METER

ATMOS 51 INTEGRATOR GUIDE

SENSOR DESCRIPTION

The ATMOS 51 Variance Bowen Ratio (VBR) ET Sensor is designed for monitoring the environmental variables that determine evapotranspiration rate. It computes and outputs the rate of evapotranspiration for transpiring vegetation. The latent heat flux is measured (see section 3.4 of the User Manual for equations), and it is divided by the latent heat of vaporization to get the evapotranspiration.

APPLICATIONS

- Evapotranspiration monitoring
- Microenvironment monitoring
- Crop stress monitoring

ADVANTAGES

- Robust, no moving parts design
- Small form factor
- Integrated design for easy installation
- Low-input voltage requirements
- Low-power design supports battery-operated data loggers
- Supports the SDI-12 three-wire interface
- Tilt sensor informs user of out-of-level conditions
- Little to no post processing of flux data
- No configuration necessary

PURPOSE OF THIS GUIDE

The ATMOS 51 VBR ET Sensor is designed for monitoring the environmental variables that determine evapotranspiration rate. It computes and outputs the rate of evapotranspiration. The latent heat flux is measured (Eq. 3, see Section 3.4 for equations), and it is divided by the latent heat of vaporization to get the evapotranspiration.

COMPATIBLE FIRMWARE VERSIONS

This guide is compatible with firmware versions 1.00 or newer.

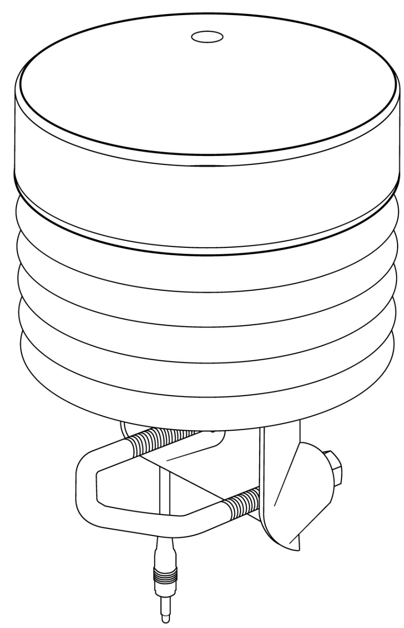

Figure 1 ATMOS 51 Variance Bowen Ratio (VBR) evapotranspiration sensor

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SPECIFICATIONS

MEASUREMENT SPECIFICATIONS

Solar Radiation	
Range	0–1750 W/m^2
Resolution	1 W/m^2
Accuracy	±5% of measurement typical

Relative Humidity	
Range	0–100% RH (0.00–1.00)
Resolution	0.1% RH
Accuracy	Varies with temperature and humidity, ±1% RH typical
Hysteresis	±0.80% RH, typical
Long-Term Drift	±0.25% RH/year, typical

Air Temperature Sensor	
Range	−40 to 60 °C
Resolution	0.01 °C
Accuracy	±0.1 °C

Barometric Pressure	
Range	26-126 kPa
Resolution	0.01 kPa
Accuracy	±0.003 kPa at 25 °C
Equilibration Time (τ, 63%)	<10 ms
Long-Term Drift	<0.03 kPa/year, typical

Tilt	
Range	0° to 180°
Resolution	0.1°
Accuracy	0°, -10°, ±1°, 10°-180°, ±10% of reading

COMMUNICATION SPECIFICATIONS

Output

SDI-12 communication

Data Logger Compatibility

METER ZL6 and EM60 data loggers or any data aquisition systems capable of switched 3.6- to 15.0-VDC excitation and SDI-12 communication

PHYSICAL SPECIFICATIONS

Dimensions	
Diameter	14 cm (5.5 in)
Height	21 cm (8.2 in)

Operating Temperature Range	
Minimum	−40 °C
Typical	NA
Maximum	60 °C

NOTE: Barometric pressure and relative humidity sensors operate accurately at a minimum of −40 °C.

Cable Length

5 m (standard)

1.5 m (5-pin M12)

75 m (maximum custom cable length for additional cost)

NOTE: Contact Customer Support if nonstandard cable length is needed.

Cable Diameter

0.165 ±0.004 in (4.20 ±0.10 mm), with minimum jacket of 0.030 in (0.76 mm)

Connector Types

Stereo plug extention connector with 4.2 ±0.2 mm (0.16 ±0.01 in), minimum jacket of 0.8mm (0.031 in)

M 12 connector with 5.5 ±0.2 mm (0.22 ±0.01 in), minimum jacket of 1.0 mm (0.039 in)

4 stripped and tinned wires

Connector Diameter

3.5 mm (diameter stereo plug)

14.4 mm (M12 connector)

Conductor Gauge

22-AWG / 24-AWG drain wire

ELECTRICAL AND TIMING CHARACTERISTICS

Supply Voltage (VCC to GND)	
Minimum	3.9 VDC continuous
Typical	NA
Maximum	15.0 VDC continuous

NOTE: ATMOS 51 must be continuously powered to work properly.

Digital Input Voltage (logic high)	
Minimum	2.8 V
Typical	3.0 V
Maximum	5.0 V

Digital Input Voltage (logic low)	
Minimum	−0.3 V
Typical	0.0 V
Maximum	0.8 V

Digital Output Voltage (logic high)	
Minimum	NA

Typical	3.6 V
Maximum	NA
NOTE: For the ATMOS 51 to meet digital logic levels specified by SDI-12, it must be excited to 3.9 VDC or greater.	
Current Drain (during measurement)	
Minimum	0.2 mA
Typical	8.0 mA
Maximum	33.0 mA
Current Drain (while asleep)	
Minimum	0.2 mA
Typical	0.3 mA
Maximum	0.4 mA
Power Up Time (SDI ready)—`aRx!` Commands	
Minimum	NA
Typical	6 s
Maximum	NA
Power Up Time (SDI ready)—Other Commands	
Minimum	NA
Typical	310 ms
Maximum	NA
Power Up Time (SDI-12, DDI disabled)	
Minimum	NA
Typical	240 ms maximum
Maximum	NA
NOTE: SDI-12 must be excited to 3.9 VDC or greater.	
Measurement Duration	
Minimum	NA
Typical	110 ms
Maximum	1,000 ms

COMPLIANCE

EM ISO/IEC 17050:2010 (CE Mark)

EQUIVALENT CIRCUIT AND CONNECTION TYPES

Refer to Figure 2 and Figure 3 to connect the ATMOS 51 to a logger. Figure 2 provides a low-impedance variant of the recommended SDI-12 specification.

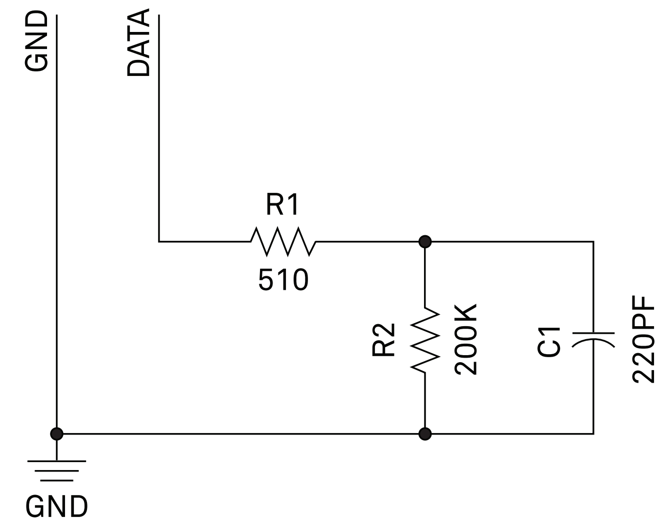

Figure 2 Equivalent circuit diagram

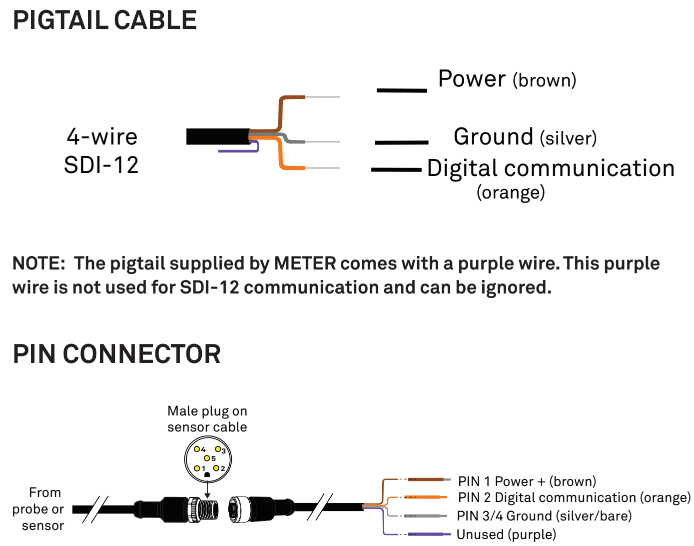

Figure 3 Connection types

PRECAUTION

METER sensors are built to the highest standards, but misuse, improper protection, or improper installation may damage the sensor and possibly void the warranty. Before integrating sensors into a sensor network, follow the recommended installation instructions and implement safeguards to protect the sensor from damaging interference.

SURGE CONDITIONS

Sensors have built-in circuitry that protects them against common surge conditions. Installations in lightning-prone areas, however, require special precautions, especially when sensors are connected to a well-grounded third-party logger.

Visit metergroup.com for articles containing more information.

CABLES

Improperly protected cables can lead to severed cables or disconnected sensors. Cabling issues can be caused by many factors, including rodent damage, driving over sensor cables, tripping over the cable, not leaving enough cable slack during installation, or poor sensor wiring connections. To relieve strain on the connections and prevent loose cabling from being inadvertently snagged, gather and secure the cable travelling between the ATMOS 51 and the data acquisition device to the mounting mast in one or more places. Install cables in conduit or plastic cladding when near the ground to avoid rodent damage. Tie excess cable to the data logger mast to ensure cable weight does not cause sensor to unplug.

SENSOR COMMUNICATIONS

METER digital sensors feature a 3-wire interface following SDI-12 protocol for communicating sensor measurements.

SDI-12 INTRODUCTION

SDI-12 is a standards-based protocol for interfacing sensors to data loggers and data acquisition equipment. Multiple sensors with unique addresses can share a common 3-wire bus (power, ground, and data). Two-way communication between the sensor and logger is possible by sharing the data line for transmit and receive as defined by the standard. Sensor measurements are triggered by protocol command. The SDI-12 protocol requires a unique alphanumeric sensor address for each sensor on the bus so that a data logger can send commands to and receive readings from specific sensors.

Download the SDI-12 Specification v1.4 and learn more about the SDI-12 protocol.

DDI SERIAL INTRODUCTION

The DDI serial protocol is the method used by the METER family of data loggers for collecting data from the sensor. This protocol uses the data line configured to transmit data from the sensor to the receiver only (simplex). Typically, the receive side is a microprocessor UART or a general-purpose IO pin using a bitbang method to receive data. Sensor measurements are triggered by applying power to the sensor. When the ATMOS 51 is set to address `0`, a DDI serial string is sent on power up, identifying the sensor. The ATMOS 51 does not report sensor measurements using the DDI serial protocol. The ATMOS 51 DDI serial message only contains information to identify the sensor to METER data loggers.

INTERFACING THE SENSOR TO A PC

The serial signals and protocols supported by the sensor require some type of interface hardware to be compatible with the serial port found on most personal computers (or USB-to-serial adapters). There are several SDI-12 interface adapters available in the marketplace; however, METER has not tested any of these interfaces and cannot make a recommendation as to which adapters work with METER sensors. METER data loggers and the ZSC device can operate as a computer-to-sensor interface for making on-demand sensor measurements. PROCHECK's SDI-12 passthrough mode may be used to communicate with the sensor, but spot measurements and data logging are not supported in PROCHECK. For more information, please contact Customer Support.

METER SDI-12 IMPLEMENTATION

METER sensors use a low-impedance variant of the SDI-12 standard sensor circuit (Figure 2). During the power-up time, sensors output some sensor diagnostic information and should not be communicated with until the power-up time has passed. After the power up time, the sensors are compatible with all commands listed in the SDI-12 Specification v1.4. `M`, `R`, and `C` command implementations are found on pages 7–10. The `XR` extended commands are used by METER systems and as a result use a space delimiter, instead of a sign delimiter as required by SDI-12.

Out of the factory, all METER sensors start with SDI-12 address `0` and print out the DDI serial startup string during the power up time. This can be interpreted by non-METER SDI-12 sensors as a pseudo-break condition followed by a random series of bits.

The ATMOS 51 will omit the DDI serial startup string (sensor identification) when the SDI-12 address is nonzero.

ATMOS 51 INTERNAL MEASUREMENT SEQUENCE

The ATMOS 51 measures its humidity, air temperature, and atmospheric pressure sensors every 1 second. Solar radiation and sensor tilt are measured every 60 seconds. Location and time data are collected from the GPS after power-on and once per day at midnight UTC time.

The averages and standard deviations of air temperature and specific humidity are determined using a digital filter with a time constant of 200 seconds. Modelled net radiation is computed every 60 seconds after solar radiation is measured. Bowen ratio, latent heat flux, and ET rate are computed at the time an SDI-12 measurement command is received by the sensor using the running standard deviations of air temperature and specific humidity.

SENSOR ERROR CODES

The ATMOS 51 has the following error codes available:

- `-9999` is output in place of the measured value if the sensor detects that the measurement function is compromised and the subsequent measurement values have no meaning.

- `-9992` is output in place of the measured value if the sensor detects lost or corrupt calibrations for that measurement.

- `-9991` is output in place of the measured value if the sensor detects insufficient voltage to perform the measurement.

- `-9990` is output in place of the measured value if the sensor detects a temporary issue with one of its measurement values. The sensor will resume outputting the measured value as normal once it detects the issue is no longer occurring.

In addition to the listed error codes, there are two additional output values for sensor metadata (`<diagnosticCode>` and `<meta>`) available in some SDI-12 commands. See the Diagnostic Codes and SENSOR METADATA VALUE sections for details.

SDI-12 CONFIGURATION

Table 1 lists the SDI-12 communication configuration.

Table 1 SDI-12 communication configuration

Baud Rate	1,200
Start Bits	1
Data Bits	7 (LSB first)
Parity Bits	1 (even)
Stop Bits	1
Logic	Inverted (active low)

SDI-12 TIMING

All SDI-12 commands and responses must adhere to the format in Figure 4 on the data line. Both the command and response are preceded by an address and terminated by a carriage return line feed combination and follow the timing shown in Figure 5.

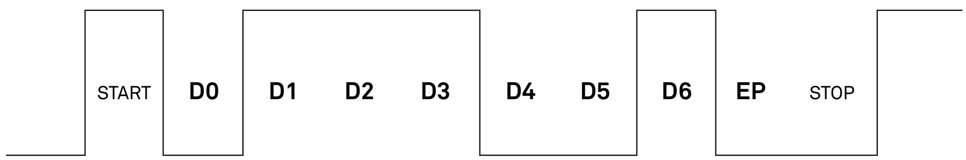

Figure 4 Example SDI-12 transmission of the character 1 (`0x31`)

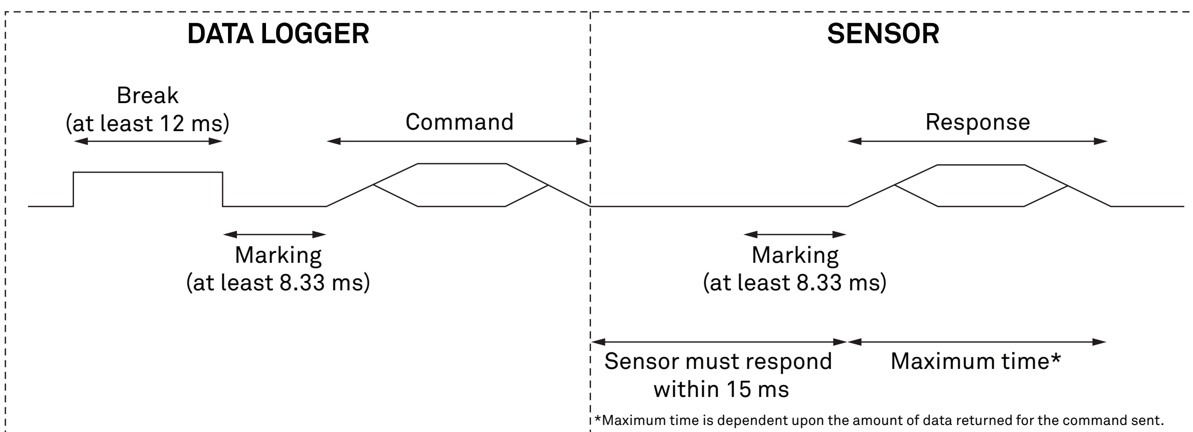

Figure 5 Example data logger and sensor communication

COMMON SDI-12 COMMANDS

This section includes tables of common SDI-12 commands that are often used in an SDI-12 system and the corresponding responses from METER sensors.

IDENTIFICATION COMMAND (`aI!`)

The Identification command can be used to obtain a variety of detailed information about the connected sensor. An example of the command and response is shown in Example 1, where the command is in **bold** and the response follows the command.

Example 1 `**1I!**114METER␣␣␣ATM51_␣␣100A510000001234`

Parameter	Fixed Character Length	Description
`1I!`	3	Data logger command Request to the sensor for information from sensor address `1`.
`1`	1	Sensor address Prepended on all responses, this indicates which sensor on the bus is returning the following information.

Parameter	Fixed Character Length	Description
14	2	Indicates that the target sensor supports SDI-12 Specification v1.4
METER␣␣␣	8	Vendor identification string (METER and three spaces ␣␣␣ for all METER sensors)
ATM51␣	6	Sensor model string This string is specific to the sensor type. For the ATMOS 51, the string is ATM51_.
100	3	Sensor version This number divided by 100 is the METER sensor version (e.g., 100 is version 1.00).
A510000001234	≤13, variable	Sensor serial number This is a variable length field.

CHANGE ADDRESS COMMAND (**aAB!**)

The Change Address command is used to change the sensor address to a new address. All other commands support the wildcard character as the target sensor address except for this command. All METER sensors have a default address of 0 (zero) out of the factory. Supported addresses are alphanumeric (i.e., a–z, A–Z, and 0–9). An example output from a METER sensor is shown in Example 2, where the command is in **bold** and the response follows the command.

Example 2 **1A0!**0

Parameter	Fixed Character Length	Description
1A0!	4	Data logger command Request to the sensor to change its address from 1 to a new address of 0.
0	1	New sensor address. For all subsequent commands, this new address will be used by the target sensor.

ADDRESS QUERY COMMAND (**?!**)

While disconnected from a bus, the Address Query command can be used to determine which sensors are currently being communicated with. Sending this command over a bus will cause a bus contention where all the sensors will respond simultaneously and corrupt the data line. This command is helpful when trying to isolate a failed sensor. Example 3 shows an example of the command and response, where the command is in **bold** and the response follows the command. The question mark (?) is a wildcard character that can be used in place of the address with any command except the Change Address command.

Example 3 **?!**0

Parameter	Fixed Character Length	Description
?!	2	Data logger command Request for a response from any sensor listening on the data line
0	1	Sensor address. Returns the sensor address to the currently connected sensor.

MEASUREMENT COMMANDS IMPLEMENTATION

Measurement (M) commands are sent to a single sensor on the SDI-12 bus and require that subsequent Data (D) commands are sent to that sensor to retrieve the sensor output data before initiating communication with another sensor on the bus.

Please refer to Table 2 and Table 3for an explanation of the command sequence and see Table 10 for an explanation of response parameters.

Table 2 aM! command sequence

Command	Response
This command reports average, or accumulated values. Please see ATMOS 51 Internal Measurement Sequence for more details.	
aM!	atttn
aD0!	a+<evaporationRate>+<latentHeatFlux>+<solarRadiation>
aD1!	a±<airTemperature>+<specificHumidity>±<bowenRatio>
aD2!	a±<netRadEstimate>+<sensorTilt>+<diagnosticCode>

NOTE: The measurement and corresponding data commands are intended to be used back to back. After a measurement command is processed by the sensor, a service request a <CR><LF> is sent from the sensor signaling the measurement is ready. Either wait until ttt seconds have passed or wait until the service request is received before sending the data commands. See the METER SDI-12 Implementation document for more information.

Table 3 aM1! command sequence

Command	Response
This command reports average or accumulated values	
aM1!	atttn
aD0!	a±<slowAirTemp>+<slowSH>±<slowBowenRatio>
aD1!	a+<slowSigmaAirTemp >+<fastSigmaAirTemp>+<slowSigmaSH>
aD2!	a+<fastSigmaSH>±<tempSHCovariance>+<minuteOfDay>

NOTE: The measurement and corresponding data commands are intended to be used back to back. After a measurement command is processed by the sensor, a service request a <CR><LF> is sent from the sensor signaling the measurement is ready. Either wait until ttt seconds have passed or wait until the service request is received before sending the data commands. See the SDI-12 Specifications v1.3 document for more information.

CONTINUOUS MEASUREMENT COMMANDS IMPLEMENTATION

Continuous (R) measurement commands trigger a sensor measurement and return the data automatically after the readings are completed without needing to send a D command.

Please refer to Table 4 and Table 5 for an explanation of the command sequence and see Table 10 for an explanation of response parameters.

Table 4 aR0! measurement command sequence

Command	Response
This command reports average or accumulated values Please see ATMOS 51 Internal Measurement Sequence for more details.	
aR0!	a+<evaporationRate>+<latentHeatFlux>+<solarRadiation>±<airTemperature>+<specificHumidity>±<bowenRatio>±<netRadEstimate>+<sensorTilt>+<diagnosticCode>

Table 5 aR1! measurement command sequence

Command	Response
This command reports average or accumulated values. Please see ATMOS 51 Internal Measurement Sequence for more details.	
aR1!	a±<slowAirTemp>+<slowSH>±<slowBowenRatio>+<slowSigmaAirTemp>>+<fastSigmaAirTemp>+<slowSigmaSH>+<fastSigmaSH>±<tempSHCovariance>+<minuteOfDay>

CONCURRENT MEASUREMENT COMMANDS IMPLEMENTATION

Concurrent (C) measurement commands are typically used with sensors connected to a bus. Measurements are initiated with a C command and subsequent D commands are sent to the sensor to retrieve the readings.

Please refer to Table 6 for an explanation of the command sequence and see Table 10 for an explanation of response parameters.

Table 6 aC! measurement command sequence

Command	Response
This command reports average or accumulated values. Please see ATMOS 51 Internal Measurement Sequence for more details.	
aC!	atttnn
aD0!	a+<evaporationRate>+<latentHeatFlux>+<solarRadiation>±<airTemperature>+<specificHumidity>
aD1!	a±<bowenRatio>±<netRadEstimate>+<sensorTilt>+<diagnosticCode>
aD2!	a±<slowAirTemp>+<slowSH>±<slowBowenRatio>+<slowSigmaAirTemp>+<fastSigmaAirTemp>
aD3!	a+<slowSigmaSH>+<fastSigmaSH>±<tempSHCovariance>+<minuteOfDay>

NOTE: Please see the METER SDI document for more information.

VERIFICATION COMMAND IMPLEMENTATION

The Verification (V) command is intended to give users a means to determine information about the current state of the sensor. The V command is sent first, followed by D commands to read the response.

Please refer to Table 7 for an explanation of the command sequence and Table 10 for an explanation of those response parameters.

Table 7 aV! measurement command sequence

Command	Response
aV!	atttnn
aD0!	a+<meta>

NOTE: Please see the METER SDI document for more information.

EXTENDED COMMAND IMPLEMENTATION

Extended (X) commands provide sensors with a means of performing manufacturer-specific functions. Additionally, the extended commands are utilized by METER systems and use a different response format and different response timing than standard SDI-12 commands. X commands are required to be prefixed with the sensor address and terminated with an exclamation point. Responses are required to be prefixed with the sensor address and terminated with <CR><LF>.

METER implements the following X commands:

• aXRx! to trigger a sensor measurement and return the data automatically after the readings are completed without needing to send additional commands.

• aXO! (with capital O as in Oscar) to suppress the DDI Serial string.

Please refer toTable 8-Table 9 for an explanation of the aXRx! command sequence and seeTable 10 for an explanation of response parameters. The aXRx! commands do not adhere to the 75-character SDI-12 response length limit. It is recommended to use a buffer that can store 125 characters for aXR3! and aXR4!.

Table 8 aXR3! measurement command sequence

Command	Response
aXR3!	a<TAB><evaporationRate><latentHeatFlux><solarRadiation><airTemperature><specificHumidity><bowenRatio><netRadEstimate><sensorTilt><diagnosticCode><CR><sensorType><legacyChecksum><CRC6><CR><LF>

NOTE: Please see the METER SDI document for more information.

Table 9 aXR4! measurement command sequence

Command	Response
aXR4!	a<TAB><evaporationRate> <latentHeatFlux> <solarRadiation> <airTemperature> <specificHumidity><bowenRatio><netRadEstimate><sensorTilt> <diagnosticCode><CR><sensorType><legacyChecksum><CRC6><CR><LF>

NOTE: This command reports instantaneous values where possible. The typical duration from the end of this command to the beginning of the command response is 300 ms. Please allow up to 350 ms for the sensor to respond to this command. This command does not adhere to the SDI-12 response format. Please see the METER SDI document for more information.

PARAMETERS

Table 10 lists the parameters, unit measurement, and a description of the parameters returned in command responses for ATMOS 51.

Table 10 Parameter Descriptions

Parameter	Unit	Description
±	—	Positive or negative sign denoting sign of the next value
a	—	SDI-12 address
n	—	Number of measurements (fixed width of 1)
nn	—	Number of measurements with leading zero if necessary (fixed width of 2)
ttt	s	Maximum time measurement will take (fixed width of 3)
<TAB>	—	Tab character
<CR>	—	Carriage return character
<LF>	—	Line feed character
<evaporationRate>	mm/hr	Evapotranspiration rate (latest reading)
<latentHeatFlux>	W/m^2	Latent heat flux (latest reading)
<solarRadiation>	W/m^2	Solar radiation (latest 1-minute reading or instantaneous value depending on SDI-12 command used)
<airTemperature>	°C	Air temperature (running average or instantaneous value depending on SDI-12 command used)
<specificHumidity>	g/kg	Mass of water vapor per mass of air (running average or instantaneous value depending on SDI-12 command used)
<bowenRatio>	—	Ratio of sensible heat flux to latent heat flux (latest reading)
<netRadEstimate>	W/m^2	Modelled net radiation (latest 1-minute value)
Parameter	**Unit**	**Description**
<sensorTilt>	°	Sensor orientation angle; 0 is level (latest 1-minute value or instantaneous value depending on SDI-12 command used)
<diagnosticCode>	—	Status of measurement subsystems (see Table 1)
<slowAirTemp>	°C	Air temperature from “slow” sensor (running average or instantaneous value depending on SDI-12 command used.)
<slowSH>	g/kg	Specific humidity from “slow” sensor (running average or instantaneous value depending on SDI-12 command used).
<slowBowenRatio>	—	Bowen ratio from “slow” sensors (latest value).
<slowSigmaAirTemp>	°C	Standard deviation of air temperature from “slow” sensor (running standard deviation).
<fastSigmaAirTemp>	°C	Standard deviation of air temperature from “fast” sensor (running standard deviation).
<slowSigmaSH>	g/kg	Standard deviation of specific humidity from “fast” sensor (running standard deviation).
<fastSigmaSH>	g/kg	Standard deviation of air temperature from “fast” sensor (running standard deviation).

Table 12 Parameter Descriptions (continued)

<tempSHCovariance>	°C * g/kg	Covariance between air temperature and specific humidity (running covariance).
<minuteOfDay>	min.	Minute into the current day (0 to 1439) in UTC time.
<meta>	—	Auxiliary sensor information. See Table 12.
<suppressionState>	—	0: DDI Serial string unsuppressed 1: DDI Serial string suppressed
<sensortype>	—	ASCII character denoting sensor type. For ATMOS 51, the character is ‘T’ (decimal value 84)
<legacyChecksum>	—	METER serial checksum
<CRC6>	—	METER serial 6-bit CRC

DIAGNOSTIC CODE

The measurement subsystems diagnostic value <diagnosticCode> contains information to help alert users to sensor-identified conditions that may introduce inaccuracies in measured or modelled sensor data. The value is a decimal number where each digit corresponds to the status of a particular measurement subsystem on the ATMOS 51. Table ? lists the status values for each digit in the subsensor error value.

Table 11 Diagnostic Codes

Digit	Sensor	Code and Meaning	Consequence for value >0
1's	Bowen Ratio	0 Bowen ratio < = 2 1 Bowen ratio > 2	1 Likely dry, sparse vegitation. R_n and G estimates may be incorrect ET may be overestimated.
10's	Level	0X Level within 1° 1X 1° to 2°off level 2X 2°to 4°off level 3X More than 4°off level; not usable	1 Poor radiation measurements 2 Degraded operation 3 No ET prediction
100's	Fast Temp and Humidity	0XX Fast T and RH good 1XX Fast T nonfunctional 2XX Fast RH nonfunctional 3XX Fast T and RH nonfunctional	1:3 Uses slow T and/or RH for variance calculations
1000's	Pyranometer	0XXX Pryanometer in calibration 1XXX Pyranometer needs calibration 2XXX Pyranometer failed	1 Degraded operation 2 No ET prediction
10000's	GPS	0XXXX GPS working normally 1XXXX GPS not functional	Backup net radiation calculation No pyranometer autocalibration

SENSOR METADATA VALUE

The sensor metadata value contains information to help alert users to sensor-identified conditions that may compromise optimal sensor operation. The output of the aV! aD0! sequence will output a <meta> integer value. This integer represents a binary bitfield, with each individual bit representing an error flag.

Table 12 lists the possible error flags that can be set by the ATMOS 41. If multiple error flags are set, the sensor metadata integer value will be the sum of the individual values. To decode an integer value not explicitly in Table 12, find the largest error flag value that will fit in the integer value and accept that error as being present. Then, subtract that error flag value from the integer value and repeat the process on the remainder until the result is zero. For example, a sensor metadata integer value of 208 is the sum of the individual error flag values 128 + 64 + 16, so this sensor sensor secondary temperature measurement error flag, sensor firmware corrupt error flag, and the sensor misorientation error flag.

Table 12 Error flag values and issue resolution

Error Flag Value	Issue Present	Resolution
0	No issue present	–
16	Sensor misorientation error will likely affect readings	Use the ZENTRA Utility app to re-level the sensor.
64	Sensor thermocouple is broken and sensor is using slow sensor temperature as a backup	Contact Customer Support for instructions on replacing the sensor daughterboard.
128	Sensor firmware is corrupt	Contact Customer Support for instructions on reloading firmware.
256	Daughterboard calibrations lost or corrupted	Contact Customer Support for instructions on reloading sensor calibrations.
512	Unable to obtain time or location data from GPS	Contact Customer Support for instructions on GPS fixes.

DDI SERIAL CHECKSUM

These checksums are used in the extended continuous commands, `XR3`, and `XR4` as well as DDI serial response. The legacy checksum is computed from the start of the transmission to the sensor identification character.

Legacy checksum example input is `<TAB>0.258 175.4 498.0 23.89 5.185 0.936 377.4 1.0 1<CR>TAE` and the resulting checksum output is `A`.

```
uint8_t LegacyChecksum(const char * response)
{
    uint16_t length;
    uint16_t i;
    uint16_t sum = 0;

    // Finding the length of the response string
    length = strlen(response);

    // Adding characters in the response together
    for(i = 0; i < length; i++)
    {
        sum += response[i];
        if(response[i] == '\r')
        {
            // Found the beginning of the metadata section of the response
            break;
        }
    }

    // Include the sensor type into the checksum
    sum += response[++i];

    // Convert checksum to a printable character
    sum = sum % 64 + 32;

    return sum;
}
```

The more robust `CRC6`, supported in firmware version 1.0 or newer, utilizes the `CRC-6-CDMA2000-A` polynomial with the value `48` added to the results to make this a printable character and is computed from the start of the transmission to the legacy checksum character.

`CRC6` checksum example input is `<TAB>0.258 175.4 498.0 23.89 5.185 0.936 377.4 1.0 10<CR>TAE` and the resulting checksum is the character `E`.

```
uint8_t CRC6_Offset(const char *buffer)
{
    uint16_t byte;
    uint16_t i;
    uint16_t bytes;
    uint8_t bit;
    uint8_t crc = 0xfc;  // Set upper 6 bits to 1's

    // Calculate total message length—updated once the metadata section is found
    bytes = strlen(buffer);

    // Loop through all the bytes in the buffer
    for(byte = 0; byte < bytes; byte++)
    {
        // Get the next byte in the buffer and XOR it with the crc
        crc ^= buffer[byte];

        // Loop through all the bits in the current byte
        for(bit = 8; bit > 0; bit--)
        {
            // If the uppermost bit is a 1...
            if(crc & 0x80)
            {
                // Shift to the next bit and XOR it with a polynomial
                crc = (crc << 1) ^ 0x9c;
            }
            else
            {
                // Shift to the next bit
                crc = crc << 1;
            }
        }
        if(buffer[byte] == '\r')
        {
            // Found the beginning of the metadata section of the response
            // both sensor type and legacy checksum are part of the crc6
            // this requires only two more iterations of the loop so reset
            // "bytes"

            // bytes is incremented at the beginning of the loop, so 3 is added
            bytes = byte + 3;
        }
    }

    // Shift upper 6 bits down for crc
    crc = (crc >> 2);

    // Add 48 to shift crc to printable character avoiding \r \n and !
    return (crc + 48);
}
```

CUSTOMER SUPPORT

NORTH AMERICA

Customer service representatives are available for questions, problems, or feedback Monday through Friday, 7:00 am to 5:00 pm Pacific time.

Email: support.environment@metergroup.com
sales.environment@metergroup.com

Phone: +1.509.332.5600

Fax: +1.509.332.5158

Website: metergroup.com

EUROPE

Customer service representatives are available for questions, problems, or feedback Monday through Friday, 8:00 to 17:00 Central European time.

Email: support.europe@metergroup.com
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Website: metergroup.com

If contacting METER by email, please include the following information:

Name	Email address
Address	Instrument serial number
Phone number	Description of problem

NOTE: For products purchased through a distributor, please contact the distributor directly for assistance.

REVISION HISTORY

The following table lists document revisions.

Revision	Date	Compatible Firmware	Description
00	6.2026	1.0	Initial release.