

## 9705 Gen 5 I<sup>2</sup>C R3D® Modules

Digital output level sensors for use in all Rochester Sensors Remote-Ready dials

Maximize your fluid level detection capabilities with Rochester Sensors remote-read R3D modules. Incorporating a remote-read system allows you to monitor your fluid or fuels levels remotely, providing a reliable, safe, and convenient solution to track usage. Utilizing the digital output from Rochester remote-read modules allows you to monitor levels in one or many tanks and is integral to any automated monitoring system.



### Application

The Rochester 9705 3V module snap-fits into the recess of your existing Rochester Sensors Junior or Senior sized R3D remote-ready dial lens to provide a low power, cost-effective solution to digitally transmit fluid levels. The sensors will detect the position of the fluid level indicator in the dial it is attached to, as well as the ambient temperature. Data from the module's integrated circuit is communicated via I2C protocol (IC to IC, bidirectional 2-wired serial bus) to the microcontroller in the end-users wired, or wireless monitoring device. Multiple 9705 R3D modules can be connected to a single monitoring circuit using unique module address configurations. 9705 Modules require a 3VDC input and offer extremely low current draw that is excellent for battery powered applications.



## General Information and Features

- Cable length = 4 ft. with flying leads
- 24 AWG – 4 conductor cable for power, ground, SDA, and SCL
- Accuracy: Module output +/- 2% of visual dial indication. (Float gauge errors not included)
- Repeatability: +/- 1%
- Operational Voltage Range: 2.2 to 3.6 VDC (Down to 1.8V I/O Voltage for I2C lines)
- Data Output: Dial position (via magnetic flux density along X, Y, & Z axes) and Temperature
- Communication Protocol: I2C serial bus
- Resolution: 16 Bit
- Operating Current: Typical  $\leq 1\text{mA}$ , Peak  $\leq 3.5\text{mA}$
- Operating Temperature Range: Dynamic  $-25^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$ ; Static  $-30^{\circ}\text{C}$  to  $+80^{\circ}\text{C}$
- Storage Temperature:  $-40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$
- Ingress Protection: IP69K rated
- Intrinsically safe in explosive atmospheres.

## Ordering Information

Rochester Part Number	Description
<b>9705-ABCXXM</b> <b>(Example: 9705-R0104M)</b>	9705 - Product Family A - Specify orientation of module: (S= Straight, R = Right Angle) B- Specify 7-bit I2C address configuration (0=0x0C, 1=0x0D, 2=0x0E, 3=0x0F) Standard part is address "0". C - Cable Type (C = 1, 4 wire cable only) XX - Cable length must be "04" (Standard length is 4 ft) M- Molded construction

## Product Certification

Rochester Sensors R3D modules are certified as intrinsically safe for Class 1, Division 1, Groups C & D hazardous locations. Products are marked and approved by ETL, ATEX, UKCA, and CE. Certification and testing has been performed to the following standards:

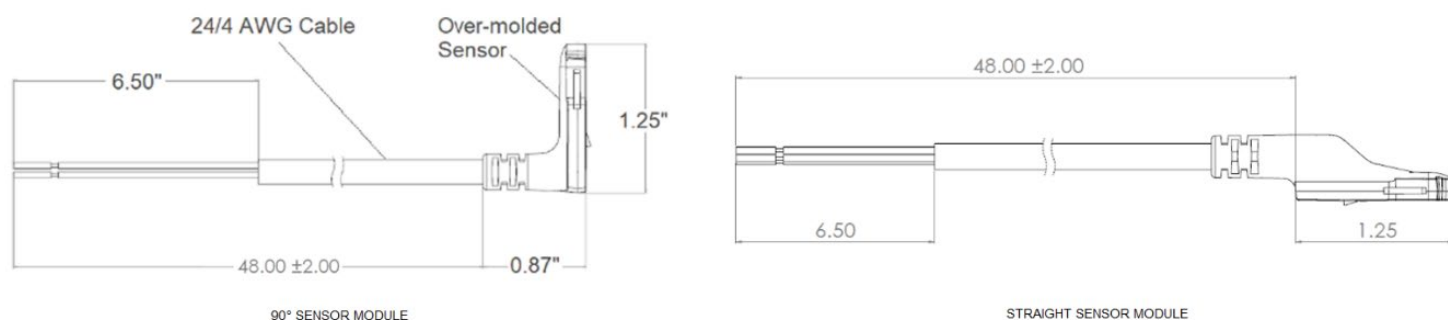
### Ordinary Locations Safety Standards

Conforms to UL STD 61010-1 Ed.3	Electrical Equipment for Measurement, Control, and Laboratory Use; Part1: General Requirements *Note: for USA ordinary locations listing certification
Certified to CSA STD C22.2 #61010-1-12 Ed.3	Electrical Equipment for Measurement, Control, and Laboratory Use; Part1: General Requirements *Note: for Canada ordinary locations listing certification

### Hazardous Locations Safety Standards

IEC 60079-0: 2017	Explosive atmospheres – Part 0: Equipment – General requirements *Note: For IECEx Certification
EN 60079-0: 2011 + C1: 2012	Explosive atmospheres – Part 11: Equipment protection by intrinsic safety “i” *Note: For IECEx Certification
EN 60079-0: 2018	Explosive atmospheres – Part 0: Equipment – General requirements *Note: For ATEX Certification
EN 60079-0: 2012	Explosive atmospheres – Part 11: Equipment protection by intrinsic safety “i” *Note: For ATEX Certification
UL 60079-11, 6th Ed., Issued 03/26/2019	Explosive atmospheres – Part 0: Equipment – General requirements *Note: For USA listing Certification
UL 60079-11, 6th Ed., Revised 03/28/2014	Explosive atmospheres – Part 11: Equipment protection by intrinsic safety “i” *Note: For USA listing Certification
CSA C22.2 No. 60079-0: 2011	Explosive atmospheres – Part 0: Equipment – General requirements *Note: For Canada listing Certification
CSA C22.2 No. 6009-11: 2011	Explosive atmospheres – Part 11: Equipment protection by intrinsic safety “i” *Note: For Canada listing Certification

## Product Construction



The 9705 product is centered around a position-sensing integrated circuit that works with existing R3D level dials. The sensor is available in both a 90 degree or straight orientation. The custom printed circuit board, components, and all electrical connections are fully enclosed in a durable molded polyamide casing which provides excellent insulation and environmental protection. Alignment and snap-fit geometry are integrated into the shape of the sensor to perfectly mate with the remote-read slots on all Rochester Sensors R3D dial faces. Interaction with the 9705 module is accomplished via a multi conductor jacketed cable. The black 600V, 105°C cable is UL Recognized (21768) with a TPU jacket that is oil, water, UV, and cold resistant. The four internal 24 AWG stranded wires are colored for easy assembly into the end user's monitoring device.

## Product Performance

The Rochester Sensors 9705 module sensor offers ideal performance for low power remote level-sensing systems. It offers fast communication, low current consumption, and a high level of accuracy in a robust package.

### Absolute Maximum

Parameter	Condition	Min	Typical	Max	Unit
Input Voltage	VDD, SDA, SCL, GND	-0.3		+4	V
Storage		-40		105	°C
Handling Temperature	Moving module or cable assembly	-25		80	°C
ESD (Cable conductors)	Human Body Model AEC-Q100-002	-10		+10	kV
Output Accuracy	Overall		≤2%		Level

## Electrical Characteristics

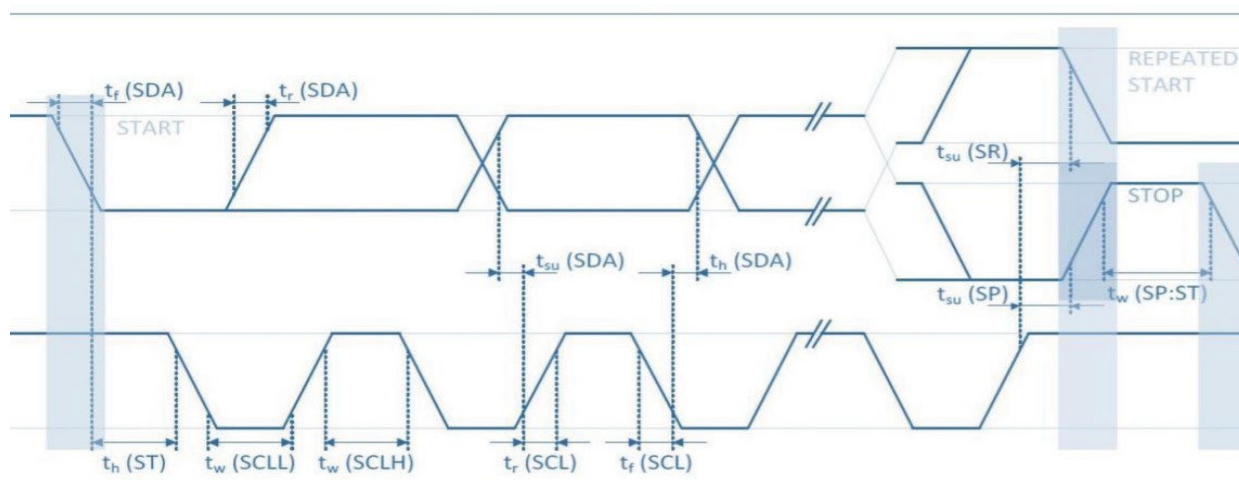
Parameter	Condition	Min	Typical	Max	Unit
Operating Voltage	VDD (VDC)	2.2	3.0	3.6	V
IO Voltage	SDA / SCL	1.65	1.8	VDD	V
Accuracy	Voltage Range	-	<1%	-	Level
Current Consumption	Ambient	-	0.22	2.5	mA
Current Consumption	@ 85°C	-	0.44	3.0	mA
Current Consumption	@ -40°	-	0.18	1.75	mA
Start up	0.0V to VDD	0.6	1.5	-	mS
Internal Pull Up	SDA / SCL to GND	9.6	10	10.6	K $\Omega$
Internal Capacitance	VDD	-	0.2	-	$\mu$ F

## Environmental Ratings

Parameter	Condition	Min	Typical	Max	Unit
Operating Temperature Range	VDD (VDC)	-30	-	85	°C
Module Accuracy	Temperature Range	-	<1%	-	Level
Output Temperature	Relative Accuracy	-	+/-5	-	°C
UV withstand	600 hrs, UVA-340 @.76W/m2, 70°C	-	Pass		

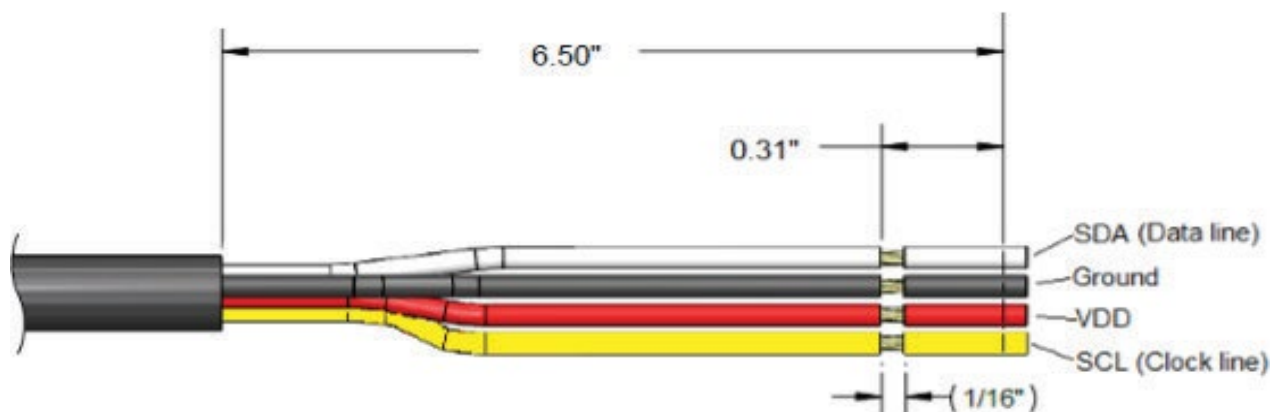
## I<sup>2</sup>C Electrical Timing Characteristics

Electrical Parameters	Symbols	I2C Standard		Units
		Min	Max	
SCL Clock Frequency	f (SCL)	-	100	kHz
SCL Clock Low Time	tw(SCLL)	4.7		μs
SCL Clock High Time	tw(SCLH)	4		μs
SDA Setup Time	tSU(SDA)	250		ns
SDA Data Hold Time	th(SDA)		3.45	μs
SDA and SCL Rise Time	tr(SDA) tr(SCL)		1000	ns
SDA and SCL Fall Time	tr(SDA) tr(SCL)		300	ns
START Condition Hold Time	tr(ST)	4		μs
REPEATED START Condition Setup Time	tSU(SR)	4.7		μs
STOP Condition Setup Time	tSU(SP)	4		μs
Bus Free Time Between STOP and START Condition	tw(SP:ST)	4.7		μs





## Product Function Overview



The Rochester Sensors 9705 module can be attached to any R3D dial face to detect the fluid level indicated. The sensor accomplishes this by detecting the position of the level indicator along an X and Y axes. The output of the module is proportional to this positional data. Users must connect a processing device to the 9705 module that can communicate via I<sup>2</sup>C protocol and interpret the raw data. The output from the module must be converted into an angular format and used in conjunction with look-up tables to produce the level percentage of the dial it is installed on. 9705 modules use a 4-wire cable to connect to the user's monitoring system: 3VDC supply, ground, and two communication wires for the I<sup>2</sup>C bus.

## Reading from Sensors:

The user's monitoring device must utilize a "master" controller which can talk to the "agent" IC inside the 9705 R3D module. The master device drives the SCL clock line and initiates the data transfer over the I<sup>2</sup>C bus. The 9705 module can then respond to the master device with the raw positional data it collects from the corresponding Rochester Sensors R3D dial. The 9705 module also provides local temperature data during this process. To begin, users must initialize the device by setting gain, setting resolution, and enabling continuous operating mode. The controller must then issue a start sequence on the I<sup>2</sup>C bus to begin data transaction with the 9705 module. Data is transferred to/from the sensor in sequences of 8 bits. The user's monitoring device must be able to process the raw X and Y positional data being received from the 9705 module into an angular format. The controller will need code and look-up tables to convert the angular output to a tank volume that can be used in conjunction with the end application.

## Pseudo Code:

```
#include <example hardware drivers>
#include <function prototypes>

void main() {

    /* Initialize sensor */
    // set gain to 3, set configuration to 0x0c,
    sensor_set_gain_hallconf(3, 0x0c);
    // set channel resolution to 3 for X, Y and Z axis
    sensor_set_resxyz(3);
    // set device in continuous operating mode
    StartBurstMode();

    // Loop to read sensor
    while (TRUE) {
        // Read sensor X,Y,Z and Temperature.
        sensor_measure(float &loTemp, int16 &loX, int16 &loY, int16 &loZ);
        // convert cartesian to angle
        int16 loAngleDeg = get_angle_deg(loX, loY);
        // convert angle to tank volume based on the tank physical shape and dial
        float tank_volume = convert_angle_to_level(loAngleDeg);
        //USER CODE TO DO SOMETHING WITH TANK VOLUME

    }
}
```

## Measurement Mode (Burst Mode):

Typical configuration for the 9705 is to enable continuous ADC readings when the device is powered. Data is always available to the host microcontroller using this mode. An alternative method to issue a command to read data is available – contact Rochester Sensors for more information.

## Dial Conversion Formula:

Direction ( $y \geq 0, x > 0$ ) =  $[\arctan(y/x)] * 180/\pi$

Direction ( $y \leq 0, x > 0$ ) =  $360 - [\arctan(y/x)] * 180/\pi$

Direction ( $y \geq 0, x < 0$ ) =  $180 - [\arctan(y/x)] * 180/\pi$

Direction ( $y \leq 0, x < 0$ ) =  $180 + [\arctan(y/x)] * 180/\pi$

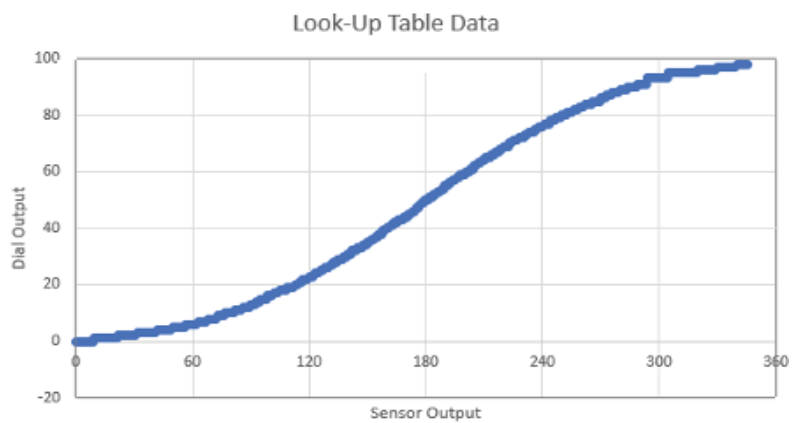


## Dial Look Up Tables:

9705 modules can be used in any R3D dial. Look-up tables for each dial offered by Rochester Sensors will be made available to all customers. The angular value should be calculated. This value can then be used along with the appropriate look-up table to interpolate a precise dial level indication.

## Sample Table – Rochester Sensors 4" Magnetel Dial:

Degree	8-bit value	Tank %
0	0	0
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	3	1
11	3	1
12	3	1
13	3	1
14	3	1
15	3	1
16	3	1
17	3	1
18	3	1
19	3	1
20	3	1



## Sample C-code:

Contact Rochester Sensors for sample C code for the 9705 module.

## Installation Instructions:

Reference DS-2013

**Warning:** For LP-Gas and other flammable product service applications, connect only to circuits and power sources classified and labeled Intrinsically Safe for Class 1, Division 1, Group C and D hazardous locations. Connection of non-intrinsically safe power could result in fire or explosion of flammable vapor which may be present.

**Warning:** Sensor not to be used as the primary means of determining high or low fuel condition. It must not be used in the absence of redundant systems in critical applications where there may be significant safety risk or financial exposure in the event of fuel overfill or fuel exhaustion condition. This sensor is not to be used for tank filling.

**Warning:** Level Gauging devices and sensors sold by Rochester Sensors, are components only.

The purchaser/installer is solely responsible for the application of these components and ensuring all necessary steps have been taken to assure each application and use meets all performance and applicable safety requirements, and/or local, national and/or international safety codes as required by the application. Rochester Sensors cannot certify that our products used solely or in conjunction with other Rochester Sensors or other vendors' products will assure desired performance and safety for any application.

Any person using or applying any products sold by Rochester Sensors is responsible for learning the performance and safety requirements for their individual application and applying them, and therefore assumes, all risks, and accepts full and complete responsibility of the product for their respective application. Rochester Sensors does not provide system design or consulting services, and cannot advise whether any specific application or use of our products would ensure compliance with all performance and safety requirements for any application.

Hall Effect modules are intrinsically safe for Class 1, Division 1, Groups C & D Hazardous Locations. See SD-583 for control drawings. Protected by U.S. Patents.

Rochester Sensors R3D modules all bear the following ATEX markings:

Ⓔ II 1G Ex ia IIB T4 Ga

Ⓔ - Explosion Protected under the ATEX directive

II – For use in areas with explosive gasses

1G – Rated for use with explosive gasses in Zone 0

- Zone 0 is areas with constant exposure to explosive gas

Ex ia – Protection method is Intrinsic Safety

- Intrinsic Safety limits the available energy in the system to prevent ignition

T4 – Maximum temperature the module housing or components may reach  
135°C (275°F)

- Note that module is not intended to be used in environments warmer than 80°C (176°F)

Ga – Equipment Protection Level: Very High (Gas)