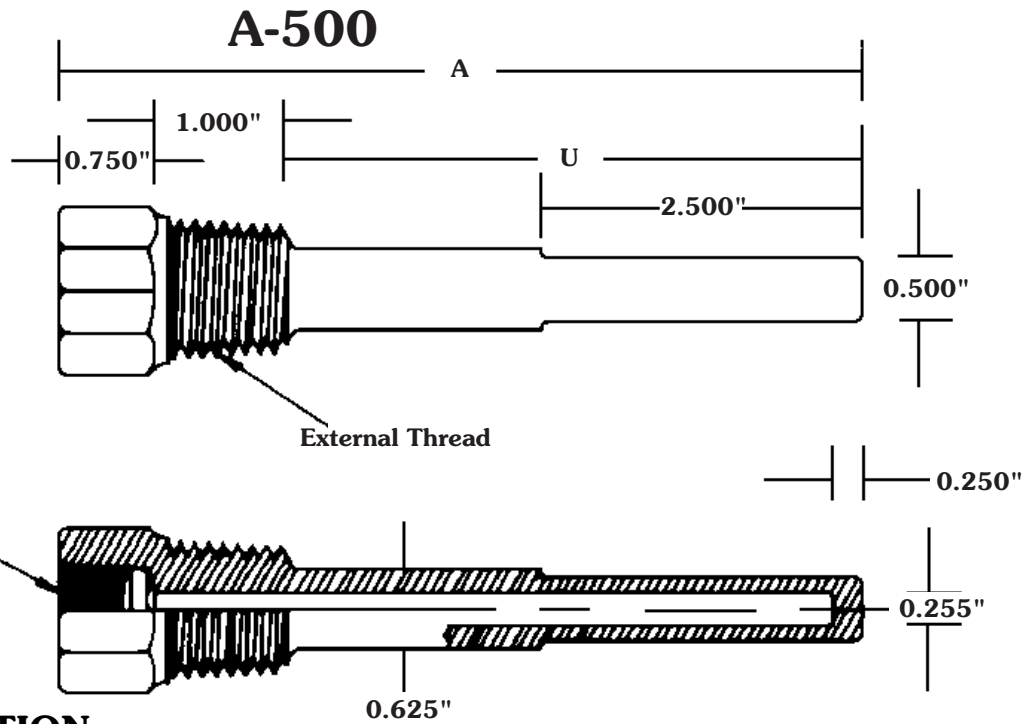
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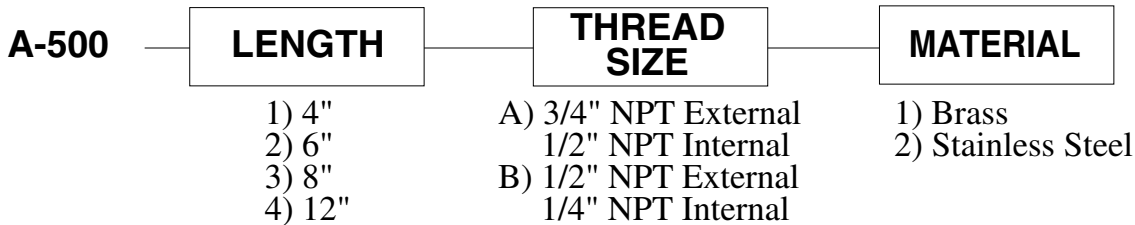
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	A	U
A-500-1 (4")	4 1/4"	2 1/2"
A-500-2 (6")	6 1/4"	4 1/2"
A-500-3 (8")	8 1/4"	6 1/2"
A-500-4 (12")	12 1/4"	8 1/2"



**ORDERING INFORMATION:  
THERMOWELL:**



**THERMAL COMPOUND:**

**A-505 (1 oz./28gm. Syringe)**

The MAMAC Systems warranty covers parts and labor for 2 years from date of shipment. MAMAC Systems reserves the right to change any specifications without notice to improve performance, reliability, or function of our products.

**A Complete Line of Control Peripherals From a Single Source**

MAMAC Systems is the only manufacturer offering more than fifty products to satisfy all temp, humidity, pressure, flow, light, speed or any other DDC controls application. MAMAC's complete line of control peripherals is available in over two thousand different configurations of supply voltage, output, range and enclosure type to make our products guaranteed compatible to all HVAC controls, industrial automation and COGEN systems worldwide.

Single source accountability, liberal 2 year warranty, worldwide service and technical support, competitive pricing, accumulated experience or more than 10,000 installations are some of the benefits offered by MAMAC Systems



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65-3927273 • Fax 65-3927276

## H8035/8036 Series Enercept® Networked Power Meters (Modbus® RTU)

Integral submetering solution eliminates the need for separate enclosures!



FIVE-YEAR  
**5**  
WARRANTY

Power meter inside a CT...Great Idea!

The Enercept H8035/8036s are three-phase networked (Modbus RTU) power meters used for energy services metering/submetering in commercial and industrial applications. These innovative meters combine power metering electronics and high accuracy industrial grade CTs in a single package, eliminating the need for external electrical enclosures and greatly reducing installation time and cost.

There are two application specific platforms to choose from. The Basic Enercept Energy Meters (H8035) are ideal for submetering applications where only kW and kWh are required. The Enercept Enhanced Data Stream meters (H8036) output 26 energy variables including kW, kWh, volts, amps and power factor, making them ideal for power monitoring and diagnostics.

Installing these meters is simple. Just connect the three, colored voltage leads to the power conductors to be monitored, and match the color coded CTs (e.g., red voltage lead and red CT must be on the same conductor). To further simplify the installation, these meters automatically detect and compensate for phase reversal, eliminating the concern of CT load orientation. Up to 63 power meters can be daisy-chained on a single RS-485 network.

### Applications

- Energy management & performance contracting
- Submetering for commercial tenants
- Activity based costing in commercial and industrial facilities
- Real-time power monitoring

### The world's most cost-effective meter

- Monitor energy parameters (kW, kWh, kVAR, PF, Amps, Volts) at up to 63 locations on a single RS-485 network...greatly reduces wiring time and cost
- Fast split-core installation eliminates the need to remove conductors
- Precision metering electronics and current transformers in a single package—reduces the number of installed components—huge labor savings
- Smart electronics eliminate CT orientation concerns—fast trouble free installation

### High accuracy

- $\pm 1\%$  system accuracy conforms to ANSI C12.1 metering standards (from 10-100% of CT rating)

### ORDERING INFORMATION

#### Modbus Basic Energy Meters

MODEL	MAX. AMPS	CT SIZE
H8035-0100-2	100	SMALL
H8035-0300-2	300	SMALL
H8035-0400-3	400	MEDIUM
H8035-0800-3	800	MEDIUM
H8035-0800-4	800	LARGE
H8035-1600-4	1600	LARGE
H8035-2400-4	2400	LARGE

#### Modbus Enhanced Data Stream Meters\*

MODEL	MAX. AMPS	CT SIZE
H8036-0100-2	100	SMALL
H8036-0300-2	300	SMALL
H8036-0400-3	400	MEDIUM
H8036-0800-3	800	MEDIUM
H8036-0800-4	800	LARGE
H8036-1600-4	1600	LARGE
H8036-2400-4	2400	LARGE

\*H8036 models work with H8920-1 LON nodes

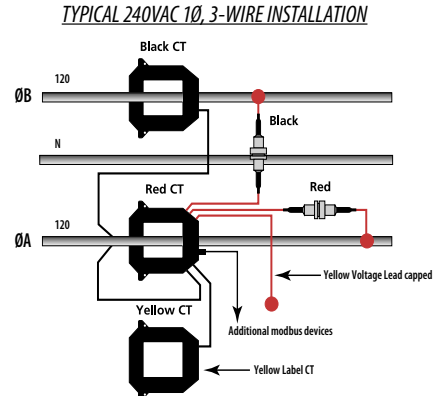
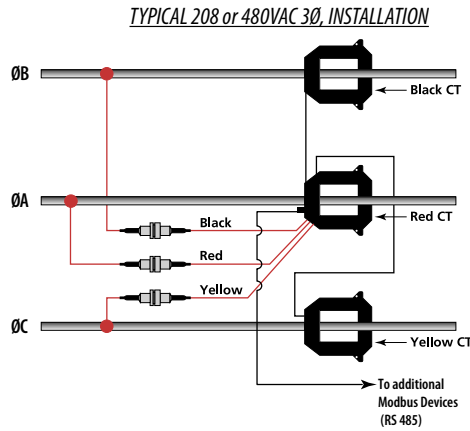
\*H8035 models work with H8920-5 LON nodes



For N2 protocol versions, order H8025-xxxx-x, or H8026-xxxx-x. Other protocols available, consult factory.



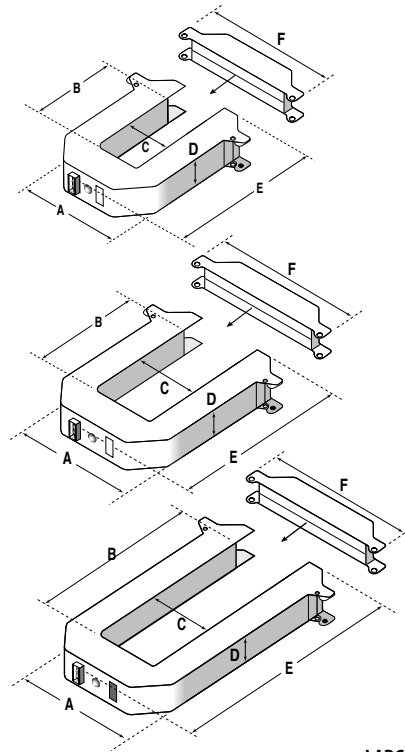
APPLICATIONS/WIRING EXAMPLE



**H8035/6 SERIES SPECIFICATIONS**

Input Primary Voltage	208 to 480VAC rms <sup>††</sup>
Number of Phases Monitored	One to Three
Frequency	50/60Hz
Primary Current	Up to 2400 amps cont. per phase <sup>††</sup>
Internal Isolation	2000VAC rms
Insulation Class	600VAC rms <sup>†††</sup>
Temperature Range	0 to 60°C, 50°C for 2400A
Humidity Range	0 - 95% non-condensing
Accuracy	±1% per ANSI C12.1 (from 10-100% of CT rating)
Output Physical Characteristics	RS-485, 2 wire plus shield
Baud Rate	9600, 8N1 format
Protocol	Modbus RTU <sup>**</sup> (*)
Current Transformer Split-Core	100, 300, 400, 800, 1600, 2400 amps

**DIMENSIONAL DRAWINGS**



**H8035 Data Output Specifications**

Data Output	kWh
	kW

**H8036 Data Output Specifications**

Data output:	kWh, Consumption	Power factor ØA <sup>†</sup>
	kW, Real Power	Power factor ØB <sup>†</sup>
	kVAR, Reactive power	Power factor ØC <sup>†</sup>
	kVA, Apparent power	Voltage, ØA to ØB
	Power factor	Voltage, ØB to ØC
	Average Real power	Voltage, ØA to ØC
	Minimum Real power	Voltage, ØA to Neutral <sup>†</sup>
	Maximum Real power	Voltage, ØB to Neutral <sup>†</sup>
	Voltage, line to line	Voltage, ØC to Neutral <sup>†</sup>
	Voltage, line to neutral <sup>†</sup>	Amps, Current ØA
	Amps, Average current	Amps, Current ØB
	kW, Real power ØA <sup>†</sup>	Amps, Current ØC
	kW, Real power ØB <sup>†</sup>	
	kW, Real power ØC <sup>†</sup>	

<sup>\*\*</sup>Detailed protocol specifications are available at: <http://www.veris.com/modbus/>

(\*) Other protocols available. Please consult factory.

<sup>†</sup> Based on derived neutral voltage.

<sup>††</sup> Contact factory to interface for voltages above 480VAC or current above 2400 Amps.

<sup>†††</sup> Do not apply 600V Class current transformers to circuits having a phase-to-phase voltage greater than 600V, unless adequate additional insulation is applied between the primary conductor and the current transformers. Veris assumes no responsibility for damage of equipment or personal injury caused by products operated on circuits above their published ratings.

SMALL 100 Amp 300 Amp	MEDIUM 400 Amp 800 Amp	LARGE 800 Amp 1600 Amp 2400 Amp
A = 3.75" (95 mm)	A = 4.90" (124 mm)	A = 4.90" (124 mm)
B = 1.51" (38 mm)	B = 2.89" (73 mm)	B = 5.50" (140 mm)
C = 1.25" (32 mm)	C = 2.45" (62 mm)	C = 2.45" (62 mm)
D = 1.13" (29 mm)	D = 1.13" (29 mm)	D = 1.13" (29 mm)
E = 4.20" (107 mm)	E = 5.57" (141 mm)	E = 8.13" (207 mm)
F = 4.75" (121 mm)	F = 5.92" (150 mm)	F = 5.92" (150 mm)



# Hawkeye® 721LC/721HC/921

**Solid- & Split-Core 4-20mA Output Loop Powered Current Transducers**

**5 Year Warranty**

The Hawkeye 721LC, 721HC, & 921 provide accurate load trending information with a proportional 4-20mA output signal. Preset slide-switches provide easy field setup of sensed amperage range without clumsy jumpers.

**APPLICATIONS**

- Load trending
- Motor control

**Loop powered analog current sensor simplifies installation**

- Power the sensor and receive the signal with only two wires...lower cabling & commissioning costs than with traditional 3-wire sensors
- Self-gripping split-core for fast retrofit installation... no need to remove conductor (H921)
- Economical solid-core features adjustable bracket for easy alignment

**Selectable factory calibrated ranges up to 200A for increased flexibility and resolution**

- Factory calibrated switch selectable ranges for high resolution and installation ease
- Three field-selectable ranges per unit... fewer versions to choose from, stock, and install
- Mounting bracket for installation flexibility
- 5-year limited warranty



**ORDERING INFORMATION**

MODEL	AMPERAGE RANGE	OUTPUT TYPE
H721LC Solid-Core	0-10/20/40A	4-20mA, loop powered
H721HC Solid-Core	0-50/100/200A	4-20mA, loop powered
H921 Split-Core	0-30/60/120A	4-20mA, loop powered

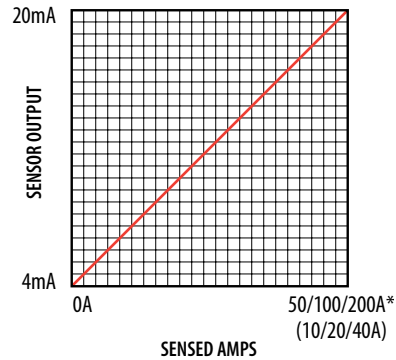


\*H921 only

**ACCESSORIES**

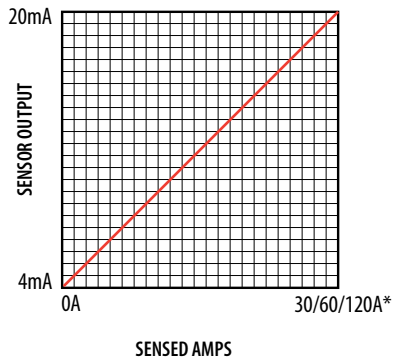
Universal Power Supply, Universal Mounting Bracket Kit...See page 234

**H721HC (LC) LINEAR OUTPUT**  
Scale software as shown



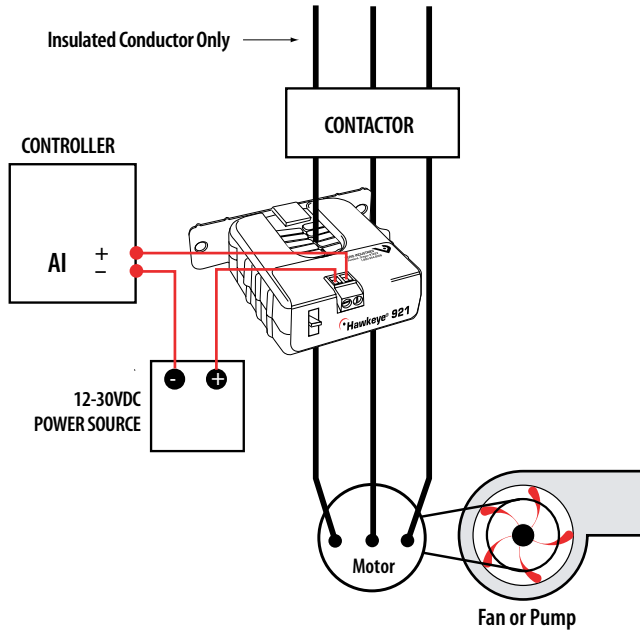
\*Factory calibrated ranges selected with the amperage range switch

**H921 LINEAR OUTPUT**  
Scale software as shown

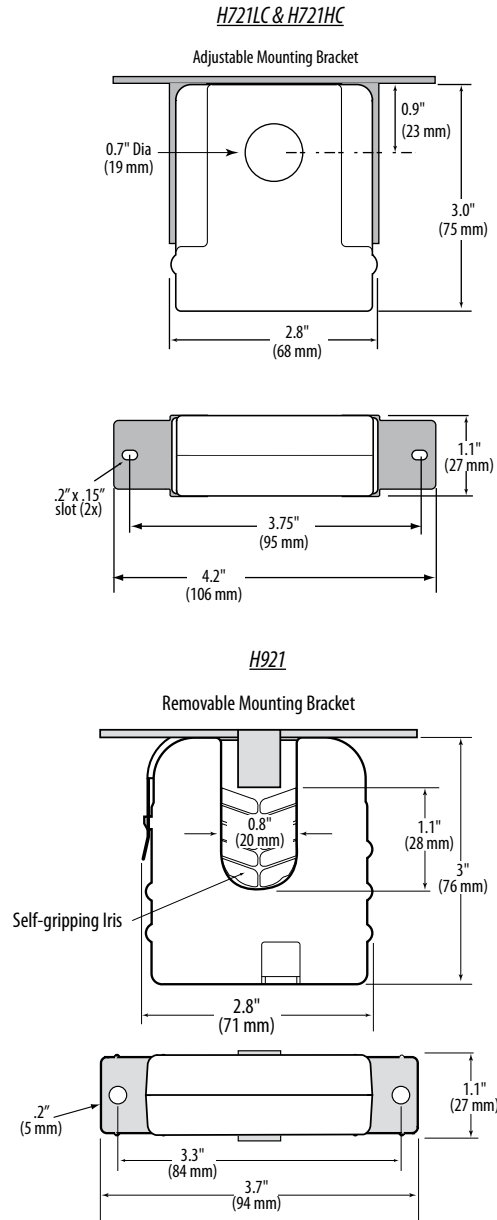


\*Factory calibrated ranges selected with the amperage range switch

**APPLICATIONS/WIRING EXAMPLE**



**DIMENSIONAL DRAWINGS**



**SPECIFICATIONS**

<b>Amperage Range</b>	See ordering table
<b>Output</b>	4-20mA DC
<b>Insulation Class</b>	600VAC rms (UL), 300VAC rms (CE)
<b>Frequency</b>	50/60Hz.
<b>Temperature Range</b>	-15° to 60°C
<b>Humidity Range</b>	10 - 90%RH non-condensing
<b>Accuracy</b>	±2%FS from 10% - 100% of selected range, but not less than ±0.4A
<b>Response Time</b>	2 sec.
<b>Supply Voltage</b>	12-30VDC Loop powered
<b>Supply Current</b>	30mA (max.)

Specification Note: For CE compliance, conductor shall be insulated according to IEC 61010-1:2001, Installation Category III or equivalent. The unit design provides for basic insulation only. For applications requiring double or reinforced insulation, please contact the factory.

# TURBINE METERS

## For Water Totalization

FTB-4105A

**\$105**



Shown smaller than actual size.

- ✓ For Water Flows from 0.13 to 132 GPM
- ✓ Scaled Pulse Output Available for Remote Totalization
- ✓ For Hot or Cold Water Applications
- ✓ Up to ±1.5% of Reading Accuracy

Designed for water billing applications, OMEGA's FTB-4100A flowmeters are highly accurate and feature tamper-resistant, non-resettable totalizers. The large faces are easy to read.

Optional reed relay scaled pulse outputs allow for remote totalization [1.8 m (6') of cable included]. The pulse output option is factory installed and must be requested at the time of order.

All FTB flowmeters feature built-in strainers and trickle flow indication and come with locking nuts and coupling pieces.

For remote rate indication for units with high-frequency pulse output, see FTB4600 Series, page F-92.

### SPECIFICATIONS

**Accuracy:** From 10% of continuous to max flow: ±1.5% of reading; below 10% of continuous flow: ±2% of reading

**Power for Pulse Output:** 6 to 16 Vdc

**Max Temp:** 93°C (200°F)

**Max Pressure:** 150 psi

**Pulse Outputs (Reed Relay):**

**FTB-4100A-P Series:** 1 gal/pulse (for remote totalization only)

**Max Reading (Gallons):** 10 million for ½" and ¾"; 100 million for 1", 1¼", 1½"

**Wetted Parts:** Brass body, stainless steel polyimide (fiberglass), polypropylene, EPDM O-ring

**Installation Requirements:** 10 pipe diameters upstream, 5 downstream

**Mounting:** Horizontal mounting required for 1", 1¼", and 1½" models; vertical mounting for ½" and ¾" sizes only

**Compatible Meter:** DPF70 (see page F-80 for details)

**MOST POPULAR MODELS HIGHLIGHTED!**

### To Order (Specify Model Number)

Model No.	Price	Flow Rate (GPM)			Conn. MNPT	Body Length mm (in)	NPT Length mm (in)	Height mm (in)	Width mm (in)	Press. Drop*	Weight kg (lb)	Max Temp °C (°F)
		Min	Cont.	Max								
FTB-4105A	\$105	0.13	6.6	13	½	110 (4.33)	60 (2.36)	70 (2.75)	70 (2.75)	3.6	0.5 (1.1)	93 (200)
FTB-4105A-P	180	0.13	6.6	13	½	110 (4.33)	60 (2.36)	70 (2.75)	70 (2.75)	3.6	0.5 (1.1)	93 (200)
FTB-4107A	109	0.22	11	20	¾	130 (5.12)	63 (2.48)	77 (3.03)	70 (2.75)	3.6	0.6 (1.4)	93 (200)
FTB-4107A-P	195	0.22	11	20	¾	130 (5.12)	63 (2.48)	77 (3.03)	70 (2.75)	3.6	0.6 (1.4)	93 (200)
FTB-4110A	229	0.5	26.4	50.0	1	260 (10.24)	67 (2.64)	140 (5.51)	92 (3.62)	3.6	2.5 (5.5)	93 (200)
FTB-4110A-P	288	0.5	26.4	50.0	1	260 (10.24)	67 (2.64)	140 (5.51)	92 (3.62)	3.6	2.5 (5.5)	93 (200)
FTB-4112A	262	0.5	26.4	50.0	1¼	260 (10.24)	73 (2.87)	140 (5.51)	92 (3.62)	3.6	2.5 (5.5)	93 (200)
FTB-4112A-P	337	0.5	26.4	50.0	1¼	260 (10.24)	73 (2.87)	140 (5.51)	92 (3.62)	3.6	2.5 (5.5)	93 (200)
FTB-4115A	466	0.8	44.0	90.0	1½	300 (11.81)	73 (2.87)	140 (5.51)	120 (4.72)	3.6	5.4 (12.0)	93 (200)
FTB-4115A-P	546	0.8	44.0	90.0	1½	300 (11.81)	73 (2.87)	140 (5.51)	120 (4.72)	3.6	5.4 (12.0)	93 (200)
FTB-4120A	805	1.3	66.0	132.0	2	270 (10.63)	Flange	226 (8.90)	155 (6.10)	2.9	12.4 (27.0)	90 (194)
FTB-4120A-P	880	1.3	66.0	132.0	2	270 (10.63)	Flange	226 (8.90)	155 (6.10)	2.9	12.4 (27.0)	90 (194)

Models with suffix "P" are for reed relay pulse output, for remote totalization only. ½" to 1½" have NPT connections; the 2" meters have flanged connections.

\* Pressure loss is at continuous flow rate. \*\* Consult Flow Engineering Department.

Comes with complete operator's manual.

**Ordering Examples:** FTB-4105A-P, pulse output meter with minimum flow rate of 0.13 GPM and maximum flow rate of 13.0 GPM, maximum water temperature 90°C (200°F), \$180. FTB-4115A, pulse output meter with minimum flow rate of 0.8 GPM and maximum flow rate of 90.0 GPM, max water temperature 93°C (200°F), \$466.



#### UNITED STATES

[www.omega.com](http://www.omega.com)  
1-800-TC-OMEGA  
Stamford, CT.

#### CANADA

[www.omega.ca](http://www.omega.ca)  
Laval(Quebec)  
1-800-TC-OMEGA

#### GERMANY

[www.omega.de](http://www.omega.de)  
Deckenpfronn, Germany  
0800-8266342

#### UNITED KINGDOM

[www.omega.co.uk](http://www.omega.co.uk)  
Manchester, England  
0800-488-488

#### FRANCE

[www.omega.fr](http://www.omega.fr)  
Guyancourt, France  
088-466-342

#### CZECH REPUBLIC

[www.omegaeng.cz](http://www.omegaeng.cz)  
Karviná, Czech Republic  
596-311-899

#### BENELUX

[www.omega.nl](http://www.omega.nl)  
Amstelveen, NL  
0800-099-33-44



## More than 100,000 Products Available!

### • Temperature

Calibrators, Connectors, General Test and Measurement Instruments, Glass Bulb Thermometers, Handheld Instruments for Temperature Measurement, Ice Point References, Indicating Labels, Crayons, Cements and Lacquers, Infrared Temperature Measurement Instruments, Recorders Relative Humidity Measurement Instruments, RTD Probes, Elements and Assemblies, Temperature & Process Meters, Timers and Counters, Temperature and Process Controllers and Power Switching Devices, Thermistor Elements, Probes and Assemblies, Thermocouples Thermowells and Head and Well Assemblies, Transmitters, Wire

### • Flow and Level

Air Velocity Indicators, Doppler Flowmeters, Level Measurement, Magnetic Flowmeters, Mass Flowmeters, Pitot Tubes, Pumps, Rotameters, Turbine and Paddle Wheel Flowmeters, Ultrasonic Flowmeters, Valves, Variable Area Flowmeters, Vortex Shedding Flowmeters

### • pH and Conductivity

Conductivity Instrumentation, Dissolved Oxygen Instrumentation, Environmental Instrumentation, pH Electrodes and Instruments, Water and Soil Analysis Instrumentation

### • Data Acquisition

Auto-Dialers and Alarm Monitoring Systems, Communication Products and Converters, Data Acquisition and Analysis Software, Data Loggers Plug-in Cards, Signal Conditioners, USB, RS232, RS485 and Parallel Port Data Acquisition Systems, Wireless Transmitters and Receivers

### • Pressure, Strain and Force

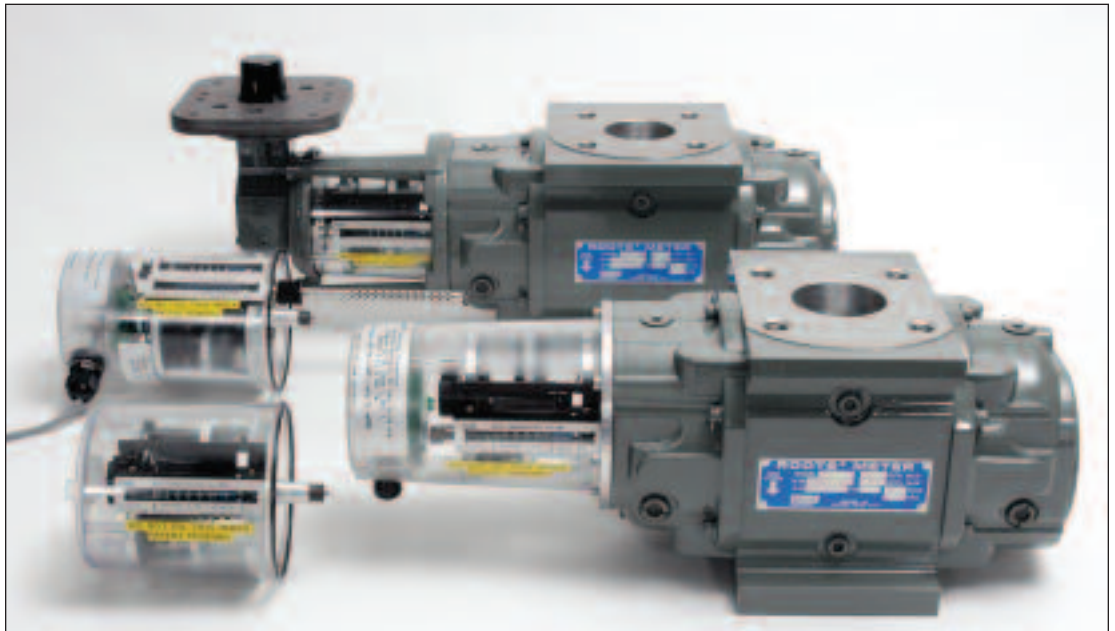
Displacement Transducers, Dynamic Measurement Force Sensors, Instrumentation for Pressure and Strain Measurements, Load Cells, Pressure Gauges, Pressure Reference Section, Pressure Switches, Pressure Transducers, Proximity Transducers, Regulators, Strain Gages, Torque Transducers, Valves

### • Heaters

Band Heaters, Cartridge Heaters, Circulation Heaters, Comfort Heaters, Controllers, Meters and Switching Devices, Flexible Heaters, General Test and Measurement Instruments, Heater Hook-up Wire, Heating Cable Systems, Immersion Heaters, Process Air and Duct, Heaters, Radiant Heaters, Strip Heaters, Tubular Heaters



## **ROOTS® Meter Series B3** **Featuring Series 3 Accessory Units**



Series B3 version ROOTS® meters are designed to provide accurate gas measurement over a wide range of flow, pressure and temperature conditions.

### **Available Types Include:**

- CTR – Non-Compensated Counter
- CD – Non-Compensated Counter with Instrument Drive
- TC – Temperature Compensated Counter
- TD – Temperature Compensated Counter with Instrument Drive
- CTR or TC with Solid State Pulser – Low Frequency pulse output
- CTR or TC with AMR Adapter
- CEX – Counter (CTR) with High Frequency Transmitter/Pulser

Series B meter bodies are also available with the integral electronic ROOTS® IMC/C2 or IMC/W2 volume, pressure and temperature corrector, or the ROOTS® IMC/W2-T for a “temperature only” corrected reading.



## ROOTS® Series B3

Meter Specifications														
SERIES B3	Units	8C175	11C175	15C175	2M175	3M175	5M175	7M175	11M175	16M175	23M175	23M232	38M175	56M175
Base Rating	acfh	800	1100	1500	2000	3000	5000	7000	11000	16000	23000	23000	38000	56000
Max. Operating Pressure	psig	175*	175*	175*	175	175	175	175	175	175	175	175	175	175
Rangeability +/-1%	ratio	26:1	31:1	40:1	100:1	76:1	120:1	67:1	124:1	116:1	40:1	169:1	90:1	53:1
Rangeability +/-2%	ratio	46:1	58:1	78:1	200:1	139:1	215:1	115:1	227:1	223:1	60:1	278:1	110:1	109:1
Start Rate	acfh	2.79	2.30	1.94	1.01	2.1	1.2	5.3	3.9	3.2	23	10.33	27	40
Stop Rate	acfh	2.03	1.74	1.57	0.82	1.8	0.8	3.4	3.2	1.9	18	5.75	20	29
Flow Rate, 0.5" w.c., Gas	acfh	800	1100	1500	2000	2580	3975	5400	7300	9950	14800	10948	20600	23000
Differential, 100% Flow	in.w.c.	0.45	0.6	0.75	0.65	1.1	1.1	1.6	1.06	2.1	1.3	2.08	1.9	2.2
Drive Rate, CD/TD	cf/rev	10/100	10/100	10/100	10/100	10/100	10/100	10/100	10/100	100/1000	100/NA	100/NA	100/NA	100/NA
Min. CTR Reading	cf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2	2	2	2	2
Nominal Pipe Size	in.	2	2	2	2	2	3	3	4	4	6	4	6	8
Flange/Flange Dim.	in.	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	9-1/2	9-1/2	9-1/2	16	15/16	18	21
Oil Capacity: Side Inlet	oz.	0.8	0.8	0.8	1.3	1.3	1.3	3	3	3	40	3.4	40	40
Oil Capacity: Top Inlet	oz.	3	3	3	7.6	7.6	7.6	21.9	21.9	21.9	154	21.8	154	154

Meter Sizing														
Model	8C175*	11C175*	15C175*	2M175*	3M175*	5M175*	7M175	11M175	16M175	23M175	23M232	38M175	56M175	
Base Rating (acfh)	800	1100	1500	2000	3000	5000	7000	11000	16000	23000	23000	38000	56000	
Meter Pressure (psig)	Corrected Capacity at Metering Pressure - MSCFH													
1	0.84	1.2	1.6	2.1	3.1	5.2	7.3	11.5	16.7	24	24	39.7	58.5	
5	1.1	1.5	2	2.6	4	6.6	9.2	14.5	21.1	30.3	30.3	50	73.8	
25	2.1	2.9	4	5.4	8	13.4	18.7	29.4	42.8	61.5	61.5	101.7	149.8	
60	4	5.6	7.6	10.1	15.2	25.3	35.4	55.6	80.8	116.2	116.2	191.9	282.9	
100	6.2	8.5	11.7	15.5	23.3	38.8	54.4	85.4	124.3	178.6	178.6	295.1	434.9	
150	8.9	12.3	17	22.3	33	56	78	123	179	256.7	256.7	424.1	625	
175	10.3	14.1	19	25.7	39	64	90	141	206	295.7	295.7	488.6	721.5	
200	11.7	16	21.9	29.1	43.7	72.8						334.8		
232												384.7		

\*Available with 200 psig Rating.

To select proper meter size, use Minimum Operating Pressure and Maximum Instantaneous Hourly Flow Rate.  
Complete Data Sheets are available for each meter size. Request Data Sheet by meter model.



### Dresser Roots Meters & Instruments

P. O. Box 42176  
Houston, TX 77242-2176  
website: www.dresser.com

### Dresser, Inc.

Inside US Ph: 800.521.1114 Fax: 800.335.5224  
Outside US Ph: 832.590.2303 Fax: 832.590.2494  
www.rootsmeters.com

# ROOTS Meters & Instruments

## **Full Range of Sizes:**

13 meter sizes offer a competitive range of rotary meters for commercial and industrial metering applications. Select the correct meter size for cost effectiveness and accurate measurement.

## **Standardized Flanges:**

Sizes 8C through 3M have a 6-3/4" (171mm) flange-to-flange dimension for standardization in the meter set design. As loads change, meter sizes are easily interchanged, saving the cost of re-piping.

## **Accurate Low Flow Performance:**

Low start/stop rates extend the rangeability (gas measured) over a wider range of flow conditions.

## **Low Pressure Differentials:**

Reducing the maximum operating speed provides lower pressure differentials for low pressure applications, as well as extending the meter's life-expectancy.

## **SERIES 3 ACCESSORY UNITS**

### **Oil-free Design:**

Series 3 accessories feature high quality and long-term reliability with an oil-free permanently lubricated design. Oil is not required for the Polymer bushings and pre-lubricated, shielded ball bearings. Permanent lubrication equates to easier installation and less maintenance.

### **Durable, Weather Resistant Cover:**

Optical Quality Lexan® covers on Series 3 accessories offer exceptional Ultraviolet protection while the cylindrical design allows the unit to easily shed rain, snow, ice and dirt. The single piece cover design provides added protection against leakage under extreme conditions.

### **High and Low Frequency Pulsar Options:**

The Counter with Electronic Transmitter (ICEX) provides a high frequency non-compensated pulse output for applications requiring information on the gas flow rate while the low frequency solid state pulsers are a lower cost option for both non-compensated (ICPWX) and temperature compensated (ITPWX) volume accumulation applications.

### **Non-Moving Odometer Masking System:**

A unique and versatile odometer masking design using opaque or semi-transparent covers offers configurable, trouble-free masking.

### **Universal Instrument Drive (ID) Assembly:**

One size fits all with the Series 3 Instrument Drive Assembly. Inventory costs are reduced by stocking one ID Assembly.

### **AMR Adapter:**

The new direct drive AMR Adapter offers you a low cost solution for Series B3 CTR or TC meters in applications that require the adaptation of a Residential ERT or Cellnet AMR. The AMR Adapter is available as a conversion kit for field installation or factory installed on new meters.

**PRODUCT  
DATA**

## General Information

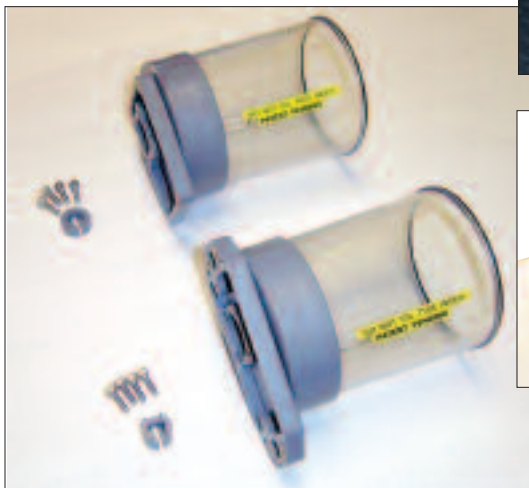
The Series B3 ROOTS® meter is a positive displacement, rotary type gas meter designed for continuously measuring and indicating the accurate measurement of gas. ROOTS® meters are suitable for handling most types of clean, dry, common gases at either constant or varying flow rates. Meters of standard construction are not directly suitable for handling acetylene, biogas or sewage gas. Contact the factory for information on specially constructed meters made of materials more compatible with these and other gases.

Volumetric accuracy of the ROOTS® meter is permanent, non-adjustable, and is not affected by low or varying line pressure. Series B3 meters may be used satisfactorily for pressures ranging from a few ounces to full Maximum Allowable Operating Pressure (MAOP). Displaced volume measurement is completely independent of the gas specific gravity, temperature, and pressure.

Series B ROOTS® meters have a MAOP rating of 175 psig (1200kPa). Every meter is static pressure tested at the factory at twice its MAOP and leak tested at 125 percent of MAOP in accordance with ASME Boiler Pressure Vessel Codes. Other pressure ratings are available. Consult Factory.

ROOTS® meters are manufactured in accordance with ANSI B109.3 for Rotary Type Gas Displacement Meters. Series B3 ROOTS® meter sizes 8C through 56M, have flanged inlet and outlet connections conforming dimensionally with ANSI/ASME standards. Sizes 8C through 2M are available with 1-1/2" NPT connections, upon special request. The meter operating temperature range is from -40°F to +140°F (-40°C to +60°C) while the temperature compensating mechanism of the TC accessory provides a corrected reading for temperatures ranging from -20°F to +120°F (-29°C to +49°C).

*Series B ROOTS® meter bodies accept a wide range of Series 3 accessories for all metering applications.*

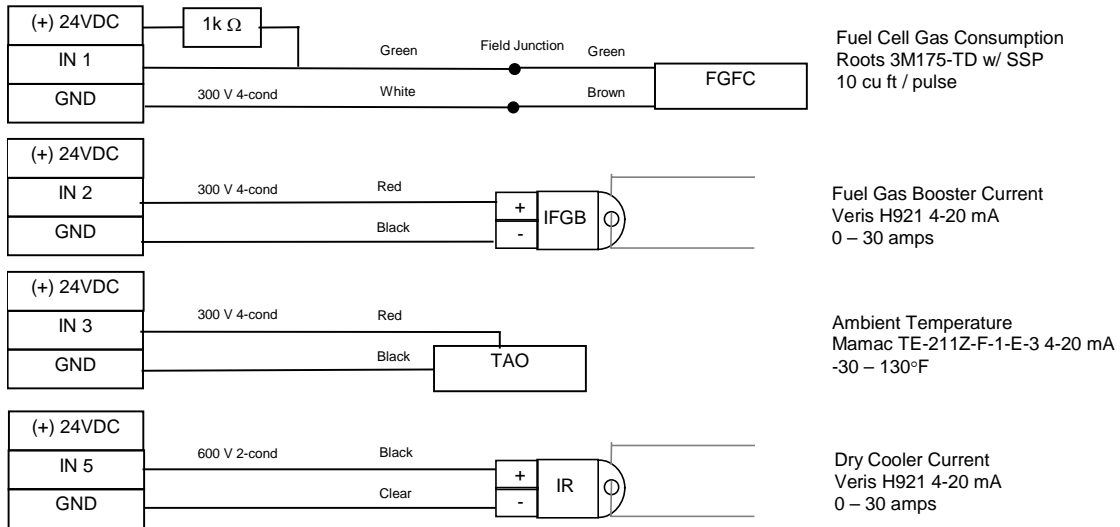


*AMR Adapter and ERT installed on a ROOTS Meter (top inlet meter installation shown)*

*AMR Adapters for Series B3 ROOTS Meter.*

## **APPENDIX B – Data Logger Wiring Diagrams**

**Obvius Acquisite A8812 Data Logger  
Digital/Analog Terminals**



**Obvius Acquisite A8812-1 Data Logger  
Modbus Terminal**

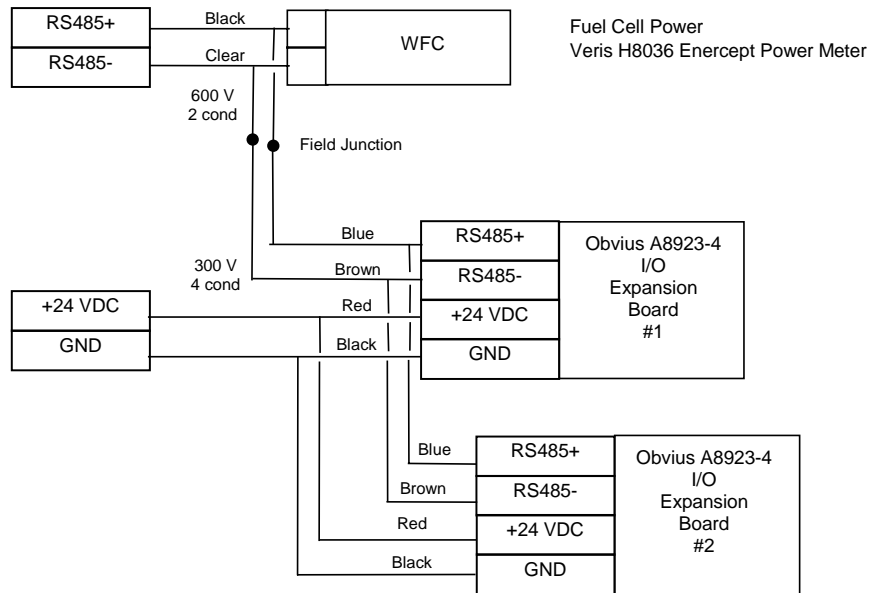


Figure 22. Data Logger Modbus Loop Wiring Schematic

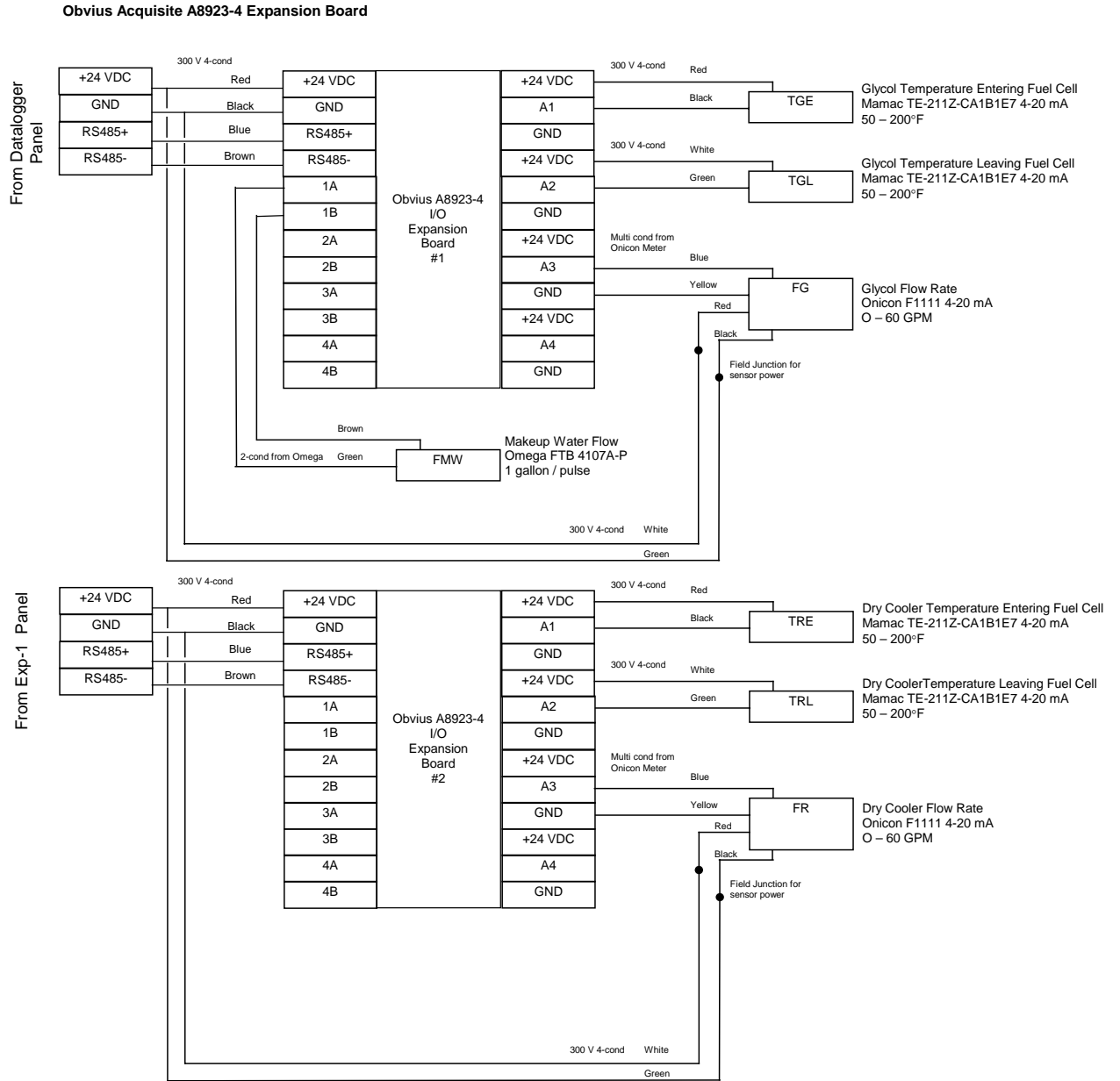


Figure 23. Expansion Board Wiring Schematic

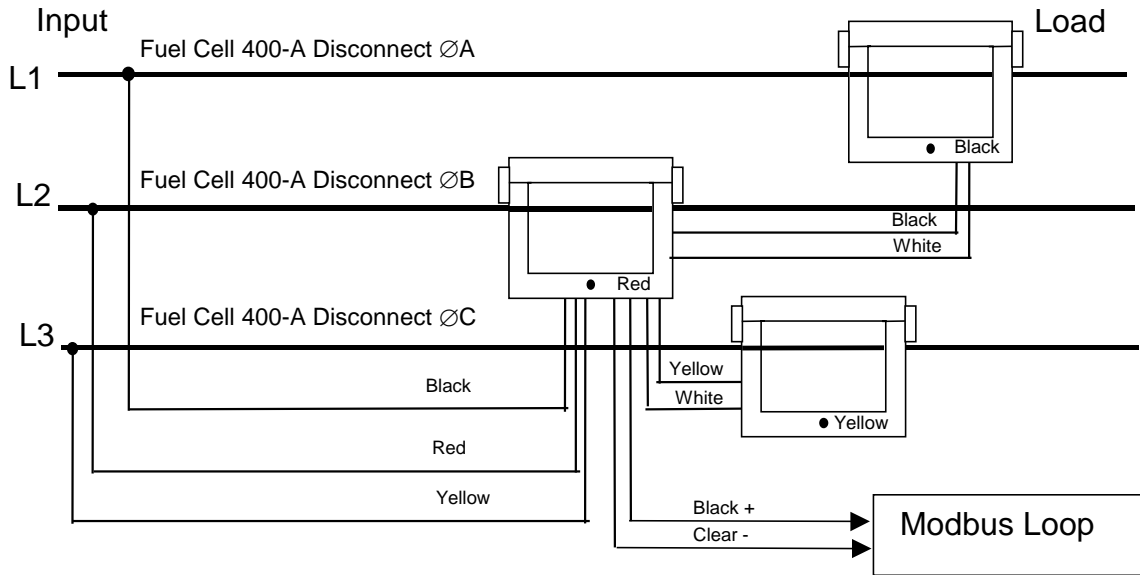


Figure 24. Fuel Cell Power Transducer Schematic