SERIES 4000 PRECISION DEWPOINT HYGROMETER

Integrale

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

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1. INTRODUCTION

1.1 General

Kahn Instruments manufactures a wide range of on-line and portable instruments for the determination of moisture content in air and gases. In addition, the company manufactures humidity calibration systems for industrial and scientific users.

The Series 4000 *Integrale* Precision Dewpoint Hygrometer is a precision instrument which may be used in calibration and standards laboratories and in exacting process monitoring and control applications where wide humidity range and high accuracy is a prime requirement.

A direct indication of dewpoint to a resolution of 0.01°Celsius (°C) is provided by the instrument display. The dewpoint may also be displayed in a number of other engineering units including °Fahrenheit (°F), Parts Per Million by Volume (PPM(V)), Parts Per Million by Weight in SF_6 (PPM(W) in SF_6), grams per cubic meter (g/m^3) and grams per kilogram (g/kg). Additionally, the instrument can measure and display the gas temperature using a remote PRT probe (supplied as standard). This temperature may be displayed in °C or °F. Relative Humidity (%RH) may then be calculated from the fundamental gas dewpoint and temperature at atmospheric pressure. The instrument may also be configured to display measured gas pressure (KPa) using an external pressure transducer, and use this measured pressure to calculate pressure compensated PPM(V), PPM(W) for SF_6, g/m^3 and g/kg.

The Series 4000 is based on the cooled mirror principle and is derived from a highly successful Transfer Standard Dewpoint Hygrometer. This Transfer Standard was developed during the early 1980's in collaboration with the EEC Bureau of Reference as a European link to the National Institute of Science and Technology (NIST) humidity standard in Washington, USA.

Dewpoints over the range -60°C to +35°C may be measured with the Series 4000 *Integrale* instrument. This is equivalent in terms of absolute humidity at atmospheric pressure to a range of 10.7 ppm(V) to 140,000 ppm(V) (parts per million by volume).

The Series 4000 Precision Dewpointmeter is also available in a “remote” configuration, where the dewpoint sensor assembly is located in a separate enclosure, remote from the monitor unit. Full range capability of the Series 4000 instrument can be achieved using the remote version with external cooling / heating to achieve the extremes of temperature required. In this configuration dewpoints over the range -95°C to +85°C may be measured (equivalent to 0.04 ppm(V) (parts per million by volume) to almost 50% V/V (percentage moisture by volume)).

1.2 Operating Principle

Within the sensor a Peltier thermoelectric device cools the plated copper mirror. At a temperature, determined by the moisture content of the sample gas, dew will form on the mirror surface. This formation of dew causes a reduction in reflected light intensity from the red LED light source and, at the same time, causes an increase in scattered light from the mirror surface. This signal change is perceived by a differential optical detection system, which in turn regulates power to the Peltier via a control circuit. The control loop maintains the mirror surface exactly at the dewpoint temperature, which is then accurately measured by an embedded 4-wire platinum resistance thermometer.

The monitoring electronics performs all the control functions for the sensor as well as measuring and displaying the dewpoint temperature. An automatic balance compensation (ABC) system is incorporated in the monitor to eliminate the effects of mirror contamination build-up ensuring continuous accurate operation. If automatic balance is not required on a specific application the ABC system can be switched off and the monitor balanced manually when required.

1.3 Calibration

Calibration is performed using precision dewpoint generators and transfer standard optical hygrometers which have been calibrated directly at the National Institute of Standards and Technology (**NIST**).

1.4 Manufacturing Quality

Your hygrometer should reach you in perfect working condition. Rigorous procedures at every stage of production ensure that the materials of construction, manufacturing, calibration and final test procedures meet the requirements laid down by our Quality System.

2. INSTRUMENT DESCRIPTION

The Series 4000 *Integrale* comprises of one self-contained monitor unit, housing both the dewpoint sensing assembly and all the control and monitoring functions within one unit. The *Integrale* monitor unit is constructed in a 19" 3U sub-rack enclosure, and requires only mains power supply and sample gas connections for operation. Refer to Appendix 1.0 for S4000 *Integrale* Front and Rear Panel Layout Diagrams and Section 5 for Technical Specification.

2.1 Front Panel

The dewpoint sensor is located on the left side of the monitor as viewed from the front, next to the GAS IN and GAS OUT ports and integral flowmeter.

On the right of the monitor are the user controls and displays. These include the power switch, the LED displays and display selection push-buttons, the MAX COOL pushbutton, the DATA HOLD LED indicator, the ABC STATUS LED indicator, the OPERATION / STANDBY switch, and the ABC INITIATE push button.

2.2 Rear Panel

It is important that air flow to the two vents located on the rear panel of the monitor not be obstructed. The operation of the instrument will be adversely affected by preventing sufficient cooling flow.

All user input and output connectors are available on the rear panel of the monitor. These include RS232 interface, User I/O, and remote pressure input (if required). In addition, the sensor heat pump overload fuse, DIP switches SW2, SW3, and SW4 and the power connector are located on the rear panel.

2.3 Dewpoint Sensor

The mirror and optics within the sensor, may be accessed from the front of the instrument for cleaning and maintenance purposes by unscrewing and removing the microscope housing.

The black blanking plug may be removed from the sensor and a microscope attached to the sensor assembly to allow the formation of ice crystals to be observed by the operator. Refer to Section 4.6.

The dewpoint sensing assembly comprises a measurement sample flow-through housing, which contains optical signal emission and detection components. These components are accurately positioned around a plated mirror, which is mounted on the Peltier cooling device.

Sample gas is transmitted into the measurement chamber through stainless steel tubing and fittings to ensure negligible contamination of the sample gas.

A high efficiency heat sink is mounted to the rear of the PTFE housing assembly. Forced air cooling is provided within the unit to cool the sensor heatsink. Both the air inlet and outlet vents are located on the rear panel of the unit, this allows the instrument to be located in a rack unit above and below other instrumentation while maintaining the air cooling flow required for continuous operation.

The sensor mirror is cooled by the Peltier cooling device to below the dewpoint temperature until sufficient dew or ice forms on the mirror surface for the optical system to detect. When this point is reached the electronic control circuit adjusts the Peltier device power until the mirror temperature is controlled at the equilibrium value where the rate of condensation equals the rate of evaporation - dewpoint.

2.4 Front Panel Controls

The following is a basic description of the function of each of the front panel user controls and connections. For further information refer to the relevant section or Section 4.

a) GAS IN & GAS OUT — 6 mm O.D. stainless steel tubing connections for the sample gas inlet and outlet.

b) Flowmeter — Provides a visual indication of the sample flow. Note that this will only operate when the unit is horizontal. All other functions on the instrument will operate correctly in any orientation.

c) Mains Power Switch — Isolates all power to the instrument, and includes a visual indication (neon).

d) OPERATE/STANDBY — Refer to Section 2.6.

e) INITIATE Pushbutton — Manually starts a Balance cycle. Refer to Section 2.8.

f) ABC STATUS LED — Indicates current status of Balance cycle. Refer to Section 2.7 and 2.8.

g)	DATA HOLD LED	Illuminates red when dewpoint display and outputs are held. Refer to Section 2.9.
h)	MAX COOL Pushbutton	Refer to Section 2.11.
i)	Unit Select Pushbuttons	Rrefer to Section 2.12.
j)	Upper and Lower display annunciators	Refer to Section 2.12
k)	Upper and Lower six digit displays	Refer to Section 2.12.

2.5 Rear Panel Controls / Connections

The following is a basic description of the function of each of the rear panel user controls and connections. For further information refer to the relevant section or Section 4.

a)	RS232	9 way “D” type connector for serial communication interface. Refer to Section 4.5.2.
b)	User I/O	12 way analog / digital. Refer to Section 4.5.1
c)	SW4 ABC Duration	Pre-sets duration of ABC Cycle. Refer to Section 2.8.
d)	SW3 ABC Frequency	Pre-sets frequency of ABC Cycle.Refer to Section 2.7.
e)	SW2 Data Hold Duration	Pre-sets duration of dewpoint data hold function. Refer to Section 2.9.
f)	Remote Temperature	Provides input for remote temperature probe (if required) 3-way circular plug connection.
g)	Remote Pressure	Provides input for Pressure transducer (if required). Refer to Section 2.13.
h)	Heat Pump Supply Fuse	Overload protection fuse for sensor’s Peltier heat pump. Fuse rating T 3.15 A 250V.
i)	AC Power Input	I.E.C. Socket for AC power supply. Fused at T3.15A 250V.

2.6 Operation / Standby Modes

During normal use this switch should be left in the “OPERATE” position.

When in the “STANDBY” mode, the heating and cooling drive to the sensor is disabled. This allows the sensor mirror to warm / cool to the ambient temperature, and therefore any dew or contamination that may have formed on the mirror should be removed.

This function is only used for applications where the sample gas dewpoint changes very quickly from “dry” to “wet”, with the possibility of flooding the sensor’s mirror, or in circumstances where a manual measurement is only taken very infrequently and it is prefered to have the sensor disabled between measurements.

When a measurement is to be taken, set the switch to the “OPERATE” position.

2.7 Automatic Balance Compensation (ABC)

During normal use the optical components of the sensor (i.e. mirror, light guides etc.) are progressively contaminated resulting in a gradual loss of sensitivity. To compensate for this a balancing system is provided. The system works by heating the sensor mirror to a temperature sufficiently high to drive off all dew present and provide a dry mirror surface. This compensates for the presence of any contamination and then the instrument reverts to the normal measuring mode. This process is fully automated and does not require any operator intervention. The initialization of this process can either be periodically, at a preset time interval, or on request.

Selecting the mode of operation for the ABC system is extremely easy. The operator needs only to configure the period between ABC cycles and the duration of the ABC cycle required. Both parameters are set by way of banks of DIP switches located on the rear panel of the instrument. The duration of the balance cycle is user definable from 1 to 8 minutes and should be set using SW4 as shown below:

ABC Duration	SW4-1	SW4-2	SW4-3	SW4-4
1 minute	ON	OFF	OFF	OFF
2 minutes	OFF	ON	OFF	OFF
4 minutes	OFF	OFF	ON	OFF
8 minutes	OFF	OFF	OFF	ON

Notes:
1. Only one switch may be in the ON position at any time.
2. One switch must be in ON position, otherwise, if an ABC is initiated it will continue indefinitely.

The frequency, or period, at which the Automatic Balance Cycle will initiate must also be set by the user. The permitted settings fir this parameter are as follows:

ABC Frequency	SW3-1	SW3-2	SW3-3	SW3-4	SW3-5	SW3-6	SW3-7
30 minutes	ON	OFF	OFF	OFF	OFF	OFF	OFF
1 hour	OFF	ON	OFF	OFF	OFF	OFF	OFF
2 hours	OFF	OFF	ON	OFF	OFF	OFF	OFF
4 hours	OFF	OFF	OFF	ON	OFF	OFF	OFF
8 hours	OFF	OFF	OFF	OFF	ON	OFF	OFF
16 hours	OFF	OFF	OFF	OFF	OFF	ON	OFF
32 hours	OFF	OFF	OFF	OFF	OFF	OFF	ON
On Request	OFF	OFF	OFF	OFF	OFF	OFF	OFF

Note that only one switch may be in the ON position at any time.

2.8 Automatic Balance Compensation On Request

If the instrument is being used for calibration applications or in system configurations where the dewpoint measurement cannot be interrupted, it is recommended that the automatic balance compensation is set to ON REQUEST using SW3 as shown in the section 2.7 above. Operation of the balance system in the ON RERQUEST mode allows the user to manually initiate a balance cycle instead if allowing the instrument to perform this task at set time intervals. The process of balancing the optics system to compensate for any increase in contamination is still performed automatically. If operating in this mode, it becomes the responsibility of the user to perform ABC cycles at suitable periods.

When operating in On Request mode, the Balance Cycle can be initiated in any of three ways:

a) manually by pressing the front panel switch INITIATE,
b) by use of the remote input on the rear of the monitor,
c) by use of the RS-232 interface.

2.9 Data Hold

The data-hold capability allows the measured dewpoint temperature to be temporarily held during and after an ABC cycle. The measured dewpoint at the moment the balance cycle starts is maintained for a time period defined by the user. This time period allows the balance cycle to be completed and the measured dewpoint to settle before returning to normal measurement mode. This function holds the display, analog output and digital output for the defined time period, and is activated whenever a Balance cycle is initiated, i.e. whether manually or automatically.

Note that the Data Hold time period starts when the ABC cycle starts. Therefore the Data Hold duration time should be set to last longer than this period to allow the instrument to settle on a new measurement, before the data hold function is switched off. This “settling period” will be different for each application, but generally the drier the gas the longer this period will be. For example at -50°C dewpoint this settling period may be in the order of 30 minutes, while at +30°C dewpoint the settling period may only be 1 minute.

The time period of the Data Hold Function is set as follows :

	Data Hold Duration
SW2-1	1 minute
SW2-2	2 minutes
SW2-3	4 minutes
SW2-4	8 minutes
SW2-5	16 minutes
SW2-6	N/A
SW2-7	N/A
SW2-8	N/A

Note that only one switch may be in the ON position at any time.

Note that to disable the Data Hold, all switches SW2-1 to SW2-5 should be in the OFF position.

2.10 Clean Optics Warning

After some time in use, when the optics have collected a considerable degree of contamination, the balance system produces a warning signal demanding that the optics need to be cleaned. This warning is given by the dual colored ABC STATUS (LED) on the Series 4000 Monitor front panel which will glow red. If this warning is ignored, the instrument cannot accurately measure dewpoint.

2.11 Max Cool

This control is a non-latching push button switch, which over-rides the dewpoint control loop system and applies maximum cooling current to the Peltier. The purpose of this control is two-fold:

a) By pressing and holding in the MAX COOL button it is possible to determine what temperature the mirror can be driven down to with reference to the sensor body temperature. This temperature will be indicated on the Monitor Unit digital display.

b) The button may also be used to determine whether or not the instrument is controlling at a dewpoint or is not able to reach it. This situation could arise when attempting to measure very low dewpoints without using suitable sensor cooling.

Momentary pressing of the MAX COOL button should cause a dip in the mirror temperature which, upon release of the button, will provoke the mirror temperature into oscillation around the dewpoint value. After a few minutes the mirror should return to its original stable temperature. If this does not happen it may be necessary to consider improving the method of sensor cooling.

2.12 Display Operation

There are two, six digit 7-segment LED displays on the front panel of the monitor unit. These can be configured to display a number of measured and calculated parameters.

Note that all parameters listed in Section 4.5.1 and 4.5.2 are available on the analog and RS232 outputs, regardless of which are displayed at any time.

During operation, if %RH is selected, the lower display will automatically display the sample gas temperature. The display is configured such that two “calculated” parameters cannot be displayed at any time.

Note that the operation of the display depends on whether the remote temperature probe is connected. If the probe is not connected, remote temperature and %RH is not displayed and °C/°F mode is selected by the upper “UNIT SELECT” push button.

2.12.1 Upper Display

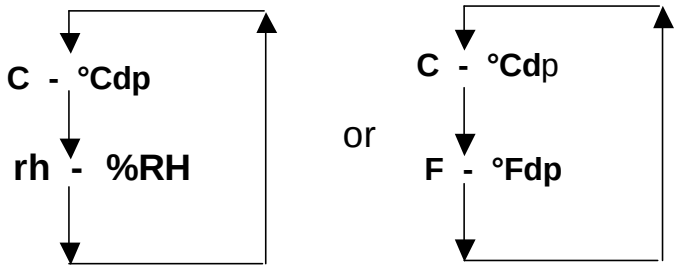
When the instrument is initially switched ON, the measured dewpoint in degrees Celsius (°C) is displayed on the upper display. The two digit annunciator, between the upper “UNIT SELECT” push button and the upper display will display “C” indicating °Cdp.

If the remote temperature probe is connected, by pressing the upper “UNIT SELECT” push button the upper display may be toggled between measured dewpoint (°C) and Relative Humidity (%RH). The two digit annunciator, between the upper “UNIT SELECT” push button and the upper display will display “rh” indicating %RH.

If the remote temperature probe is not connected, by pressing the upper “UNIT SELECT” push button, the upper display may be toggled between measured dewpoint in °C and °F. The two digit annunciator will display “F” indicating degrees Fahrenheit.

The “UNIT SELECT” switch will scroll through the functions as follows:

Upper Display : %RH Mode Dewpoint only Mode



Notes:

1. If the display is configured to °F mode (by means of the lower display), then the upper display will toggle between %RH and °Fdp.

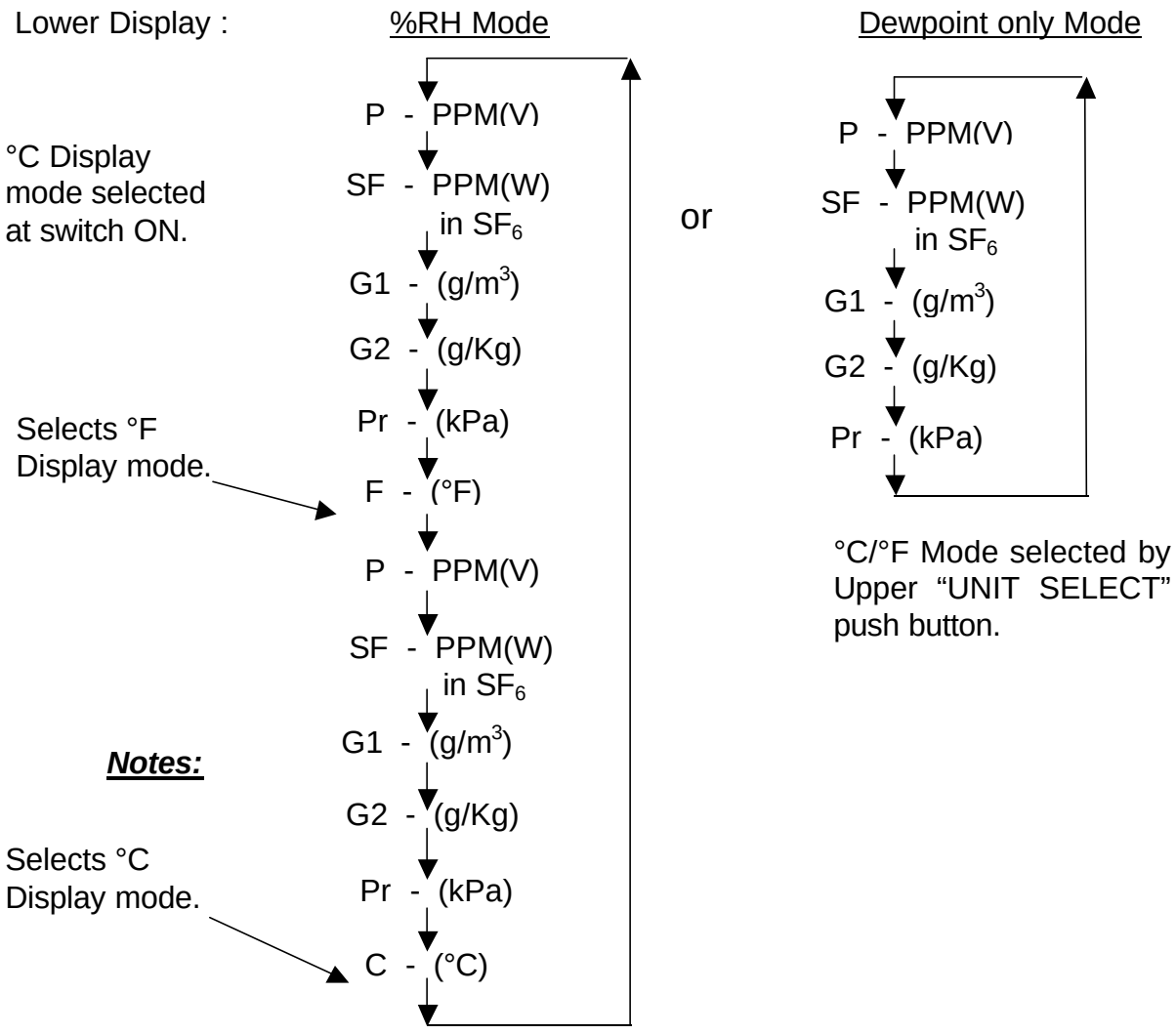
2. When %RH is selected on the upper display, the lower display automatically displays Sample Gas Temperature either in °C or °F.

2.12.2 Lower Display

When the instrument is initially switched ON, the water content in PPM(V) (Parts Per Million by Volume) is displayed on the lower display. By pressing the lower "UNIT SELECT" push button the function of the lower display will change to display one of the following:

- Parts Per Million by Weight in SF_6 (PPM(W))
- Parts Per Million by Volume (PPM(V))
- Grams per cubic meter (g/m^3)
- Grams per kilogram (g/kg)
- Pressure (kPa)
- Sample Gas Temperature (°C)
- Sample Gas Temperature (°F)

The "UNIT SELECT" switch will scroll through the above functions as follows :



1. If a pressure transducer is not connected to the instrument, then by default, atmospheric pressure (101.3 kPa) is selected and displayed.

2. During a data hold cycle the measured dewpoint reading is held and therefore the PPM(V), PPM(W), g/m^3, and g/kg parameters will also be temporarily held. The sample gas temperature and pressure parameters are not held.

3. If the upper display is indicating %RH, and the lower "UNIT SELECT" push button is pressed, then PPM will be displayed, and the upper display reverts to dewpoint in either °C or °F.

2.13 Pressure Measurement

A remote pressure transducer may be connected to the S4000 *Integrale* Monitor. This allows on-line measurement and display of the sample gas pressure, as well as calculation of pressure compensated PPM(V), PPM(W), g/m^3, and g/kg.

If a pressure transducer is not connected to the instrument, a default pressure of 101.3 kPa (atmospheric pressure) is assumed, and all pressure dependent parameters are calculated using this pressure.

The pressure is displayed in kPa, and is available as a digital output on the RS232 interface. Refer to Section 4.5.2.

The standard pressure range is 0 to 50 psi absolute, but special pressure ranges may be supplied to order. Contact Kahn Instruments Technical Sales Department for further information.

Remote Pressure Connection

A 6 pin circular socket (type Hirose RM12B Series bayonet) on the monitor unit rear panel marked REMOTE PRESSURE provides the supply voltage (+15VDC) and signal input voltage (1-6VDC) scaled over the range of 0-50 psia required for the pressure measurement circuit.

Pin connections are as follows:

Pin Number	Function
1	N/C
2	N/C
3	N/C
4	Signal Input
5	0 VDC
6	+15 VDC

3. INSTALLATION

3.1 General

The Series 4000 Precision Hygrometer is supplied with a full accessory package. Please check that you have received all the items listed on the Packing List.

The monitor unit has a universal power supply, capable of operating from any power supply between 90 to 260 Volts A.C.

The monitor unit has a single 3 pin plug connection for the AC supply.

A power lead is supplied fitted with a 3 pin IEC socket for connecting onto the instrument. A suitable fused power plug, conforming to local electrical safety regulations, must be fitted to the free end of the cable. The power lead is approximately 2 meters long with 3 cores color coded as follows:

Brown	- Live
Blue	- Neutral
Green/Yellow	- Ground

WARNING!: This instrument must be connected to electrical ground for safety.

3.2 Installing the Monitor

The Series 4000 Precision Hygrometer monitor requires an operating environment of 0 to 40 °C, 0 to 90 % RH.

The monitor case is designed for 19" 3U rack mounting. However, it can be used as a bench mounted device without any special preparation.

For rack mounting, simply screw the monitor front panel to the front of the rack using quantity 4 M6 x 15 mm screws and plastic inserts. The unit should be supported by suitable horizontal runners. The front panel mounting alone is not sufficient to support the weight of the entire unit.

NOTE: A minimum depth behind the S4000 front panel of 511 mm is required for the monitor, its connectors and wiring. Also, it is important that a sufficient flow of ambient air reach the rear of the unit. The ventilation holes on the top of the instrument must not be obstructed.

3.3 Connecting the Sample Gas

Sample gas connections are made through pipe couplings located on the front of the monitor unit marked "GAS IN" and "GAS OUT". These couplings are suitable for use with 6 mm O.D. stainless steel or PTFE tubing. If the vent gas is not routed to another test set or measuring instrument then lower quality tubing may be used on the "GAS OUT" port.

Before operation, the sensor mirror and optical surfaces should be cleaned as described in section 6.1.

3.4 Electrical Connections

Refer to the rear panels of the Series 4000 *Integrale* Monitor Unit.

The instrument requires only a power supply for operation. A 2 meter power cord is supplied, as standard. A suitable fused power plug, conforming to local electrical safety regulations, must be connected to the free end of the cord.

IMPORTANT: Before connecting the instrument to an AC power source make sure that the power supply is within the limits of the operating voltage specified on the rear of the unit.

Once the power cord and sample gas connections are made and checked the instrument is ready for operation.

If indication of %RH relative humidity and remote gas temperature are required, the remote P.R.T. probe should be placed in the gas flow, and the probe connected to the connector on the rear of the unit.

Further electrical connections for analog or digital I/O may be required, refer to Section 4.5.

4. OPERATION

4.1 General

Operation of the Series 4000 *Integrale* Precision Hygrometer is very simple as long as necessary precautions are taken to provide an accurate sample of the gas to be measured. Statistical information indicates that the vast majority of failures are caused either by incorrect sampling methods, sampling positions or inadequate protection against dangerous substances.

4.2 Sampling Hints

The Series 4000 Precision Hygrometer sensor is designed to operate in a flowing gas stream. It is provided with a sampling chamber, which enables a small sample of gas to be passed over a Peltier cooled, plated copper mirror. The sample gas is bled off to atmosphere through the Monitor Unit front panel coupling marked "GAS OUT".

Although the correct operation of the sensor is not flow-rate dependent it is important to ensure that the flow velocity through the sample line, connecting the sample source to the Monitor Unit, is high enough to avoid long time lags in response to changes in humidity at the sample source. We therefore recommend a flow rate of between 50 and 200 cm^3/min. (0.05 to 0.2 l/min.) be set. The ideal figure is 150 cm^3/min (0.15 l/min). A flowmeter is provided on the front panel of the Monitor Unit.

Flow regulation is not provided within the Monitor Unit. If gas flow must be regulated, add a precision needle valve or similar device at a suitable location in the sample gas stream ***before*** the "GAS IN" coupling on the unit. Take care not to introduce errors into the system by using inferior quality valves or making poor connections. Avoid pressure gradients in the system by excess flow restriction after the sensor. If the test gas has a very high flow rate then a by-pass arrangement is preferable to a flow restriction after the sensor.

The general rules to be adhered to when arranging a sampling system are as follows:

a) Ensure the sample is representative of the gas under test.

   The sample point should be as close to the critical measurement point as possible. For example, in a glove box application connect the sensor at the exit of the glove box not at the gas entry point.

b) Minimize dead space in sample lines.

Try to avoid too many "T" pieces or unnecessary tubing. Where possible, build up the sampling pipe specifically for the job and do not use tubing previously installed for another application. Dead space in sample lines increases response time by holding water molecules which are more slowly released to the passing gas sample.

c) Remove any particulate matter or oil from the gas sample.

Particulates entering the sensor measurement chamber will cause contamination of the sensitive optical components, this will result in the need for more frequent cleaning of the sensor optics. If particulates such as desiccant dust or rust are possible, use a particulate in-line filter. Kahn instruments' technical sales staff will be pleased to give advice.

d) Use high quality fittings.

We recommend that, wherever possible, stainless steel tubing and fittings be used. This is particularly important at low dewpoints since other materials have hygroscopic characteristics and absorb moisture in the pipe walls. Absorbed moisture will slow down measurement response and, in extreme circumstances, give false dewpoint readings.

For temporary applications, or where stainless steel tubing is not feasible, use high quality thick-walled PTFE pipe which exhibits similar characteristics to stainless steel.

Always use the shortest run of tubing possible between two points. Use the smallest diameter tubing possible to reduce response time. However, take care not to induce pressure differentials by aiming for too high a flow-rate through small diameter tubing. A sample flow-rate between 50 and 200 cm^3/min. (0.05 and 0.2 l/min.) will be satisfactory for the Series 4000 *Integrale* Dewpoint Hygrometer to operate correctly.

4.3 Which Gases to Measure?

The Series 4000 *Integrale* Precision Hygrometer, by nature of its design, is suitable for measurement of the moisture content of a wide variety of gases. In general, if the gas (in conjunction with water vapor) is not corrosive to base metals then it will be suitable for measurement by the Series 4000 *Integrale* Precision Hygrometer. However, gases containing entrained solids should be filtered before presentation to the Series 4000 Sensor.

Care should be taken with gas mixtures containing other potentially condensable components in addition to water vapor to ensure that only water can condense onto the cooled mirror surface.

The Series 4000 Sensor Unit will not contaminate high purity gases. Components which are likely to out-gas (epoxy, most plastics etc.) are not used in the manufacture of the sensor. Therefore, the instrument is safe for use in critical semiconductor and fiber-optic applications.

While the Series 4000 Sensor is designed to be operated at atmospheric pressure, each sensor is factory tested to a sample gas pressure of 10 psig before any calibration work is performed. In its standard form, the sensor unit is not suitable for measuring samples below atmospheric pressure.

4.4 Operating the Hygrometer

4.4.1 General

Use the following instructions with reference to the front panel of the Series 4000 *Integrale* Monitor Unit, and the functional descriptions provided in Section 2.

Check that the sensor optics are clean as described in section 6. If the optional microscope is not being used ensure that the black blanking plug is screwed into the microscope fitting on the front of the Monitor Unit to prevent stray light from interfering with the optical detection system. Set the sample gas flow-rate to between 50 and 200 cm^3/min. (0.05 and 0.2 l/min.) as indicated on the Monitor Unit front panel flow meter.

The temperature measurement and %RH calculations within the instrument are fully automatic and do not require any user adjustment or maintenance.

When the Monitor Unit is switched on a red neon illuminates in the power switch and the digital display should illuminate.

4.4.2 Operating the Automatic Balance Compensation System

Upon first switching ON the instrument, press the INITIATE button to manually initiate a balance cycle. The dual colored ABC STATUS (LED) will glow green. Note: it may glow amber if the Dewpoint Meter is not already balanced or, flash amber for an instant at the start of a balance cycle until dew or frost, if present, on the cooled mirror surface is evaporated.

The instrument will now perform a balance cycle to compensate the ABC system for the current level of contamination of the optical system.

4.4.3 Periodic ABC Operation

For process monitoring and control applications the instrument should be operated in automatic balance mode with duration and period of the ABC cycle set by the user as shown in section 2.7. The time settings used will depend on the application, generally the drier and cleaner the gas the longer the ABC frequency. For most applications an ABC frequency of 4 to 8 hours is realistic.

The ABC system will self-initiate and compensate the control electronics for build-up of contamination on the optical surfaces. Also, it will illuminate a front panel red alarm LED ABC STATUS when the optics loop can no longer compensate for optical contamination.

A balance cycle can be initiated at any time, regardless of when the last periodic cycle was performed simply by pressing the front panel INITIATE button. This balance cycle will be in addition to the periodic ABC cycles and will not reset the periodic timer.

4.4.4 On Request ABC Operation

Operation of the balance system in its On Request mode allows the user to manually initiate a balance cycle instead of allowing the instrument to perform this task at set time intervals. If operated in this configuration, the instrument will only perform an ABC cycle when the user initiates the process through use of the front panel switch marked INITIATE (see section 2.8), the Remote ABC initiate terminal on the rear panel (see section 4.5.1) or via the RS232 interface (see section 4.5.2).

For laboratory use or calibration work it may be desirable to operate the Series 4000 in this mode, to prevent the automatic initiation of the balance cycle causing interference with critical measurements.

4.5 User Inputs / Outputs

4.5.1 Analog Inputs / Outputs

The monitor unit features, as standard, the following inputs and outputs. These are available on the “User I/O” connector located at the rear of the monitor unit.

Pin Number	Function	Range	Notes
1	0V Analog		
2	Dewpoint 4-20mA	-60 to +30 °Cdp	Max 500 Ω Load
3	Dewpoint 10mV/ °C	-100 to +100 °Cdp	
4	Temperature 4-20mA	-50 to +50 °Cdp	Max 500 Ω Load
5	Temperature 10mV/ °C	-80 to +80 °C	
6	% RH 4-20mA	0 to 100 %	Max 500 Ω Load
7	% RH 0-1 V D.C.	0 to 100 %	
8	0V Digital		
9	Data Hold TTL	5V = Data Held	Digital Output
10	ABC TTL	5V = Balancing	Digital Output
11	Optics Alarm	0V = Alarm	Digital Output
12	Remote ABC Initiate	0V to initiate	Input

The “USER I/O” connector located on the Monitor rear panel is a 12 way screw-terminal type and accepts wire pin or bare wire connections.

4.5.2 Digital Interface

The monitor unit features, as standard, an RS-232 interface. An RS-485 interface is optional. Refer to Section 7.1.

The 9 pin "D" type socket connector on the monitor unit rear panel marked “RS 232” has the following pin connections :

Pin Number	Function
1	N/C
2	Transmit data (TXD)
3	Receive data (RXD)
4	N/C
5	Signal Ground (GND)
6	N/C
7	Clear to send (CTS)
8	Request to send (RTS)
9	N/C

The serial link has the following protocol:-

9600 baud rate
8 data bits
1 stop bit
No parity.

The following parameters may be read via the RS232 interface :

- Dewpoint ($^{\circ}$C)
- Dewpoint ($^{\circ}$F)
- Water Content (PPM(V))
- Water Content in SF_6 (PPM(W))
- Water Content (g/m^3)
- Water Content (g/kg)
- Pressure (KPa)
- Relative Humidity (%RH)
- Temperature ($^{\circ}$C)
- Temperature ($^{\circ}$F)

To initiate data transfer from the S4000 instrument, a request command is required.

The commands are :

dpc<CR>	or	**DPC**<CR>	for Dewpoint in°C
dpf<CR>	or	**DPF**<CR>	for Dewpoint in °F
ppm<CR>	or	**PPM**<CR>	for Water Content in PPM(V)
sf6<CR>	or	**SF6**<CR>	for Water Content (PPM(W)) in SF_6.
gm3<CR>	or	**GM3**<CR>	for Water Content in g/m^3
gkg<CR>	or	**GKG**<CR>	for Water Content in g/kg
prs<CR>	or	**PRS**<CR>	for Pressure in Kpa
rh<CR>	or	**RH**<CR>	for Relative Humidity in %
tpc<CR>	or	**TPC**<CR>	for Temperature in °C
tpf<CR>	or	**TPF**<CR>	for Temperature in °F

(CR = carriage return (13 ASCII))

The S4000 instrument will respond with, for example, the following:

-15.47 degC
or
27.56 degF
or
5347.97 PPM(V)
or
110.76 PPM(W) SF6
or
3.76 gM3
or
4.52 gKG
or
101.3 KPa
or
25.7 %RH
or
72.68 C
or
-42.39 F

Additionally, a Balance cycle may be initiated through the RS232 interface.

To initiate an ABC the request command is **abc<CR>** or **ABC<CR>**

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4.6 Microscope

It is possible in certain circumstances that between 0 and -20 °C. super-cooled water may form on the mirror surface instead of ice. The theory for this phenomenon is quite complex but the effect is that, for a sample of fixed water vapor concentration, the controlled mirror temperature is affected by as much as 2 °C. Super-cooled water formation leads to dewpoint values lower than would be seen if ice crystals were formed. If you require further advice on this matter please contact Kahn Instruments' Technical Sales Department.

The microscope allows direct viewing of condensate on the mirror surface providing visual evidence that ice crystals have formed in the critical region between 0 and -20 °C dewpoint.

The microscope is fitted into the sensor cover by replacing the black screw threaded plug with the microscope. Ensure the instrument is measuring a dewpoint then screw the microscope into the sensor cover until sharp focus of the mirror surface is achieved. As a guide to the focal point, the microscope should only have about four to five threads showing when it is screwed in. Fine adjustment will be necessary to obtain sharp focus.

When the instrument is controlling at a dewpoint condensation is seen on the mirror as small bright red specks on a dark background. Liquid water is seen as rounded droplets and ice as sharp-edged crystals.

5. TECHNICAL SPECIFICATIONS

5.1 General

Accuracy - complete system, nominal:	+/- 0.1 °C. dewpoint - displayed. +/- 1.0 % RH - displayed.
Cooling rate:	5 °C. / second (average).
Response speed:	Approx. 1 minute above 0 °C dewpoint and 1 hour at -60 °C dewpoint. Variable between these limits.
Sensitivity:	0.01 °C.
Repeatability:	0.1 °C. dewpoint.
Power supply:	90 to 260 Volts AC 50 - 60 Hz.
Power consumption:	Max. 250 VA.
Power Fuse:	3.15 Amp 250V 20 mm. Time delay.
Heat Pump Fuse:	3.15 Amp 250V 20 mm. Time delay.
Operating temperature:	0 to 40 °C. Performance quoted at 21 °C ambient.
Operating environment:	0 to 90% RH.
Dimensions (mm):	19" sub-rack. 133H (3U) x 511D.
Weight:	9.8 kg (21.6 lb).

5.2 Sensor

Mirror cooling:	Three stage Peltier with forced air cooling.
Mirror:	Plated copper.
Dewpoint range:	-60 to +35 °Cdp.

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Notes : 1. Upper dewpoint limit is dependent on ambient temperature. Generally dewpoints up to 2 °C below ambient can be measured.
2. Lower dewpoint limit is dependent on ambient temperature. Refer to Appendix 3.0 : S4000 *Integrale* Depression Range.

Gas Temperature range:	-80 to +80 °C.
% Relative Humidity range:	< 0.5 to 99.9%.
Photo detection system:	Wide band red LED and dual photo-detectors. All protected from the gas by quartz light guides.
Sample flow rate:	50 to 200 cm^3/min. Flow meter 50 to 500 cm^3/min.
Pressure:	Maximum 10 barg.

5.3 Control Electronics

Digital display:	Dual 6 digit 7-segment LED, with 2 digit 7-segment unit annunciators.
Units (Top):	°C dewpoint or °F dewpoint.
Units (Bottom):	PPM(V) or PPM(W) in SF_6 or g/m3 or g/Kg or kPa. Note : If a pressure transducer is not connected to the instrument, by default, atmospheric pressure is selected i.e. 101.3 kPa.
Resolution:	0.01 °C. (Dewpoint and Temperature) 0.01 °F. (Dewpoint and Temperature) 0.01 PPM(V) or PPM(W) 0.01 g/m^3 0.01 g/kg 0.1 kPa 0.1 %RH
Outputs	
Analog:	10 mV / °C dewpoint 4-20mA over the range -60 to +30 °C dewpoint
Digital:	Data Hold Balance Cycle Optics Alarm

Inputs, Digital:	Remote ABC Initiate
Serial Comms Type :	RS232 (RS485 Option)
Serial Comms Data:	Dewpoint (°C) Dewpoint (°F) Water Content (PPM(V)) Water Content in SF_6 (Sulphur Hexafluoride) PM(W)) Water Content (g/m^3) Water Content (g/kg) Pressure (kPa) Relative Humidity (%RH) Temperature (°C) Temperature (°F) ABC Initiate
%RH Calculation:	Calculated using water vapor pressure tables (D Sontag ITS-90). Over water for temperatures between 0 and 100 °C and over ice for temperatures between –100 and 0 °C.
Gas Temperature Accuracy:	+/- 0.2 °C.
PRT Probe Type:	Stainless Steel, sheathed, with 2 meter cable. 1/10 DIN class B 3 wire PRT.

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6. MAINTENANCE

6.1 Cleaning the Optical System

The Kahn Series 4000 *Integrale* is a precision optical dewpoint hygrometer, which uses a four component optical system to detect condensation of water from a gas sample. This system comprises a light emitting diode (LED), two photo-detectors and a mirror surface. The LED and scattered light photo-detector are isolated from the gas stream by light guides so only the ends of the light guides inside the measurement chamber and the mirror surface require cleaning. The reflected light detector receives light through a 0.8 mm hole in the chamber housing and should not normally require attention.

When in the AUTO MODE, the Series 4000 instrument activates an Automatic Balance Compensation system (ABC) on a regular basis to compensate for contamination of these optical components. However, this ABC system, or the manual balance system, has a finite limit of effectiveness beyond which compensation cannot be ensured. When this limit is reached the red ABC STATUS LED on the monitor front panel will light, warning of heavy contamination. At this point it is necessary to clean not only the mirror surface but also the light guide ends.

6.1.1 Cleaning Procedure

(a) Ensure that all surfaces are at a temperature above that of the freezing point of the cleaning fluid.

(b) Remove the metal sensor sealing cap assembly at the front of the sensor unit (including black plastic plug or microscope) by unscrewing it in an anti-clockwise direction. Take care not to misplace the "o" ring seal which seats in the PTFE block and seals against the quartz glass viewing window.

(c) Check the "o" ring seal for damage and replace if necessary.

(d) As a general rule, clean the mirror and light guide ends with a Q-tip soaked in distilled water.

If contamination is oil-based then one of the following solvents may be used instead of distilled water: methanol, ethanol, isopropyl alcohol.

A spray may be used along with a Q-tip wool bud as long as it does not leave a film coating on the optics and providing it contains only the recommended solvent as above. Take care not to leave deposits on any of the optical surfaces**.**

(e) Ensure that all the cleaning fluid has evaporated before replacing the metal sensor sealing cap assembly. Take care to ensure that the "o" ring seal is correctly seated.

(f) After assembly, press the INITIATE push-button to initiate an ABC cycle. Then re-balance the instrument.

In a clean environment it is quite normal for the instrument to operate satisfactorily for several months without the need for optics cleaning. However, it is good practice to ensure the cleaning procedure is carried out regularly rather than waiting for the red ABC STATUS LED to illuminate.

7. OPTIONS

7.1 RS485 Output

An RS485 interface is available as an option to the standard RS232.

Using RS485, the request commands and responses are identical to those stated in Section 4.5.2, the RS485 serial link has the same protocol, see below:

9600 baud rate,
8 data bits,
1 stop bit,
No parity.

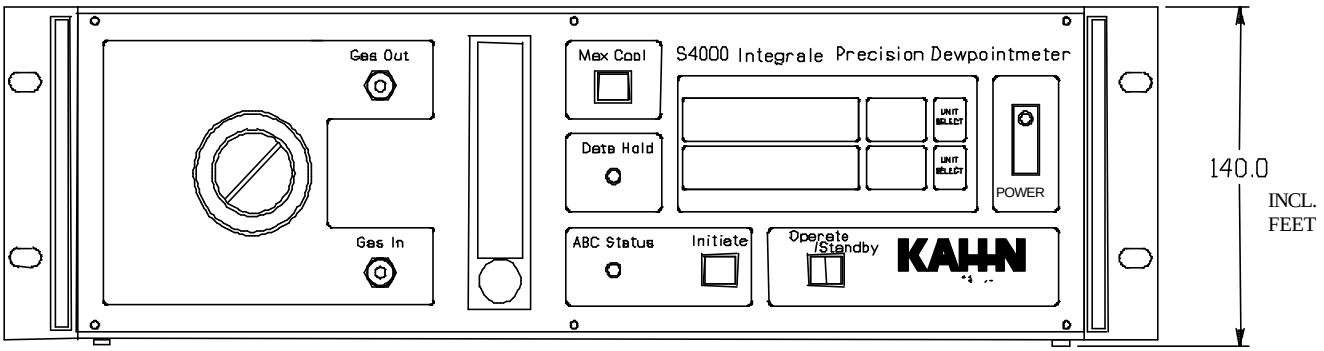
7.2 Remote Pressure Transducer

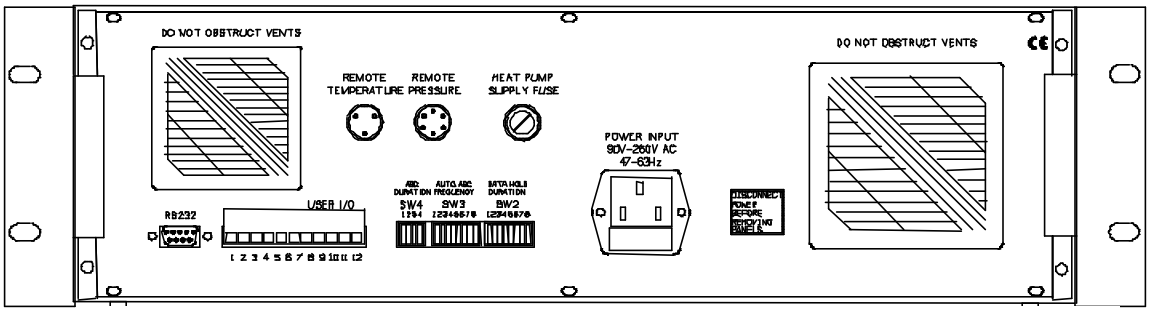
The standard S4000 *Integrale* Dewpoint Meter is configured such that all pressure sensitive parameters are calculated at 101.3 kPa (atmospheric pressure).

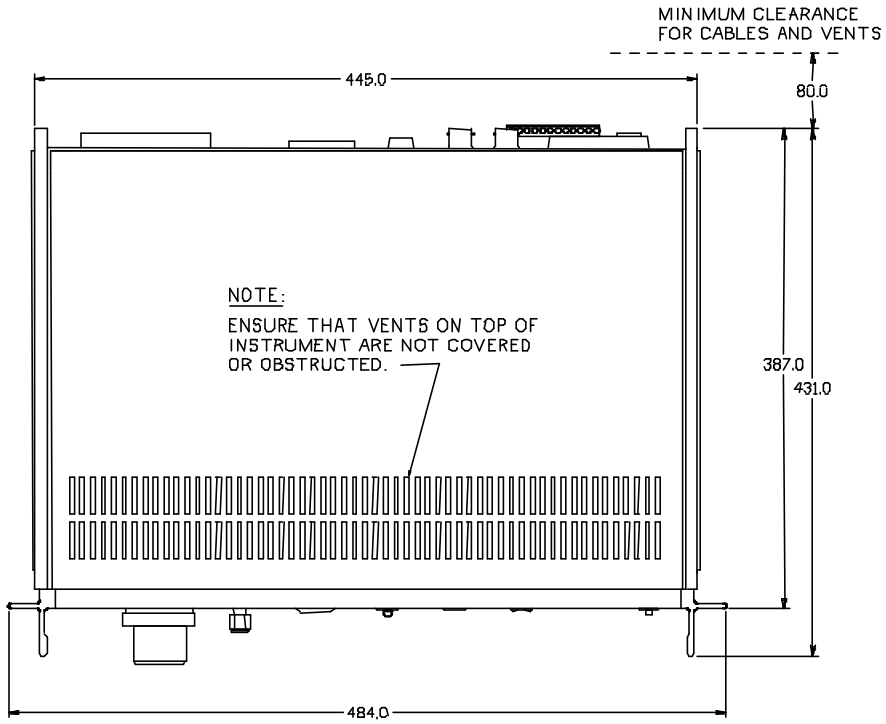
As an option, the instrument can be supplied with a pressure transducer to allow the actual sample gas pressure to be monitored, and the PPM(V), PPM(W), g/m^3 and g/kg parameters to be pressure compensated.

The standard pressure range is 0 to 50 psi absolute, i.e. at / around atmospheric pressure. But particular pressure ranges may be supplied to order. Contact Kahn Instruments' Technical Sales Department for further information.

APPENDIX 1 S4000 *Integrale* Outline Drawings







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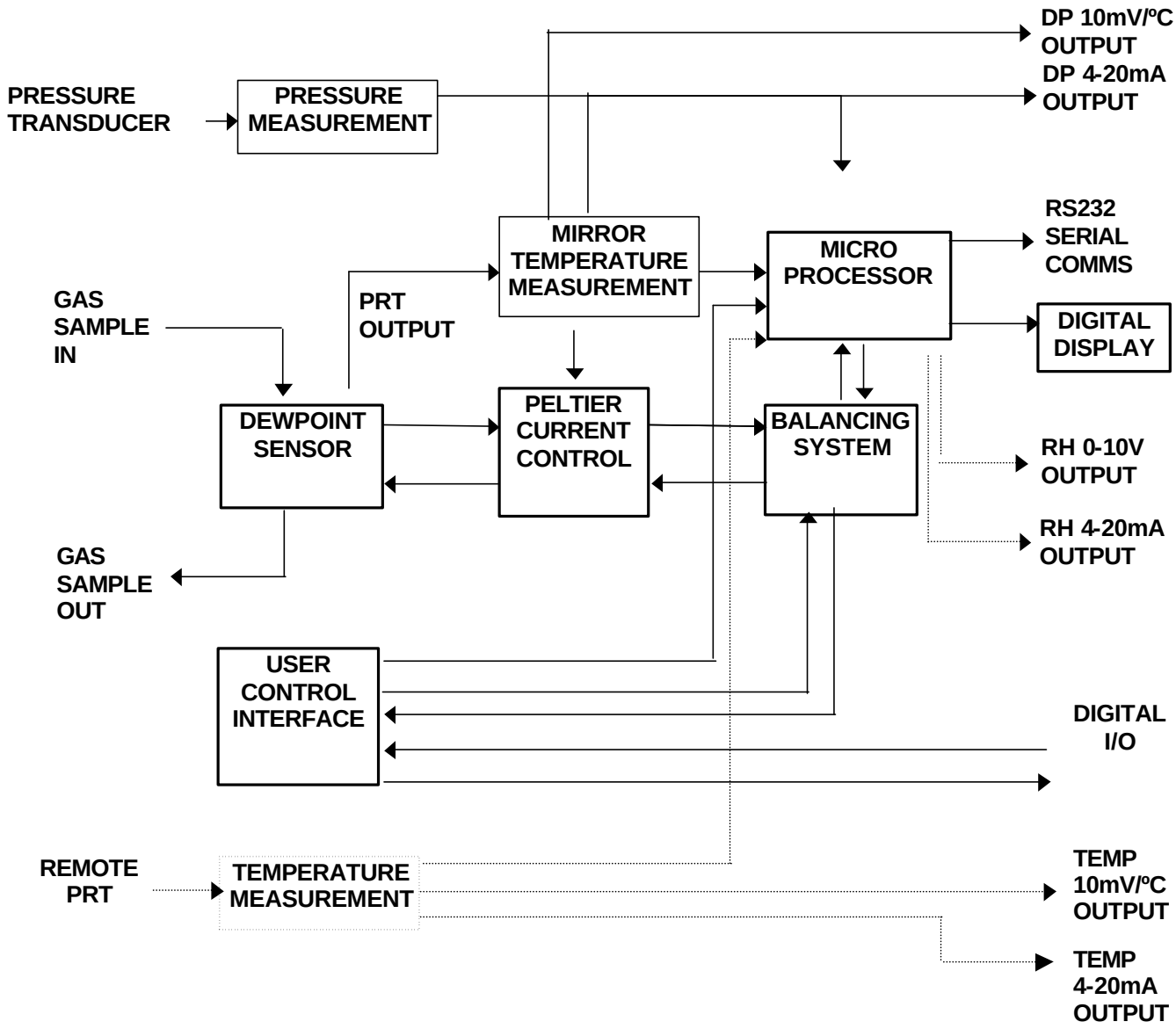
APPENDIX 2 System Schematic



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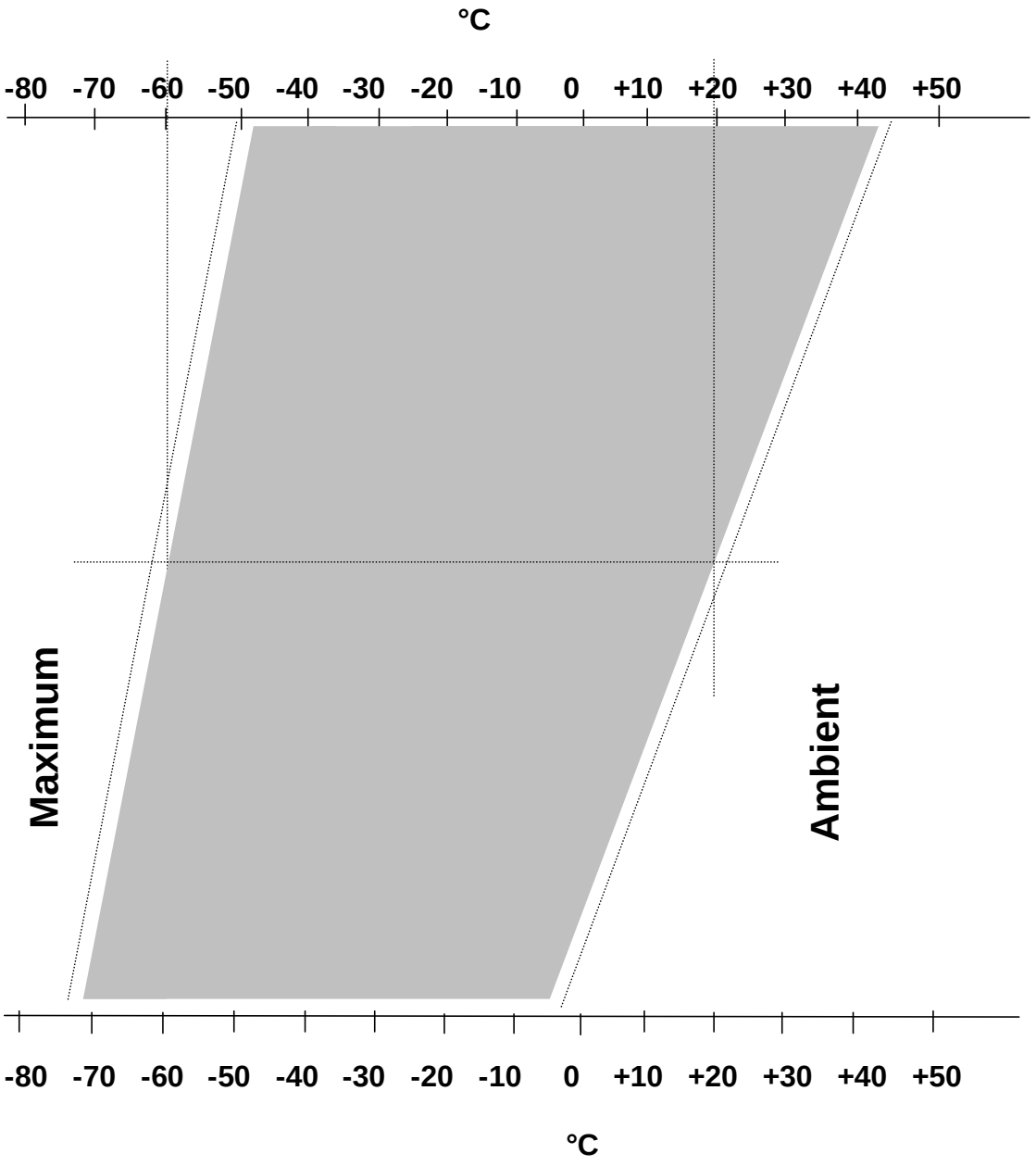
APPENDIX 3 S4000 *Integrale* Depression Range



As shown, with the S4000 *Integrale* Dewpointmeter operating in an ambient temperature of +21°C, the maximum depression is –62°C. The upper dewpoint measurement limit is +19°C dewpoint and the lower dewpoint measurement limit is -60°C dewpoint.

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