

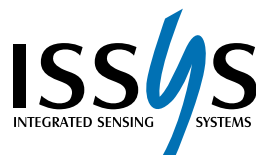
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# User Manual For Installation and Operation

ISSYS PN 105916

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## Integrated Sensing Systems, Inc. Micro Liquid Density Sensors



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# 1. DESIGNATED USE

## 1.1 Micro Density Products Overview

Integrated Sensing Systems, Inc. has created a line of micro density measurement products built around ISSYS core technology of fluidic sensors, software and packaging. These products are available in two versions, which are focused on two completely different application markets. This manual will cover both products.

## 1.2 MicroMCS, Methanol Concentration Sensor

The microMCS has a very focused application target, the direct methanol fuel cell (DMFC). The microMCS is the replacement for the previous ISSYS FC10 methanol concentration sensor. It is an improvement over the FC10 with upgraded electronics and software.

The microMCS differs from the FC10 in that the unit uses the density of the methanol water mixture and mixture temperature in an internal equation that calculates wt% methanol. The standard measurement range is 0-10wt% methanol in water. Optional methanol ranges are available, consult the factory if there is an interest. Concentration and temperature outputs are communicated using the standard voltage outputs. A digital RS232 output is available as an option.

### Example Applications

Direct methanol fuel cells

Measuring methanol concentration in windshield deicing solutions

### 1.3 MicroLDS, Liquid Density Sensor

The microLDS is a general-purpose liquid density sensor that is targeted at embedded OEM applications where density is needed in a small package. It has a density measurement range of 0.6 to 1.3 grams/cc. The microLDS is available with the RS232 connection and also a version of the ISSYS Fluidic Communication Software to allow the user to adjust the operation of the meter.

#### Example Applications

Embedded density in analytical applications  
Glycol in water measurements  
Binary liquid concentration measurements

## 2. SAFETY CONSIDERATION

### Warning!

Incorrectly applying this instrument can result in property damage and/or personal injury. Before installing and operating this instrument, read this User Manual.

### 2.1 Operational Safety Considerations

- The micro liquid density products are not designed for operation in hazardous environments. Strict compliance with these installation and operation instructions is a requirement.
- The instrument's external surface temperature can increase due to the power consumption of internal electronic components, and hot process fluids passing through the sensor. Additional precautions should be taken when high fluid temperatures exist to make sure the maximum operating temperature of the instrument is not exceeded.
- The manufacturer reserves the right to modify technical specifications and installation instructions without prior notice. Please contact your local agent to confirm that you have the latest version of the micro Density User Manual or contact Integrated Sensing Systems, Inc.

## 2.2 Installation, Commissioning and Operation

- Mechanical installation, connection to the electricity supply and outside electronics, and routine maintenance of the instrument must be carried out by trained, qualified technicians authorized to perform such work by the facility's owner/operator. The technician must have read and understood this Users Manual and follow the instructions for safe operation of the instrument.
- Assistance in clarifying the chemical resistance properties of the wetted materials exposed to process fluids, including fluids used for cleaning the sensor, is available from ISSYS. Changes in fluid temperature, chemical concentration or the degree of contamination in the process fluid can result in changes in the wetted material chemical resistance properties. Liability for wetted material chemical compatibility in a specific application is the responsibility of the user. The user is responsible for determining if the fluid wetted materials are compatible with the process fluid.
- If welding is being done on the metal tubing feeding the instrument, the welding equipment must not be grounded using the instrument. It is also important to not over heat the instrument from the heat generated when welding the tubing feeding the instrument. The installer must ensure that the system is correctly wired in accordance with the wiring diagrams. The transmitter must be grounded, unless the power supply is galvanically isolated, e.g. galvanically isolated power supply according to SELV (separated or safely extra-low voltage) or PELV (protected extra-low voltage).
- The micro density sensors have no repairable components. Do not attempt to open the case.
- Do not subject the instrument to mechanical shock, such as dropping it, as this may damage the instrument.
- Supplying the instrument with power outside of the specified range of voltage and frequency will damage the instrument.
- Process pressure spikes over 60 psi (4 bar) and rapid pulsating pressures can damage the instrument.
- Freezing and solute crystallization can permanently damage the instrument.
- In certain applications, adequate filtration of the incoming fluid is recommended to prevent clogging the sensor.

## 2.3 Returning Instrument to the Factory

The following procedures must be carried out before an instrument is returned for repair or calibration:

- Contact ISSYS for a Return Merchandise Authorization (RMA) number prior to sending the instrument back. Download an RMA form from the ISSYS website, complete the form and include a copy of the RMA form inside the shipping container. Clearly print the RMA number on the outside of the shipping box.
- Enclose special handling instructions if necessary, for example a Material Safety Data Sheet (MSDS) for the chemicals used in the instrument as per Regulation (EC) No. 1907/2006 REACH.
- Do not return this instrument if traces of hazardous substances have not been removed. Pay special attention to the grooves used in seals and crevices that could trap residues. This is very important if the substances are hazardous to health, e.g. flammable, toxic, caustic, and carcinogenic.
- Costs incurred for additional cleaning, waste disposal and personal injury (burns, etc.) due to inadequate cleaning will be charged to the owner/operator.

## 2.4 Notes on Safety Conventions and Alert Icons

The micro density sensors are designed to meet state-of-the-art safety requirements, have been tested, and left the factory in a condition in which they are safe to operate. These devices can, however, be a source of danger if used incorrectly or for other than the designated use. Consequently, always pay particular attention to the safety instructions indicated in these Operating Instructions by the following icons:

### Warning!

“Warning” indicates an action or procedure which, if not performed correctly, can result in injury or a safety hazard. Comply strictly with the instructions and proceed with care.

### Caution!

“Caution” indicates an action or procedure, which if not performed correctly, can result in incorrect operation or destruction of the device. Comply strictly with the instructions.

### Note!

“Note” indicates an action or procedure which, if not performed correctly, can have an indirect effect on operation or trigger an unexpected response on the part of the device.

## 3. PRODUCT IDENTIFICATION

### 3.1 Product Description

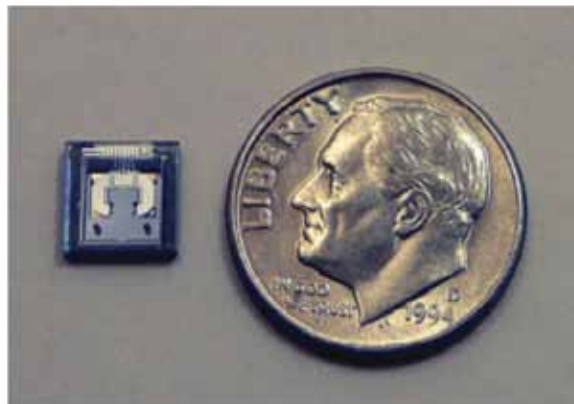
The compact micro density sensors will continuously monitor the density or concentration of fluids in wide variety of applications. The instrument measures liquid density between 0.6 to 1.3 g/cc with three-digit uncertainty of ( $\pm 0.001$  g/cc). The fluid temperature range is from 5 to 70°C. The Maximum operating pressure is 60 psig.

The compact micro density sensors uses a state-of-the-art, proprietary Micro Electro Mechanical System (MEMS) fluidic sensor. This sensor measures fluid density based on the Coriolis principle. The MEMS chip integrates mechanical elements, sensor, and electronics into a tiny package. The micro density sensors have the advantages of high accuracy, very small compact packaging, and fast response time. Installation and system integration is simple since the measuring cell and control electronics are housed in one package.

### 3.2 Technology Overview

The MEMS sensor, created using micro fabrication technology, is a chip-level device that can sense fluidic properties. The electronics used in the device are fabricated using integrated circuit (IC) process sequences. Like wise, the micromechanical components in the fluidic chip are fabricated using compatible “micromachining” processes that selectively etch away parts of the silicon wafer or add new structural layers to form the mechanical and electromechanical devices. The result is a hollow, electrically oscillated silicon structure through which the fluid flows. Embedded in the chip is a 100 ohm platinum RTD for close coupled temperature measurement. Fluid properties such as density are calculated based on a vibrational frequency shift. Factory calibration determines the fundamental vibrational frequency using multiple fluids with known densities.

Size Comparison of MEMS Density Sensor





### 3.3 Available Product Features

- Methanol concentration (standard on microMCS)
- Temperature measurement
- Digital communication (optional)
- Analog outputs: two 0.5-4.5 volts
- Internal fluid bypass 0.018" for low pressure drop measurement
- Fluidic communication software (optional)
- Concentration measurements (optional)

### 3.4 Instrument Nameplates

The serial number for the unit is on the front of the device along with basic configuration information.



### 3.5 Incoming Transport, Additional Shipping and Storage

Every micro liquid density sensor instrument is shipped with a CD-ROM that contains the User Manual, any other relevant documentation and the optional ISSYS Fluidic Communication Software (if purchased). Inspect the package and contents to ensure that no damage has occurred during shipping. Contact the factory if damage has occurred or is suspected prior to installation.

On receipt, inspect the following items:

- Check the packaging and the contents for damage.
- Check to ensure nothing is missing and that the scope of supply matches the order.

If additional transport is required:

- Always transport the instruments in the containers in which they are delivered.
- The covers fitted to the process connections prevent mechanical damage to the sealing faces and prevent ingress of foreign matter during transportation and storage. Do not remove these caps until immediately before installation.

Storage

- Pack the instrument to protect it against damage while in storage. The original packaging will provide optimum protection.
- The permissible storage temperature range is  $-20$  to  $+80$  °C ( $-4$  °F to  $+176$  °F) with the optimum being  $+20$  °C ( $+68$  °F) and moderate humidity.
- The instrument must be protected from direct sunlight during storage to avoid unacceptably high surface temperatures.

## 4. INSTALLATION

### 4.1 General Configuration Information

Every effort is made at the factory during calibration and testing to configure the device to the customer's requirements based on which model was purchased. This includes density units, the temperature units, voltage output process variable selection and ranges. For the microMCS the outputs are set for methanol concentration 0-10 (wt%) and temperature 0-70( C).

The goal is for the microMCS to be ready to generate data as soon as it is plumbed and wired into the system.

For the microLDS the density is set at grams/cc and the temperature is C. Additional measurement units are available. The device can be custom configured to the customer's requirements at the factory (for an additional charge) or can be customized by the customer using the optional ISSYS Fluidic Communication Software.

## 4.2 Physical Installation

The micro density sensors are insensitive to mounting orientation and the direction of flow. The instrument should be securely mounted to a solid support structure using the mounting holes at the edges of the case. All effort should be taken to avoid introducing stress the case of the instrument when mounting the unit to a structure.

 Note:

Do not mount the sensor to a structure that can be stressed due to outside forces. This stress can cause a shift in the density measurement.

The MEMS sensor oscillates at a very high frequency (>20KHz), It is not affected by any vibration of the tubing or vibration transmitted through the mechanical mount.

## 4.3 Fluidic Connections

Fluid connections are available using either plastic barbed fittings or 1/8" stainless steel compression fittings. The plastic barbed fittings are sized for 1/16" ID flexible tubing.

When using stainless steel tubing, take care not to mount the sensor in a system where torque on the steel tubing can be transmitted to the sensor.

 Note:

Always use the hex nut on the compression fitting to tighten the compression fitting. NEVER use the body of the sensor as a counter force to tighten the compression fitting. This can transmit torque into the sensor and cause a measurement shift.

Turbulence from valves, elbows, t-connections, etc. do not affect the operation of the micro density sensor.

 Caution!

Cavitation or high frequency water hammer can effect the operation of the sensor or possibly result in mechanical damage.



## 4.4 Fluid Filtration

Due to the small internal dimensions of the MEMS sensor, install a filter in the incoming tubing to keep particles from contaminating the filter. This is very important in applications that are potentially dirty.



### Caution!

Particles can permanently plug the sensor. The minimum recommend filtration is 50 microns. The product warranty does not cover sensor plugging due to particles.

## 4.5 Thermal Insulation

If mounting the micro liquid density sensor on a thermally conductive surface that is contact with a heat source, the use of a thermal insulation pad between the sensor, bracket and/or mounting surface is recommended to reduce thermal gradients during operation.



### Note!

A thermal gradient across the sensor can lead to measurement errors.


## 4.6 System Pressure and Pressure Spike Protection

Avoid exceeding the published operating pressure specification of the instrument. Ensure that cavitation does not occur in the line feeding the instrument. Cavitation will negatively influence the instrument's performance. No special measures need to be taken for fluids, that have a vapor pressure similar to water under normal conditions. In the case of liquids with a high vapor pressure (hydrocarbons, solvents, liquefied gases) or mounting in suction lines, it is important that the line pressure does not drop below the vapor pressure, causing the liquid to flash. It is important to ensure that dissolved gases that occur naturally in many liquids do not outgas. Outgassing can be prevented when line pressure is sufficiently high.

The following installation locations are generally preferred:

- Downstream from pumps (no danger of vacuum)
- At the lowest point in a vertical pipe.

Liquid pressure spikes exceeding 300 psi (20 bar) can damage the instrument. These spikes can occur due to water hammer, which is a very rapid rise in pressure due to the sudden closure of a valve in the line downstream of the instrument. Be very careful of installations where a valve is used to control the backpressure of the liquid line since these valves can open and close rapidly resulting in a rapid wave of high pressures. A special pressure spike suppression device sometimes called a Pressure Snubber can be added to meter inlet to prevent this type of damage. The use of flexible tubing to connect the instrument can also help to dampen these pressure spikes.

 Warning

Be very careful concerning system pressure when using barbed fittings and elastomeric tubing to connect the density sensor. The max pressure rating for these fittings is a function of the tube material and internal diameter of the tubing. Overpressure may cause of failure of the connection, resulting in a leak that could damage the instrument or the equipment around the instrument.

## 4.7 Internal Bypass

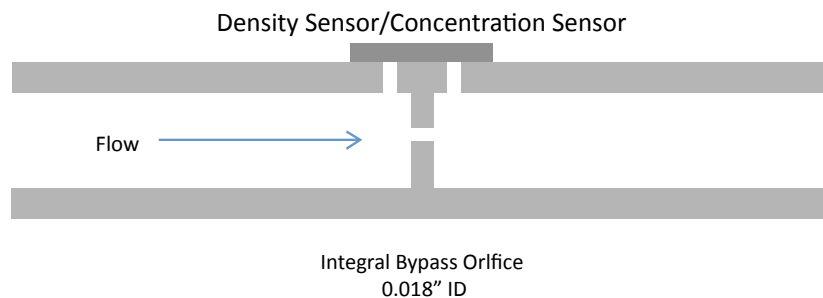
The micro density products are available with and without a 0.018 inch internal bypass orifice.

### No Bypass Applications

In this configuration all the fluid flows through the sensor. This application is for measuring small amounts of fluid.

### Bypass Applications

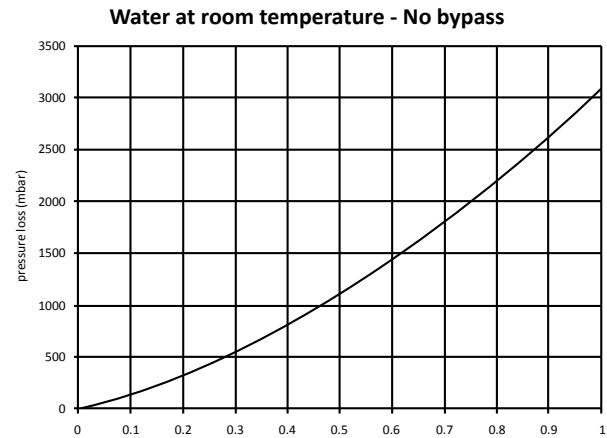
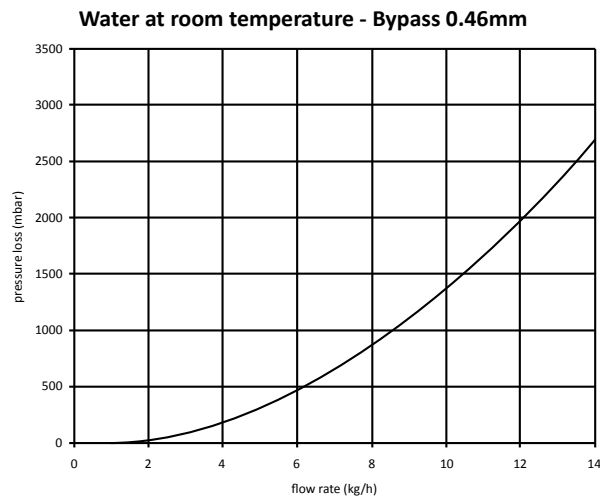
A bypass is added to the sensor to allow a higher flow of fluid through the sensor at much lower pressure drop. The following diagram shows how the density sensor is mounted on the bypass orifice. The flow of fluid through the orifice creates differential pressure, which drives a very small amount of fluid through the sensor.



The differential pressure generated by the orifice is the  $(\text{flowrate})^2$ . For higher flow through the density sensor, increase the flowrate through the orifice. The differential pressure generated is also a function of the density of the fluid.

 Note!

In bypass mode the response time to detect a step change in density is dependent on the flowrate through the sensor. Higher flows will result in a faster response time. This must be considered when utilizing the sensor output for a control application.











## 4.8 Wiring

The micro density sensors come standard with a 2 meter cable. The diagram shows the color code for the wiring connections for the sensor.

### Micro Density Sensor Wiring

Wire Color      Function

-  V+ Power 5-12 VDC (Do not exceed 13VDC)
-  V- Power Common
-  RS232 Transmit
-  RS232 Recieve
-  Signal Ground Common (GND)
-  Signal Out + Channel (1) 0.5 to 4.5 volts, 0-10wt% MeOH in Water
-  Signal Out + Channel (2) 0.5 to 4.5 volts, 0-70C
-  Case Ground (optional)

#### Note!

It is recommended to use the lowest possible voltage to power the sensor.

## 5. OPERATION

### 5.1 Analog Communication

Analog outputs are standard. The outputs are 0.5 to 4.5 volts. The microMCS outputs are configured at the factory to 0 to 10wt% methanol concentration and 5-70C temperature. The microLDS analog outputs are scaled from 0.6 to 1.3 grams/cc and temperature 5-70 C. Use the optional ISSYS Fluidic Communication Operating Interface to create custom ranges of density and temperature for the microLDS.

### 5.2 Digital Communication (Optional)

An RS232 digital communication interface is available as an option. This can be used to communicate density and temperature to an external computer for control. It is also required to use the ISSYS Fluidic Communication Operating Interface Software.

#### **Communication Protocol:**

The meter only supplies data in response to a request command. The following command structure must be adhered to if the user does not wish to use the ISSYS Fluidic Meter read out software.

Communication port settings: Baudrate: 19,200 Data bits: 8 Stop bit: 1

Parity: none Flow control: none Termination char: none

Send the following set of 8 bit hex numbers: 0x01, 0x00, 0x00, 0x00, 0x08, 0x02, 0x03. Wait at least 95ms.

The response from the meter will be a string of 8 bit ASCII characters. There will always be two characters @! followed by a four character ID tag, followed by the data as an ASCII representation of a floating point number. There will always be a final @!. These two symbols are used to frame the ID and data for each variable for parsing.

**A Typical Output String would be as follows:**

@!000823.53@!00050.80342@!00060.00000@!00000@!00090025.10@!

TheIDtagsforthevariablesare

0008–sensortemperature

0005–densityinselectedunits(g/cc),

0006–referencedensity(option)ifapplicable

0000–flowswitchactuation:0,noflow;1,flowisaboveswitchsetting(settableinsoftware orfrompushbuttons)

0009–externalsensor(option)value;temperatureorpressure

Ifthedensityisoutofrange(<0.5g/cc),DensityRangewillbeoutputafterthetemperature valueanddensityIDtaginsteadofthedigitaldataasinthefollowingstring.

@!000823.53@!0005DensityRange@!Anyothercommandisnotsupportedandshould notbesent.

### 5.3 ISSYS Fluidic Communication Operating Interface (Optional)

The density meter to computer interface is controlled with a Lab view executable file. For detailed instructions on using this software see the ISSYS Fluidic Communication Software manual.

Here is a basic description of the operation of the software.

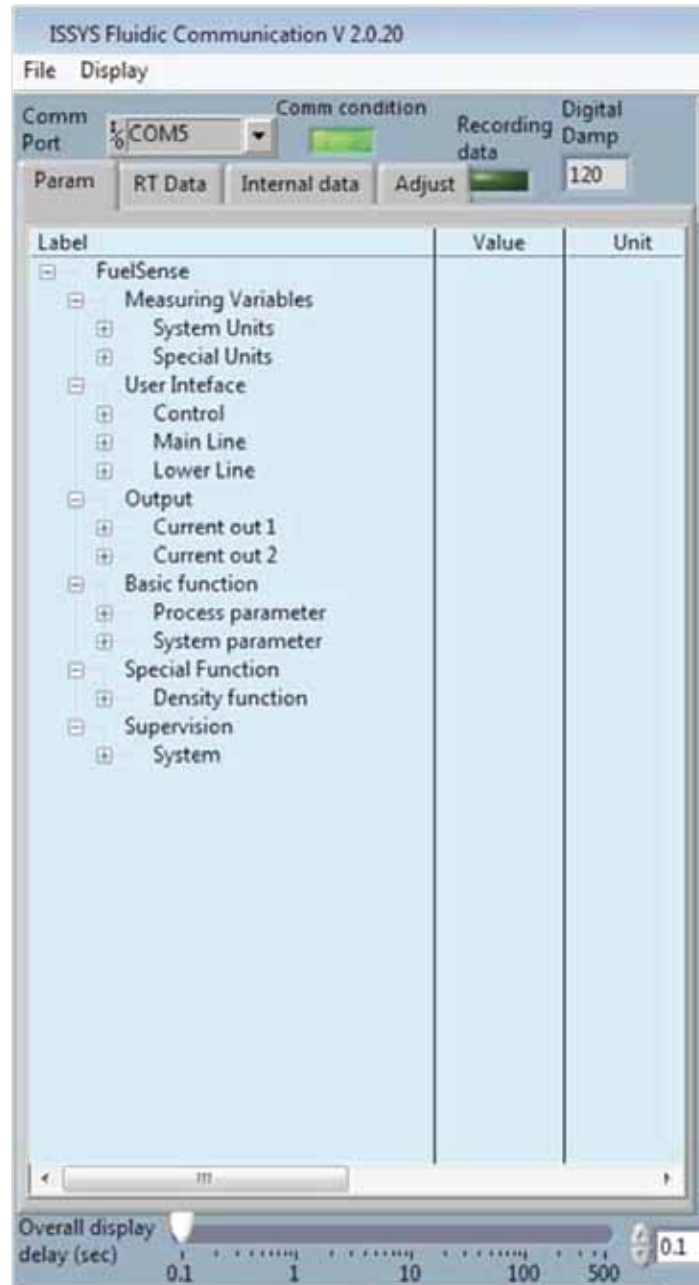
#### Overview:

The Fluidic Communication software is set up as four screens to allow adjustment of the meter, plotting data, recovering internally recorded data and adjustments. It is easy to understand how to navigate each screen. The following is a review of each of the screensand a general description of how to navigate each screen.

#### Operation

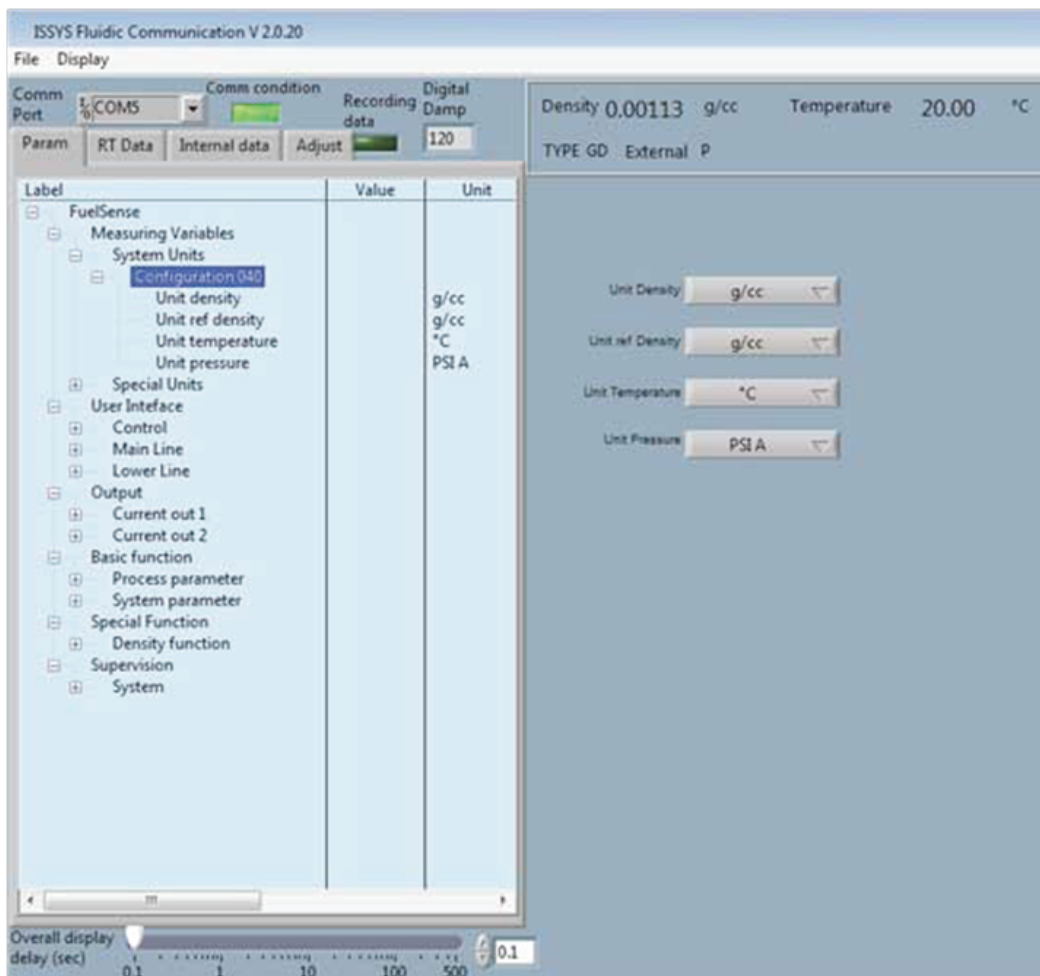
##### Parameter Screen Overview





The Parameter screen is built as a tree structure. It is the primary screen for making configuration changes to the FS-GDM. The functions that can be changed are labeled in the tree structure.

The following screen is an example of changing the units of the different measurements. It is important to point out that the fourth level down in the tree is where the changes can be made. Configuration 040 is the fourth level down.

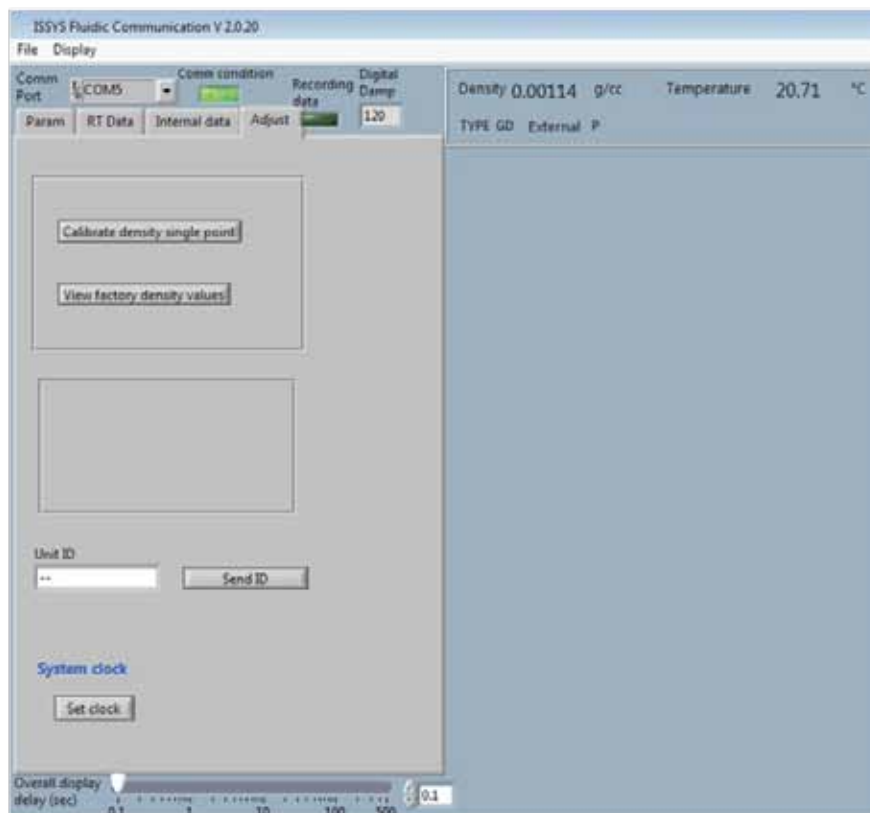


### RT Data Overview

The RT Data Screen provides the ability to plot up to 4 measured values on the screen. This is under the Graph function. To select the values to measure, select the variables by holding the control button and then clicking on the measured values to be graphed. The second function of this screen is to log data on the internal hard drive of the computer.



The final screen is the Adjust screen. This allows the user to adjust the meter calibration and reset factory values. This screen should only be accessed by a trained technician.



## 6. MAINTENANCE

### 6.1 Cleaning the sensor tube

The first step in cleaning the flow tube is using a high flow rate of de-ionized water to rinse the flow channel several times. The flow direction of cleaning fluid should be opposite the normal flow direction through the sensor. The next step is to use isopropyl alcohol rinse to remove the water. The final step is to gently blow the flow channel with nitrogen or dry compressed air.

Verify that the flow channel is sufficiently clean, fill with water and confirm that the density reading is correct. If water and IPA does not clean the sensor, the next step is to clean the sensor tube with a hydrocarbon such as hexane. Call the factory for advice on alternative cleaning treatments.

 Caution!

Do not use highly acidic or highly alkaline solutions to clean the flow channel as these solutions may damage the flow channel and affect the performance of the instrument.

## 6.2 Exterior cleaning

The micro density sensors are not sealed. Do not apply any fluid to the outside of the sensor. Use a dry cloth to clean the outside of the sensor.

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## 7. TROUBLESHOOTING

### 7.1 Liquids containing bubbles

Bubbles in the liquid can potentially get trapped in the sensor tube which will cause an error. Make sure the liquids are bubble free.

### 7.2 Fluid temperature changes and gradients

If the process has rapid and significant temperature variations ( $> 4$  °C/minute), the instrument needs some time to settle to the new temperature. During this transition the instrument's temperature compensation will lag and the density measurement will not be accurate during this transition period.

If the ambient temperature is very different from the fluid temperature it is recommended the sensor be insulated to avoid influences on the temperature measurement. In that application extremes, insulation or heat tracing might be required for the housing and the flow channel to have the same temperature.

### 7.3 Disposal

There are no toxic materials used in the Micro Liquid Density Sensor construction. Observe the Country regulations for the disposal of any device containing printed circuit boards and electronic components.

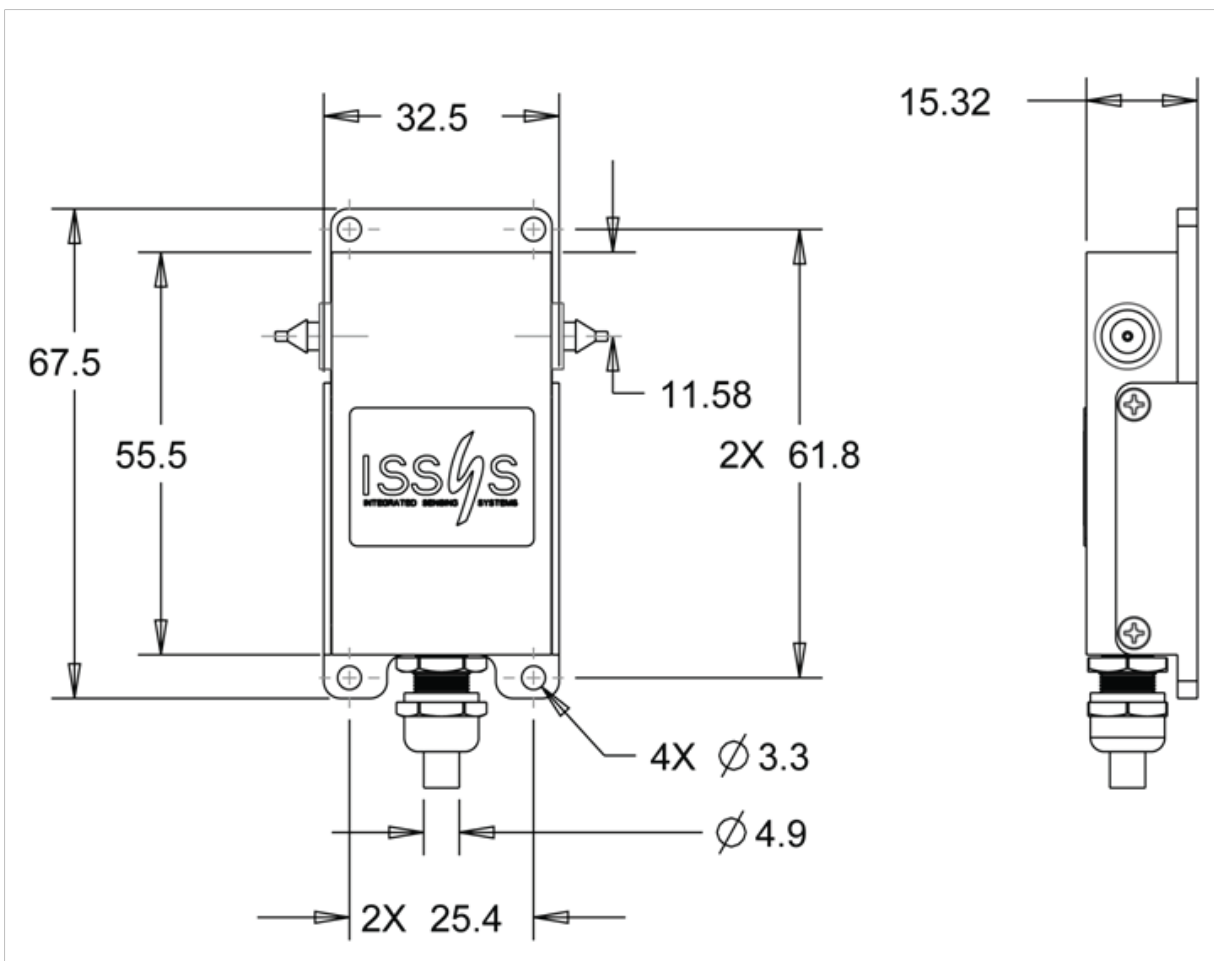
## 8. TECHNICAL DATA

### 8.1 Performance information

### 8.2 Material and mechanical specifications

Wetted materials:

- Silicon
- Glass-Pyrex®7740 Borosilicate
- Stainlesssteel
- High Performance Chemically Resistant Cross Linked Epoxy



## 8.3 Legal disclaimer

ISSYS assumes no responsibility for infringement of patents or rights of others based on ISSYS applications, assistance or product specification since ISSYS does not possess full access concerning the use or applications of customers' products. ISSYS also assumes no responsibility for customer' product designs and the impact of the design on the device or other components in the products or samples being tested or monitored by the product and interactions between these items.

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## 8.4 Patents

This device is protected by pending US and International patents and the following granted patents: US Patents 6,477,901, 6,923,625, 7,059,176, 7,228,735, 7,351,603, 7,381,628, 7,568,399, 7,581,429, 7,628,082 and Jap. Patent 4,568,763.

## 8.5 ISSYS Contact Information

Mailing and Shipping Address:

391 Airport Industrial Drive  
Ypsilanti, Michigan, USA 48198

Phone/Fax:

Phone: 734-547-9896  
FAX : 734-547-9964

Websites:

[www.mems-issys.com](http://www.mems-issys.com)  
[www.microcoriolis.com](http://www.microcoriolis.com)