Moisture Management System

ST-2200A

User Manual

Confidential

Sensortech Systems™ Inc.
The Measurement and Control Company

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ABOUT THIS MANUAL 1

Introduction

The ST-2200A is the most advanced radio frequency moisture analyzer currently available. Featuring state of the art sensor technology coupled with the flexibility of digitally programmable processing.

In order to get optimum results from your instrument, you are strongly recommended to read this manual and familiarize yourself with all the features. For those anxious to switch on and get started, please read chapters 2, 3, 4 and 6 for the most basic features and installation guidance.

This chapter is essentially a summary of the manual and should be used in conjunction with the table of contents to locate a desired section of interest.

Chapter 14	Trouble shooting	Common problems and solutions.
Chapter 15	Quick reference	Table of functions, Error messages.
Chapter 16	Sample Calibration	Gypsum board calibration procedure.

Each chapter follows a common format, beginning with simple user function explanations and keystroke examples. Later chapters assume basic keyboard knowledge and omit each individual key press. If difficulty is experienced, the user should read the early chapters and become better acquainted with parameter inputs.

Technical Assistance

Every effort has been taken to ensure the accuracy of this user manual. In the event of problems using this equipment and / or the manual, please don't hesitate to call our technical service line:

Tel: (805) 981-3735
e-mail: support@sensortech.com
http://www.sensortech.com

Office hours are 8am – 4:30pm PST, Monday - Friday.

In our efforts to continue serving our customers, we invite your comments relating to this or any other of our products.

INSTALLATION 2

Unpacking

Most ST-2200A systems will be packed in two boxes. One box will contain the processor and the other one a sensor. If a small sensor is purchased, it may be included with the processor package.

Visually inspect packages for any sign of physical damage before opening. If damage is noted, contact carrier or Sensortech for instructions.

Unpack both cases, being careful not to discard documentation or mounting brackets etc..

Contents should include:

ST-2200A Processor unit
ST-2200A Sensor unit
Inter-connecting cable
Processor mounting brackets
Documentation (packing list, engineering drawings, user manual)
Optional accessories (may include sensor hardware)

If any of the above are missing or damaged, please contact the factory.

Installation

The ST-2200A moisture analyzer operates on AC line voltages of 85vac - 250vac with no adjustment needed. A suitable AC supply should be routed to the processor, power the unit from a 50W or greater uninterruptable power supply.

IMPORTANT

The processor enclosure should be grounded via the rear panel safety ground terminal located on power terminal strip. Failure to provide an adequate ground may result in serious injury to personnel.

Do not mix serial numbers.

Do not modify any components without contacting Sensortech Systems, Inc., first.

The processor is panel mounted with the mounting brackets provided. For panel cut out details, see chapter 13.

Remove front processor bezel by gripping top and bottom and applying slight outward force. Bezel will easily release. Slide mounting brackets into upper and lower T slots on processor enclosure.

Feed processor through panel cutout from rear of panel. Secure brackets to front panel. Slide processor forward through panel until it is possible to clip bezel onto processor. Slide processor back until bezel sits firmly against panel. Secure set screws on mounting brackets to tighten instrument in place.

Sensor

A 25 foot multi-conductor cable is provided to connect sensor to processor. If more cable is needed it may be purchased as an option. The customer may provide his own cable, but should contact factory for specification and termination procedures.

Normally, in a permanent installation, the cable should be installed in a suitable conduit. Since the cable has a plug installed at sensor end, it should be pulled through conduit from sensor to processor.

Connect cable to sensor terminal strip on rear of processor, taking care to ensure correct connections (see chapter 13).

The physical mounting of sensor is dependent upon sensor type and application. Ensure sensor frame is grounded to process frame (conveyor frame etc.). This is not a safety requirement, but may influence instrument performance. For detailed mounting considerations, see chapter 11.

At this time the instrument is operational and can be tested prior to connecting any auxiliary inputs or outputs.

Switch on AC power to instrument. See chapter 3 for basic operating procedures. This is a good time to pre-zero and standardize instrument (allow approximately 30 minute warm up time).

Auxiliary inputs, alarm outputs, analog and digital outputs may next be connected, but it is suggested they be connected one at a time and each tested before proceeding. In this manner, wiring faults can be easily diagnosed and corrected.

BASIC OPERATING PROCEDURE 3

Numerous operator functions are available to provide calibration and configuration parameters. These functions are logically nested into groups.

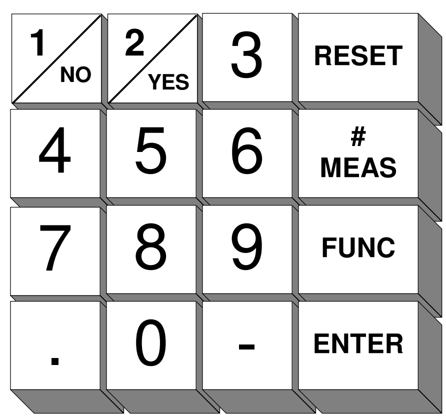
Function Groups

0	General
20	Limits
30	Dielectric Calibration
40	Temperature Calibration
50	Weight Calibration
60	Distance Calibration
100	Utilities
120	I/O Configuration
140	Diagnostics

Keyboard

A four by four matrix keyboard provides operator input. The following is a brief explanation of each key function.

0 - 9	Provide digital entry of parameter values.
.	Decimal point for fractional values.
-	Negates digital value
RESET	Clear function (see later detailed explanation)
# MEAS	Measurement Key.
FUNC	Function Key.
ENTER	Enter Key.

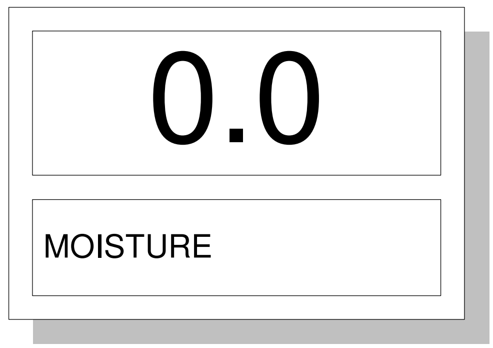


Or C (Reset) for clear on older models

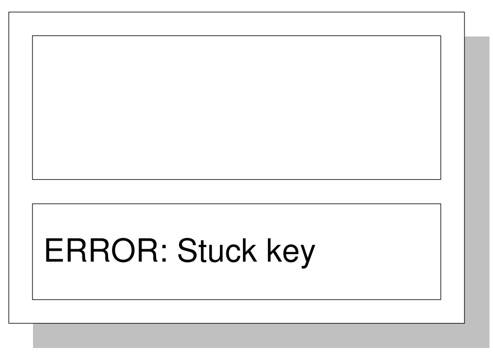
When the instrument is first powered up, it runs certain self-diagnostics. If no problems are found, it will enter measurement mode with the lower indicator displaying MOISTURE, and the upper displaying actual numeric content. If a problem is found, the lower display will indicate an error message. This sequence is shown next page.

Immediately upon power up, the instrument displays message shown at right, whilst performing self-diagnostics.

After approximately 5 seconds, measurement begins and moisture is displayed.

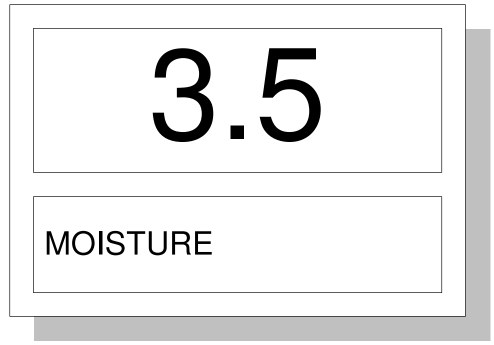


In the event of a self-test failure, an error message is flashed in lower display. The example at right can be simulated by applying power to unit while maintaining any key pressed on the front panel. When an error has been rectified, pushing RESET key can clear the message.

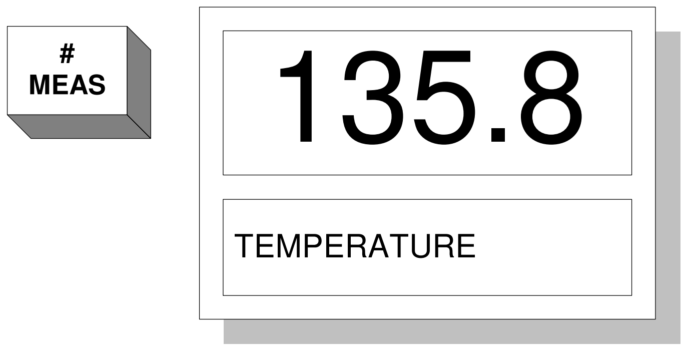


<u># MEAS Key</u>

Pressing this key whilst in measurement mode will scroll through the four measurements i.e. Moisture, Temperature, Weight, Distance. The lower display will indicate relevant variable whilst upper display will indicate value of variable.



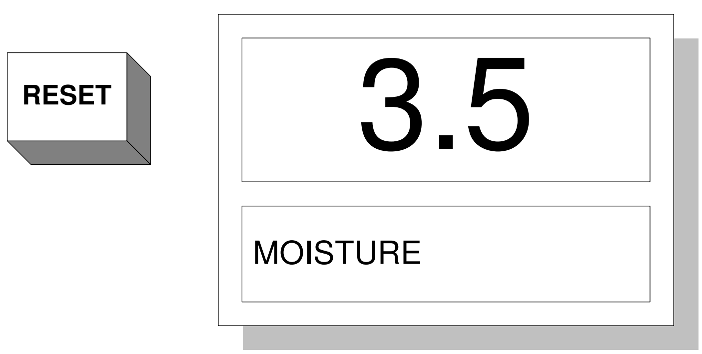
Press



Press

Further pressing the # MEAS key will continue scrolling through measurement variables. Pressing RESET returns to moisture measurement at any time.

Press



FUNC Key

The function key provides access to desired parameters. Pressing this key whilst in measurement mode will cause lower display to scroll through main function groups (excluding utilities, I/O config. and diagnostics). To return to measurement mode, press RESET or # MEAS keys at any time (see fig.1)

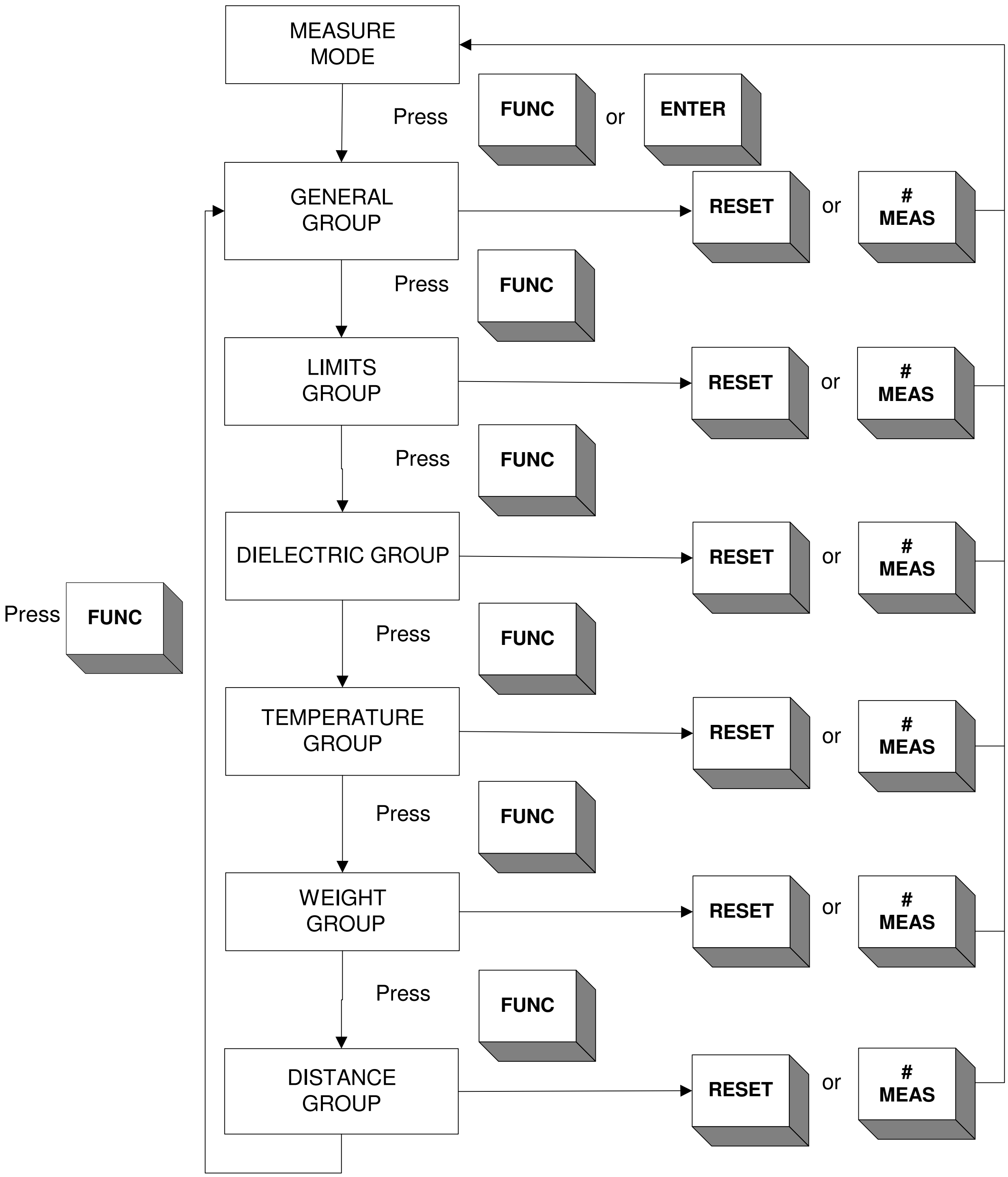


Figure 1. Main Function Group Access Sequence

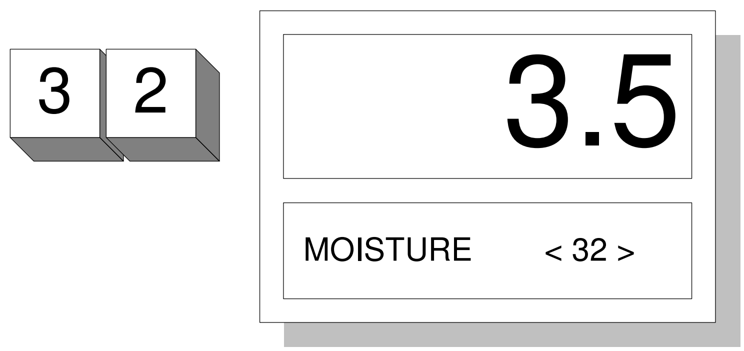
To enter the sub group functions from a main function group scroll to desired group by repeatedly pressing function key, and press ENTER key. The flow chart of figure 1 illustrates the access sequence to the main function groups.

Utilities, I/O configuration and diagnostics are considered advanced functions, so are not normally accessed by function scroll. These functions may be accessed directly as follows:

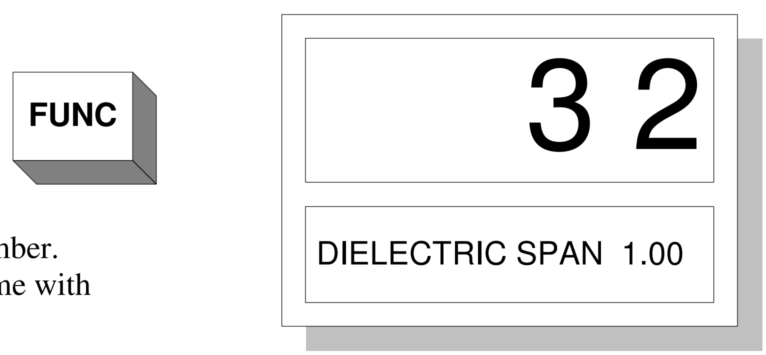
Press 1, 0, 0, FUNC	Lower display indicates UTILITIES
Press ENTER	Enters Utilities sub group.
Press 1, 2, 0, FUNC	Lower display indicates I/O CONFIG.
Press ENTER	Enters I/O Config. sub group.
Press 1, 4, 0, FUNC	Lower display indicates DIAGNOSTICS
Press ENTER	Enters Diagnostics sub group

If the function number of a specific parameter is known, enter this number using digital keys, followed by pressing FUNC key. This will immediately access desired parameter e.g. Dielectric Span (32):

Press



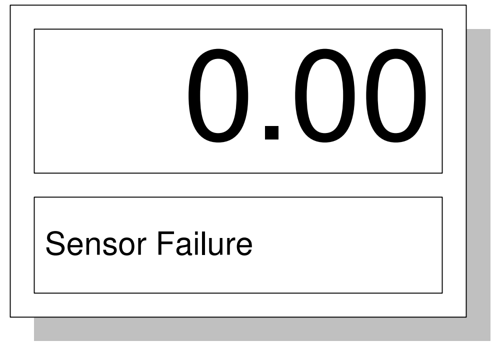
Press



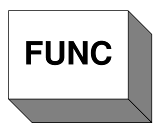
Upper display indicates function number.
Lower display indicates function name with numeric value at right.

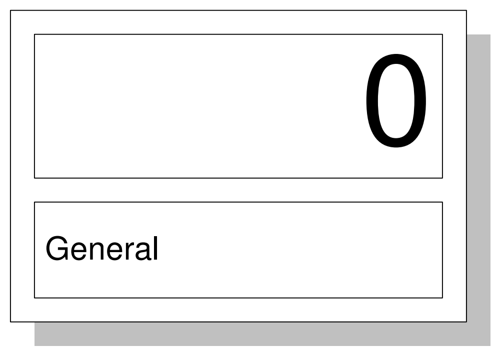
If an error message can not be cleared, i.e. "Sensor Failure", pressing the FUNC key will cause unit to enter General Group. At this point any function may be entered for access.

I.E.

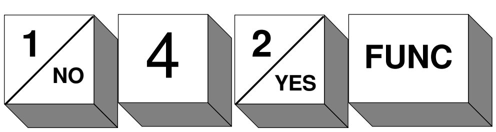


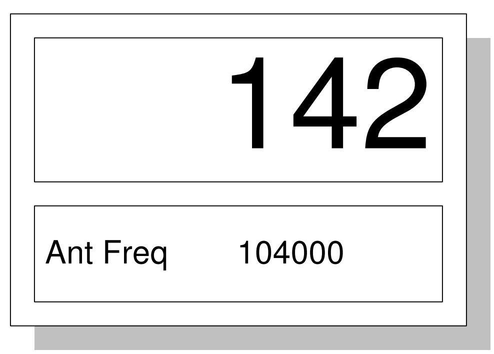
Press:





Press:



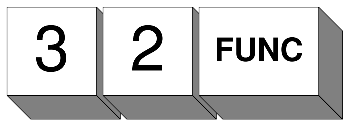


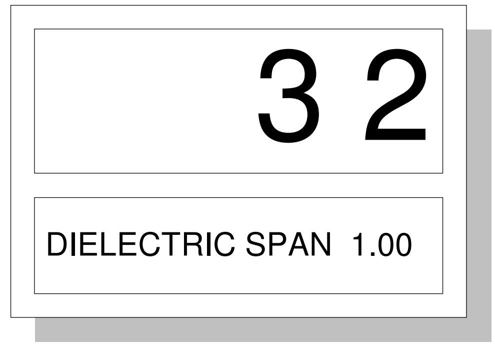
<u>ENTER Key</u>

When a parameter value has been entered (displayed in lower right display), it is not yet entered to memory. If a mistake was made in entering value, it may be cleared with the RESET key. Memory is updated by pressing ENTER key. Note: No parameters may be changed without first entering password code (function 2).

Example: To change dielectric span to value 1.85

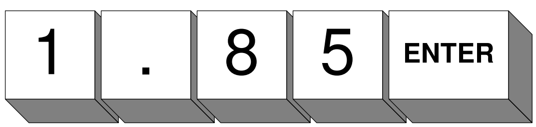
Press





Lower display indicates current span value.

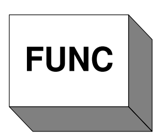
Press

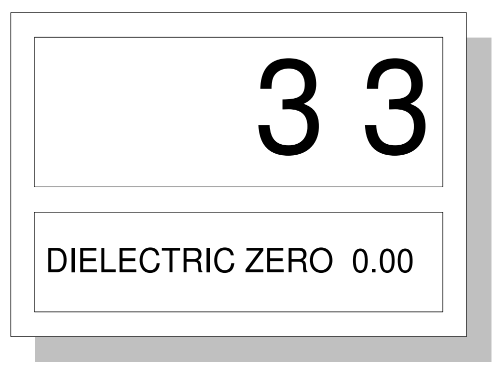


Note: The value 1.85 is displayed, but not entered until pressing ENTER.

To view or change next function:

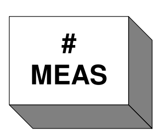
Press

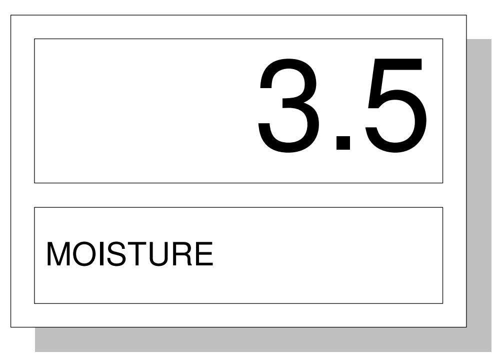




<u>OR</u> to return to measurement mode;

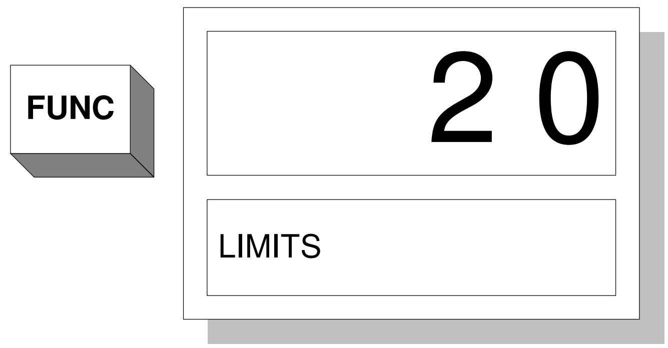
Press



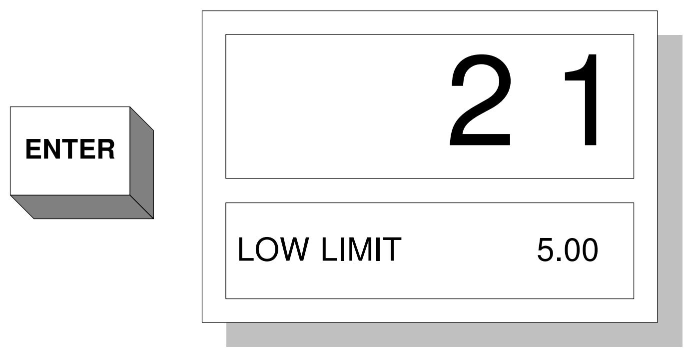


The ENTER key has a secondary function. When in a main group, pressing ENTER will cause jump to sub group e.g. Limit Group (20), pressing ENTER will jump to function 21 (Low Limit).

Press



Press



<u>RESET Key</u>

This key has several functions. If a wrong value is entered without pressing ENTER, pressing RESET will erase the entry and a new value may be entered. If no new value is entered, the parameter will revert to its original value.

Pressing RESET whilst in a sub group function at any time other than following a digital entry, will cause jump to main group. In the previous example, if the RESET key had been pressed, a jump to LIMIT main group (20) would be made.

If any errors occur, there will be a flashing indication in the lower display.
When the problem is remedied, pressing the RESET key may clear the error indication.

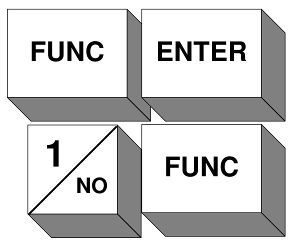
GENERAL GROUP FUNCTIONS 4

<u>1</u> <u>Product Code</u>

Up to ten (10) calibrations can be stored in non-volatile memory. This allows pre-calibration for different products.

Usage:

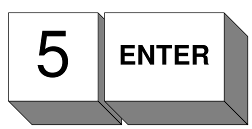
Press



or

To change product code (e.g. to 5)

Press



Press # MEAS to return to measurement.

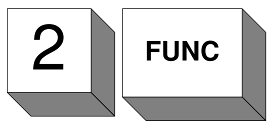
<u>Note:</u> This is the only parameter that can be changed without first entering valid password.

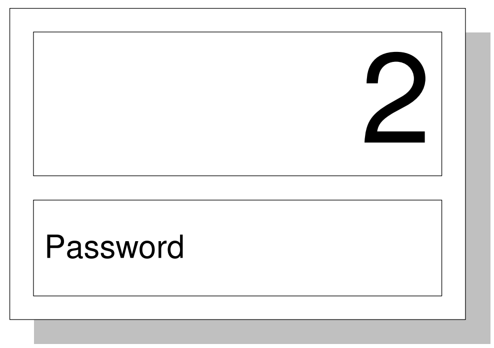
Product code can also be changed with a D.C. voltage. Apply voltage to DVM referenced to AGND in 1VDC +/-0.2VDC increments. Change 137F to AutoMode - 137 FUNC 3 ENTER. 1 Volt equals Product Code 1, 2 Volts equals Product Code 2, etc.

<u>2 Password</u>

In order to protect the instrument from accidental or unauthorized parameter changes, a password code must be entered prior to any other actions. A time out period of five minutes will elapse from time of last key entry after password entry. Thus, if numerous operations are required, the time out will be extended every keystroke and for a further five minutes after final entry. If it is desired to shorten this unprotected period, simply enter an invalid password, and protection will immediately take effect. A valid password may be 3 to 6 digits with no leading zeros.

To enter password:

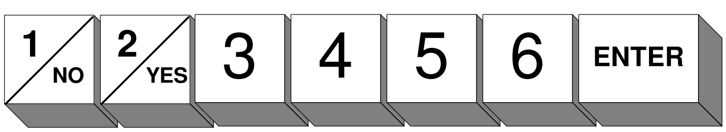
Press 

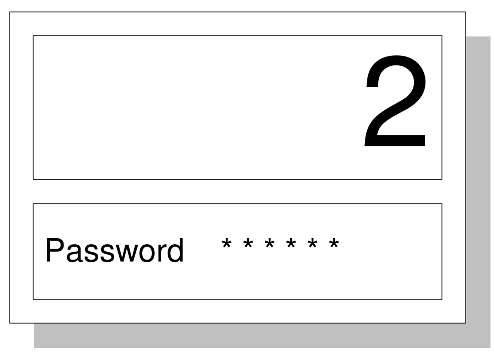


Note: Password is factory set to 1, 2, 3, 4, 5, 6.
To change password, see New Password function.

Enter password code e.g. 1, 2, 3, 4, 5, 6.
Each digit is echoed with asterix in lower right display.
To enter code:

Press:





<u>Note:</u> If an invalid code is entered, the appropriate error will be indicated by a flashing lower display. Pressing RESET key can clear this.

<u>IMPORTANT</u> Having entered the correct password, you must exit password function by pressing FUNC to advance to next function; pressing # MEAS to return to measurement; pressing RESET to return to general group. Pressing any other keys may invalidate password.

3 Sample Rate

The sensor circuitry samples every 10 milliseconds (100 samples/sec.). The processor is capable of handling this sampling rate, but in many applications a slower rate is desirable.

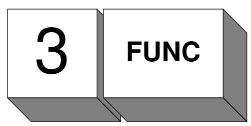
Three processor sampling rates can be programmed, namely:

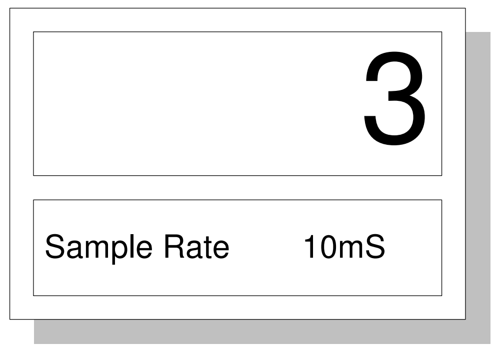
10 millisecond
100 millisecond
1 second
Auto

The slower rates are actually medians of the 10mS rate, resulting in cleaner, smoother displays.
Note: If even referencing is used, sampling time will be doubled.

To display sampling rate:

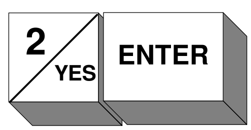
Press

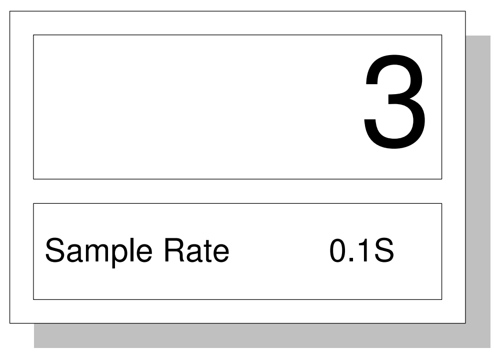




To change sampling rate:
e.g. to 100mS:

Press





Sample Rate codes are:

1 = 10mS
2 = 100mS (0.1S)
3 = 1S

In Auto Mode, short term product voids or gaps are ignored, e.g. gaps between cookies.

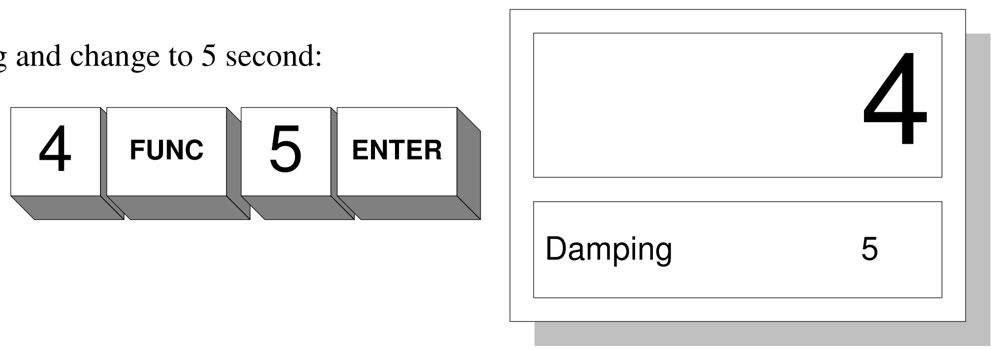
4 Damping

Damping or Averaging allows the user to smooth the response of the instrument by averaging successive samples. A running average is made whereby an averaging buffer is updated at selected sampling rate. Each new sample is added to the buffer and the oldest sample is discarded. Buffer length is determined by the amount of damping required, but maximum buffer size is 120. Thus at 1 second sampling, this would equate to 2 minute averaging. Only integer values may be entered e.g. 1, 2, 5, 100. Thus at 10mS sample rate the only valid entries are 0, 1.

Sample Rate	Averaging Range	Averaging Time
10mS	0, 1	0, 1 second
0.1S	0 - 12	0 - 12 second
1S	0 - 120	0 - 120 second

To display averaging and change to 5 second:

Press



If a damping value exceeding the above limits is entered, an appropriate error message is displayed. In this case the actual value remains unchanged.

<u>5 Decimal</u>

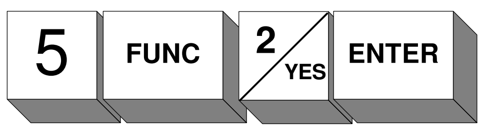
The upper four-digit display can indicate 0, 1, or 2 decimal places. The degree of resolution is programmable. <u>Note:</u> Sample rate, Damping and decimal point choice should be considered carefully. If the fastest sample rate is chosen together with minimum damping and two decimal place resolution, the resultant display may appear noisy.

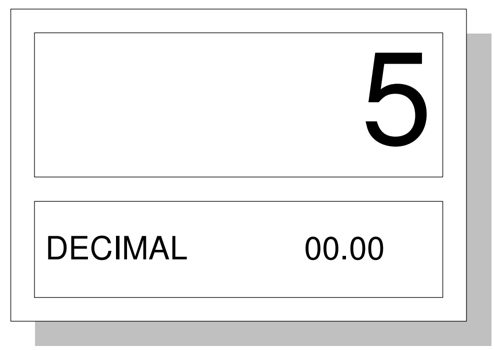
To select decimal point:

Press 0, ENTER	Lower display indicates DECIMAL 0000
Press 1, ENTER	Lower display indicates DECIMAL 000.0
Press 2, ENTER	Lower display indicates DECIMAL 00.00

To display and change decimal place (e.g. 2 d.p.):

Press:





<u>6 Pre-Zero</u>

CAUTION! This is a critical calibration parameter and will affect all calibrations.

The purpose of pre-zero is to remove the influence of the surrounding environment upon the sensor e.g. a metal beam located three inches from the face of the sensor, or a plastic window between sensor and sample. If this residual dielectric were not negated, it would cause problems when calibrating.

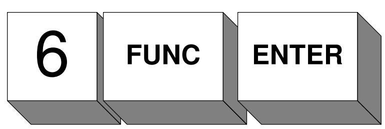
When the instrument is pre-zeroed, a single dielectric measurement is made and stored in memory, this pre-zero value is subsequently subtracted from all future readings. The actual pre-zero value is not normally shown, but can be displayed in diagnostics (function 146). The basic moisture algorithm is shown below:

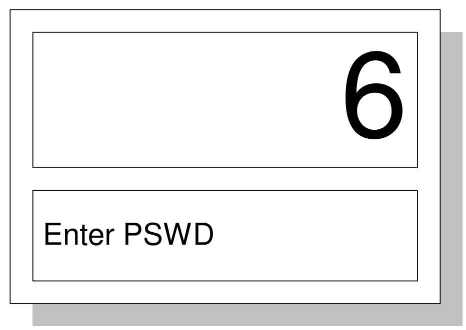
Moisture = Dielectric Span * [Dielectric - Prezero] + Dielectric Zero

Pre-zero is performed as follows:

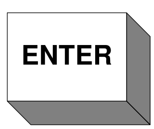
<u>IMPORTANT</u>: Ensure all product is removed from sensor, and that sensor surface is clean.

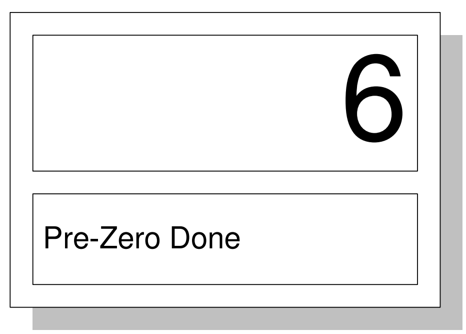
Press:





Instrument responds: Enter Password.
Press 1, 2, 3 , 4, 5, 6.





Pre-Zero is not performed until the ENTER key is pressed. If any errors occur during Pre-Zero, e.g. debris is noticed on the sensor, press RESET key, clean off sensor and press ENTER once more.

7 Standardization

CAUTION! This is a critical calibration parameter and will affect all calibrations.

DO NOT STANDARDIZE UNIT WITHOUT A STANDARDIZATION PLATE, TUBE, ETC. IT WILL CAUSE ERRONEOUS READINGS. PLEASE CONTACT THE FACTORY SHOULD YOU HAVE ANY QUERIES.

The purpose of standardization is to provide uniformity of calibration between instruments, and to provide a repeatable reference.

The standardization value is used as a secondary span coefficient, and may be considered as a scaling factor S.F. See following equation:

Moisture = S.F. * Dielectric Span * [Dielectric – Pre-zero] + Dielectric Zero

Due to manufacturing and component tolerances, no two sensors will be identical. The scaling factor or standardization value will compensate for these differences.

During standardization, dielectric span is forced to one (1), and dielectric zero forced to zero (0). The equation becomes:

Moisture = S.F. * (Dielectric – Pre-zero)

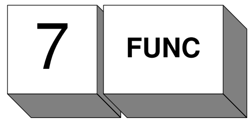
Transposing equation gives:
S.F. = Moisture / (Dielectric – Pre-zero)

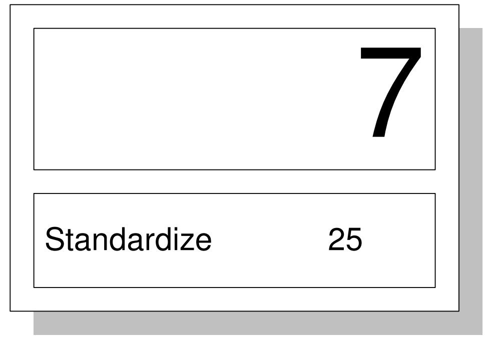
If a known reference sample is available, Standardization function allows the operator to enter that moisture value and the processor will calculate S.F. from the above equation. Reference materials are available with very stable dielectrics, which can also be used as standards. In this case the reference is placed on the sensor and an arbitrary value is entered in place of moisture e.g. Phenolic plate with target value 25.

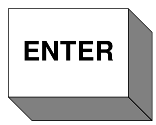
<u>IMPORTANT!</u> Ensure instrument has been properly pre-zeroed prior to standardizing.

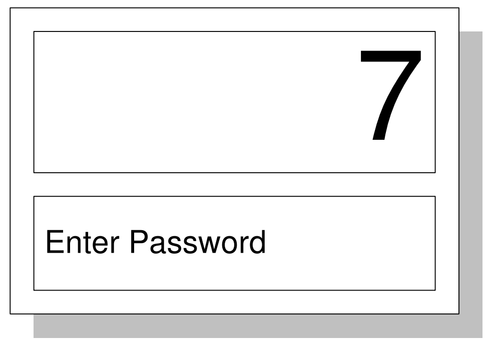
Proceed with standardization as follows:

Press:

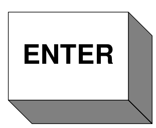


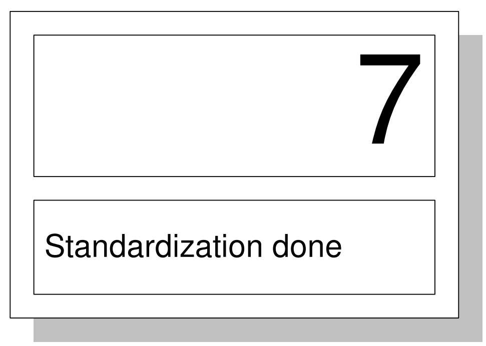






Put in Password, Press:





<u>Note:</u> Pre-zero and standardization should generally be checked at the same time. If a new instrument is being installed, it may be necessary to repeat each function since they are somewhat inter-dependant.

<u>8 Sampling Mode</u>

There are 4 modes of sampling, namely:

Mode 0 Continuous sampling. In this mode nothing can interrupt the sampling interval.

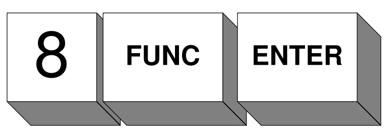
Mode 1 Sample on Command. A gating input to SOC on the rear panel suspends sampling and holds the last measurement on both the display and the analog output.

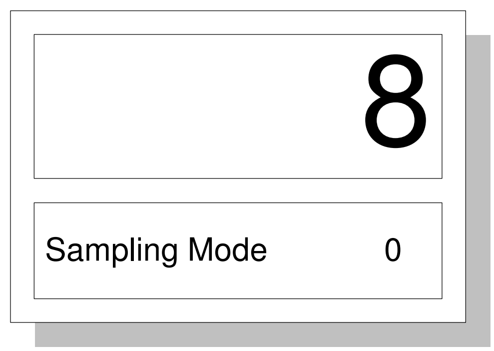
Mode 2 Timed sampling. Used in conjunction with sampling mechanisms, the output is frozen throughout a sample collection period. At the expiration of fill time, a one-second sample is taken and the display updated. Immediately following sampling, a digital output is strobed high for a purge period. Fill time and purge times are operator functions in the limits group (see later). FUNCS 27, 28

Mode 3 Automatic Product Detection. Similar to mode 1, but instead of using external proximity device to trigger sampling, the instrument detects the presence of sample. Product loss and return thresholds are operator functions in the limits group (see later). FUNCS 25, 26
<u>IMPORTANT:</u> APD sets a minimum damping value of 1 second.

Mode 4 Similar to Mode 1, but when no product is present, instrument returns to reference level set in Function 29. Uses SOC input as in Mode 1.

To view sampling mode:

Press: 



To change sampling mode press "desired mode number", followed by ENTER.

<u>9 Batch Averaging</u>

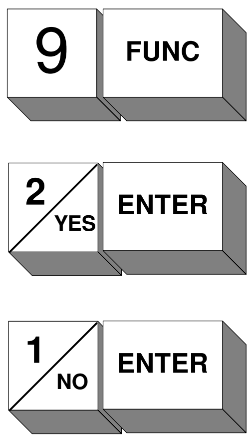
Batch averaging is a special case of damping. Used in conjunction with sample on command or APD, it provides an open ended averaging of sample during sampling interval. The digital and analog outputs display the last batch average while SOC is high (high - hold; low - sample). When SOC goes low, the instrument starts sampling, but display is not updated until SOC returns high. This indicates end of batch when the display will be updated with the previous batch average. A maximum batch time of six minutes is permitted. If the batch exceeds this time, a current average will be output and a new average begun.

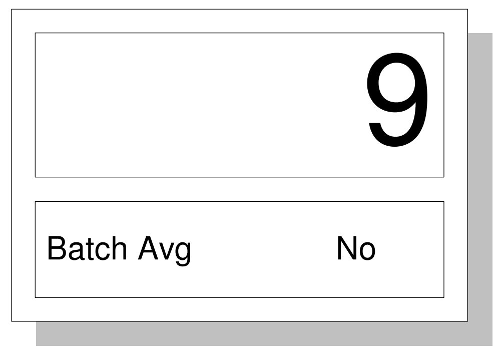
To view batch averaging function:

Press:

To toggle function "on",
Press:

To toggle function "off"
Press:





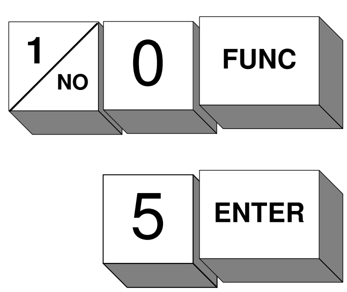
<u>IMPORTANT</u>
Setting batch averaging on, presets damping to zero.

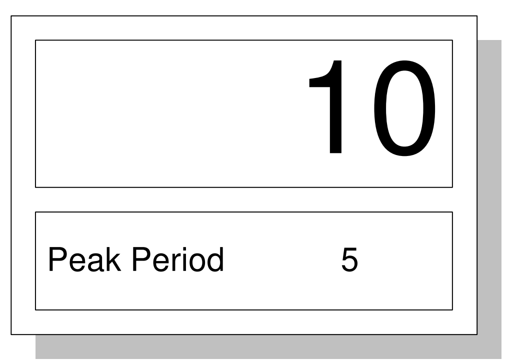
<u>10 Void Time</u>

Associated with Sample Rate 3F Mode 3 is Void Time. This function programs the time interval over which any voids are detected. Units are seconds and range is 1-99s.

Press:

Press:

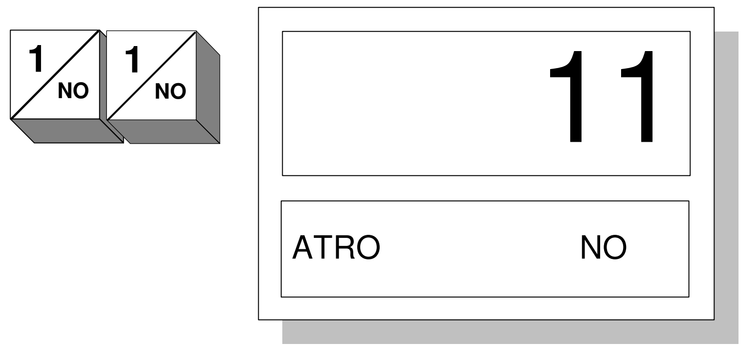




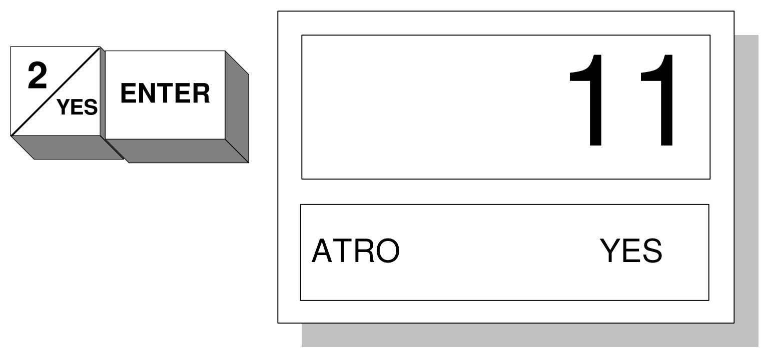
<u>11</u> <u>ATRO (Dry Basis)</u>

All instruments shipped from factory are in “total” (Wet Basis) mode. To change to ATRO (Dry Basis):

Press:



Press:



Wet Basis Moisture

$$\frac{\text{(Beginning Weight – End Weight)}}{\text{Beginning Weight}} \quad x \quad 100 \quad = \quad \text{Wet Basis Moisture}$$

ATRO / Dry Basis

$$\frac{\text{(Beginning Weight – End Weight)}}{\text{End Weight}} \quad x \quad 100 \quad = \quad \text{ATRO / Dry Basis}$$

Wet Basis Moisture Converts to ATRO

$$\frac{\text{Total Moisture}}{100 - \text{Total Moisture}} \quad x \quad 100$$

ATRO Converts to Wet Basis

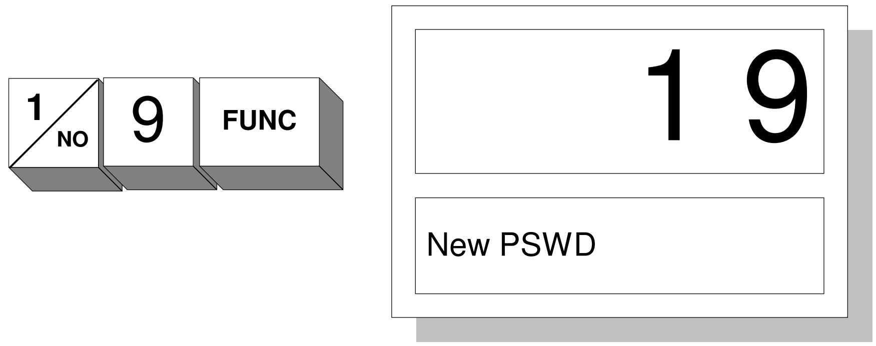
$$1 / (1 + (100 / \text{ATRO})) \quad x \quad 100$$

Note: All calculations with Sensortech Beta V2 software must be done in wet basis moisture. If readings and measurements are in ATRO / Dry Basis, they must be converted to total moisture first.

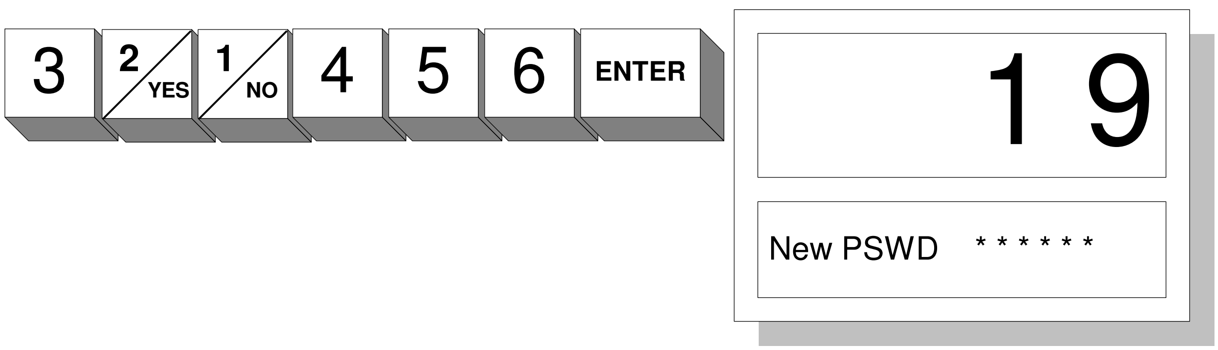
19 New Password

All instruments shipped from the factory will have a password code of 1 2 3 4 5 6. This code can be changed to any other six digit code using New Password function. To change password it is first of all necessary to enter the old password in function 2 (see earlier). The following example demonstrates accessing new password function and changing to a new code e.g. 3 2 1 4 5 6.

Press:



Press:



Each digit entry is echoed by asterix in display. This number sequence is now the valid password and must be entered in function 2 for future access.

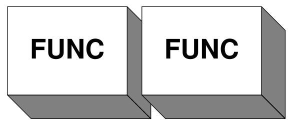
Press # MEAS to return to moisture display.

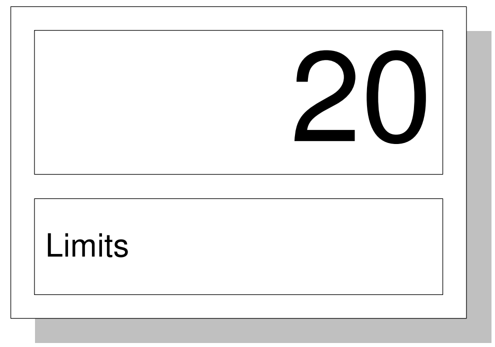
LIMITS FUNCTION GROUP 5

This group contains parameters pertaining to analog and digital outputs, including alarm outputs.

To access limits group from measure mode:

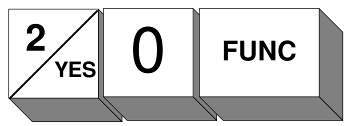
Press





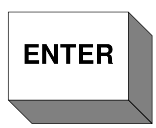
Or from any other group:

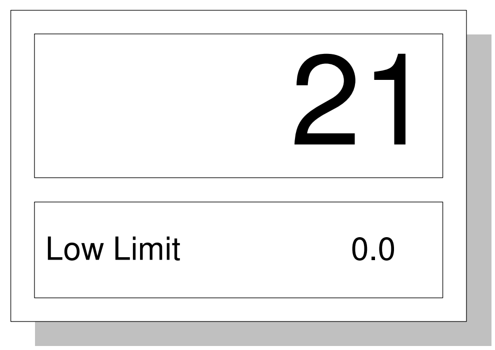
Press



Moisture Alarm Limits

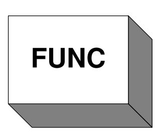
Press

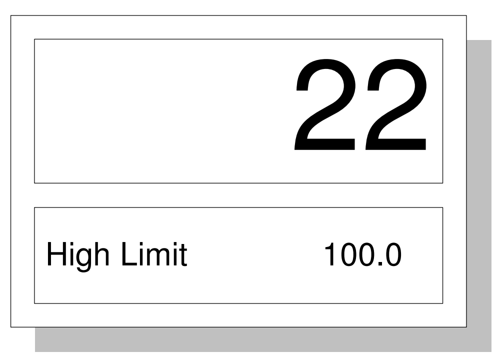




This is the low moisture alarm limit. If moisture drops below low limit, low limit relay is activated. To change level, enter desired number (-5.0 to +99.9) and press ENTER.

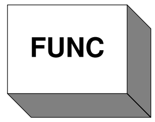
Press

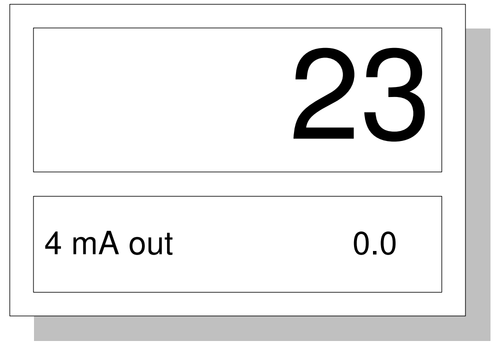




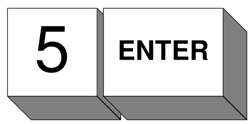
This is the high moisture alarm limit. If moisture exceeds high limit, high limit relay is activated. To change level, enter desired number (0 - 9999) and press ENTER.

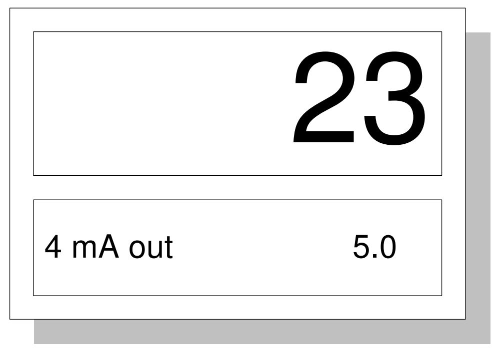
<u>4 mA Analog Output Setting</u>

Press 

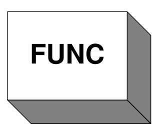


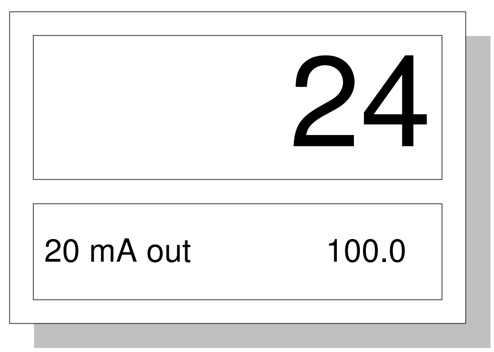
This function determines the moisture level to correspond to minimum analog output (4 mA). example: A product has a moisture range never exceeding 5% - 10%. In this case the 4 mA level would normally be set to 5.0% moisture.

Press 

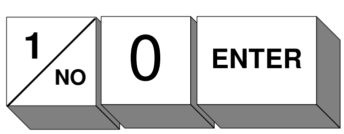


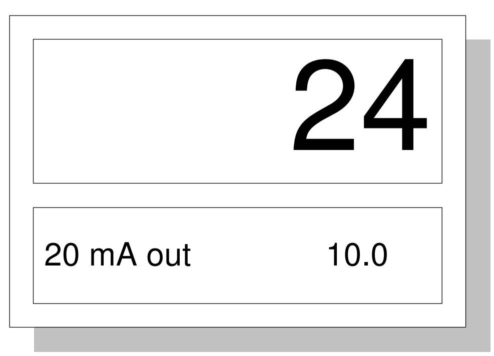
<u>20 mA Analog Output Setting</u>

Press 



This function determines the moisture level to correspond to maximum analog output (20 mA). In the above example, this would normally be 10% moisture.

Press 



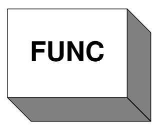
Automatic Product Detection Threshold (APD)

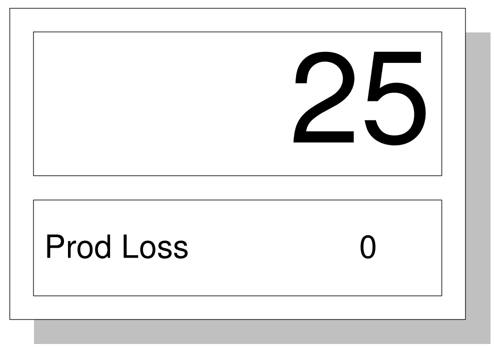
Sampling mode 3 (function 8) detects presence of product automatically, and only samples when product is present. To detect product presence, the processor measures the difference between antenna frequency and low reference frequency, named Delta Frequency.

Delta Frequency is compared to a programmable threshold level named product loss.
Delta Frequency can be viewed in diagnostics **function 158.**

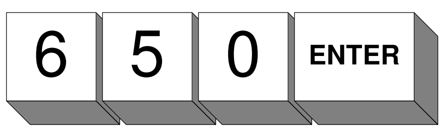
To determine what level product loss should be set to, record value of Delta Frequency with no product on sensor. Record Delta frequency with very dry product on sensor. The appropriate product loss level is given by the average of the two-recorded Delta Frequencies.
Example:

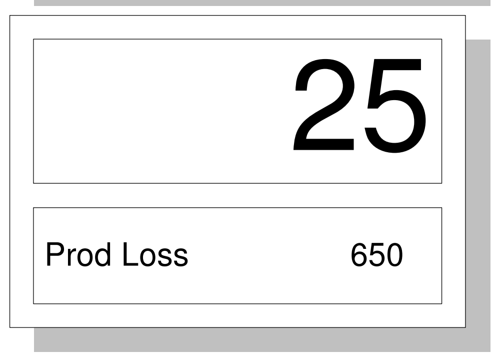
Delta Frequency with no product = 430
Delta Frequency with dry product = 870
Average Delta Frequency = 650 = Product Loss level

Press 

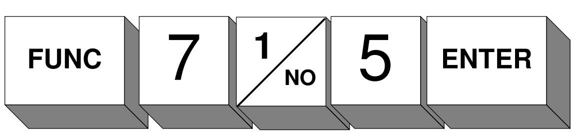


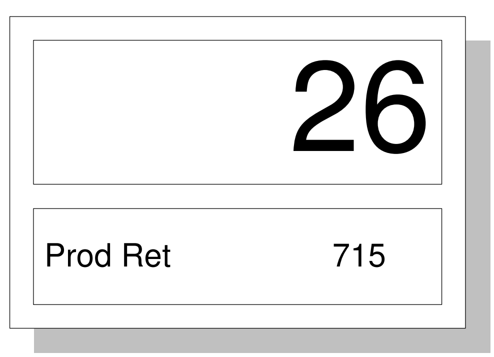
To set product loss level:

Press 



Product return is detected in the same manner, but a certain hysteresis can be applied to prevent sample jitter.
Product return level is typically set at 10% above loss level (e.g. 650 + 65 = 715).
To set product return level:

Press 

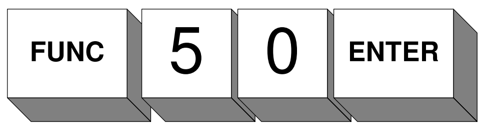


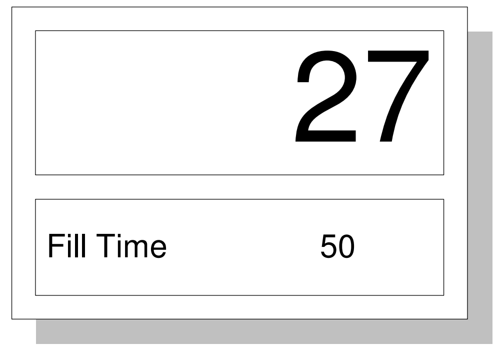
IMPORTANT: Product return must be higher than product loss. If a lower value is entered, an appropriate error message is displayed.

<u>Timed Sampling Parameters</u>

Sampling mode 2 (function 8) provides sampling at programmable intervals, and also provides a digital output to purge a sampling mechanism after sampling. The time between sampling is termed the Fill Time, the digital output duration is termed the Purge Time.
To change fill time:

Press

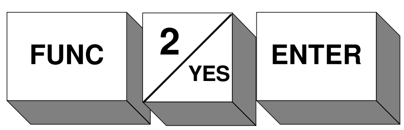


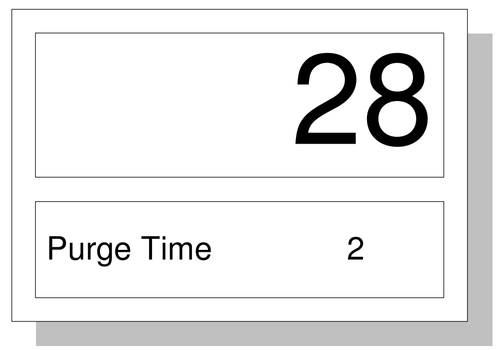


Note: Time is indicated in seconds.

To change Purge Time:

Press





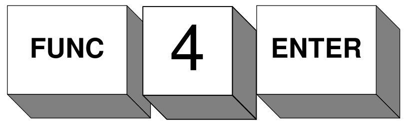
In the above example, the total sequence would be:

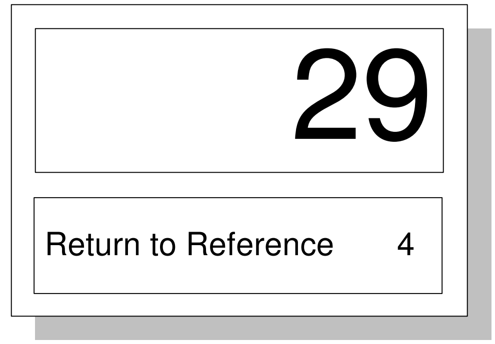
> A 50 second sample fill period during which the upper display would indicate the last moisture value. The lower display would indicate HOLD.
> A 1-second sampling period, after which the display would be updated with new sample moisture.
> A 2-second purge period during which the sensor would be cleared of product.
> Repeat 50 second fill period, etc.

In all the preceding examples, we have sequentially accessed functions in the limits group by pressing FUNC, having first entered the sub group by pressing ENTER.

Any function could be individually accessed by entering the relevant function code followed by FUNC. To exit limits function group, press ENTER to jump to upper function level, or press # MEAS to return to measurement mode.

Return to Reference:

Press 



Used in conjunction with sampling mode (8F4). The number entered here will be displayed (with corresponding 4 to 20mA output) while no product is present.

CALIBRATION FUNCTIONS 6

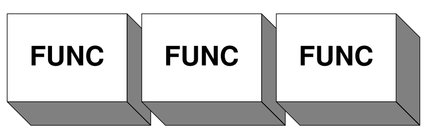
30 DIELECTRIC FUNCTION GROUP

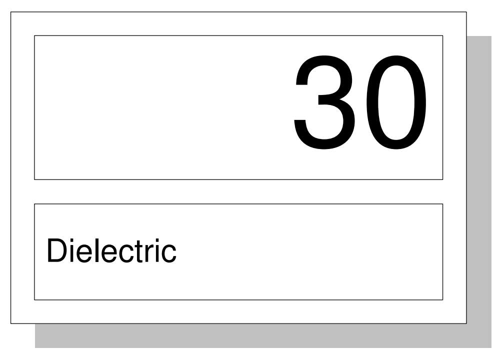
The primary moisture measurement of the ST-2200A uses the principle of dielectric determination. Since moisture has a much higher relative dielectric than most solids, it is possible to relate to moisture content.

Calibration to actual moisture content can be achieved by measuring raw dielectric and applying a multiplying coefficient (span) and an offset coefficient (zero). In order to calibrate the instrument it is necessary to take samples of product and perform a laboratory analysis to determine moisture content. The laboratory results are compared to the instrument values and a regression analysis performed. From the regression it is possible to determine span and zero coefficients.

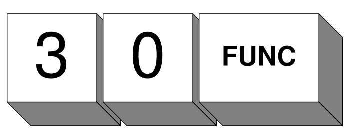
The theory of calibration is covered in greater detail in the next chapter (see "Calibration Theory"). If calibration appears daunting, **CALL THE FACTORY**, we are here to help. Simply provide the sample data and we will perform all calculations and advise how to enter coefficients.

When the instrument is initially shipped from the factory, it has a default dielectric span of one (1.000). To change this setting:
From measurement mode:

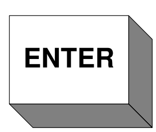
Press 

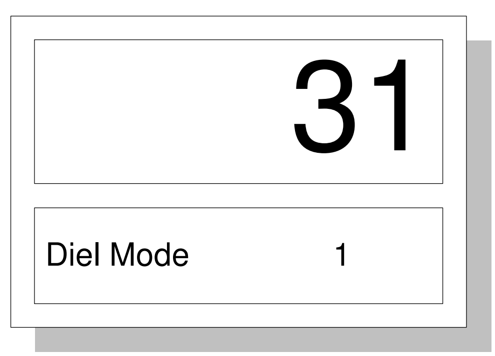


Or from any other group:

Press 

To enter dielectric sub-group:

Press 



The dielectric mode refers to referencing algorithm. Currently only mode 1 is available.

To access dielectric coefficients:

Press **FUNC**

32
Diel Span 1.000

The appropriate dielectric span can now be entered, followed by pressing ENTER.

Maximum range = -99.999 to +99.999 Default = 1.000

Note: A negative span would be appropriate if display of solids is required.

Press **FUNC**

33
Diel Zero 0.00

The dielectric zero can now be entered by pressing appropriate digits followed by ENTER.

Maximum Range = -999.99 to +999.99 Default = 0.00

Further pressing FUNC key will scroll through sub-group again. To return to measure mode, press # MEAS key.

To continue to the next function group:

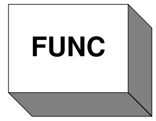
Press **RESET**

30
Dielectric

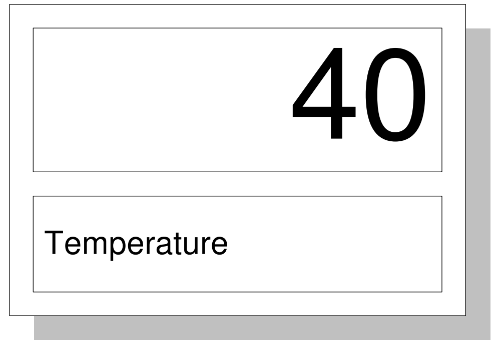
You have now returned to the upper function group level. Any other function can be accessed by entering the appropriate function code followed by FUNC, or to proceed to the next function group, simply press FUNC.

40 TEMPERATURE FUNCTION GROUP

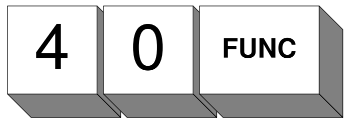
Press



Or from any group other than dielectric:

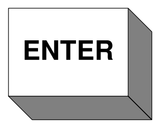


Press

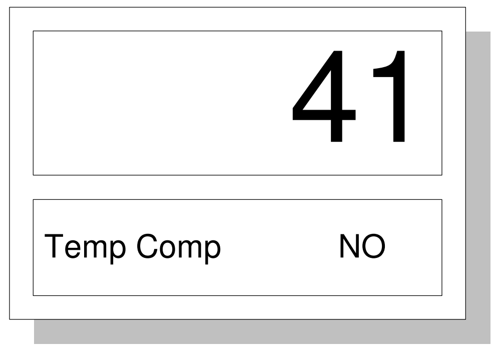


To enter temperature sub-group:

Press

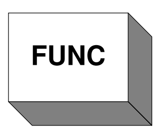


Temperature compensation can be toggled on
or off by pressing 2, ENTER or 1, ENTER respectively.



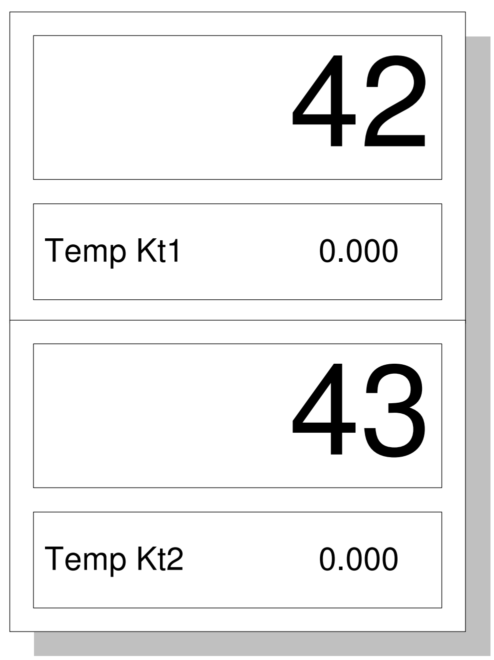
If a temperature transducer is connected to analog channel 1, temperature will be measured and may be displayed and, or transmitted via the digital interface, regardless as to whether compensation is turned on. Internal moisture compensation will only be performed with this function "ON." If temperature compensation is required (typically if product temperature varies more than +/- 5 deg C.), then the compensation coefficients need to be entered. To calculate coefficients, see "Calibration Theory" next chapter.

Press

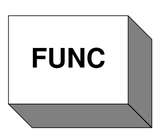


This is the first temperature coefficient.
Value can be entered by pressing desired digits,
followed by ENTER.

Maximum range = -99.999 to +99.999
Default = 0.000



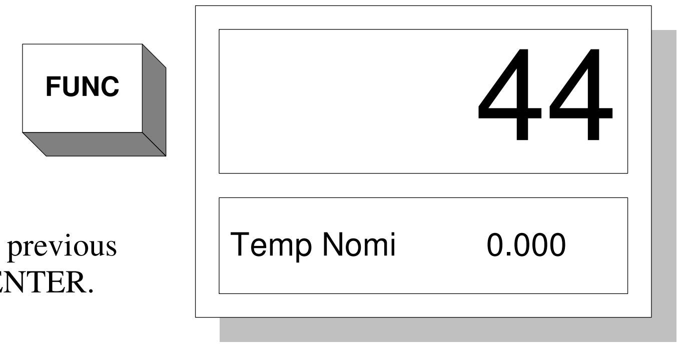
Press



This is the second temperature coefficient.Value can be changed as above. Range and Default same as Kt1.The next coefficient is nominal temperature. This is either the mid range product temperature or can be the average product temperature during initial calibration.

Note: All auxiliary inputs i.e. Temperature, weight and distance, are 10 bit converted numbers in the processor. The processor sees these inputs as values ranging from 0 - 1023. For compensation purposes, these "engineering units are adequate. If the user wishes to record or display an auxiliary input, it should be calibrated in meaningful units e.g. degrees Celsius, lbs./ft^3, etc. To calibrate auxiliary inputs, see later chapter on I/O Configuration.

Press



A nominal temperature can be entered as in previous cases, by using desired digits followed by ENTER.

Maximum range = -999.99 to +999.99
Default = 0.00

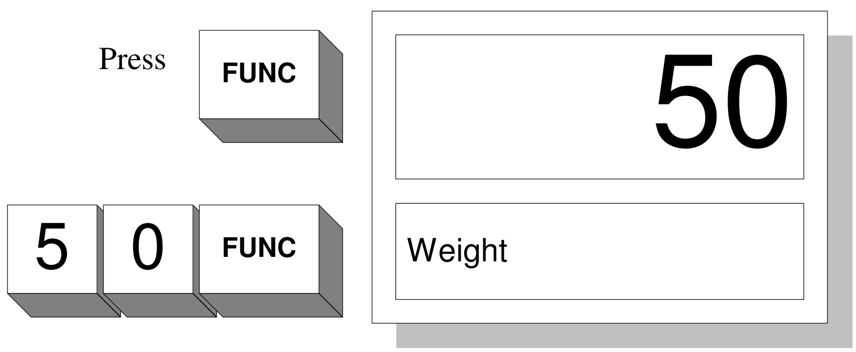
Further pressing the FUNC key will repeat scrolling through the temperature sub-group. To exit this group press RESET key to return to upper function level, or # MEAS key to return to measure mode.

To advance to weight group from temperature:

Press

Or from any other group:

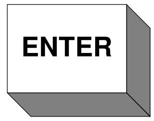
Press

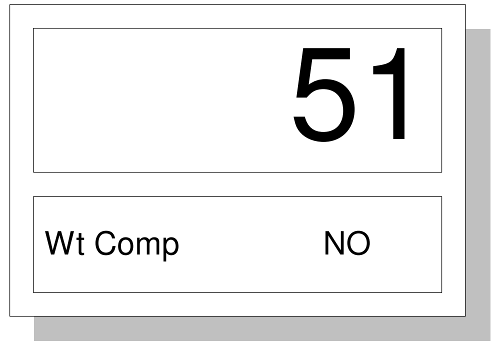


50 WEIGHT FUNCTION GROUP

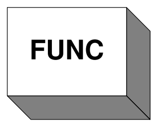
The weight group contains functions relating to the mass of product. Mass can be related to many different measurements depending upon application. Actual weight might be derived from a weigh belt, with the dielectric sensor integrated into same belt. Nuclear gauges can be used to determine mass in many applications and, though costly, might already be installed for another valuable measurement e.g. basis weight gauge. If the product is a paste or fluid constrained in a pipeline, density is related to pressure, and a simple pressure gauge might be adequate. In all cases, a similar compensation is required (see "Calibration Theory").

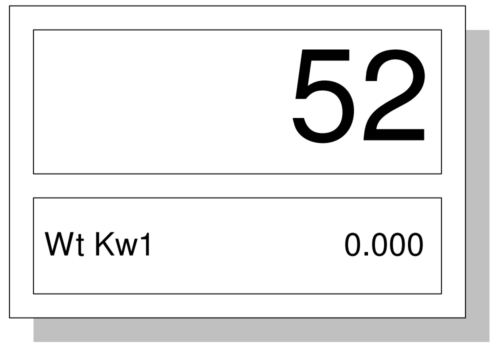
To enter weight sub-group:

Press 

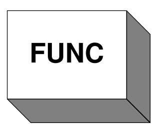


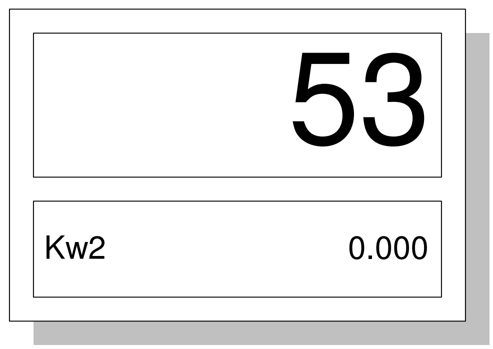
Similar to temperature, this function can be toggled on or off with 2 and 1 respectively. Weight can be displayed and transmitted regardless, but will only compensate moisture measurement if "ON."

Press 



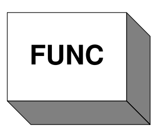
Weight coefficient is designed for future non-linear compensation algorithm. Not yet implemented.

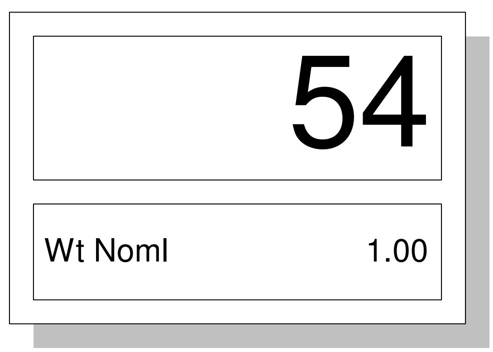
Press 



Similar to temperature, it represents mid range product weight, or weight during initial calibration. Enter value using digit keys followed by ENTER.

Maximum range = -999.99 to 999.99
Default = 0.0

Press 



This function is unique to weight group, allowing user input of weights via keyboard. If a user makes products of known but differing weights, the actual weight may be entered here, avoiding multiple calibrations for different product weights.

Weight input is entered like any other parameter. Key in digits followed by ENTER.

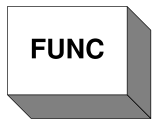
Maximum range = 0 to 999.9 Default = 0.0

60 DISTANCE FUNCTION GROUP

This input compensates for variation in distance between sensor and product. The ST-2200A measures moisture based upon dielectric determination by coupling the product capacitance with the antenna capacitance (via electric field). Since this coupling or sensor / product interface is itself a capacitance, it must be held constant or else compensated for. This topic is discussed in more depth in the next chapter.

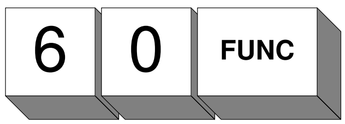
To advance to distance group from previous weight group:

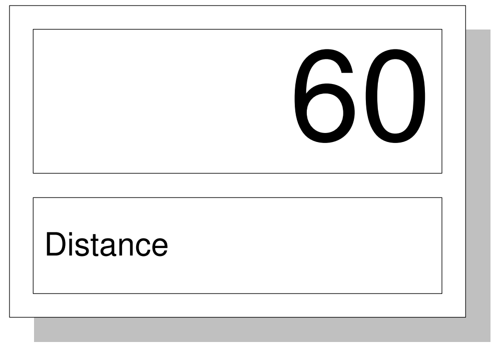
Press



Or from any other group:

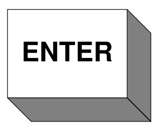
Press

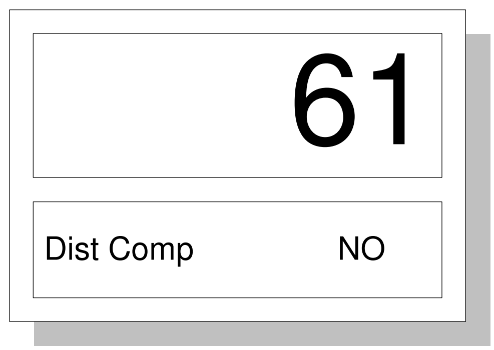




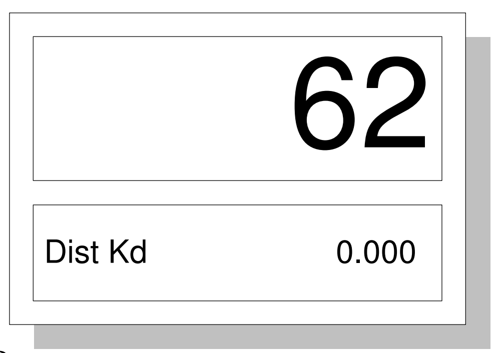
To enter distance sub-group:

Press

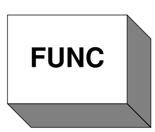




As previous compensations, when turned off, the variable is still measured and can be displayed, but will only affect moisture when turned "ON".



Press

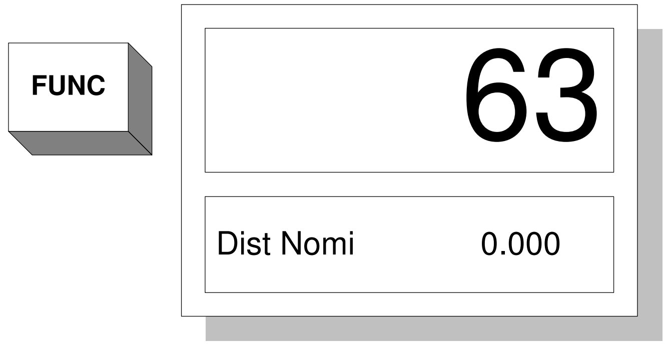


Distance coefficient, provides linearization of distance correction. Input value using digit keys followed by ENTER.

Maximum Range =-99.999 to 99.999

Default = 0.000

Press



Nominal distance, not used in current algorithm.

Calibration Record Sheet

Date						
31 Diel. Mode						
32 Diel. Span						
33 Diel. Zero						
43 Kt1						
44 Nomi. Temp						
52 Kw						
53 Nomi. Wt.						
62 Kd						
63 Nomi. Dist						

Comments

CALIBRATION THEORY 7

This chapter deals with mathematical aspects relating to calibration and more fully explains the algorithms used. The following information is not necessary in order to use the Sensor (Instrument). It is provided for advanced users who do not wish to avail themselves of factory assistance in calibration.

Basic Calibration

The ST-2200A measures the dielectric constant of a product using a patented "Resonant Frequency Technique". Dielectric measurements are performed at 10 millisecond intervals (100 samples per second). Two reference capacitors are switched in place of the Sensor once per second for 10 millisecond each. These are termed the high and low references and produce high and low reference frequencies. The antenna frequency and reference frequencies are processed to produce a very stable calibration signal. The calibration signal can be viewed in diagnostic function 145 and is referred to as Raw Dielectric.

Since the raw dielectric is a function of Sensor capacitance combined with product capacitance, the first step is to isolate the product capacitance. This is achieved with the Pre-Zero function (6). When the Sensor Pre-Zero function has been completed, the dielectric of the empty Sensor is measured and stored in non-volatile memory. This value is subsequently subtracted from all future measurements.

Product Dielectric = Raw Dielectric - Pre-Zero

The product dielectric is proportional to moisture content and can be scaled to give exact moisture by applying a multiplier (Span) and a bias (Zero).

Moisture Content = Span * Product Dielectric + Zero . . . . . . (1)

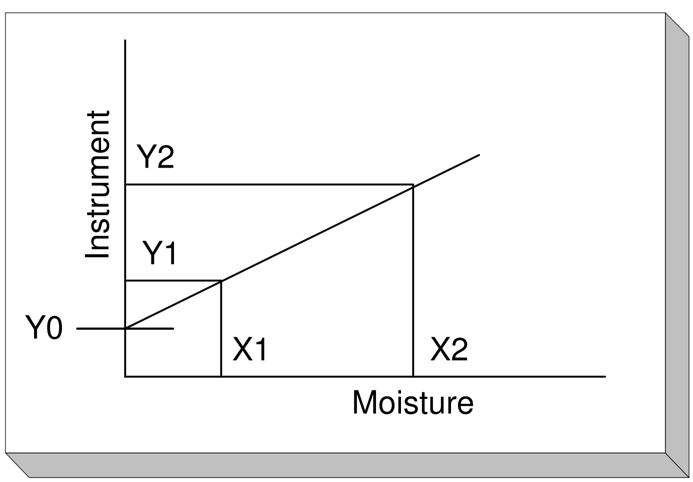


Figure 7.1 Uncalibrated Sensor vs. Moisture

Figure 7.1 shows a typical Sensor response to moisture before calibration. A linear function is obtained of the form:

Sensor = slope * Moisture + constant

where: slope = (Y2 - Y1)/(X2 - X1)
constant = Y0 (also called intercept)

The positive intercept is a result of the dry product having some residual dielectric.

In order to obtain a calibrated response it is necessary to normalize the equation by dividing both sides by the slope, then subtracting constant.

(Sensor - constant)/slope = Moisture

Comparing to equation (1) we have: Span = 1/slope
Zero = - intercept/slope

Note: Sensor Span adjusts the slope of the graph.
Sensor Zero applies a constant offset to negate intercept.

If the graph of figure 7.1 were obtained with a known Span and Zero, the desired Span and Zero can be calculated from:

Required Span = Original Span/slope
Required Zero = (Original Zero - Intercept)/slope

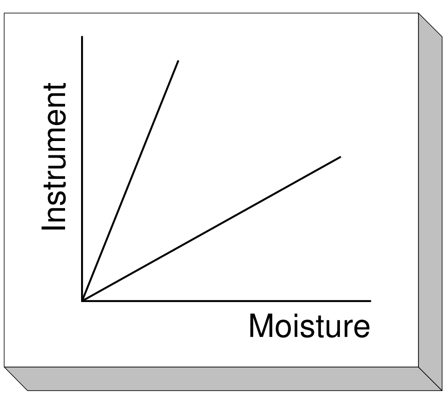


Figure 7.2a Effect of Span Control

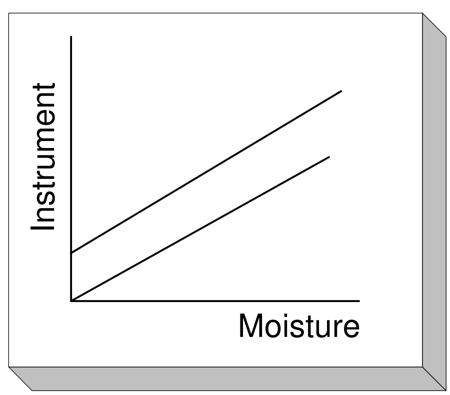


Figure 7.2b Effect of Zero Control

Figure 7.2a demonstrates the effect of Span control on the sensitivity of the Sensor, while 7.2b shows how the Zero control applies a direct offset to the Sensor.
To plot a graph like that of figure 7.1, it is necessary to take samples of product for laboratory analysis, while recording Sensor readings. Figure 7.3 shows an example of basic calibration.

Product Moisture	1.8	1.9	2.1	2.6	3.8	4.2	4.9	5.2	5.5
Sensor	3.2	3.3	3.6	4.6	6.0	6.3	7.7	8.0	8.5

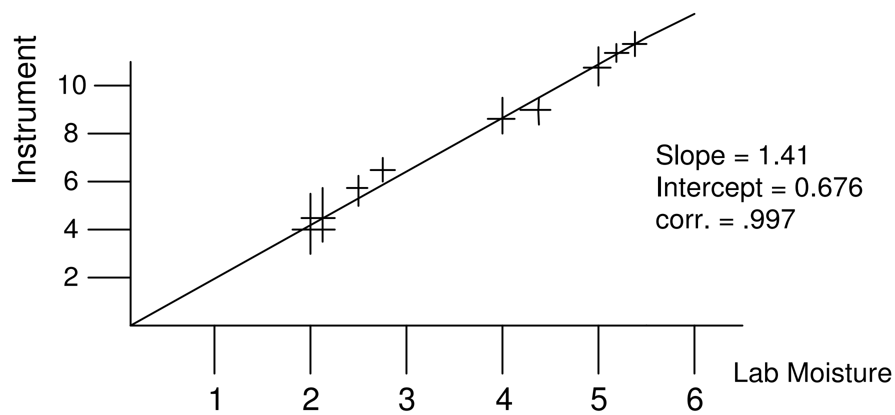


Figure 7.3 Regression Plot of Sensor vs. Lab Moisture

The data obtained in the above example can be plotted as shown, or a regression program can run to determine the relationship between Sensor and actual moisture. In this example, the equation is:

Sensor = 1.41 * moisture + 0.676

If the Sensor coefficients were originally:

Span = 2.5   Zero = 0.0

Required Span = original Span/slope = 2.5/1.41 = 1.773
Required Zero = (original Zero - intercept) / slope = (0.0 - 0.676) / 1.41 = -0.48

Entering these coefficients into dielectric Span (function 32) and dielectric Zero (function 33) will produce an output corresponding to moisture.

Note: A regression program will provide necessary coefficients, but a graphical plot is useful to view the quality of data i.e. shows up any bad data points.

Temperature Compensation

It has been previously stated that water has a much higher dielectric constant than most solids, or even other liquids. The dielectric constant for water is often stated to be 80. In fact the figure just quoted refers to water at 25 deg. C. At 85 deg. C., the dielectric drops to approximately 58. If all other materials were as predictable or as well documented as water, compensation would be easy. Unfortunately, most products are made from a combination of materials each having unique dielectrics. In the case of solid materials, the dielectric constant is usually quite stable with temperature, but other liquids are not so accommodating. In most of these cases, the most practical way of determining temperature influence is to actually measure the effect. In the laboratory, temperature tests may be performed on known samples to study their dielectric variance with temperature. Samples may be frozen and allowed to return to room temperature whilst monitoring dielectric. Samples may also be heated and allowed to cool to room temperature, but in this case they must be weighed before and after testing to allow for any evaporative losses. A general case compensation algorithm has been developed by Sensortech Systems based upon testing of a wide range of products. This is of the form:

$$D_T = [1 + Kt1\ (T_N - T_A)]\ \text{Raw Dielectric} + Kt2\ (T_N - T_A) \quad . \ . \ . \ . \quad (2)$$

where:

D_T = temperature compensated dielectric
Kt1 = temperature coefficient 1
Kt2 = temperature coefficient 2
T_N = nominal temperature
T_A = actual temperature

This is really a dual compensation. The Kt1 coefficient is a temperature dependant multiplier used mainly to compensate for change in water dielectric. The Kt2 coefficient is used to compensate for dielectric changes in the base material.

IMPORTANT: The temperature correction algorithm (equation 2) is a general case and is really a compromise. A specific algorithm could be empirically determined for each individual application, but this would be very time consuming and require considerable mathematical knowledge. In most cases the general equation will be adequate over a limited moisture range (say 10%) and limited temperature range (say 30 deg. C.).

In order to determine the coefficient values Kt1 and Kt2 requires similar data collection as for the basic dielectric equation. This time however, a third variable must be monitored ie. temperature. If the data is obtained from a real process, a good method is to monitor temperature and uncorrected Sensor display and take samples whenever any variable is at an extreme. In other words if the process is running unusually hot or the display shows high moisture and vice versa. Having collected the extreme points, a few mid points are fairly easily obtained. The database obtained must now be grouped into temperature groups.

Temperature Compensation Data Collection Guidelines

In order to correlate moisture levels with temperature, take measurements of samples with similar actual moisture levels at varying temperatures. Then repeat the measurements with a different moisture level at a series of different temperatures. The objective is to have 16 rows of data representing 4 different moistures each measured at 4 different temperatures.

For each of the 16 conditions you record an ST-2200A or PMT-330 Sensor reading. Product temperature and product moisture must be independent variables.

In the following example, a table of 48 values (16 actual moisture; 16 product temperature and 16 corresponding Sensor values would be taken. There are statistical packages available to perform multiple regression analysis. From the table, select a group of data at similar temperatures but differing moistures and perform a simple linear regression to determine Sensor values versus actual moisture.

Slope = A, Intercept = B.

At this point the Sensor should be reasonably calibrated for the given product temperature. This will be called the nominal temperature. To verify calibration, take the Sensor values for the nominal temperature group and divide this value by

Slope A and subtract B/A.

The resulting values will represent the projected Sensor value with

Span = 1/A and Zero = -B/A

Repeat the same calculation for the other 12 Sensor readings and this will give the predicted Sensor value for the new Span and Zero values.

From the measured data calculate the 'PREDICTED SENSOR VALUE'

$M_P = M_A / A - B/A$ which can be simplified to $M_P = (M_A - B)/A$

where
M_A = ACTUAL PRODUCT MOISTURE (%)
M_P = PREDICTED SENSOR VALUE
A = Slope
B = Intercept

From the measured data calculate the 'ERROR PREDICTED–ACTUAL'

$E_P = M_P - M_A$

where
E_P = ERROR PREDICTED–ACTUAL
M_P = PREDICTED SENSOR VALUE

M_A = ACTUAL PRODUCT MOISTURE (%)

ACTUAL PRODUCT MOISTURE	ACTUAL SENSOR MOISTURE	ACTUAL PRODUCT TEMPERATURE	PREDICTED SENSOR VALUE	ERROR PREDICTED-ACTUAL
M_A	M_S	T_1	M_P	E_P
		T_1		
		T_1		
		T_1		
		T_2		
		T_2		
		T_2		
		T_2		
		T_3		
		T_3		
		T_3		
		T_3		
		T_4		
		T_4		
		T_4		
		T_4		

From the table above, plot a graph of error versus temperature. Run a linear regression of error vs. temperature.

From the regression data obtain slope of line = Z.

Using the ST-2200A perform the following:

a. Enter $KT_1 = 0$ (Function 42)
b. Enter $KT_2 = Z$ (Function 43)
c. Enter T_N = nominal temperature determined in (a) above (Function 44)
d. Activate temperature compensation - go to Function 41, press 2 <Enter>

At this point the ST-2200A is temperature compensated. Select a suitable Temperature Sensor with a 4-20mA output and connect it to compensation input AI1 (TEMP). The Temperature Span and Zero must be calibrated (Functions 121 &122).

Consult factory for how to do this. At this point Sensor should compensate for temperature.

Weight Compensation

The most well known method for continuous moisture measurement is probably that of Near Infrared Spectroscopy. This involves the reflection of an infrared source off the product, and the measurement of reflected energy of specific IR wavelengths that are absorbed by moisture. These wavelengths are compared to non-absorbed reference wavelengths, providing a percentage moisture measurement. Radio frequency moisture determination, and in fact any penetrating measurement, has to take into account the mass of product in order to provide a percentage measurement. This is because the Sensor effectively counts the water molecules within the Sensor field. If more product is squeezed into that field, it will produce a higher moisture reading, even though the percentage water figure may be constant. In order to correct for this, the product mass, weight or density must be taken into consideration.

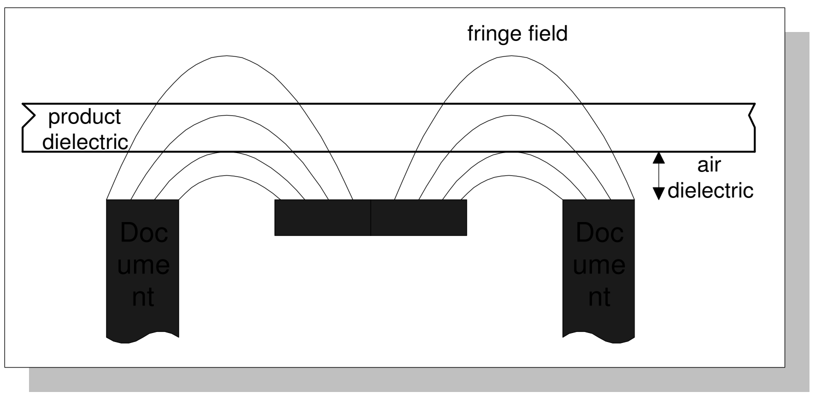


figure 7.6 Radio Frequency Field Through Product

Figure 7.6 shows the typical radio field passing through a product. The dielectric effect of the product will be a function of its dielectric constant and the length of flux paths passing through the product (fringe field lines). The latter will be a function of product thickness and distance from Sensor. The distance relationship will be discussed later. If a parallel plate Sensor were used, the field lines would be uniform and a doubling in product thickness would produce a doubling in dielectric. The Sensor shown is a single sided or planar Sensor, with a non-linear field. Doubling of product thickness will cause an increase in dielectric, but not by a factor of two. Sensor response would be of the form:

$$\text{Sensor} = \text{Product Dielectric} * (\text{Mass})^{Kw}$$

where:

Mass = weight, density, thickness etc.
Kw = coefficient determined by antenna geometry (less than 1)

From this relationship, the compensation algorithm becomes:

$$\text{Compensated Sensor} = \text{Product Dielectric} * (\text{Nominal Mass} / \text{Actual Mass})^{Kw}$$

The value of Kw coefficient will depend upon antenna geometry, product presentation and form of mass measurement e.g. thickness, weight etc. To determine Kw, a constant moisture product of varying mass is presented to Sensor. A graph of log (Sensor response) vs. log (mass) must be plotted. Kw is given by the slope of this line (see figure 7.7 a & b).

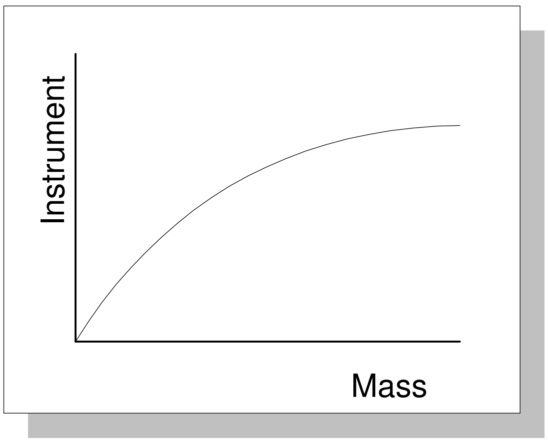


figure 7.7a Plot of Sensor vs. Product Mass

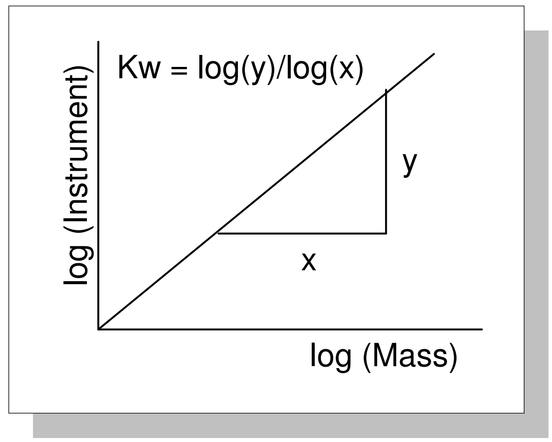


figure 7.7b Plot of Sensor vs. Log of Product Mass

Distance Compensation

The product dielectric is coupled to the antenna via an interface dielectric such as air (see figure 7.6). In some cases direct contact may be made, or a fixed interface such as a Teflon window may couple the product. The important thing is that whatever coupling exists between product and Sensor, must remain constant in order to be neglected. In the case of direct contact or a window, this would be the case. If an air gap exists between product and Sensor and this gap varies, the total dielectric will change. If the gap can be measured, it can be compensated. If the antenna were a point source, then the RF energy would decrease according to the inverse square law and a simple compensation based upon the square of the distance would be possible. In practice the antenna is a finite width radiator producing a more complex relationship. It is further complicated by field distortion through the product. Figure 7.6 shows the typical field pattern emanating from a planar electrode, but this is somewhat idealized, as the field is actually distorted or refracted within the product. The amount of distortion is a function of product dielectric and is both density and moisture dependent. This distortion will also affect the field in the air gap and the distance relationship (see figure 7.8).

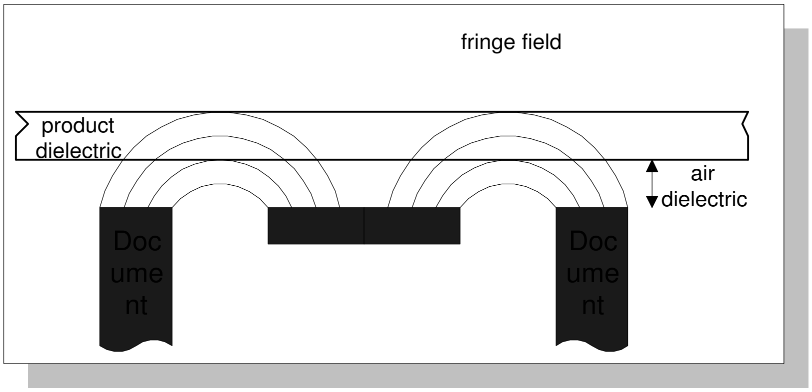
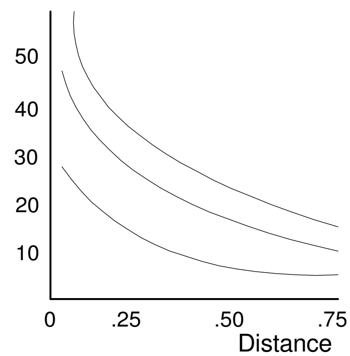


Figure 7.8 Field Distortion due to Product Dielectric

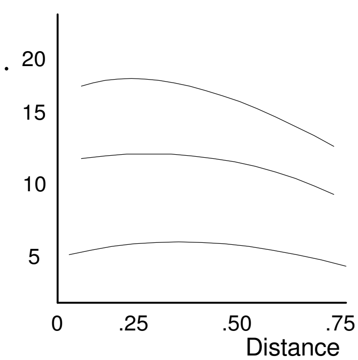
In practice, the product density usually remains fairly constant at a fixed point in the process, and the moisture similarly should not vary too greatly. If this is the case, distance may be corrected by an equation of the form:

$$\text{Compensated Sensor} = \text{product dielectric} * (\text{distance} + Kd)^2$$

If moisture and density are uncontrolled such as raw material measurement, it is better to control or constrain the distance variation rather than try to compensate for it.



The example at left shows three lumber samples of differing moisture, at varying distances from the Sensor. No compensation is applied and an inverse relationship is apparent



In this example the same lumber samples are measured at varying distances. The Sensor has a compensation equation:

$$M_c = M_u (D + 0.14)^2$$

The offset coefficient Kd (.14) is determined by trial and error to obtain flattest response.

<u>Suggestions</u> for taking product samples.

Note: The calibration can only be as good as the sampling method.

a) Take the sample as close to the Sensor as possible.

b) Process as large a sample as possible.

c) If using damping, take a series of samples over the range of the sampling period. Example: 30 secs damping - take a sample every 5 secs for 30 seconds.

d) Use a homogenous sample representative of the whole. In the above example, thoroughly mix 30 sec sample.

e) If using small samples, test samples two or three times (to show repeatability) and average results if necessary.

f) Use the most accurate testing method available. An oven dry test with a 100g sample is generally more accurate than a lamp dry test with a 10g sample.

UTILITIES 8

Limited sets of utilities are currently available to facilitate ease of calibration. These may be expanded at a future date, but currently include configuration default and code copy.

<u>Default</u>

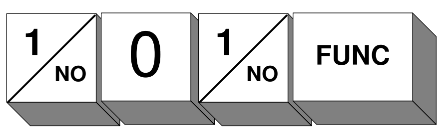
CAUTION! This is a catastrophic function affecting all parameters.

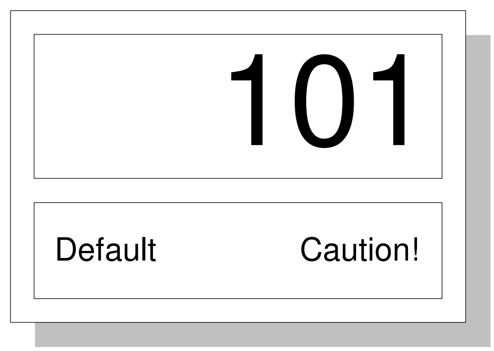
This function provides the capability of resetting all parameters to initial factory default settings. It should only be used if the non-volatile memory has been corrupted or replaced, or operator confusion has reached such a point that a fresh start is considered appropriate!

All user parameters will be over written by this function and are unrecoverable. For this reason a caution flag is indicated on the display to warn the operator. If the instrument is linked to a host computer, it might be desirable to download all parameters to the host prior to defaulting.

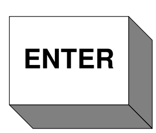
From measure mode:

Press





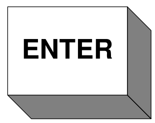
Press

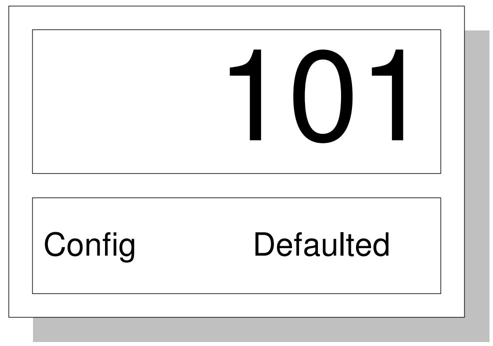


Because this is such a catastrophic function,
the password must be entered before proceeding.

Enter password code, the lower display indicates asterix as shown.

Press

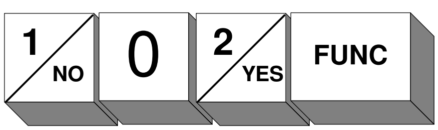


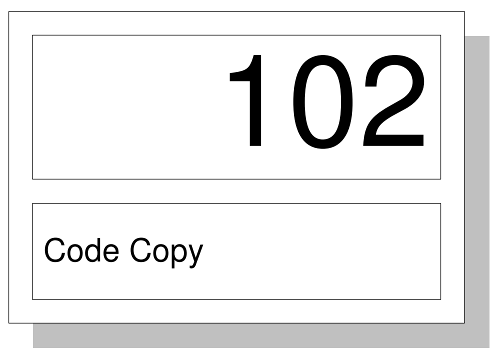


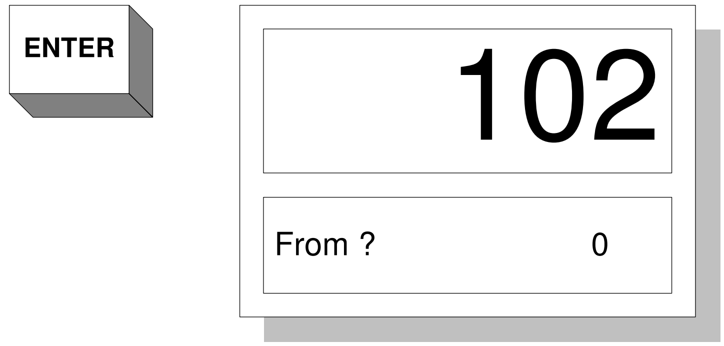
Code Copy

This is a convenient means of transferring information from one product code to another. For example, if a specific product has been calibrated and all the related limits, sampling times, averaging, etc. have been entered, a new product might just require a zero offset change. In this case it would be possible to copy the original parameters to a new product code and then just change the zero offset for the new product code.

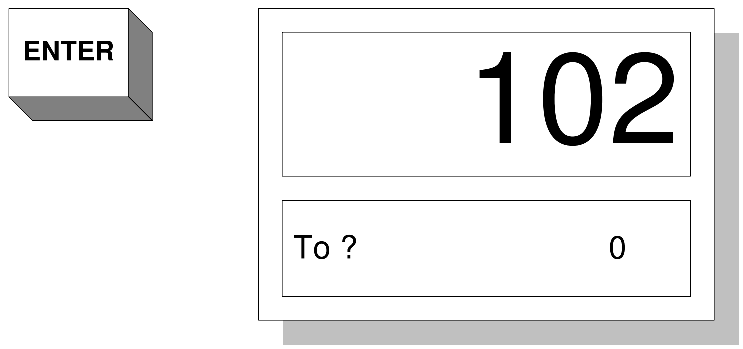
Press



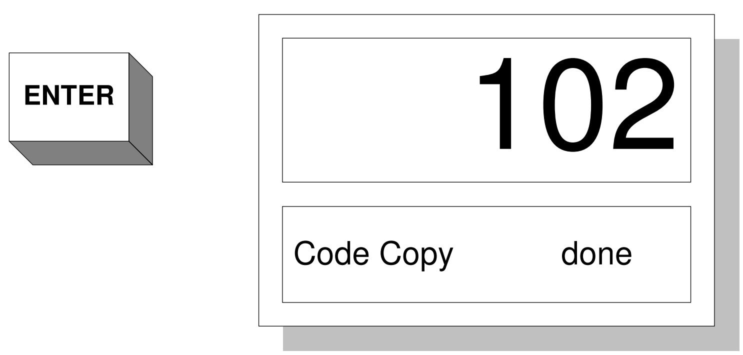


Press 

At this point enter the product code number you wish to copy (1 - 10).

Press 

At this point enter the destination product code number (1 - 10).

Press 

The source product code has been successfully copied to its destination.

I/O CONFIGURATION 9

The ST-2200A is equipped with substantial input/output capability. This includes gated sample input, timed sampling output, alarm limits, 4 - 20 mA analog output, dielectric input, 3 auxiliary analog inputs, serial RS232 and RS485 outputs.

I/O configuration basically conditions the various inputs and outputs in terms of scaling, offsets and times. Note: Alarms and timed sampling output parameters are located in the limits group.

Compensation Inputs

All Compensation inputs are 0 - 5 volt or 4 - 20 mA. These analog levels are converted by an on-board 10 bit A/D converter. Thus input resolution is approximately 5 mV. Input transducer conditioning may be provided by intermediate signal conditioning modules.

121 Temperature Span

This function provides a digital multiplier affecting input sensitivity, that is volts/degree. If it is desired to display temperature in actual units, a calibration procedure will provide this parameter. A typical calibration procedure is described later in this section.

Range = +/- 99.999
Default = 1

122 Temperature Zero

Provides a digital offset or bias. Developed from the same calibration procedure (intercept).

Range = +/- 999.99
Default = 0

123 Weight Span

Similar to above.

124 Weight Zero

Similar to above.

125 Distance Span

Similar to above.

126 Distance Zero

Similar to above.

Compensation Input Calibration Procedure

Similar to the procedures used for dielectric calibration (see chapter 7), it is necessary to provide known conditions e.g. temperature, weight, etc. and to record the corresponding display. A linear regression is performed on the data in order to calculate the necessary span and zero coefficients. The following example is for temperature using an infrared pyrometer.

A thin walled aluminum can was painted flat black and the pyrometer directed on the outside of the can. The can was filled with water at various temperatures, measured by a glass bulb thermometer immersed in the can. Readings were taken of the glass thermometer and the displayed temperature (press # MEAS key in measurement mode). The following table shows results.

Thermometer (deg. C.)	2.5	17.2	22	32.5	35.3	43	50	68	72	74	75
Display	511	583	607	671	683	721	771	871	891	911	915

Regression analysis gave:

slope = 5.6476   intercept = 487.1 R^2 = 0.99933

Desired span = Actual span / slope = 1 / 5.6476 = 0.1771 (function 121)

Desired zero = - intercept / slope = - 487.1 / 5.6476 = -86.27 (function 122)

Note: For a wider temperature range, a calibrated black body source would be required.
Weight and distance inputs can be similarly calibrated with appropriate references e.g. weights and shims.

127 4 mA Configuration

This function forces a 0 percent analog output. This is to facilitate calibration using the 4 mA trimpot adjustment located on the I/O board. This is a factory-preset adjustment and should not normally be required.

To implement this function press:

1, 2, 7, F	Lower display indicates "4 mA Config."
ENTER	Analog output is forced to 0 percent

128 20 mA Configuration

This function forces a 100 percent analog output. This is to facilitate calibration using the 20 mA trimpot adjustment located on the I/O board. This is a factory-preset adjustment and should not normally be required.

To implement this function press:

1, 2, 8, F	Lower display indicates "20 mA Config."
ENTER	Analog output is forced to 100 percent

129 Equal HI Reference

Normally the instrument references once per second for a 10 millisecond high reference period and 10 millisecond low reference period. 98 antenna samples are taken between references. In some applications it is necessary to use a differential sensor.
For example, when measuring through a conveyor belt, in order to eliminate the belt influence a dual sensor measures both the upper belt and product while the reference element measures the lower return belt with no product. These two measurements are antenna and high reference respectively. In order to obtain a similar response on both measurements, equal high reference/antenna samples are required. In this case alternate 10 millisecond samples are taken of both measurements resulting in a 20 millisecond update rate.
To implement this function press:

1, 2, 9, FUNC	Lower display indicates "Equal HI Reference No"
1, ENTER	Lower display indicates "Equal HI Reference Yes"

130 Intensity

Relates to lower display intensity. The lower display consists two 16 character alpha-numeric displays cascaded. This function allows balancing the intensity with that of the upper display and also between left and right lower displays. A two digit octal number (00 - 77) controls intensity, where the left digit controls lower left display and the right digit controls lower right display. 0 is highest intensity and 7 is lowest.
Default = 33
Typical value = 33
Limits = 00 - 77

To implement this function press:

1, 3, 0, FUNC	Lower display indicates "Intensity 00"
4, 4, ENTER	Lower display indicates "Intensity 44"

Note: you will notice the lower display is much lower intensity.

131 Display Minimum

The upper digital display can be limited in its upper and lower range. It has no sign, therefore cannot display negative numbers. If the displayed variable is outside the range of the upper display, it will be displayed on the lower display. All negative values are shown on the lower display. If the instrument is displaying a zero value, there is a possibility of upper and lower displays flashing alternately. This can be prevented by setting display minimum to a small negative value, say -0.2. A deadband between 0 and -0.2 will exist, but will prevent the flashing display.

Range = +/- 999.99
Default = 0.2
Typical = -0.2

To implement this function press:

1, 3, 1, FUNC	Lower display indicates " Disp Min 0.0"
-, ., 1, ENTER	Lower display indicates " Disp Min -0.1"

132 Display Maximum

This function limits the maximum number indicated on the upper display. If this level is exceeded, the upper display indicates HHHH, while the lower display indicates actual value.

Range = 0 - 9999.99
Default = 9999
Typical = 100

To implement this function press:

1, 3, 1, FUNC	Lower display indicates " Disp Max 9999.00"
1, 0, 0, ENTER	Lower display indicates " Disp Max 100.00"

133 Baud Rate

Sets the data bit rate for digital communications.

1 = 300
2 = 1200
3 = 2400
4 = 4800
5 = 9600
6 = 19200

To implement this function press:

	1, 3, 3, FUNC	Lower display indicates "Baud Rate 9600"
Enter desired code 1 through 6 followed by ENTER e.g. 1, ENTER		Lower display indicates "Baud Rate 300"

134 Device Address

The RS485 serial digital interface allows many ST-2200A instruments to be serially linked to a host computer on one wire pair. When communicating on a common line it is necessary to give each device a unique address.

To implement this function press:

	1, 3, 4, FUNC	Lower display indicates "Device Addr 0"
Enter desired address e.g. 5, ENTER		Lower display indicates "Device Addr 5"

Range 0 to 99
Default 0

135 Communication Type

The ST-2200A has two types of serial communication, RS232 for short range links, and RS485 for long distances. Both methods are treated similarly by the internal processor, but have separate interface circuitry. In order to avoid contention, it is not possible to use both ports simultaneously. This function specifies which type of communication is active.

1 = RS485
2 = RS232

To implement this function press:

	1, 3, 5, FUNC	Lower display indicates "Comm Type RS485"
To change:	2, ENTER	Lower display indicates "Comm Type RS232"

136 Host Options

Host options are really diagnostic functions used in troubleshooting and development of serial communications interface. Two options are available, individually or combined.

1 = Echo. When enabled, ST-2200A echoes any data it receives back to the host
2 = Checksum disabled.

Default is fifty-six.

137 Prod Code Display

Provides user with ability to display product code (default).

137 FUNC Prod Code Display. Lower display indicates "Yes".
1 ENTER Lower display indicates "No".

Product code will no longer be displayed in bottom display.

Auto mode (3) allows for automatic product code change with corresponding change in D.C. voltage at DVM relative to AGND.

3 ENTER Lower display indicates "Auto".

138 Safe Alarm

Provides the ability to change alarm relays (High, Low alarm) from Normally Open (default) to Normally Closed.

138 FUNC Lower display indicates "Safe Alarm NO"
ENTER Lower display indicates "Safe Alarm YES"

Ref: Chapter 5.

DIAGNOSTICS 10

Extensive diagnostic features are provided for technician use in function group 140. These are considered advanced user functions and are not accessible by scrolling through main groups. To access diagnostics requires direct entry e.g. 141 FUNC. Most of these functions are display only, and provide valuable information indicating instrument performance.

After initial installation and calibration, it is recommended to view functions 142 through 162 and record values on the diagnostics record sheet provided later in this chapter. Although extensive testing is performed during manufacture, many values are application dependent and should be checked in-situ.

141 Digital Voltmeter

A DVM input is provided on the instrument rear panel. This feature is an operator convenience used to check power supply levels etc. It uses the on board A/D converter and is not intended as an instrument grade meter. With a 0 - 20 volt range it has a resolution of 20mV. Digital readout is provided on the main display when function 141 is entered.

142 Antenna Frequency

A six-digit number is displayed proportionate to antenna frequency. This is not actual frequency. A display of 105000 is approximately 8 MHz. The number should be reasonably stable with no product on sensor, but will fluctuate according to product dielectric.

143 Low Reference Frequency

This number represents one of the internal reference frequencies and should be reasonably stable after instrument warm up (approximately 30 minutes).

144 High Reference Frequency

As above, this number represents one of the internal reference frequencies and should be reasonably stable after instrument warm up (approximately 30 minutes).

145 Raw Dielectric

This number is computed from the previous signals using a proprietary relationship to eliminate the influence of ambient condition changes and component aging, etc.

<u>146 Dielectric Pre - Zero</u>

The purpose of pre-zero (function 6) is to subtract the basic antenna capacitance from the total dielectric measurement, thus measuring only the product capacitance. Pre-zero is performed with no product on sensor by measuring raw dielectric and storing this value (PZ). In normal measurement mode, this pre-zero value is subtracted from the raw dielectric measurement prior to calibration coefficients being applied.
The number displayed here is the PZ value.

<u>147 Dielectric Standardization Factor</u>

Standardization sets a secondary span value to force the instrument to a specific reading on a known reference material. This secondary span value or standardization factor is displayed here.

<u>148 Antenna Loss</u>

This number represents antenna signal amplitude. Not currently implemented, this value may be used for future dielectric loss measurements.

<u>155 Raw Temperature</u>

Represents the 10 bit converted temperature input. No damping or other signal processing has been applied to this signal. Range 0 - 1023.

<u>156 Raw Density</u>

As above, but representing density/weight input.

<u>157 Raw Distance</u>

As above, but representing distance input.

<u>158 Delta Frequency</u>

This is the difference between antenna frequency and low reference frequency, used to establish product loss levels used in functions 25 and 26 (see chapter 5).

<u>160 Display Test</u>

Tests all segments on upper and lower displays. Usage:

Press 1, 6, 0, FUNC, ENTER	Test takes approximately 20 seconds

<u>161 Keyboard Test</u>

Tests all key switches. Usage:

Press 1, 6, 1, FUNC, ENTER	Lower display responds "press any key"
Press key e.g. 3	Lower display echoes character 3
Press # MEAS	Lower display echoes "MEASURE"
Press FUNC	Lower display echoes "FUNCTION"
Press ENTER	Lower display echoes "ENTER"
Press RESET	exits function 161

<u>162 Software Version</u>

Factory set to display current software version e.g. 210

Diagnostics Record Sheet

Date						
142 **Ant. Freq.**						
143 **Low Freq.**						
144 **Hi Freq.**						
145 **Raw Diel.**						
146 **Diel. PZ**						
147 **Diel Std.**						
155 **Temp.**						
156 **Wt.**						
157 **Dist.**						
158 **Delta Freq.**						

Comments

SENSORS 11

Overview

The heart of the ST-2200A is a sophisticated dielectric sensor. Capable of resolving capacitance levels of 10^{-15} Farad, the sensor utilizes state of the art phase lock loop technology. ECL logic and ultra high bandwidth operational amplifiers enhance performance. All processor interface lines, including power supplies are either optically or transformer isolated to eliminate ground loop problems. Figure 1 shows a block diagram of the sensor electronics.

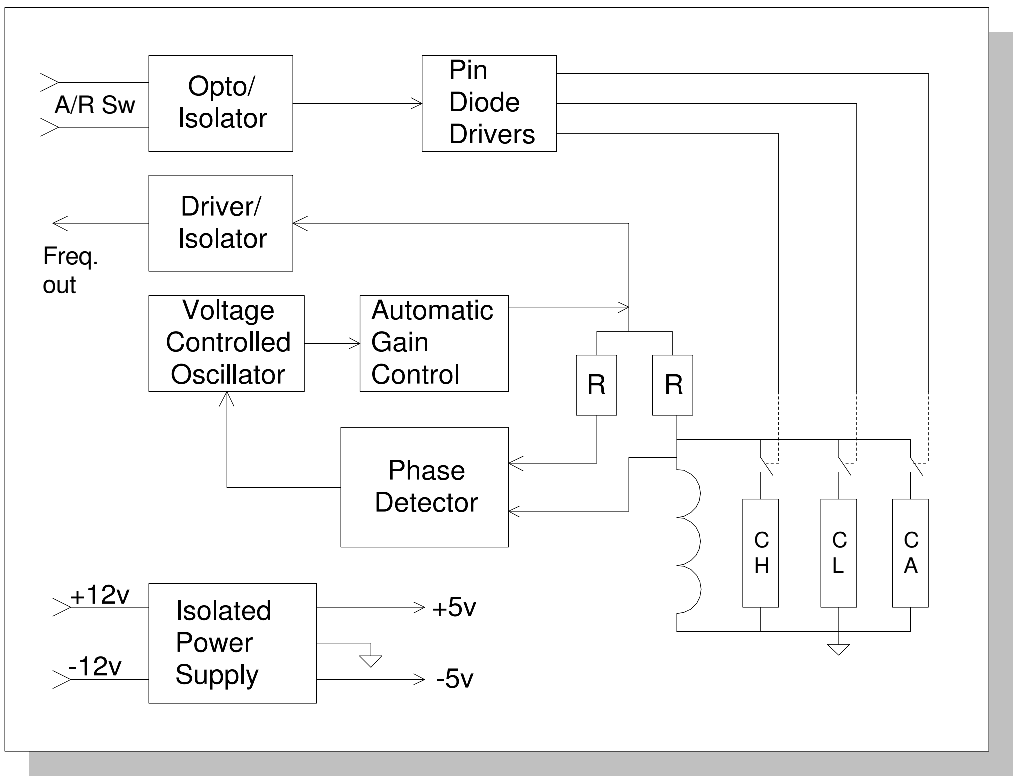


Figure 1. Sensor Block Diagram

Three capacitive elements: C_A, C_H, C_L are sequentially switched in parallel with a precision inductor.

C_A represents the antenna capacitance, whereas C_H and C_L are precision reference capacitors.

Whichever capacitor is currently switched in circuit, forms a parallel tuned circuit with inductor. The resonant frequency of this network constitutes the "lock frequency" of the phase lock loop.

This frequency is isolated and transmitted via interconnecting cable (differential RS485) to the signal processor.

Switching is performed by PIN diodes. The signal processor sends two switch signals, opto-isolated in the sensor. These two signals are decoded into three conditions, namely, Antenna, High Reference and Low reference.

The purpose of the reference components is to stabilize the instrument over a wide range of ambient conditions. The three frequencies are measured by the signal processor (32 bit precision) and form the inputs to a proprietary algorithm used to eliminate most drift factors.

Antenna Design

From an electronic standpoint, antenna is a misnomer. A truer description would be electrode or probe, since antennae tend to denote devices designed for maximum propagation efficiency, usually achieved by standing wave theory.

For dielectric measurement, standing waves are to be avoided at all cost since this would produce non-uniform energy distribution. The Sensortech Systems probe is essentially a deliberately mismatched antenna to provide broadband uniform dielectric coupling to product.

Antenna geometry (shape, size, etc.) is mainly a function of application, since provided the above criteria are met, it is largely a matter of mechanical design as how best to couple to the product. Sensortech Systems, Inc. has over a period of years, developed many unique electrode designs including: parallel plate, planar, cylindrical (pipeline), probe and co-axial types. The most widely used style is the planar type shown in figure 2. Consisting of a central electrode between two ground planes, or multiple electrodes interspersed with ground plane, this style provides a single sided measurement preferred in most industrial applications.

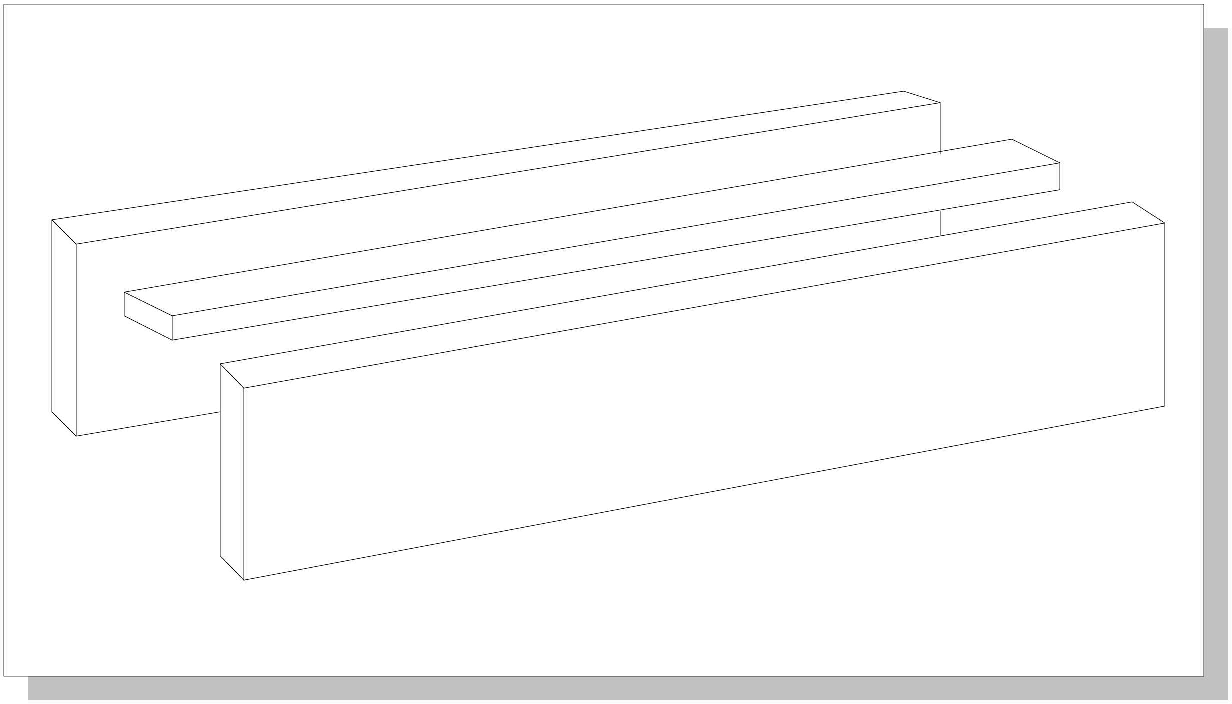


Figure 2. Typical Planar Sensor

1.0 Overview

The ST-2200A provides a serial interface that can be set up for the RS485 or RS232 hardware standard. The communication protocol, which is the same for both these standards, is of a master/slave type. This implies that all commands originate from the master. The master is the Host computer while the slave is the remote instrument, namely the ST-2200A.

Only printable ASCII characters in the following range are used in this protocol:

21 to 7F	(hex)
33 to 127	(decimal)

The main goal of implementing this serial interface in the ST-2200A is to provide:

1. digital output of the measurement data.
2. simple method of downloading calibration data.

The RS232 interface will be a 3-wire connection and will not have any form of hardware or software flow control.

1.1 Data Speed and Format

The data format is **7 bits, even parity, 1 stop bit, no flow control,** while the communications speed can be selected from one the following: 300, 1200, 2400, 4800, 9600, 19200 bps.
The default speed will be 9600 bps.

The com port settings can be changed from these locations:

- In Windows 3.X, Main, Control Panel, Ports, Com X, Settings.
- Windows 9.X, My Computer, Control Panel, Ports, Com X, Settings.

Note: The com port must match in File, Set Up, Interface Settings in ST-2200 Beta V2 software and ST-2200 processor.

When using a conversion device between RS232 and RS485, the converter (at the computer end) is normally set to DTE and controlled by RTS

1.2 Packet Structure

1.2.1 Host to ST-2200A

The typical Host to ST-2200A packet structure is as follows:

Start Addr Command/Data Checksum End

Start:

This field consists of 1 character, namely '>'.

Addr:

This field consists of 2 characters that specify the ST-2200A's address. For single digit addresses, this field must contain a leading zero.

The device address must be in the range of 01 to 99.

Command/Data:

The contents of this field depend on the various commands, which are defined in the next section.

Checksum:

This field contains a 3 digit checksum of every character in the Addr and Command/Data fields of the packet. The checksum is calculated by performing a modulo-256 addition. The data in this field is represented in decimal format, with leading zeros when necessary.

This field is absent in some of the response packets as shown in the next section.

End:

This field consists of 1 character, namely the ASCII carriage return (CR).

NOTES:

1. The space character (20 hex, 32 decimal) is used as delimiting character between some fields.

2. There is no delimiter between the following fields:
   - Start and Addr
   - Addr and Command/Data
   - Checksum and End

3. Delimiter usage in the Command/Data field is discussed in the next section wherever it is required.

1.2.2 Host commands

1. Moisture Request:

> Addr M CR

2. Temperature Request:

> Addr T CR

3. Density/Weight Request:

> Addr D CR

4. Distance Request:

> Addr d CR

5. Complete Measurement Data Request:

> Addr * CR

6. Function Request Command:

> Addr F <NNN> CR

where <NNN> is a 3 digit function number (with leading zeros when necessary) that corresponds to the configuration data that requires to returned.

NOTE: The ST-2200A user manual provides information on the various functions that will allow modification of individual configuration items.

7. Function Entry Command:

> Addr F <NNN> <DATA> Checksum CR

where <NNN> is a 3 digit function number (with leading zeros when necessary) that corresponds to the configuration data that requires to be changed.

<DATA> is the entry for the function.

NOTE: A delimiter must be inserted only between the following items:

- <NNN> and <DATA>
- <DATA> and Checksum field

8. Calibration Request:

> Addr C <NN> CR

where <NN> is a 2 digit number (with a leading zero when necessary) that corresponds to 1 of the 10 calibration profiles in the ST-2200A that requires to be changed.

9. Calibration Entry:

> Addr C <NN> <DATA> Checksum CR

where <NN> is a 2 digit number (with a leading zero when necessary) that corresponds to 1 of the 10 calibration profiles in the ST-2200A that requires to be changed.

<DATA> consists of several data items that make up one complete calibration profile of the ST-2200A.

NOTES: A delimiter must be inserted only between the following items:
- <NN> and <DATA>
- each data item within the <DATA> field
- <DATA> and Checksum field

The function and calibration entry requests will be accepted from the Host only if the ST-2200A is in the measurement mode and not in the function mode. i.e. the display should be showing measured moisture, temperature, density or distance values.

1.2.3 ST-2200A to Host

The typical ST-2200A to Host packet structure is as follows:

Start Data Checksum End

Start:

This field consists of 1 character, which can be one of the following:

A For ACK response packet

N For NAK response packet

Checksum:

This field contains a 3 digit checksum of every character in the Data field of the packet. The checksum is calculated by performing a modulo-256 addition. The data in this field is represented in decimal format, with leading zeros when necessary.

This field is absent in some of the response packets as shown in the next section.

End:

This field consists of 1 character, namely the ASCII carriage return (CR).

Data:

The contents of this field depends on the various responses, which are defined in the next section.

This field is absent in some of the response packets as shown in the next section.

NOTES:

1. The space character (20 hex, 32 decimal) is used as delimiting character between some fields.

2. There is no delimiter between the following fields:
   - Start and Addr
   - Addr and Data
   - Checksum and End

3. Delimiters usage in the Data field is discussed in the next section wherever it is required.

12.4 ST-2200A Responses

The contents of this field depends on the various commands, as follows:

1. Measurement Data Response:

   > <DATA> CR

   where <DATA> is measurement data that was requested (ie. moisture, temperature, density or distance). In the case of the complete measurement data request, <DATA> will contain all four data items.

2. Function Data:

   A <DATA> Checksum CR

   where <DATA> is the data pertaining to the function

   NOTE: A delimiter must be inserted only between the <DATA> and Checksum fields.

3. Calibration Data Response:

   A <DATA> Checksum CR

   where <DATA> consists of several data items that make up one complete calibration profile of the ST-2200A.

   NOTES: A delimiter must be inserted only between the following items:
   - each data item within the <DATA> field
   - <DATA> and Checksum field

4. Data Acknowledgement:

   A CR

5. Negative Acknowledgment

N <CODE> <INFO> CR

where <CODE> is 2 digit error code (with leading zeros when necessary).

Some of the defined codes are as follows:

01	Undefined command.
02	Communication receive error.
03	Checksum error.
04	Invalid character received.
05	Password expired.
06	ST-2200A is in function mode locally.
07	Invalid function code.
08	Function does not allow entry or is not available for Host.
09	Function requires auxiliary I/O board.
10	Invalid calibration profile number.
11	Data out of range.
12	Range conflict in data with related data item (such as high/low limits).

<INFO> is a 1 digit information code that identifies the exact nature of the error. This is used with the following error codes:

Code 02:

<INFO> field is bit mapped as follows:
bit 0 = 1 ==> receiver overrun error
bit 2 = 1 ==> receiver framing error
bit 5 = 1 ==> receiver parity error

Code 03:

<INFO> is a value from 0 to 255 indicating the checksum as calculated by the ST-2200A.

Code 11 during calibration entry:

<INFO> is a value from 1 to 12 that indicates which of the 12 data fields is in error.

Code 12 during calibration entry:

<INFO> is a value of 1 or 2 indicating
1 Low and high moisture limits have conflicting values.
2 Low and high 4-20 mA limits have conflicting values

1.3 Data Formats

1.3.1 Measurement data

The measurement data for moisture, temperature, density/weight, and distance will be represented as a four digit number (containing leading zeros) with an implied decimal place of one.

For example,

24.5 will be sent as 0245
12.0 will be sent as 0120

1.3.2 Function data

The function data that can be uploaded or downloaded consists of integer or floating point numbers. An integer number can be up to a 5 digit number while a floating point number can be a 7 digit number not including sign and decimal characters.

The ST-2200A function command responses that contain floating point numbers will always send these numbers with 2 decimal places only.

1.3.3 Calibration data

The calibration data that can be uploaded or downloaded consists of 13 floating point data items, in the following order:

Moisture span
Moisture Zero
Temperature coefficient 1
Temperature coefficient 2
Nominal temperature
Density coefficient
Nominal density
Distance coefficient
Nominal distance
Moisture high limit
Moisture low limit
4-20 mA high limit
4-20 mA low limit

Each data item can be a 7 digit number not including sign and decimal characters.
There must be a delimiter (ie. space character) between the data fields.
The ST-2200A calibration command responses will always send its floating point numbers with 3 decimal places only.

1.4 Examples

The following examples are shown within double quotes which are not part of the packet. The End character <CR> is shown as an exclamation mark (!). The delimiter (space) is seen as a blank character.

1.4.1 Host Commands

Moisture Request to unit #1: ”>01M!"

Function 1 Request to unit #2: ">02F001!"

Function 21 Entry to unit 1: ">01F021 1.54 066!"

Calibration Request for profile 8 unit 1:

">01C08!"

Calibration Entry for profile 4 to unit 1:

">01C04 2.2 -0.5 0 0 0 0 0 0 0 55.0 4.5 60 4 099!"

1.4.2 ST-2200A Responses

Moisture Response (24.5%): "A0245!"

Function 1 Response (Product Code=1): "A1 081!"

Function 21 Entry acknowledgement: "A!"

Calibration Request for profile 8 unit 1:

"A6.200 2.500 0.000 0.000 0.000 0.000 0.000 0.000 0.000 75.000 8.500 60.000 6.000 074!"

Calibration Entry acknowledgement: "A!"

1.4.3 Typical Dialogs

```
 Host    |          | ST-2200A
|          |
Data request    | -------> |
| <------- | Data Response
|          |
Function Request        | -------> |
| <------- | Function Response
|          |
Function Request        | -------> |
 (wrong format)         | <------- | N01...undefined command
|          |
Function 22 Entry | -------> |
| <------- | N05...password expired
Function 2 Entry        | -------> |
(password)      | <------- | ACK
Function 22 Entry | -------> |
| <------- | ACK
|          |
Calibration 3 Entry | -------> |
| <------- | ACK
|          |
```

1.5 List of ST-2200A functions

The following is the list of functions provided on the ST-2200A to display or modify its configuration. The functions marked by an asterisk are not available to the host.

Code	Function		
00	General		
01		Product code	
02		Password	
03		Sample Rate	
04		Damping	
05		Decimal selection	
06		Pre-zero	*
07		Standardization	*
08		Sampling Mode	
09		Batch Average mode	
10		Void Time	
11		ATRO (Dry Basis)	
19		New Password	*
20	Limits		
21		Low moisture limit	
22		High moisture limit	
23		4 mA out moisture	
24		20 mA out moisture	
25		Auto product loss	
26		Auto product return	
27		Timed sampling fill time	
28		Timed sampling purge time	
29		Reference	
30	Dielectric		
31		Dielectric mode	
32		Dielectric span	
33		Dielectric zero	
40	Temperature		
41		Temperature compensation	
42		Temperature coefficient...Kt1	
43		Temperature coefficient...Kt2	
44		Temperature nominal	

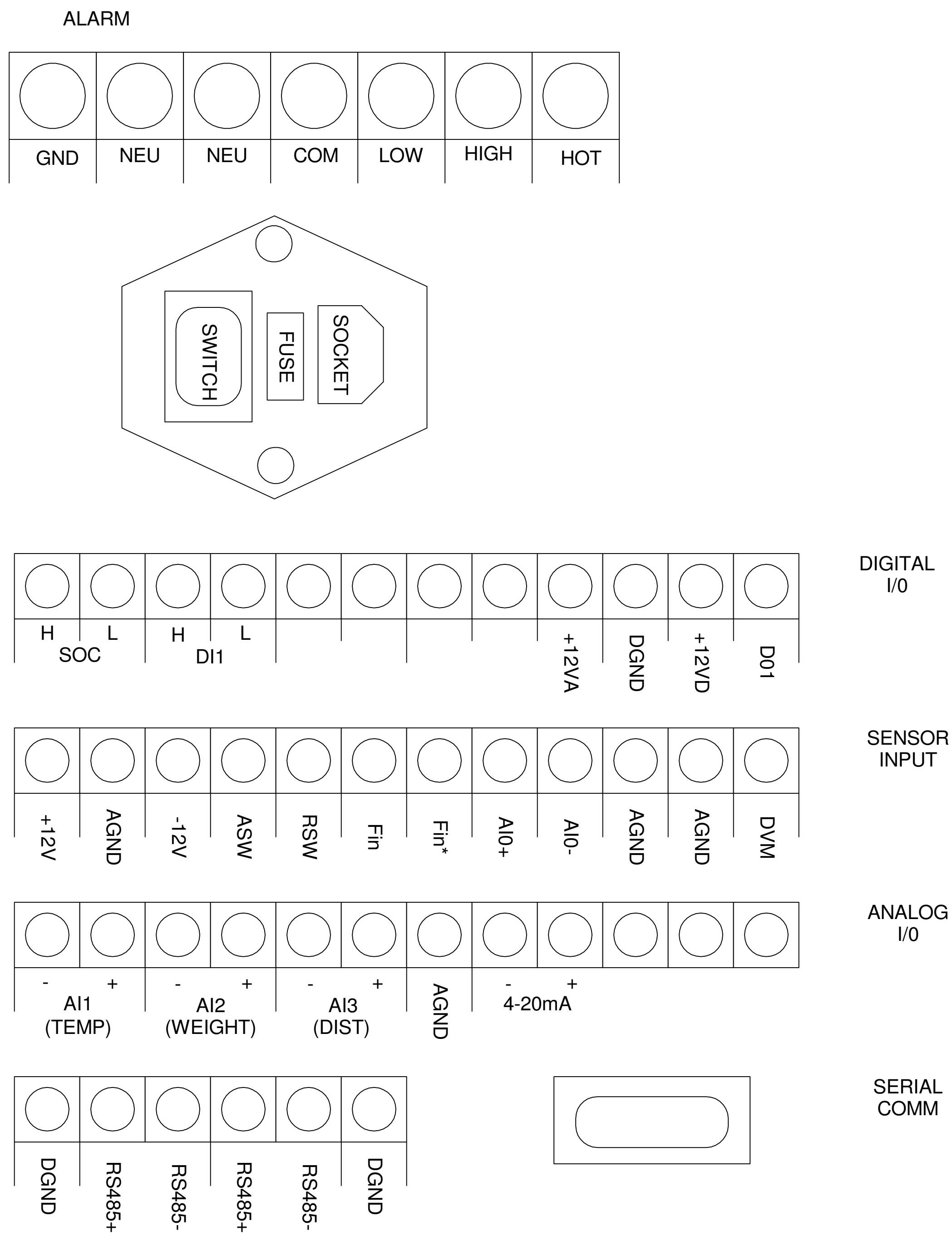
50	Weight	
51	Weight compensation	
52	Weight coefficient...Kw	
53	Weight nominal	
54	Weight...keyboard entry	

Code | Function

60	Distance	
61	Distance compensation	
62	Distance coefficient...Kd	
63	Distance nominal	
100	Utilities	
101	Default configuration	*
102	Copy code profile	*
120	I/O Configuration	
121	Temperature span	*
122	Temperature zero	*
123	Weight span	*
124	Weight zero	*
125	Distance span	*
126	Distance zero	*
127	4 mA calibration	*
128	20 mA calibration	*
129	Equal High load referencing selection	*
130	Alpha-numeric display intensity	*
131	Numeric Display minimum	*
132	Numeric Display maximum	*
133	Host Interface Baud Rate	*
134	Host Interface Device Address	*
135	Communication Interface Type (RS485/232)	*
136	Host Options	*
140	Diagnostics	
141	Voltmeter	
142	Antenna frequency	
143	Low frequency	
144	High frequency	
145	Pure Dielectric	
146	Pure dielectric pre-zero value	
147	Pure dielectric standardization value	
148	Dielectric loss input	
155	Temperature input	
156	Weight input	

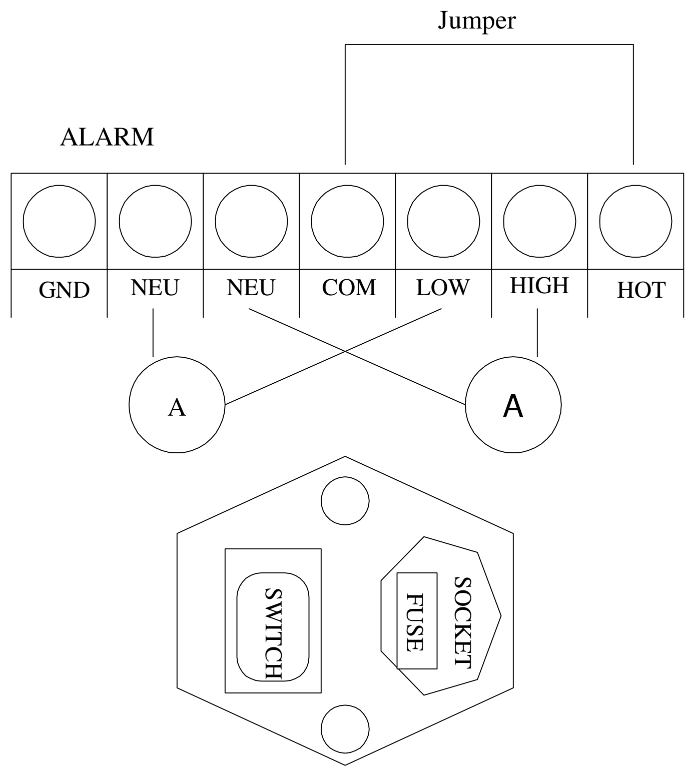
157	Distance input	
158	Delta frequency (F_low - F_ant)	
160	Display test	*
161	Keypad test	*
162	Software Version	*

ELECTRICAL CONNECTIONS 13



Note: Both 485+ are tied to each other.
Both 485- are tied to each other.

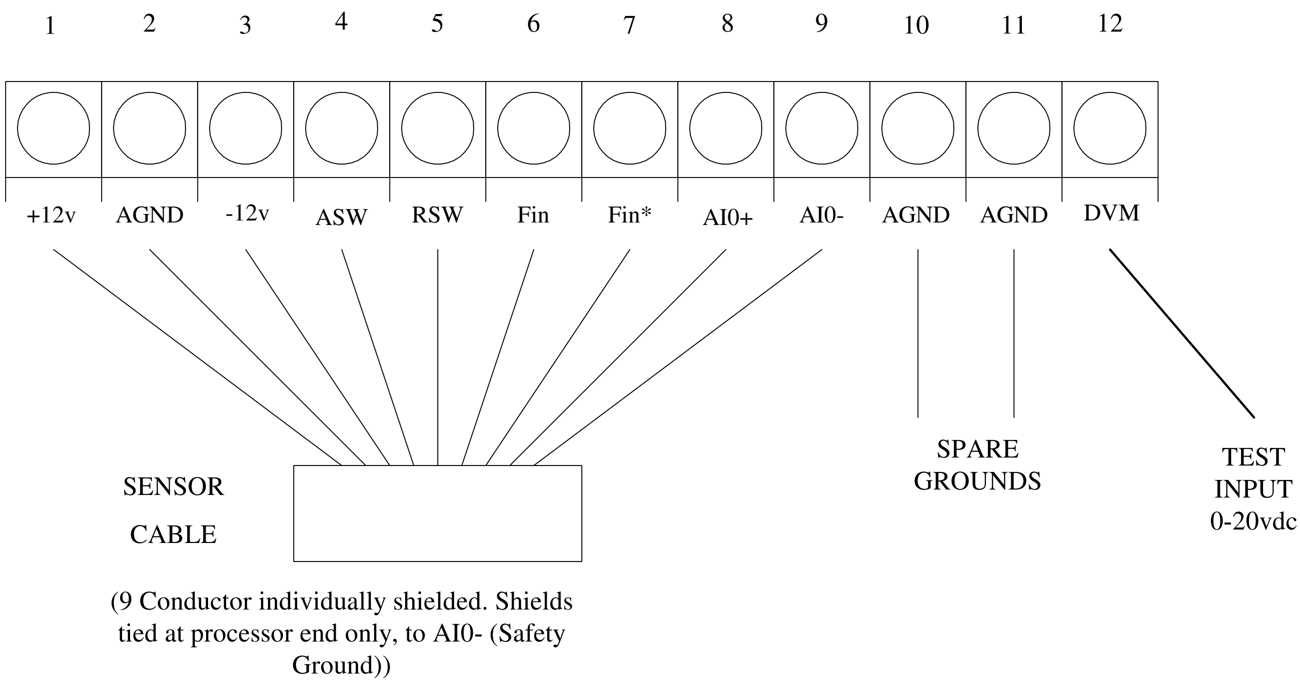
Dwg.1 ST-2200A Rear Panel



<u>Dwg.2 Main Power Terminal Strip</u>

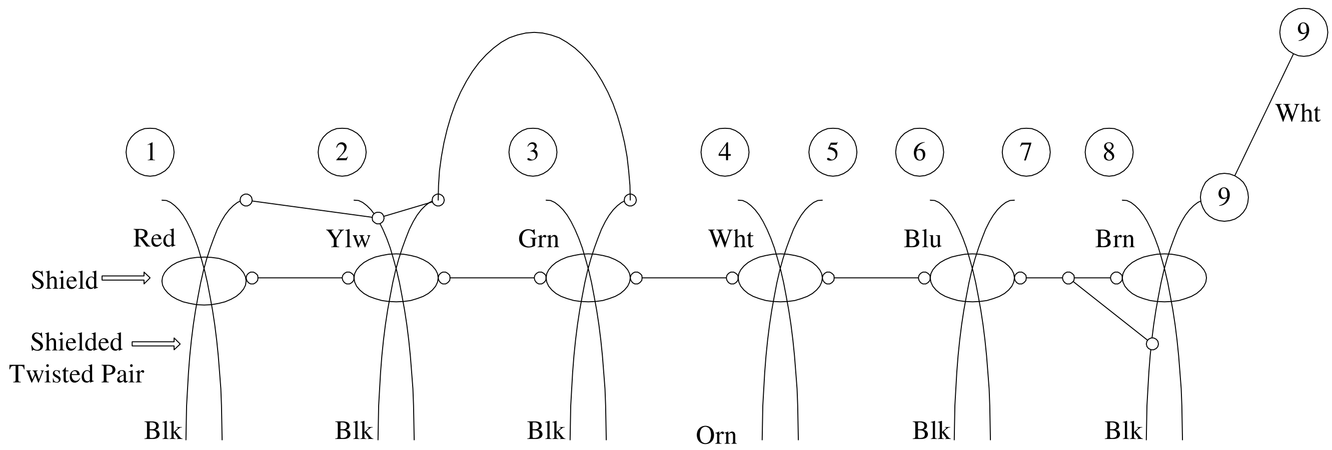
Showing Power and Alarm Connections
Note: Alarms are solid state switches requiring AC supply 24VAC - 240VAC
Minimum 6 watt load required
<u>IMPORTANT</u>: Ensure safety cover is replaced after service.

Note: Do not apply external power source. A.C. Power supplied by processor.

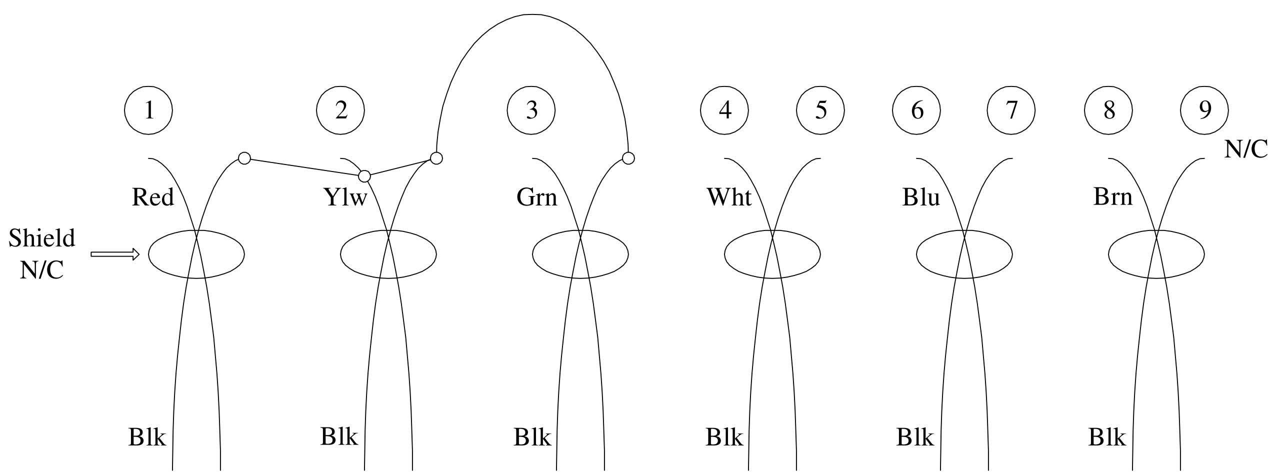


Dwg.3 Sensor Input Connections

Processor End

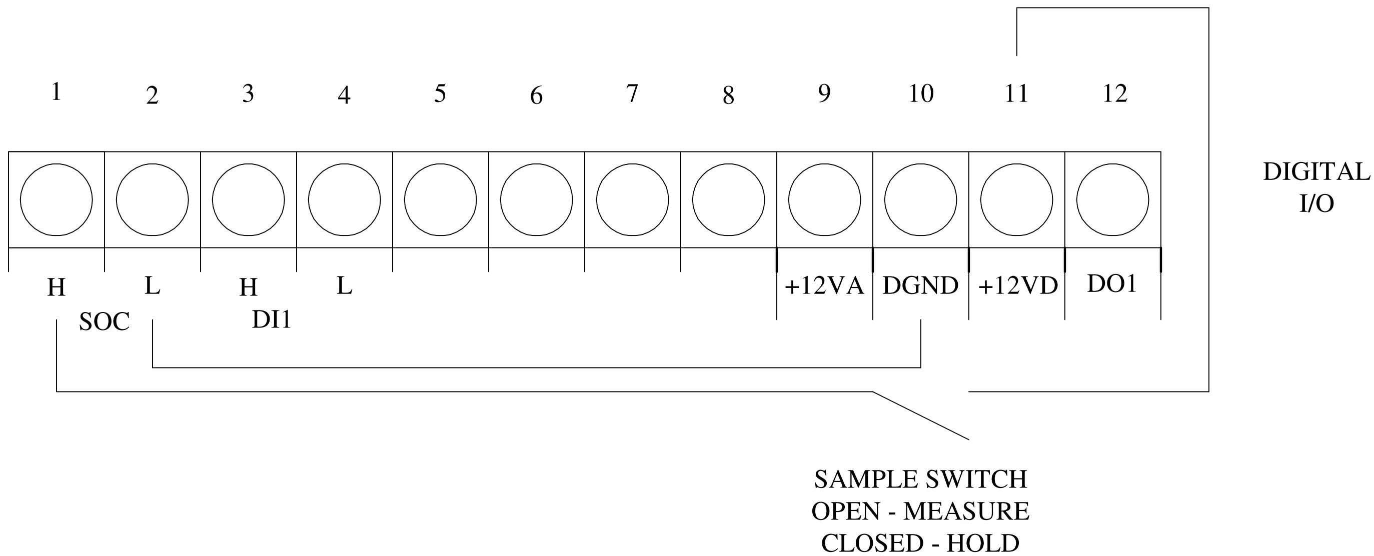


Sensor End



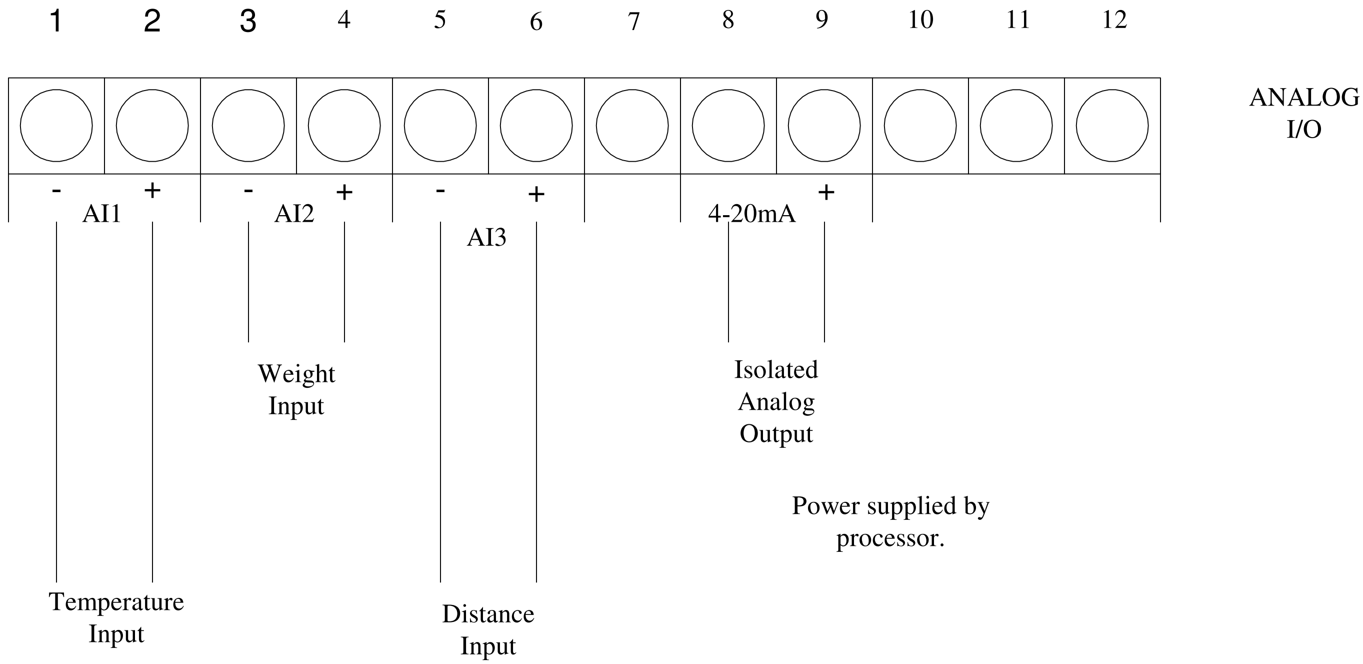
Dwg. 4 Multi-Conductor Cable Schematic

20 AWG Shielded
30V 6 Shielded Pair



<u>DWG. 5 Sample on Command</u>
using mechanical switch
and instrument power

Auxiliary Input (DI1): TTL / CMOS input (currently inactive).

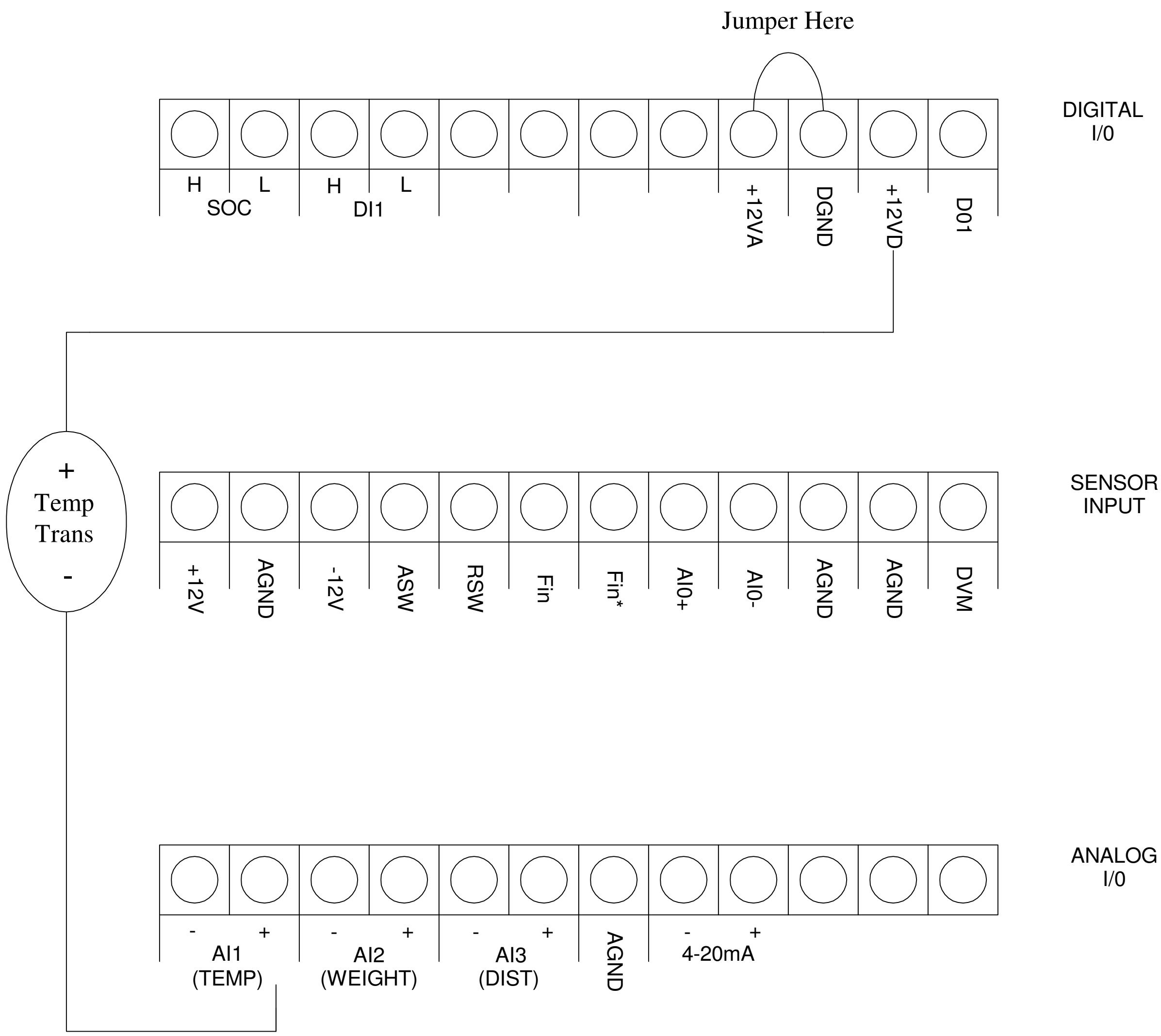


Dwg. 6 Analog I/O Terminal Strip

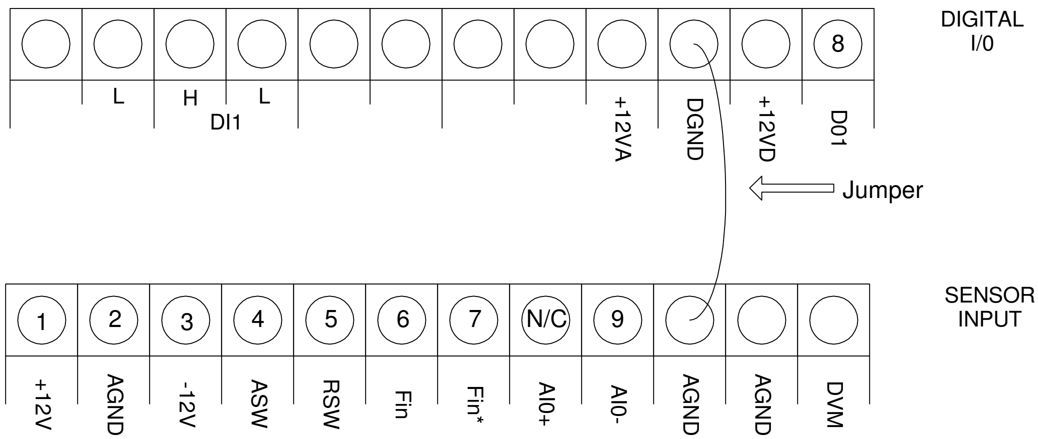
Temperature, Weight and Distance inputs: 4 - 20 mA, 0 - 5 dcv, or 0 - 10 vdc.
Analog Ground: return for single ended inputs.
4 - 20 mA Analog Output: Ground Isolated, 1K load max.

24 Volt supply is available for temperature probe (RTD), etc.

Connect as follows:

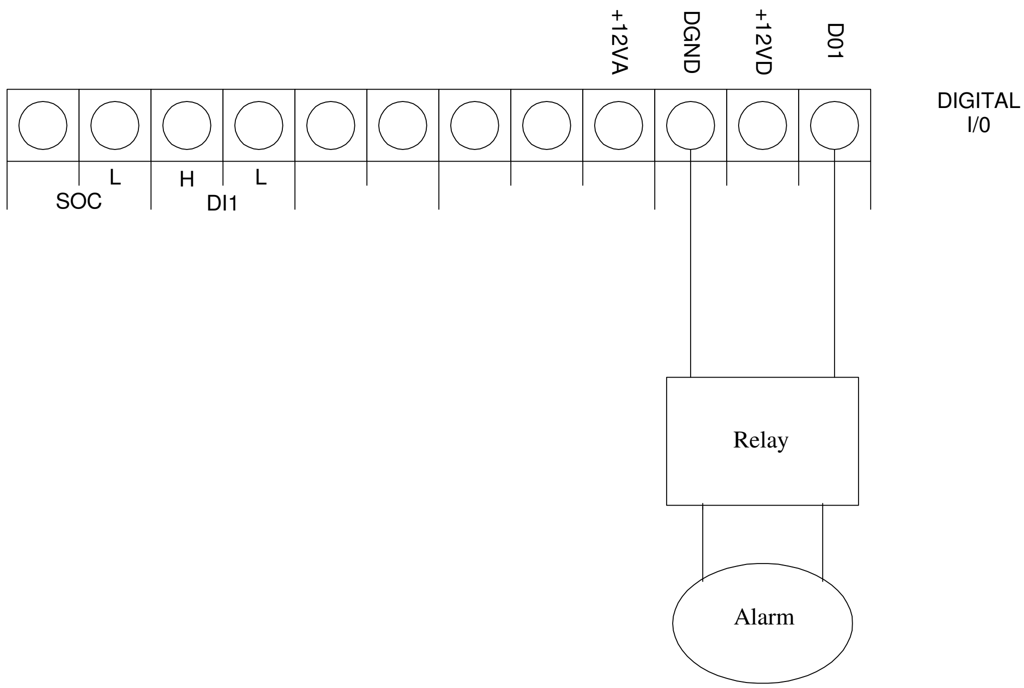


Dwg. 7 Temperature Connection



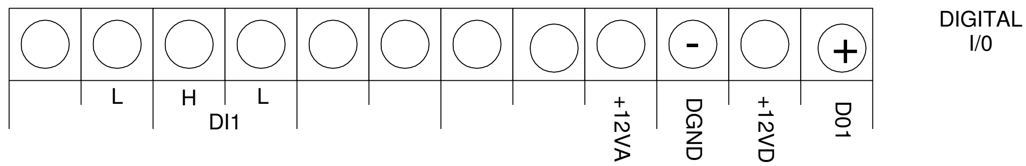
Interconnect cable pins 1 to 7 and 9 connect to sensor input.
Pin 8 connected to DO1 on Digital I/O.
DGND and AGND jumpered together.

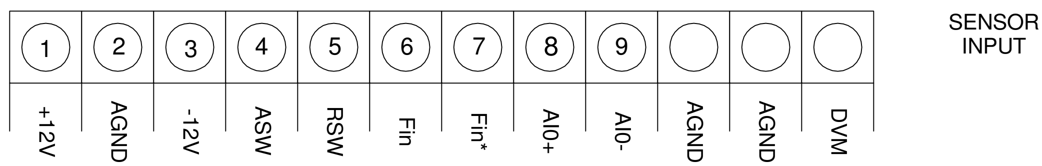
Dwg. 8 DO1 Connections for Sampling Sensor using single interconnect cable



Used in conjunction with APD (8F3) to signal No Product / Product.
DO1 relative to DGND is a 5VDC signal that can be fed directly to a P.L.C. or to an alarm via a relay.
No Product = 5V
Product = 0V

Dwg. 9 DO1 Connections for No Product Alarm





Interconnect cable pins 1 to 9 connect to Sensor input.

2 conductor cable connections: DO1 on Digital I/O at processor is connected to + (Positive) on relay at sensor. DGND on Digital I/O at processor is connected to - (Negative) on relay at sensor.

Note: Digital ground and analog ground are not jumpered together.

<u>Dwg. 10 Connections for sampling sensor using 2 interconnect Cables</u>.

TROUBLESHOOTING 14

INDEX OF TROUBLESHOOTING SUBJECTS

1.) 4-20mA Output Does Not Work:

Warning: **Do not** apply an external power source to 4-20mA output - it is powered by the processor. Doing this will damage 4-20mA output.

Check 4-20mA output relative to AGND with an ammeter. There should be a minimum of 4mA regardless of processor settings. If not, contact Sensortech. If an ammeter is not readily available, a 250-ohm resistor may be placed across 4-20mA output relative to AGND. A DVM may then be used to check for a voltage across the resistor. At 4mA there should be 1 volt present, at 20mA there should be 5 volts. If there is no voltage, contact Sensortech.
The unit can be forced to output 4mA or 20mA using 127F and 128F respectively. If the current / voltage changes when implementing 127F / 128F, but does not otherwise change, the problem is an incorrect processor setting (23F, 24F, 32F and 33F).

2.) Always Displays 0.0% or a Fixed Display:

This could be a result of many different things. DIELECTRIC PRE-ZERO 146F, DIELECTRIC SPAN 32F, STANDARDIZATION FACTOR 147F or DIELECTRIC ZERO 33F could all be set incorrectly. The antenna could also be too far from the product (ANTENNA LOCATION), the signal could be blocked or SATURATED by a material in between the sensor and the product, or the product density or moisture content too low to be shown with present settings. Sensor problems such as the antenna not being connected (via the coax cable - where applicable) can also have the same effect.

3.) Antenna Location:

The typical radiation pattern affords a sensor reading of up to 6 inches. This does not mean the sensor should be placed 6 inches from the product. In almost all cases the sensor should be as close as possible to the product. If the sensor is the non-contact type, it should be 1/4 inch from the product. A material that has a high dielectric value (carbon fiber) or is lossy (metal) should not obstruct the antenna. Antenna should also be parallel to the product. Even though this may not cause a loss of reading, it will cause a reading that may not be representative of the product (DOES NOT MATCH READINGS).

4.) Bad Ground:

When a sensor is manufactured at Sensortech, often times the mechanical / physical connections that hold the sensor together are used as the return / ground for the sensor. Modifying the antenna without maintaining electrical continuity of the mechanical / physical connections may cause the antenna to work improperly. Do not modify antenna without contacting Sensortech first. Grounding (safety ground) the sensor will often times quiet noise, but may not compensate for the return / ground achieved by the mechanical / physical connections of the original design.

5.) Coax Cable Connections:

With an ohmmeter, check continuity from center of coax connector, labeled '10', to screw of top electrode. Check continuity from center of coax connector, labeled '12', to screw of bottom electrode (if unit has two cables). Disconnect cable from sensor box (remote mount 2 cable sensor) and check for continuity between outside shield of both connectors. Also, there should not be continuity from center conductor to shield of cable.

6.) Diagnostics:

Functions 142, 143, 144, 145, 146, 147 and 158 are read-only parameters. Having these numbers available when speaking with a technician greatly aids in diagnosing problems. 142, 143, and 144 Functions (or just 143 and 144 Functions) all having the same numbers suggests SENSOR SWITCHING problem. 145 and 146 Functions being approximately equal but opposite sign (of each other while product is on / in sensor) suggests improper DIELECTRIC PRE-ZERO. This can be verified by removing product; if adding 145 and 146 Functions yields a negative number, pre-zero unit again.

7.) Dielectric Pre-Zero:

Dielectric Pre-Zero 146F is a number that the processor subtracts from the Raw Dielectric 145F to determine product moisture. This number is derived from the ambient dielectric of the antenna when the user Pre-Zero's the processor. Care should be taken when pre-zeroing the processor that the sensor is NOT covered with the product. The sensor should be clean. The processor does not know if there is or is not a product present when you Pre-Zero. Check 145F and 146F. If there is product on the sensor and 145F and 146F are almost identical (except for sign), then the unit was probably pre-zeroed with the product on it. Clean off sensor and pre-zero again.

8.) Dielectric Span:

The default for dielectric span 32F is 1; this is the number that should be in the unit when it arrives from the factory. Dielectric span is a multiplier or scaling factor that determines how aggressively a unit responds to changes in moisture. If dielectric span is too low, there may be little or no change in displayed moisture per moisture change in product. If too high, it may cause the display to be erratic. The dielectric span should never be a negative number if it is desired that moisture be displayed.
An example of how it effects displayed moisture: If product changes 2%, moisture and the display changes 1%, the dielectric span should be doubled (as it is not sensitive enough). If, however, the product changes 2%, moisture and the display changes 4%, the dielectric span should be halved (as it is too sensitive). It can easily be determined through regression analysis, which was described earlier in the book.

9.) Dielectric Zero:

The default for dielectric zero 33F is 0. Dielectric zero is equivalent to an offset. After determining the proper dielectric span 32F for product the display may change 2% with a corresponding 2% change in product moisture. The display may still read too high or low, though. The adjustment can be made with dielectric zero.
An example of how it effects displayed moisture: If product is 10% moisture and display reads 16%, the dielectric zero should be changed by -6 (6 more negative than the dielectric zero when the sample was taken). If product is 10% moisture and display reads 8%, the dielectric zero should be changed by +2 (2 more positive than the dielectric zero when the sample was taken). If the dielectric zero is too negative, and or the dielectric span too small, the unit may read 0.0 or low all the time (even when product is present).

10.) Display Goes Negative With Product:

On a high temperature unit, check coax cable connections. The antenna cable, labeled '10', connects to left RF connector (when viewed from bottom of box), labeled '10'. The reference cable, labeled '12', connects to the right RF connector. If these connections are correct, check COAX CABLE CONNECTIONS. Reversing cables will result in a negative number being stored in STANDARDIZATION FACTOR 147F in negative display with product.

11.) Display Reads High All The Time:

This can be caused by all the problems listed under DISPLAY READS LOW ALL THE TIME.
It can also be caused by:
- Product adhering to the sensor / sensor face.
- Product between electrodes of sensor.

- Product distance changing (closer) relative to the sensor (belt on which product is conveyed is thinning, change of rollers, etc.).
- Sensor distance changing (closer) relative to the product (moved sensor).
- Incorrect setting HIGH LIMIT.

12.) Display Reads Hold All The Time:

This occurs when unit is either in Sample on Command Mode 8F1, Timed Sampling 8F2, or Automatic Product Detection 8F3. In Sample on Command Mode an outside voltage (usually switched by proximity switch or Programmable Logic Controller) controls the unit. When voltage is applied to SOC, the unit will read hold. Check SOC for presence of voltage. If present, disable voltage source. If hold message disappears, the problem is with the voltage-controlling source. If the hold message is still present, try resetting the processor by powering down and restarting after a 10-second period. In timed sampling mode the unit is controlled by an internal counter. Attempt to reset processor by powering down and restarting after a 10 second period. If this does not succeed, defaulting the processor may work. This, however, should be a last resort. All information concerning the processor's setup should be recorded before this drastic action is taken, as all setup information will be lost during the default process. Contact Sensortech before taking this action. Automatic Product Detection is controlled by Product Loss 25F and Product Return 26F. The processor compares the numbers stored in these functions to Delta Frequency 158F to determine when there is product (Product Return 26F) and when there is no product (Product Loss 25F). Incorrect settings in these functions will cause the unit to display hold while product is present. Product loss should always be more positive than Delta Frequency without product. Product return should always be more positive than product loss.

13.) Display Reads Low All The Time:

This can be caused by lack of product (this includes a low flow rate (PRODUCT FLOW) or low product density), improper settings for DIELECTRIC SPAN, DIELECTRIC ZERO, LOW LIMIT, and bad PRE-ZERO (resulting in erroneous number being stored in DIELECTRIC PRE-ZERO). It can also be caused by a change in position of the sensor in relation to the product (i.e. moved further away).

14.) Display is too Noisy:

This can be caused by a variety of problems, the PRODUCT FLOW could be inconsistent, the ANTENNA LOCATION could be too far from the product, the DIELECTRIC SPAN could be set too high. Some of the problem can be compensated for by increasing the damping. Damping of 60 seconds is not uncommon in field applications. Noise can also be attributed to processor-sensor interconnect cabling being run outside of shielded conduit, or in close proximity to other types of cabling (high voltage power cabling). Noise can also be attributed to product inconsistency; often times product moisture changes more rapidly than expected. Taking multiple samples during a short period and testing for moisture will often show this. The problem may also be caused by intermittent cable connections including coaxial cable connecting the antenna to the sensor and BAD GROUND.

15.) Display is too Sluggish:

This is usually a case of too much damping, very consistent product moisture, or incorrect (too low) DIELECTRIC SPAN. See also ALWAYS DISPLAYS 0.0% OR A FIXED DISPLAY.

16.) Does Not Display Moisture:

Due to programmed scrolling features, sometimes moisture will not display in the bottom display. This can usually be remedied by pressing the RESET or MEAS# key. It may take several key presses.

17.) Frequency In:

With an oscilloscope, check signal on pins 6 and 7 (Fin and Fin*) relative to pin 2 (AGND) on the back of the processor. The signal should be an approximate 5 or 8 MHz sine wave depending on the tuning and type of sensor. If the signal is not present, check SENSOR POWER at sensor end of connecting cable. If signal is present, check DIAGNOSTIC.

18.) High Limit:

High limit 22F determines when the relay alarm on the back of the processor labeled High Alarm actuates. It also determines when the display reads High. If this is set too low, the display will read high all the time.

19.) Low Limit:

Low limit 21F determines when the relay alarm on the back of the processor labeled Low Alarm actuates. It also determines when the display reads Low. If this is set too high, the display will read low all the time.

20.) Multi-Conductor Cable Inspection:

If cable is connected to processor, make sure that it is powered down. With a DMM, check continuity from one end of the cable to the other pin for pin. If there is no continuity from end to end in any wire (except pin 9 which has no connection at sensor end), then there is an open in the cable. Also, check for continuity between wires/pins. All pins should be isolated from each other. If there is continuity, there is a short in the cable.

21.) No Display:

Verify appropriate A.C. power is hooked to the processor. Turn power switch on. If there still appears to be no power, check fuse. Fuse is located in the sidewall of the power plug. If still no power, contact Sensortech.

22.) Product Flow:

Product flow is one of the most important criteria pertaining to calibration of, and reliable readings from the unit. Readings will vary with product density, product height, speed of product passing sensor (note: calibration can not be done in a static situation), product distribution, etc. It can not be overstated that product flow / product consistency needs to be maintained at the sensor location. If this can not be achieved, then sensors determining these variables must be used. The processor can use data from these additional sensors to correct moisture readings.

23.) Reference Frequency Error:

This can occur occasionally when either the phase lock loop locks on to a harmonic frequency (usually observed on start ups / power glitches) or when one of the reference frequencies is not present or is conceived of as being incorrect by the processor. Press RESET several times; this may clear it. If the message does not clear, check processor cable connections at processor and sensor end. Check MULTI-CONDUCTOR CABLE INSPECTION, SENSOR POWER and SENSOR SWITCHING.

24.) Saturated:

The sensor's resonant frequency is affected by product dielectric (an electrical property). Product dielectric also includes product conveyance system (belt, web, chain, etc.). An increase in product dielectric is usually denoted by a downward shift in counts / frequency. The more product dielectric, the greater the shift. Unfortunately, due to component limitations, the maximum allowable frequency shift is fixed. After this point, the counts / frequency do not change. This means the sensor can no longer respond to further changes in moisture. This may also occur if the product resistivity is low enough to short the sensor signal.

***To determine saturation**:* Note 142F with product. If possible, increase product moisture otherwise open sensor box and touch antenna wire (Contact Sensortech for instructions). Note 142F: If there is little or no change in counts / frequency, the signal is saturated. If the counts / frequency increase, this is also indicative of saturation. Sometimes this problem can be alleviated by moving the sensor to a different location (drier product, different conveyance system, etc.) by moving the sensor further away from the product or by utilizing a different sensor. Contact Sensortech.

25.) Sensor Failure:

Press RESET several times; this may clear it. Check cable connections at processor and sensor end. Check MULTI-CONDUCTOR CABLE INSPECTION, SENSOR POWER, SENSOR SWITCHING and FREQUENCY IN.

26.) Sensor Power:

With a DVM check pin 1 (+12V) relative to pin 2 (AGND) at the processor. Do the same for pin 3 (-12V) relative to pin 2 (AGND); there should be +12 volts and -12 volts D.C. respectively. If there is low or no voltage at the processor, disconnect sensor from cable and check again. If the voltage is now correct, there is a problem with the sensor; contact Sensortech. If there is still no voltage, disconnect the cable from the processor and check again. If the voltage is now correct, there is a short in the cable. If there is still no voltage, the problem is in the processor; contact Sensortech.

27.) Sensor Switching:

With an oscilloscope check signal on pins 4 and 5 (ASW and RSW) relative to pin 2 (AGND) on the back of the processor. The signal is digital in nature and will toggle between 0 and 5 volts once a second. If the signal is present, remove cable from sensor and check corresponding cable pins in connector. The voltages and toggling will be the same. If the signal is present, there is a problem with the sensor; contact Sensortech. If the signal is not present at the processor, remove cable from sensor and check again. If signal is present, there is a problem with the sensor; contact Sensortech. If the signal is still not present, disconnect cable from processor and check for signal again. If the signal is present, there is a short in the cable. If the signal is still not present, the problem is in the processor; contact Sensortech.

An alternative to the above procedure requiring only a digital voltmeter is as follows:

1. Select antenna frequency by pressing 1, 4, 2, FUNC.
2. Lock on antenna frequency by pressing decimal point key.

3. Measure voltage at pins 4 & 5 relative to pin 2.
4. Repeat procedure for low (143FUNC) and high (144FUNC) reference frequencies.

The truth table below gives expected results.

CHECKING PINS RELATIVE TO PIN 2

	4	5
142F Locked	**5VDC**	**0VDC**
143F Locked	**0VDC**	**5VDC**
144F Locked	**0VDC**	**0VDC**

28.) Standardization Factor:

After a unit is pre-zeroed in the factory, it is standardized. The standardization factor 147F is derived at this time. Its only use is to make all units leaving the factory equally as sensitive to product moisture. When a customer has more than one unit, a standardization plate is generally supplied. This can be used to discount antenna distance variations from product when used properly. Normally though, the customer should not need to standardize a unit. Check 147F. If this number is less than 15 or greater than 200, pre-zero and then standardize the unit with the standard plate 1/4 inch (or distance from sensor to product) from sensor at 25. If unit is direct contact in nature, standardize with plate directly on sensor at 80. If a standard plate is not available, the unit can be standardized with the product, but this method does not allow for easy replication at a later date. If the product is running at 8%, standardize the unit at 16. This will generally give the unit good sensitivity. The high reading can then normally be compensated for using the Dielectric Zero 33F.

29.) Will Not Hold Number:

If unit is in 8F0 (Continuous Sampling Mode), sampling can not be interrupted.

If unit is in 8F1 (Sample on Command Mode), check for D.C. voltage at SOC relative to AGND. Voltage source must be stable when applied.

If unit is in 8F2 (Timed Sampling Mode), check to see that antenna has product over / on / in it before purge cycle is initiated.

If unit is in 8F3 (Auto Product Detect Mode), check to see that 25F (Product Loss) and 26F (Product Return) are set properly.

QUICK REFERENCE 15

Function Number	Description	Range Low	Range High	Default
00	General			
01	Product code	1	10	1
02	Password	******	******	******
03	Sample Rate	1	1S	10ms
04	Damping	0	120	0
05	Decimal selection	0	2	1
06	Pre-zero			
07	Standardization			25
08	Sampling Mode	0	4	1
09	Batch Average mode	No	Yes	No
10	Void Time			1
11	ATRO			No
19	New Password			******
20	Limits			
21	Low moisture limit	-5.0	99.9	-5.0
22	High moisture limit	0	9999	100
23	4 mA out moisture	0	100	0
24	20 mA out moisture	0	100	100
25	Auto product loss	0	9999	0
26	Auto product return	0	9999	9999
27	Timed sampling fill time	0	99	1
28	Timed sampling purge time	0	10	1
29	Reference	0	100	15
30	Dielectric			
31	Dielectric mode	1	3	1
32	Dielectric span	-99.999	99.999	1
33	Dielectric zero	-999.99	999.99	0
40	Temperature			
41	Temperature compensation	No	Yes	No
42	Temperature coefficient...Kt1	-99.999	99.999	0
43	Temperature coefficient...Kt2	-99.999	99.999	0
44	Temperature nominal	-999.99	999.99	0
50	Weight			
51	Weight compensation	No	Yes	No
52	Weight coefficient...Kw	N/A	N/A	0
53	Weight nominal	-999.99	999.99	0

54	Weight...keyboard entry	0	999.9	0
Function Number	Description	Range Low	Range High	Default
60	Distance			
61	Distance compensation	Off	On	Off
62	Distance coefficient...Kd	-99.999	99.999	0
63	Distance nominal	N/A	N/A	0
100	Utilities			
101	Default CAUTION!!			
102	Code Copy			
120	I/O Configuration			
121	Temperature span	-99.999	99.999	1
122	Temperature zero	-999.99	999.99	0
123	Weight span	-99.999	99.999	1
124	Weight zero	-999.99	999.99	0
125	Distance span	-99.999	99.999	1
126	Distance zero	-999.99	999.99	0
127	4 mA calibration			
128	20 mA calibration			
129	Equal High referencing	No	Yes	No
130	Alpha-numeric display intensity	00	77	33
131	Numeric Display minimum	-999.99	999.99	-.2
132	Numeric Display maximum	0	9999	9999
133	Host Interface Baud Rate	300	19200	9600
134	Host Interface Device Address	0	99	0
135	Communication Type	RS232	RS485	RS485
136	Host Options	0	255	56
137	Product Code	No	Yes	Yes
138	Safe Alarm	No	Yes	No
139	Compensation WTD	1	6	WTD (1)
140	Diagnostics			
141	Voltmeter			Display
142	Antenna frequency			Display
143	Low frequency			Display
144	High frequency			Display
145	Raw Dielectric			Display
146	Dielectric pre-zero value			0.0000
147	Dielectric standardization value			50.00
148	Dielectric loss input			Display
155	Raw temperature			Display
156	Raw weight			Display

157	Raw distance			Display
158	Delta frequency			Display
160	Display test			Display
161	Keyboard test			Display
162	Software Version			210*

* As of 2000

SAMPLE CALIBRATION 16

Even though your facility may not produce Gypsum Board, reading this section may provide insight to calibrating and troubleshooting the ST-2200 for your product.

Gypsum Board Calibration Procedure

Mounting the Antenna:

The antenna should be mounted parallel and ¼ inch from the product. The distance can be checked with anything that is ¼ inch in diameter (drill bit, 1/4inch bar stock, etc.) and a straight edge that rides on top of the conveyance system (rollers, belt, etc.). The concept most important here is that the antenna is parallel to the product. If a section of antenna is further from the product, it will react less (be less sensitive to changes in moisture) than the section that is closer. This can be further aggravated if the product does not have uniform moisture distribution. See PARALLEL ANTENNA VERIFICATION. The antenna and sensor should also be isolated from vibration. Vibration can loosen nuts, bolts, and electronic components.

Parallel Antenna Verification:

This procedure should be done in FACTORY SETTINGS. Place a standard plate (or product with approximate dimensions of standard plate) over one end of antenna. Note display. Place standard plate over other end of antenna. Make sure to use the same section of plate with same orientation. Note display. If there is a difference in readings, the antenna is not parallel to the product. The side that displayed higher readings is closer to the product than the other.

Factory Settings:

Before changing any settings it is advised that all working settings be recorded, so they may be re-entered when finished with FACTORY SETTINGS procedure. These settings disable modes that might interfere with instant display updates. Remember to record working settings before changing to these settings: 3F1, 4F0, 8F0, 9Fl, 11Fl, 32F1, 33F0
Also, if temperature, weight, or distance compensation is on, turn it off.

High Temperature / In-Kiln Sensor:

Note: The antenna and connecting coaxial cables are for high temperature applications, The sensor box / electronics are not. These must be mounted in a location that is shielded from excess heat. A rule of thumb is if it's too hot for you, it's too hot for the electronics. Do not mount directly to kiln walls where there is a possibility for direct beat transference. Do not mount over kiln doors where an open door might heat the electronics via convection.

These calibration guidelines are for a 436HT3E sensor. After allowing electronics to warm up for a half-hour pre-zero and standardize unit. With a DIELECTRIC SPAN of I and a DIELECTRIC ZERO of 0 the unit should read 0 with no product on sensor and 25 with standard plate over sensor. If unit does not read the above, re-zero and standardize. When unit does read as stated above, run product, add damping to smooth / calm display and change DIELECTRIC ZERO to match desired readings. If being compared to another functional unit, readings from both units can be used in a regression analysis to make them identical. Auto product detect may be activated at this time. This will cause the unit's display and output to hold its last reading until product returns. This can be advantageous when using ST2200 output to control burners. Without A.P.D. the unit’s output would gradually return to zero (0), turning burners off (to compensate for perceived product dryness).

Low Temperature / Out of Kiln Sensor:

These calibration guidelines are for a 436OF3E sensor. After allowing electronics to warm up for a half-hour pre-zero and standardize unit. With a DIELECTRIC SPAN of 1 and a DIELECTRIC ZERO of 0 the unit should read 0 with no product on sensor and 25 with standard plate over sensor. If unit does not read the above, re-zero and standardize. When unit does read as stated above, change DIELECTRIC SPAN 32F to 1.5 and adjust DIELECTRIC ZERO 33F to match desired readings. If being compared to another functional unit, readings from both units can be used in a regression analysis to make them identical. Auto Product Detect 8F3 and Batch Average 9F; may be employed if an average of the entire board is desired. Display and output will hold until next board. If profiling is desired, A.P.D. and Batch Average should not be used. Sample Rate 3F should be set to l0mS and Damping 4F to zero (0).

Calibration settings for a 412OF3E sensor.
Same as for 436OF3E sensor except DIELECTRIC SPAN 32F is 3.0. Adjust DIELECTRIC ZERO 33F as necessary.

Why Doesn't the Handheld Sensor Match the On-Line Sensor?

Regardless of a manufacturer's attempt to control moisture during the mixing / forming pouring stage of the process, a board product will have uneven distribution of moisture when leaving the dryer section. This is a result of the mixing process, the drying process (convection and otherwise), and the physical makeup of the drying environment - chain drive, different decks, etc.

Note: Before equilibration the only way a product is capable of having absolute uniformity is if it is either bone dry (over-dried) or not dried at all. A typical board may look very much like this:

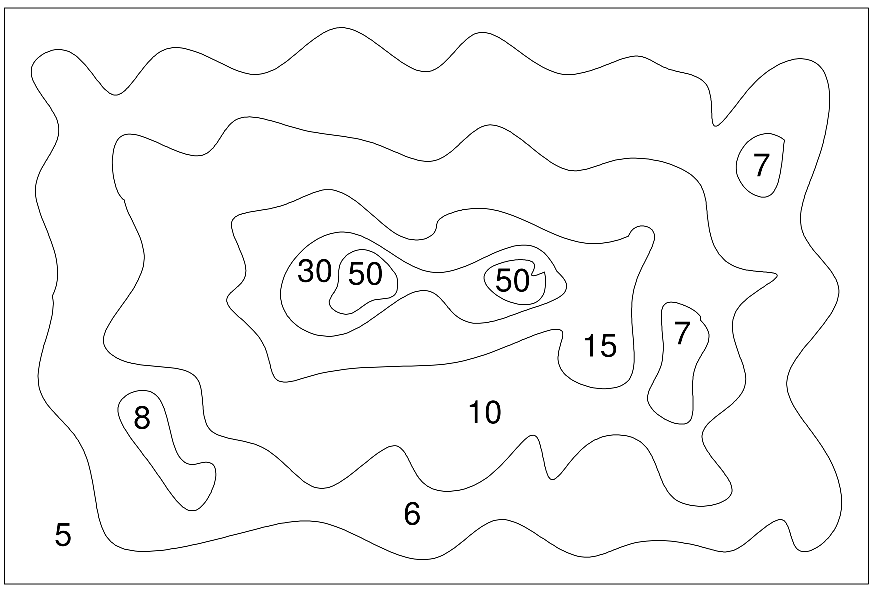


Fig. 1

Variable 5%-50% of moisture in a gypsum board.

When spot checking boards on the line, moisture will vary depending on the position of the handheld moisture sensor.

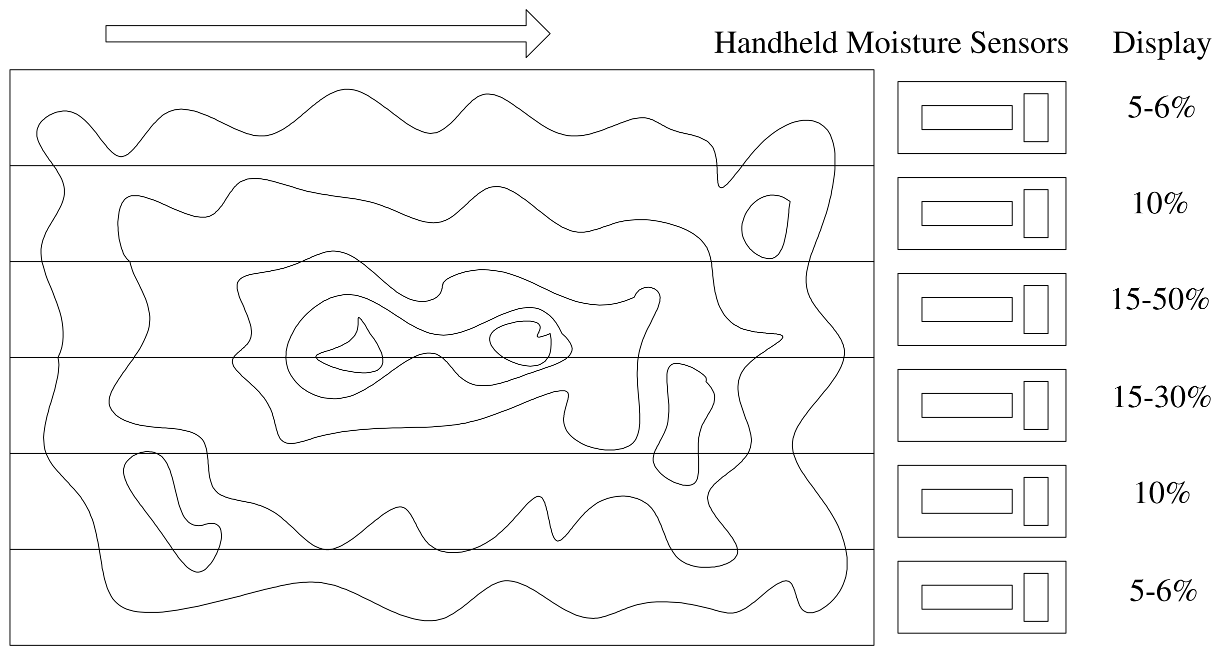


Fig.2 (Not to Scale)

NOTE: HANDHELD ANTENNA SAMPLING AREA, APPROX 3"

The handheld moisture sensor will display a very small strip of the board. The on-line sensor, however, will show an average across the board.

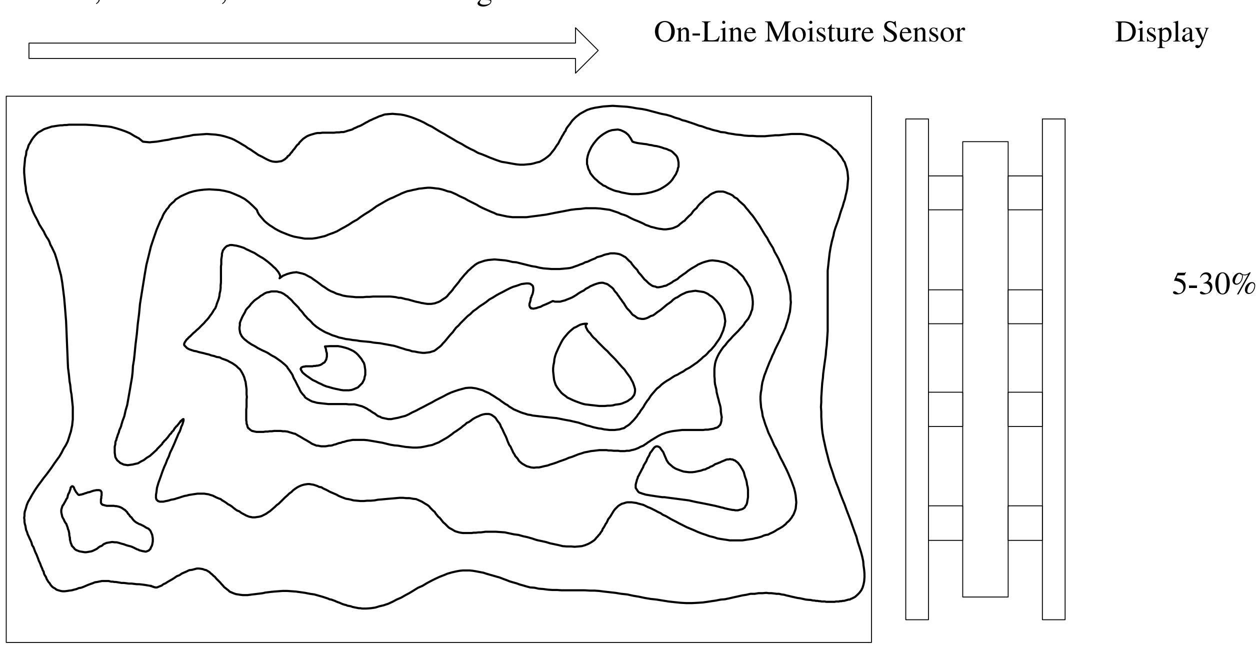


Fig.3 (Not to Scale)

NOTE: ON-LINE ANTENNA SAMPLING AREA, APPROX 36"

If batch averaging is applied, this may further aggravate the problem as it gives an average of the entire board - length as well as width.

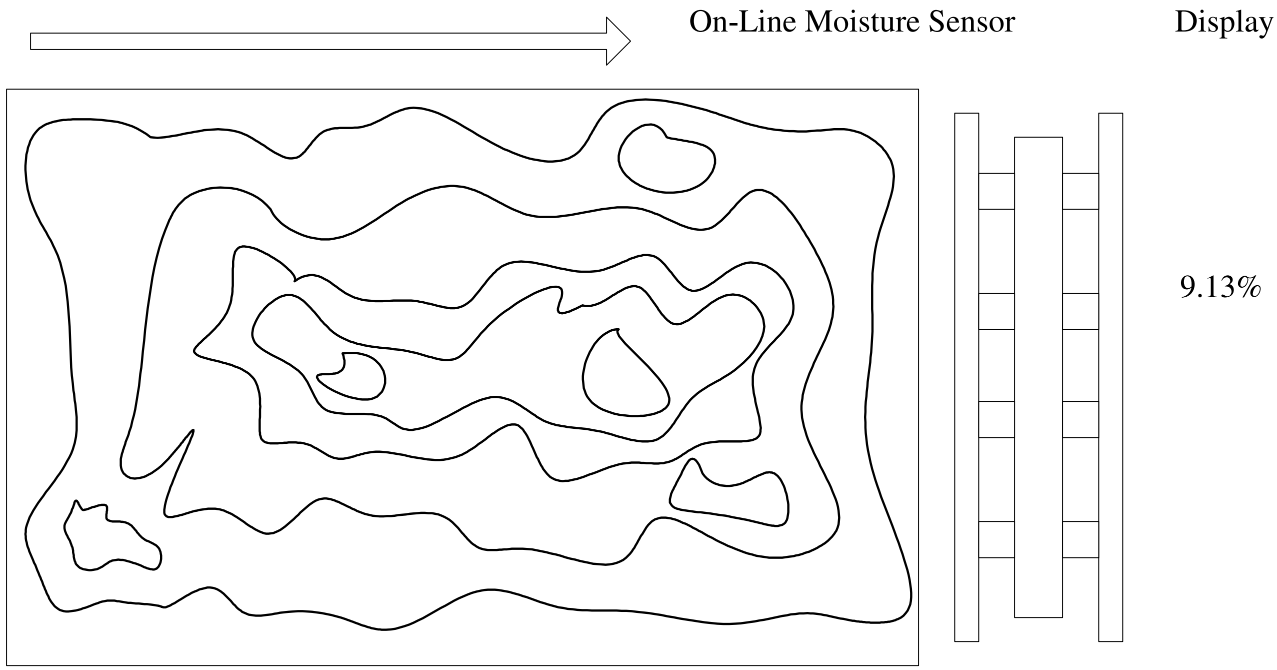


Fig.4

NOTE: ON-LINE ANTENNA SAMPLING AREA, APPROX 36"

The only way to compare and calibrate out differences is to record on-line reading and then obtain an accurate average of the board with a handheld sensor:

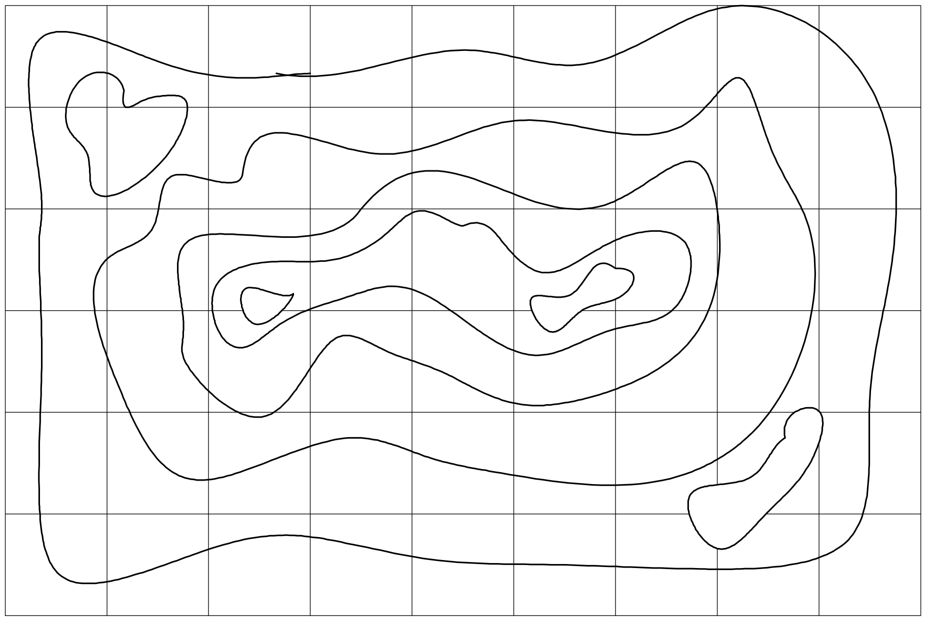


Fig.5 (Not to Scale)

Using the board above with the % values shown in Fig. 1, you would calculate an approximate average value of 9.13%. Counting left to right. top to bottom, assigning the following approximate values:

5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
5.5	8	8	8	8	8	8	7	5.5
5.5	8	12.5	32	27	32	12.5	8	5.5
5.5	8	12.5	26	13	27	11	8	5.5
5.5	7	8	9	10	8	8	8	5.5
5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5

Summing all values and dividing by 54 yields an average of 9.13%.

It is very difficult to compare the handheld sensor to the on-line moisture sensor because the on-line sensor measures a much larger cross section of product, whereas the handheld sensor only measures a particular spot on the product.