STARLOG

Weather Instruments

Model 6501
Model 6504

CE

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1. INTRODUCTION

This supplement describes the installation and operation of weather monitoring instruments available from UNIDATA, including:

Model 6501–B	Ambient Temperature Instrument
Model 6501–C	Ambient Temperature & Global Radiation Instrument
Model 6501–D	Ambient Temperature, Global Radiation and Relative Humidity Instrument
Model 6501–E	Ambient Temperature and Relative Humidity Instrument
Model 6501–F	Global Radiation Instrument
Model 6504-FS	Wind Speed and Wind Direction Instrument

Model 6503 Wind Run Anemometers are also available. See supplement 6227.

Model 6501 Instruments – Each of the Model 6501 Instruments has two versions, the only difference being the cabling option, for example,

–BS fitted with a STARLOG Quick Link interconnection system, known as «SQL»

–BU fitted with a 6-core cable assembly

The individual measuring devices which combine to make these instruments are also available from UNIDATA. Contact your distributor for details.

The Model 6501 Instruments may be added to the Wind Speed/Direction Instrument (Model 6504-FS) to form an Instrument Cluster. This allows you to monitor an even greater variety of weather conditions at a site.

Wind Speed, Direction, Sigma Theta and Vectors

In addition, this supplement describes how you can use the Model 6504-FS Wind Speed and Wind Direction Instrument to log Wind Sigma Theta and vectors. These extra features are available through STARLOG Software.

STARLOG Software Version	Appears in software's List of Instruments as...
Version 3	EWP – Extended Wind Package
Version 2	Model 6504X – Extended Wind Package

1.1. Superseded Models (see Appendices)

Several different versions of weather instruments have been available from UNIDATA. *Appendix B* is a list of current models and their predecessors.

Model 6504-FS supersedes models 6504A and 6504N. While it is technically the same, the new model is physically different: it has a different shape than the Model 6504A and uses different cabling and mounting than the Model 6504N. *See Appendix C.*

The Wind Speed and Direction Instrument is only available with «SQL» connection; the Model 6504F is no longer available.

1.2. New Temperature Calibration for Model 6501

Model 6501 supersedes Model 6505. While technically the same, the new model is physically different; it is housed within a louvered radiation shield and the **Temperature Range is changed** from -10°C to 60°C (Model 6505) to -17.8°C to 60°C (Model 6501). *See Appendix D.*

1.3. New Calibration for Models 6501D & 6501E

Due to changes in instrument design, calibration differs according to the serial number of the instrument.

Serial Number 1100 onwards	see Sections 4 and 2.4.1
Serial Number 913 to 1099	see Appendix E

2. STARLOG WEATHER MONITORING SCHEMES

UNIDATA's Weather Instruments are designed for automatic monitoring and collection of weather data in a STARLOG Data Logging System. When the instruments are connected to a STARLOG Data Logger, data sensed by the instruments is logged and stored according to a program you define using the STARLOG Software Package.

The STARLOG Software Package runs on a computer compatible with IBM systems (PC/XT/AT, PS/2). You can generate a data logging program – called a Scheme – then load the Scheme into a Data Logger. To learn how to use this program see the STARLOG Users Manual (supplement 6203 for users of Version 2, or 6245 for users of Version 3).

This section provides you with information you will find helpful in creating and executing a Weather Monitoring Scheme using Version 3 for STARLOG Software. See *Appendix F* for important notes for users of Version 2 Software.

2.1. Which Data Logger To Use

The Weather Instruments are typically being recorded using a STARLOGGER (Model 6004) or Portable Data Logger (Model 6003). The PDL's resolution (8 bit) is sufficient for most weather monitoring projects.

You can also use a MACRO Data Logger (Model 7000), in either PDL compatibility mode (8-bit resolution) or MDL mode (implementing 12-bit resolution). See section 2.4 if you are using the MACRO. Please note that the *accuracy* of an instrument is determined by its quoted specification – and not the available resolution of the Data Logger.

2.2. Adding an Instrument

Use the **Instruments** window in the **Scheme Editor** to add the weather instrument to the Scheme.

The list of instruments includes many variations of Weather Instruments. Models no longer available also appear in the list, in case you already use one of the older models. In some cases, you may receive a Model so new that it doesn't appear in the list yet.

If the model you have does not appear in the instrument list, you will want to add it first using the **Instrument Editor.**

» NOTE: The 6504-FS has superceded the 6504A and 6504N. All instruments will operate properly if you select the 6504A from the list of instruments. Some early versions of software may not list the 6504-FS – if this isn't listed in your Instrument List, choose the 6504A or 6504N.

When you add a weather instrument to a Scheme, the following channels are used. Using Version 3 STARLOG Software, these channel assignments are fixed: they must not be used for any other instruments.

Default Channel	Transducer Description
c1	Wind Speed
a0	Ambient Temperature
a1	Solar Radiation
a2	Wind Direction X component
a3	Wind Direction Y component
a7	Relative Humidity
WDIR*	Wind Direction Result

* This is a pseudo channel. There is no corresponding pin or terminal. Data read on a2 and a3 is used to determine the wind direction. Then, the result is stored in memory. To look at and use this result, the logger assigns this memory location the pseudo channel name of WDIR.

Ensure that you make the proper connection to the Field Termination Strip, if you are using that option, or the INPUT SIGNALS connector.

The connections described in this supplement (see Section 3 Installation) assume that you are using these channels.

2.2.1. Scaling Factors and Range

The weather instruments are calibrated to measure these ranges:

Description	From	To	Address
Temperature	–17.8°C	+60°C	16
Solar Radiation	0 watts/sqm	1500 watts/sqm	17
Humidity note 3	0% RH	100% RH	23
Wind Speed note 2	0 m/s	35.71 m/s	29
Wind Direction note 1	0°	359°	18,19
Logger Reading	000	255	

Notes:

1. The wind direction is determined by formula (**dirs**), from the two channel readings (which represent 180° and 270° wind vectors). (See BASIC program section 5.2.1.)
2. The wind speed is calculated by dividing the number of pulses recorded each second by 7.14. If the Data Logger is sampling every 5 seconds (5 sec cycle time) the wind speed channel (c1) prescale must be set to divide by 5 (likewise set to divide by 2 for 2 sec cycle, etc.) For approximate conversion in the Data Logger program, divide the pulses per second by 7.
3. The Humidity Transducer (from serial #1100 onwards) is calibrated differently from previous Weather Instruments. (See Appendix E if your instrument has a lower serial number.)

2.2.2. Scaling and Calibration Model 6501D and Model 6501E (serial #1100 onwards)

Humidity transducers from serial #1100 have been calibrated from 0% to 100% R.H.

The correct scaling of the humidity sensor is:

Transducer Range/mV	0 to 2550
Transducer Scaling/Formula	0 to 100

2.3. What to Log

You may want to log raw or average values for all weather elements that you measure. You might also want some minima and maxima data. This is all possible by simply selecting the appropriate instrument (channel) and log action

```
╔═[■]═══════════════ Log Buffer 1 ══════════════4=[↑]═╗
║6004B - STARLOGGER Data Logger 128K + KB              ▲
║Channel Xducer   RAW MAX MIN T1  T2  T4  AVE SD  ave▒
║a0      Temp     [X] [X] [X] [ ] [ ] [ ] [X] [-] [X]▒
║a1      Radn     [X] [X] [X] [ ] [ ] [ ] [X] [-] [X]▒
║a7      R.H.     [X] [X] [X] [ ] [ ] [ ] [X] [-] [X]▼
╚══════════════════════════════════════════════════════╝
```

(i.e., raw, average, maximum, etc.)

The wind direction, in general, should be averaged over the log interval or a sub interval. This gives a more meaningful value of wind direction over a period of

```
╔═[■]═══════════════ Log Buffer 1 ══════════════4=[↑]═╗
║6004B - STARLOGGER Data Logger 128K + KB              ▲
║Channel Xducer   RAW MAX MIN T1  T2  T4  AVE SD  ave▒
║c1      Speed    [X] [X] [X] [ ] [ ] [ ] [ ] [-] [ ]▒
║WDIR    S        [ ] [ ] [ ] [-] [ ] [ ] [X] [-] [X]▼
╚══════════════════════════════════════════════════════╝
```

time. Use the **Log Buffer** window to indicate that you wish to log averages: **AVE** is over the log interval and **ave** is over the sub interval.

2.3.1. The Extended Wind Package

To understand wind data more fully, you may want to log Sigma Theta and Wind Vectors (speed and direction). The Extended Wind Package enables you to obtain this information and appears in the Instrument List as **EWP- Extended Wind Package.**

In STARLOG Software Version 2, the Extended Wind Package is listed as 6504X. Instead of adding a 6504-FS (or 6504N/A–D), you need to add the 6504X to your scheme.

WARNING: In order to use the standard Extended Wind Package, the wind direction instrument must use the default channels.

Additional calculations are necessary in order to get Sigma Theta and Wind Vector data. This is automatically included in the Logger Program when the **EWP** is chosen. Psuedo channels wx, and wy are added to the Log Buffer List. Similar to Wind Direction, wx and wy are components used to calculate both speed and direction Wind Vectors. These calculations are done after the data has been unloaded from the data logger. In order to obtain valid Sigma Theta and Wind Vector information, these components must be logged as average values over the log or sub interval, i.e.,

```
[■]════════════════ Log Buffer 1 ═══════════════4=[↑]
6004B - STARLOGGER Data Logger 128K + KB
Channel Xducer   RAW MAX MIN T1  T2  T4  AVE SD  ave
c1      Speed    [X] [ ] [ ] [ ] [ ] [ ] [ ] [-] [ ]
WDIR             [ ] [ ] [ ] [-] [ ] [ ] [X] [-] [ ]
wx               [ ] [ ] [ ] [-] [ ] [ ] [X] [-] [ ]
wy               [ ] [ ] [ ] [-] [ ] [ ] [X] [-] [ ]
```

AVE_x	Sigma Theta X component
AVE_y	Sigma Theta Y component
AVE_vx	Wind Vector X component
AVE_vy	Wind Vector Y component

Then, to plot the resulting data, you would select the following when creating a Report:

Sigma	Sigma Theta
vDirn	Wind Vector (direction)
vWind	Wind Vector (speed)

» Note: It is not necessary to log wx and wy if only Sigma Theta is required and vice versa for x and y if Wind Vectors only are needed.

See Appendix A for more information about how data is calculated.

2.4. When To Log

The more samples that are averaged, the less noticeable will be the fluctuation in recordings due to wind direction variation.

In general, wind direction values should be averaged over the log interval or a sub interval (that is, a number of samples before the wind direction vectors are recorded in the Data Logger).

Set the Log Interval and Sub Interval in the **Program** window.

2.5. Using a Macro Data Logger

In PDL Compatibility Mode proceed as described in previous sections. Please note that only eight of the 16 analog channels (A0 to A7) are available in this mode.

If:

a) you want to use more than eight analog channels, or

b) take advantage of the 12-bit resolution (MACRO mode), and

c) you are using a previous version of STARLOG Software (earlier than Version 3.0),

then:

1. Add the instrument to the Scheme.
2. Edit the transducer to assign it to a hi-resolution channel (A0 to A15). Check that the **Output Range** (mV) is 0 to 5000 millivolts.

2.6. Using a Portable Data Logger

To use a Portable Data Logger with these instruments, you will want to ensure that the scan rate switch is set correctly. This switch is set at 5 seconds when delivered from the factory. If this scheme uses a different scan rate or you have changed the switch setting since your logger arrived from the factory, remember to set the switch.

» Note: The Scan Rate in the STARLOGGER and MACRO Data Logger is set using the Software Package. (See the STARLOG Users Manual for details.)

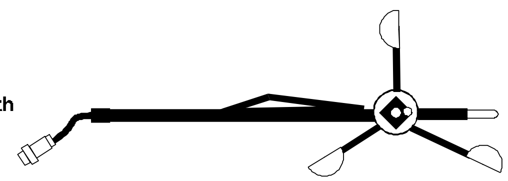
3. INSTALLATION

The Model 6501 Weather Instruments and the Model 6504–FS Wind Speed and Wind Direction Instrument can be installed easily by mounting them on a vertical mast or pipe.

UNIDATA suggests that the Wind Speed and Wind Direction Instrument is mounted on the top of a mast or pipe and in the event the Weather Instrument is also used, then it is mounted approximately five meters lower.

Instrument towers (models 6700A & 6700B) designed for use with Weather Instruments and the Weatherproof Enclosures (model 6701) are available.

Weather instruments are exposed to extreme environmental conditions. In addition, the instruments are subject to damage from lightning discharges and other interference.



3.1. Mounting and Cabling

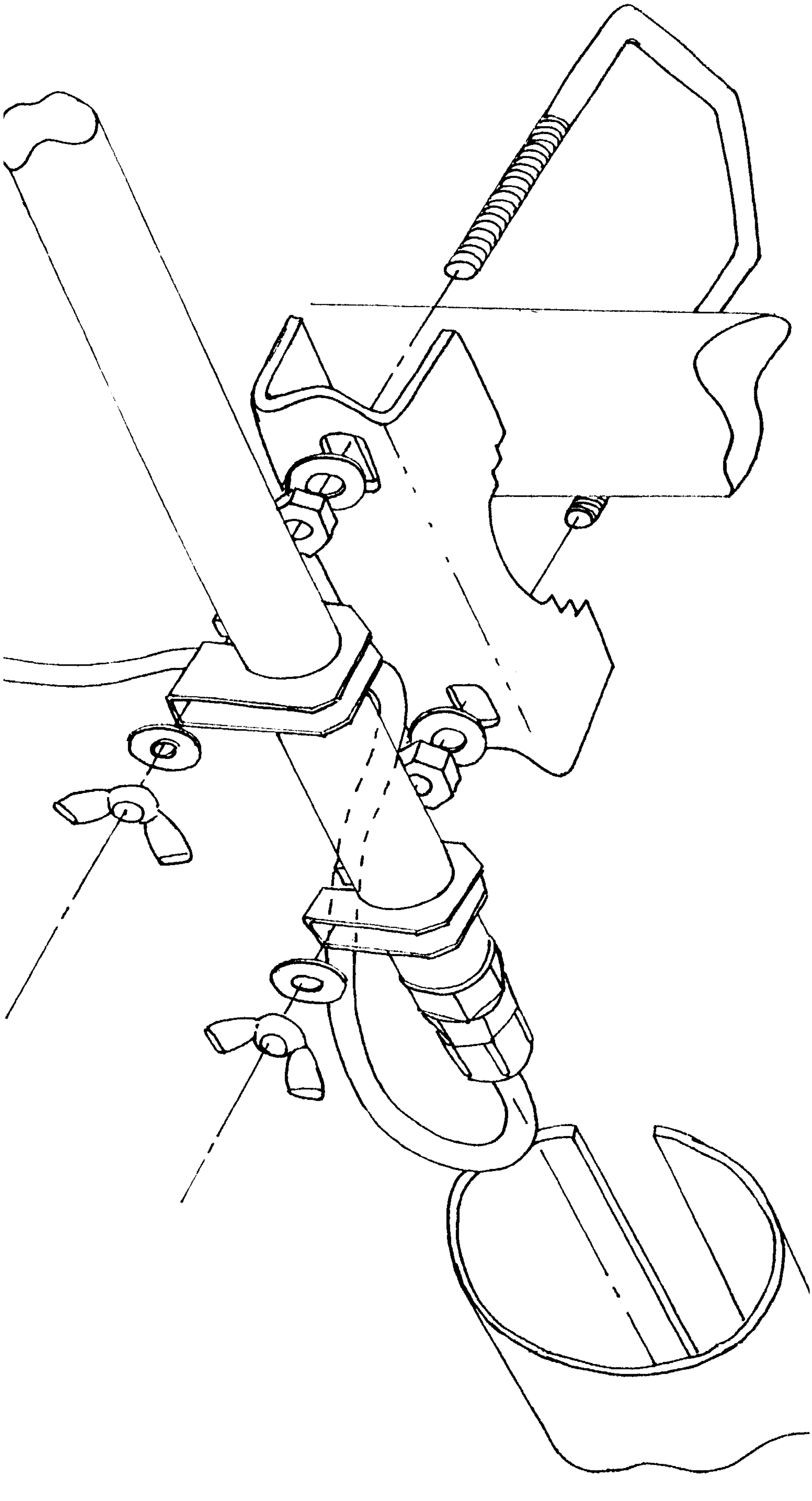
Weather instruments usually come complete with universal pipe mounting hardware to allow simple clamping of the instruments to a vertical mast or pipe. In addition, a PVC cover is provided to protect the signal cable gland and the mounting hardware from the weather (and bird attack).

The mounting hardware consists of:

- U-Clamp, universal saddle, 2 washers, 2 hexagonal nuts
- 2 wing nuts, 2 washers
- white PVC cable cover
- 2 D clamps (fitted on the 6501 mounting arm)

The Model 6504-FS Wind Speed/Wind Direction includes a 0.8 metre cable (for lengths up to 30 metres order Model 6603B/30).

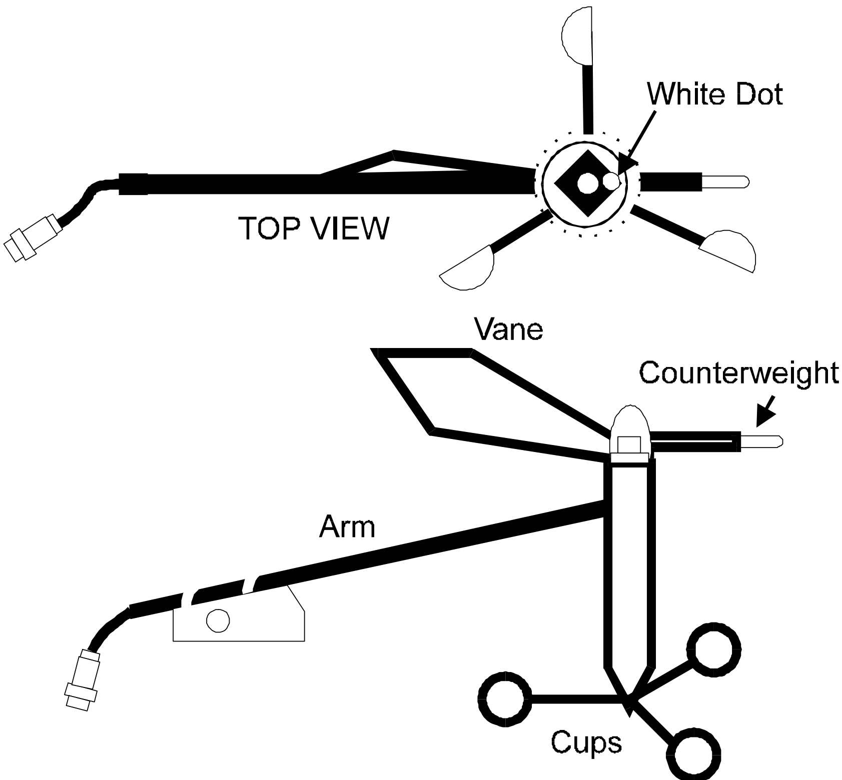
NOTE: Ensure that the mounting bracket and instrument metalwork is connected to a good ground (through the tower or via a grounding cable). Make certain that no other earth is introduced to the



installation. (The system ground is isolated from the instrument mast for lightning protection).

3.1.1. Mounting Weather Instruments to an Instrument Tower

1. Locate the tower in open air, away from structures or objects which may influence wind passage (if using the 6504-FS) or cast a shadow on the solar radiation sensor (if using the 6501).
2. Fit the U-clamp and saddle around the mast at the desired height. Using two flat washers and two hexagonal nuts, tighten the U-clamp firmly with a small spanner. Make sure that each nut is tightened such that the *flats* are *horizontal* (see diagram). Further tighten (don't loosen) nuts to make them horizontal.
3. Slide the D clamps on the weather instrument mounting arm over the U-clamp bolt extensions. Place two washers and wing nuts onto the U-clamp blots (see diagram on the next page).
4. Align the weather instrument so that the mounting arm is horizon-



tal and the white screened housing points vertically (downwards). Tighten the wing nuts firmly by hand.

6504-FS – Ensure that the 6504-FS instrument arm points due South.

6501 – When monitoring global solar radiation, ensure that the arm of the 6501 points opposite the 6504-FS.

5. Screw together the instrument and cable connectors (tighten firmly by hand). You may wish to smear the cable/gland with ’Silastic’ compound to guarantee a weatherproof seal.
6. Position the signal cable under the righthand D clamp. Slide the PVC cable cover over this clamp (the slot in the cover slides over the flats of the hexagonal nuts). Feed the signal cable out through the slot in the cover (whilst the cover is between the two D clamps). Continue sliding the cover over the lefthand D clamp. This protects the cable and clamp hardware from both weather deterioration and external electrical noise.
7. The cable may then be strapped to the outside of the mast or fed into the cenre of the mast through a hole positioned below the clamping position.

3.1.2. Other Options for Mounting the 6504-FS

When mounting the Wind Speed and Wind Direction Instrument in any other manner than an instrument tower, make the following considerations:

* It is possible to screw the instrument mounting plate onto any other type of pole, piece of timber, etc., however care should be taken that when in position, the barrel of the instrument is vertical.

3.1.3. Assembly of the Model 6504-FS

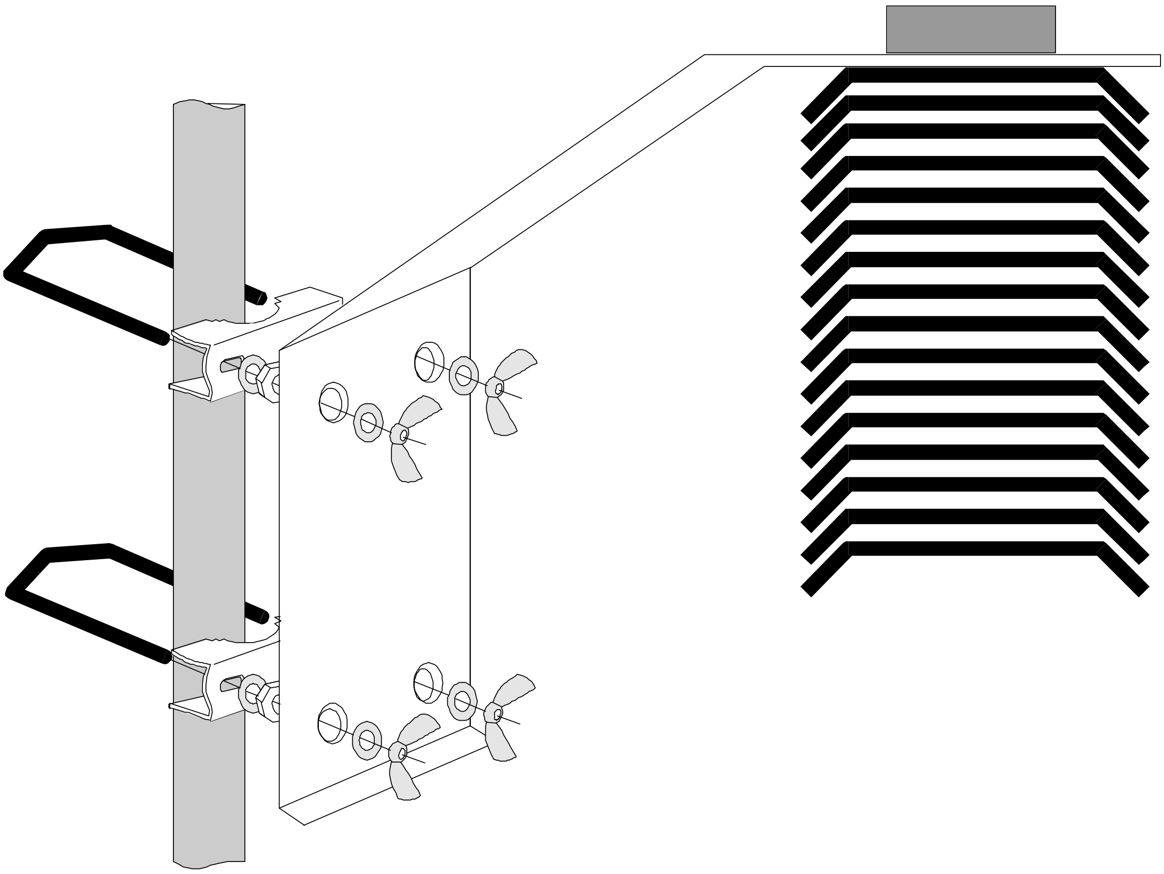
The Model 6504-FS is packed with its wind vane unattached. This needs to be fitted onto the top of the instrument with the single screw and O ring provided. The silver metal weighted end of the wind vane should point in the direction of the white spot on the 6504.

You can remove and replace the wind vane and/or the anemometer cups.

1. The wind vane is removed by screw on the top of the barrel.
2. The anemometer cups are removed by loosening a nut.

3.2. Connections: Model 6504-FS and 6504N

Wind Speed/Direction Instrument		STARLOGGER & PDL		MACRO Data Logger		«SQL»
Colour	**Function**	**Pin**	**Term**	**Pin**	**Term**	**Pin**
red & purple	+5V	13	15, 16 or 17	18	49	1
green & brown	common	23	41	1	31	7
yellow	wind speed	12	5†	12	5	2
grey*	direction 180 (y)	4	30	3	30	3
white	direction 270 (x)	3	33	21	33	4



Model 6501 Mounting

* black in the 6504N

† Using the Model 6103D FTS this is 5, for Model 6103B this is 7.

In the table above, *Pin* refers to the pins of the INPUT SIGNALS connector on a Logger, while *Term* is an abbreviation for numbered screw terminals on a Field Termination Strip. *SQL* refers to the weatherproof socket pin number. Refer to the supplement included with your Logger or Field Termination Strip for more information about these connections.

WARNING ! ***If you have a 12-core cable supplied for earlier products (6504A–E) see connection details in Appendix B.***

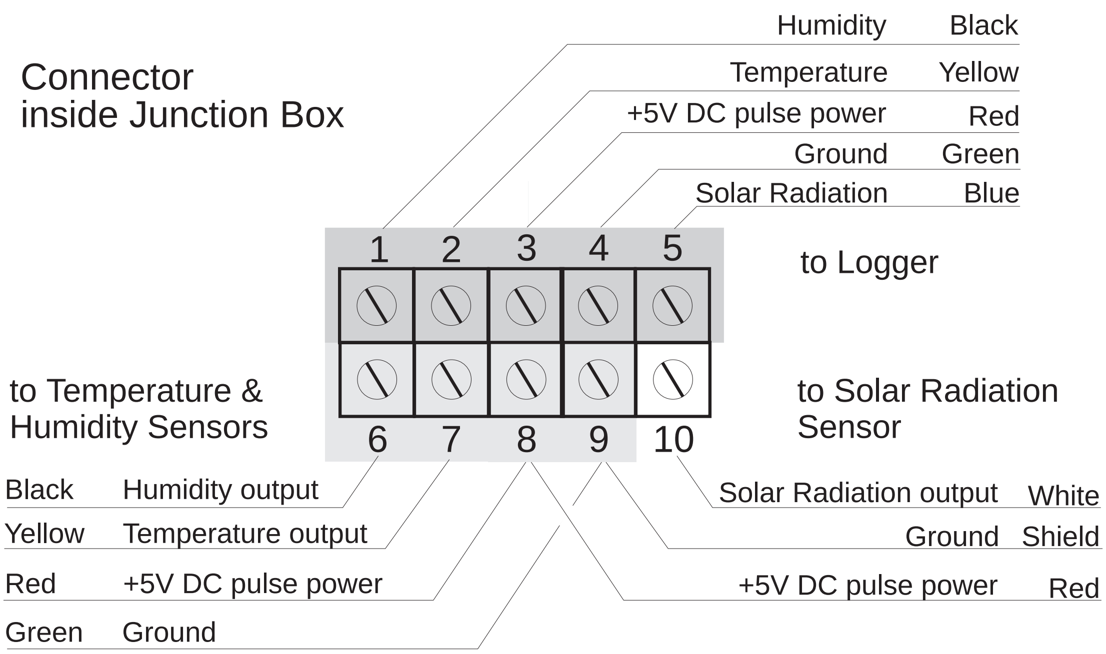
3.3. Mounting and Cabling for the 6501 Instruments

Weather instruments usually come complete with universal pipe mounting hardware to allow simple clamping of the instruments to a vertical mast or pipe.

The mounting hardware consists of:

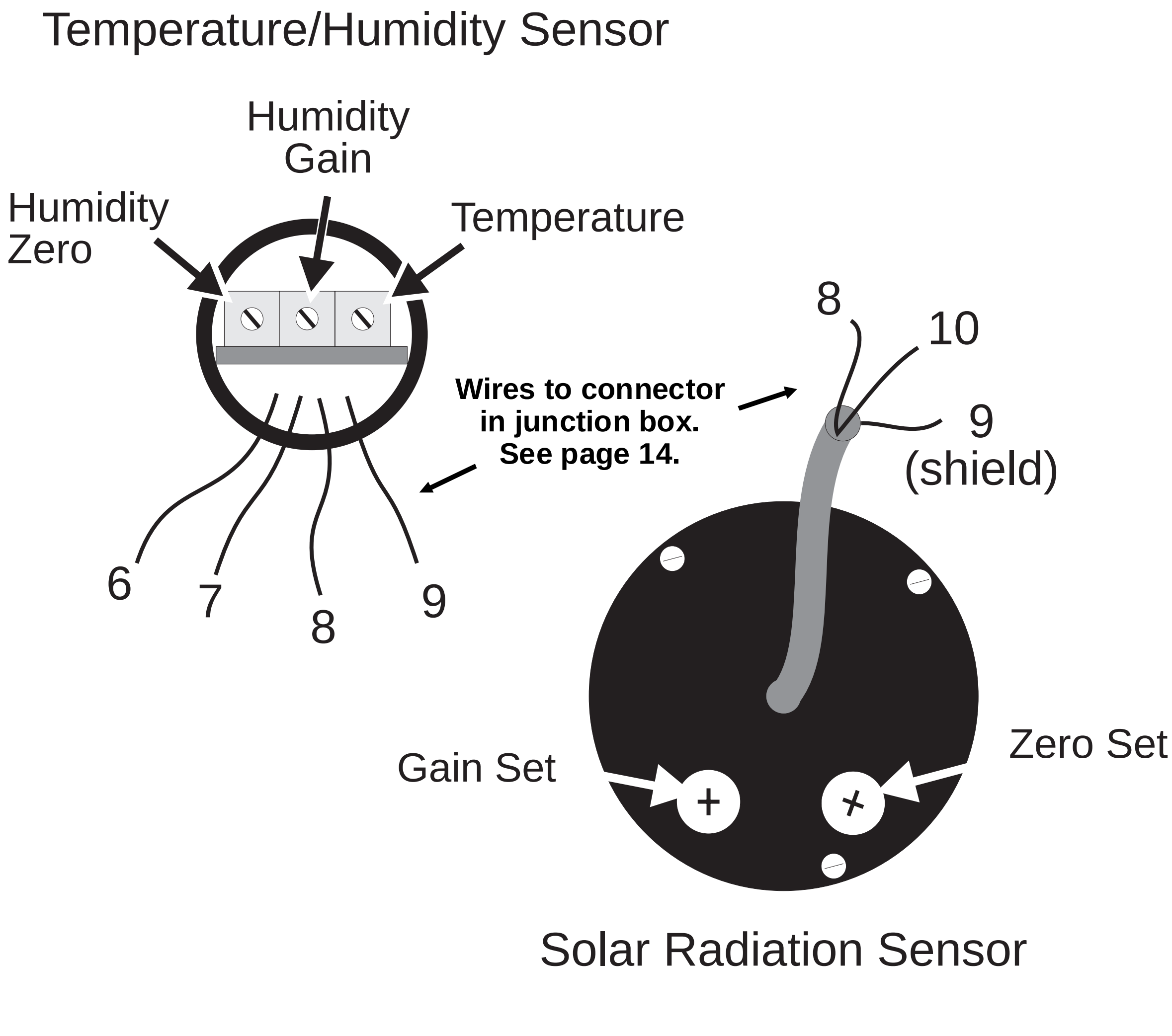
– 2 U-Clamps, universal saddles, 4 washers, 4 hexagonal nuts
– 4 wing nuts, 4 washers

NOTE: Ensure that the mounting bracket and instrument metalwork is connected to a good ground (through the tower or via a grounding cable). Make certain that no other earth is introduced to the installation. (The system ground is isolated from the instrument mast for lightning protection).



3.3.1. Mounting Procedure for 6501 Weather Instruments

1. Locate the tower in open air, away from structures or objects cast a shadow on the solar radiation sensor (if included).
2. Fit the U-clamps and saddles around the mast at the desired height. Using four flat washers and four hexagonal nuts, tighten the U-clamp firmly with a small spanner. Make sure that each nut is tightened so the *flats* are *horizontal* (see diagram). Tighten (don't loosen) nuts to make them horizontal.
3. Place the mounting bracket holes over the U-bolt. Fasten with four washers and wing nuts (see diagram).
4. Align the weather instrument so that the mounting bracket is horizontal and the white radiation screen points vertically (downwards). Tighten the wing nuts firmly by hand. When monitoring



global solar radiation, ensure that the arm of the 6501 points opposite the 6504F.

5. Screw together the instrument and cable connectors (tighten firmly by hand). You may wish to smear the cable/gland with 'Silastic' compound to guarantee a weatherproof seal.
6. The cable may then be strapped to the outside of the mast or fed into the cenre of the mast through a hole positioned below the clamping position.

3.4. Connections: Model 6501B/C/D/E

Connector inside Junction Box			STARLOGGER & PDL		MACRO Data Logger		«SQL»
#	**Colour**	**Function**	**Pin**	**Term**	**Pin**	**Term**	**Pin**
1	black	humidity	8	18	5	18	3
2	yellow	temperature	1	39	20	39	2
3	red	+5V DC pulsed power supply	13	15, 16 or 17	18	49	1
4	green	ground	23	41	1	40	7
5	blue	solar radiation	2	36	2	36	6
6	black	humidity o/p	output from humidity sensor				
7	yellow	temperature o/p	output from temperature sensor				
8	red	+5V DC	power to humidity/temperature sensor				
	red	+5V DC	power to solar radiation sensor				
9	green	ground	ground for humidity/temperature sensor				
	shield	ground	ground for solar radiation sensor				
10	white	solar radiation o/p	output from solar radiation sensor				

4. CALIBRATION (Model 6501)

Check the instrument against known standards and if the readings are incorrect, service and recalibrate as described in the following sections.

Shown below are the locations of the appropriate adjustments.

- Temperature and Humidity calibration trimmers are located inside the sensor housing.
- Solar Radiation trimmers are inside the black cover of the Solar Radiation Sensor. To access them, you must first remove the white lid of the gill screen. Then extract the protective sealant from the holes to expose the trimmers.

4.1. Ambient Temperature Servicing

To recalibrate the temperature (only required after replacement of circuit components):

1. Remove the Gill Screen.
2. Open the junction box and locate the nut holding the probe in place.
3. Remove the probe by unscrewing the nut holding it in place.
4. Place an accurate 0.1°C thermometer and the Model 6501 Instrument's Temperature Probe in a temperature stabilised enclosure.
5. Adjust the Temperature trimmer so that the reading using the Logger Test program is the same as the thermometer (using -17.8 to 60 scaling). The adjustment range is approximately 0.5°C.

The PCB should be recoated with lacquer when any components are replaced. This provides protection against corrosion and moisture.

4.2. Relative Humidity Servicing (from serial #1100)

These instruments include an updated humidity sensor and re-designed electronics. The calibration trimmers are located inside the temperature/humidity housing. Two of the trimmers (offset and gain) are sealed. The unsealed trimmer is for fine adjustments of the temperature reading.

The following describes how to calibrate a Humidity Probe using saturated solutions of Magnesium Chloride ($MgCl_2$) and Sodium Chloride (NaCl). An accurately calibrated humidity sensor will output 1920.15mV for the NaCl solution (75.3% humidity) and 841.5mV for the $MgCl_2$ solution (33%) at 25°C.

1. Place probe into saturated solution of $MgCl_2$. Wait for the reading to stabilise.
2. Adjust the Humidity Zero trimpot so the output reads 33%. (841.5mV : 84 on Portable Data Logger, 689 on STARLOGGER or MACRO Logger high resolution channel.)
3. Place the probe into saturated solution of NaCl. Wait for reading to stabilise. Adjust the Humidity Gain trimpot so that output reads 75.3%. (1920.15mV : 192 on Portable Data Logger, 1573 on STARLOGGER and MACRO Data Logger high resolution channel.)
4. Repeat steps 1 and 2 until no adjustments are necessary.

Humidity Test Solutions

Test environments are a sealed enclosure (jar large enough to house the circuit board) with a saturated solution of certain salts (there must always be undissolved salt in the solution to ensure solution is saturated. Use distilled water).

Salt	% Humidity at Specified Temperatures				
	10°C	20°C	25°C	30°C	40°C
NaCl	76%	75.7%	75.3%	74.9%	74.7%
$Mg(NO_3)_2.6H_2O$	57%	55%	52.9%	52%	49%
$LiCl.H_2O$	13%	12%	12%	11%	11%
K_2SO_4	98%	97%	97%	96%	96%
KCl	88%	85%	84.3%	84%	81.7%
$MgCl_2$	34%	33%	33%	33%	32%

NaCl = Sodium Chloride
$Mg(NO_3)_2.6H_2O$ = Magnesium Nitrate
$LiCl.H_2O$ = Lithium Chloride
K_2SO_4 = Potassium Sulphate
KCl = Potassium Chloride
$MgCl_2$ = Magnesium Chloride

4.2.1. Global Solar Radiation Servicing

This unit has two adjustments: Gain and Zero.

1. First, place the sensor on a black surface so that it is protected from light. Adjust the Zero trimmer (down from a +ve reading) so that the Data Logger reads 0.
2. Now, expose the sensor, then adjust the Gain so that the Data Logger reads the same as a reference pyranometer set in the same plane, in an open (cloudless) sky, around noon.

5. INSTRUMENT TESTING

5.1. Using STARLOG Test Mode

When connected to a STARLOG Data Logger, your computer can be used to interrogate the Weather Instruments and test their operation and your Weather Monitoring Scheme. Using the **STARLOG Test Mode** menus in STARLOG Software you can test a logger and test a scheme.

1. Connect the required instruments to the Data Logger (see section 3).
2. Connect the Logger to a computer running STARLOG Software Version 2 or greater.
3. Load the Scheme into the Logger, then choose **Scheme Test Mode** from the **Control Panel** .
4. Check that the logger is operating by checking the clock value changing at address 4.
5. If the readings are erratic or non-sensical, check that connections are sound and that the correct address is being displayed on the test screen.

Once you are in Test Mode, you can examine data inside the Logger to determine whether the inputs are scaled correctly. A test screen is automatically created for each Scheme. You can also create your own test screen. See the STARLOG Users Manual 6245 or 6203 for details on how to use Test Mode.

5.2. Special Wind Direction Measurements

The measurement of wind direction can be used to determine other characteristics such as the deviation of the wind (wind sigma) and a measure of the wind stability.

Wind direction values may be averaged in the Data Logger program by averaging the two signal channels. This overcomes the difficulty of averaging a ‘north’ direction varying about 0 to 359 degrees.

5.2.1. Wind Direction - BASIC Program Example

The wind direction is a special case as it uses two analog channels and the reading of the actual wind direction must be computed before display.

Following is a program that reads the 180° & 270° channel values and converts them to a 0 to 359 compass direction and deviation from the unit circle:

```
10      REM Calculate and display Wind Direction in Degrees 0 - 359
20      GOSUB 80
30      D=57.29*(ATN(((C2/127.5)-1)/((C3/127.5)-1)))
40      IF C<127.5 THEN D=180+D
50      IF D<0 THEN D=D+359
60      PRINT USING “###”;D
70      GOTO 20
80      ON ERROR GOTO 190
90      INIT#1,"COM:",9600
100     INPUT #1,X$:IF X$"*" THEN 100
110     PRINT #1,"G001202K"
120     INPUT #1,X$
150     ON ERROR GOTO 0
160     C2=VAL("&H"+LEFT$(X$,2))
170     C3=VAL("&H"+MID$(X$,3,2))
180     RETURN
190     RESUME
```

» NOTE: Line 30 and Line 40 may be used to process instantaneous data logger value (as in this example) or averaged Data Logger recordings.

5.2.2. Measure of Wind Deviation

The following BASIC statement will provide a measure of the deviation of the wind direction:-

```
55  S=1-SQR((((C2-127.5)/127.5)^2)+(((C3-127.5)/127.5)^2))
```

ie,

$$S = 1 - SQR\left\{\left[\frac{(C2-127.5)}{127.5}\right]^2 + \left[\frac{(C3-127.5)}{127.5}\right]^2\right\}$$

6. SPECIFICATIONS

Signal Cable:	PVC 6 wire multicore with overall shield (max length 30m)
Signal Connector:	7 pin SQL
Cable Gland:	M16 Nylon
Mounting:	D Clamps (2) with protective clamp cover
Clamps:	U-Clamp up to 65mm OD pipe
Gill Screen:	126mm by 210mm, UV stabilised Luran-S

Wind Speed

Range:	1.5 to 40 metres per second
Startup Speed:	0.8 metres per second
Endure Velocity:	55 metres per second (199 km/h)
Accuracy:	±2%
Type:	Cup Anemometer (VDO/UNIDATA)
Output Signal:	1 (8-bit) counter channel, 6 pulses per revolution, 8 pulses = 1 m/sec

Wind Direction

Range:	Continuous, no 360° jitter
Accuracy:	±1% vectorially
Sigma Resolution:	±1° relative
Type:	Vane, magnetically coupled (VDO/UNIDATA)
Output Signal:	2 analog channels, 0–2.55 V DC

Ambient Temperature

Calibrated Range:	-17.8 ° to 60 °C
Calibration Accuracy:	±0.5°C
Type:	Solid state, LM34 element
Output Signal:	1 analog channel, 0–2.55V DC

Global Solar Radiation

Calibrated Range:	0 to 1500 Watts per sq metre
Calibration Accuracy:	±5%
Spectral Response:	500—1020nm
Type:	Silicon, Flat cell
Output Signal:	1 analog channel, 0–2.55 V DC

Relative Humidity

Range:	5% RH to 95% RH
Accuracy:	±5% over calibrated range (33% – 75.3%)
Type:	Capacitive, gold grid absorption
Output Signal:	1 analog channel, 0–2.55V DC

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APPENDIX A
Wind Direction Package

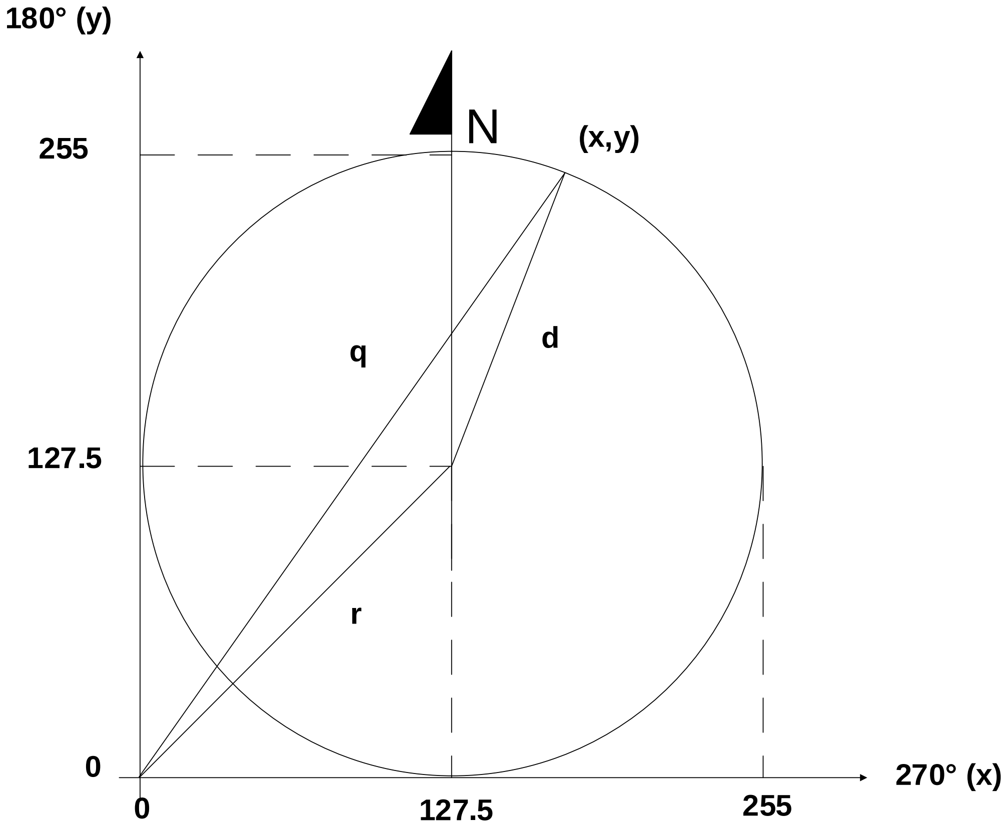
An ideal wind direction instrument outputs two positive voltages x,y such that each touple satisfies the locus:

$$\{(x,y)\} : x^2+y^2+255x+255y+127.5^2=0$$

ie. a circle with radius r=127.5 and centre c=(127.5,127.5)

eg.

a wind from due north would give an output of			(128,255)
"	south	"	(128,0)
"	east	"	(255,128)
"	west	"	(0,128)



The wind bearing θ — where θ is measured as degrees from true north (the line x=127.5) in a clockwise direction rather than the mathematical convention of the line y=127.5 in an anticlockwise direction — is given by the equation:

$$\theta = \frac{180}{\pi} \arctan\left(\frac{x-127.5}{y-127.5}\right)$$

Problem:

The reading from the wind direction instrument (x,y) may not necessarily be on the circle $x^2+y^2+255x+255y+127.5^2=0$ with radius r=127.5 and centre c=(127.5,127.5).

However the wind direction given by the above formula is still a valid accurate direction.

If the (x,y) values are to be used to calculate sigma theta (s_θ) then they must somehow be "normalised" such that they lie on the ideal instrument curve described above. This transformation must not alter θ.

Solution:

Use the relationship m=y/x to get "normalised" values of x,y (x',y') which lie on the above curve.

1. Transform (x,y) such that x>127.5 , y>127.5 , $y \geq x$
   now (x,y) lie in the octant such that $0<\theta\leq\pi/4$

2. Note m=y/x $1<m\leq 2$
   now m'=256y/x mod 256 $256<m' \leq 0 \Rightarrow 255 \leq m' \leq 0$

3. Use m' to reference a 256 byte lookup table for x'
   Use m' to reference a 256 byte lookup table for y'

   where (x',y') such that m'=y'/x'

   $x'^2+y'^2+255x'+255y'+127.5^2=0$

4. Transform (x',y') back to the original octant of (x,y)
   now (x,y) normalised to (x',y').

A.1. Using Corrected (x,y) to calculate Mean Wind Vector ($\overline{w}$)

Given

$\overline{w} = {}^1/_n \; \Sigma \; s_i \hat{d}_i$ s_i = wind speed i

di $= q_i - r$ $\hat{d}_i = d_i/|d_i|$

$|d_i| = 127.5$

Then   w, q, d, r are vectors

$$\overline{w} = {}^1/_n \; S \; s_i(q_i - r)/127.5$$
$$= {}^1/_{127.5n} \; (\Sigma \; s_i l_i - \Sigma \; s_i r) \; ; \; s = {}^1/_n \; \Sigma \; s_i$$
$$= {}^1/_{127.5} \; ({}^1/_n \; \Sigma \; s_i l_i - \overline{s} r)$$
$$= {}^1/_{127.5} \; \left(\Sigma \; \frac{s_i x_i}{n} - \overline{s}127.5 \; , \; \Sigma \; \frac{s_i y_i}{n} - \overline{s}127.5 \right)$$

Therefore

$$\log \quad \frac{1}{n} \Sigma s_i x_i - \bar{s}127.5 \qquad 2 \text{ bytes}$$

$$\log \quad \frac{1}{n} \Sigma s_i y_i - \bar{s}127.5 \qquad 2 \text{ bytes}$$

Multiply by 1/127.5 when unloading to correct for the circle having a radius of 127.5 instead of unity.

» Note: When s127.5 is subtracted the result may be negative. But as the result will still be a 2's compliment integer it may be logged as such.

A.2. Using Corrected (x,y) to calculate Sigma Theta ($\sigma\theta$)

Given

$$R = {}^{1}/_{n} \Sigma \hat{d}_i \qquad \hat{d}_i = d_i / |d_i|$$

$$q_i = (x_i, y_i) \qquad d_i = q_i - r$$

$$r = (127.5, 127.5)$$

$$\bar{q} = {}^{1}/_{n} \Sigma (x_{\bar{i}}, y_{\bar{i}})$$

$$= (\bar{x}, \bar{y})$$

Then

$$R = 1/n \Sigma d_i / 127.5$$

$$R = 1/n \Sigma (q_i - r)/127.5$$

$$= (\bar{q} - r)/127.5$$

$$= (\bar{x} - 127.5, \bar{y} - 127.5)/127.5$$

$$|R| = \{(\bar{x}/127.5 - 1)^2 + (\bar{y}/127.5 - 1)^2\}^{1/2}$$

MARDIA K. V. Statistics of Directional Data, 1972 Academic Press

$$\sigma_\theta = (-2\ln|R|)^{1/2} \qquad 0 < |R| \le 1$$

Therefore

$$\log \quad \bar{x}, \bar{y} \quad 2 \text{ bytes}$$

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APPENDIX B
List of Weather Instrument Revisions

<table>
<tr><th colspan="2">Current Model</th><th>Supersedes</th></tr>
<tr><td>6501B</td><td>Temperature Probe</td><td rowspan="7">The 6505 series.

When used in conjunction with the 6504F Wind Speed and Wind Direction Instrument, the 6501 series supersedes the 6504C, 6504D, and 6504E.</td></tr>
<tr><td>6501C</td><td>Global Radiation Sensor</td></tr>
<tr><td>6501D</td><td>Temperature and Relative Humidity Probe</td></tr>
<tr><td>6501–B</td><td>Weather Instrument – Temperature</td></tr>
<tr><td>6501–C</td><td>Weather Instrument – Temperature and Global Solar Radiation</td></tr>
<tr><td>6501–D</td><td>Weather Instrument – Temperature, Global Solar Radiation and Relative Humidity</td></tr>
<tr><td>6501–E</td><td>Weather Instrument – Temperature & Humidity</td></tr>
<tr><td>6504F</td><td>Wind Speed and Wind Direction Instrument</td><td>When used with the 6501 series, this supersedes the 6504C, 6504D and 6504E.</td></tr>
<tr><td rowspan="2">6504–FS</td><td rowspan="2">Wind Speed and Wind Direction Instrument fitted for «SQL» and including 6501N</td><td>6504N Wind Speed and Wind Direction Instrument</td></tr>
<tr><td>6504A Weather Instrument–WD</td></tr>
</table>

Please note that the Model 6501–B, C, D and E Instruments are available fitted with «SQL» (6501–BS) or with a 6 core cable assembly (6501–BU).

B.1. Related Products

Current Model		Supersedes
6501N	Instrument Pole Mount and Cover	
6501SQL	Weather Instrument «SQL» Assembly	

Current Model		Supersedes
6501U	Weather Instrument 6 core Cable Assembly	
6503A	Wind Run Anemometer for standard speeds	------------------
6503B	Wind Run Anemometer for very light winds	------------------

APPENDIX C
The Model 6504 Instrument Clusters

UNIDATA used to manufacture combinations of weather instruments as Instrument Clusters. These models, (see list on the next page) are no longer available – instead, you can order each instrument separately.

You can use the 12-core cable supplied with previous models to connect new model 6504F, 6504N and 6505B/C/D/E instruments – just unplug the old instrument then plug in the new one.

C.1. CONNECTIONS: 12-CORE CABLE

Various Instruments		«SQL»	Portable Data Logger		MACRO Data Logger	
Colour	**Function**	**Pin**	**Pin**	**Term**	**Pin**	**Term**
red & orange1	+5V	1	13	15, 16 or 17	18	49
green, lt blue (grn), brown, purple	common	7	23	4, 10, 32, 41	1	31
black2	humidity	8	8	18	5	18
yellow	wind speed	2	12	7	12	5
grey	direction 180	3	4	30	3	30
white	direction 270	4	3	33	21	33
pink	temperature	5	1	39	20	39
blue2	solar radiation	6	2	36	2	36
	rainfall		11	9	11	1
blue2	humidity	6	8	18	5	18
	log flag (link)3		19–23	link	10	L1 (link)

In the previous table, Pin refers to the Logger's Input Signal connector pins, Term. is an abbreviation for numbered screw terminals on a Field Termination Strip (FTS). SQL refers to the weatherproof socket pin number. Refer to the supplement included with your Logger or FTS for more information.

Notes:

1. The +5V DC cables are soldered together (connected in parallel) at both ends of the cable to provide a low resistance path for the power signals. This is also the case for the ground cables. This helps to reduce measurement errors due to cable losses.
2. For Model 6504E WDTH Instrument Cluster, the Humidity signal is connected to Pin 6 of the cluster, in place of the solar radiation signal.
3. Log-Flag must be installed on the connector to allow the logger program to detect the signal plug connection and begin recording the input signals. If the FTS is being used, this link is already made on the FTS.

C.2. CABLE ASSEMBLY

1. Screw the cover over the connector, insert and lock the cable tension relief.
2. Ensure that the cover feeds the cable towards the cable gland, when the connector is plugged into the Data Logger.
3. Tighten cable gland, leaving about 200mm loose cable inside the enclosure.

C.3. LIST OF PREVIOUS MODELS

6504A	Wind Speed And Wind Direction
6504B	Wind Speed/Direction and Ambient Temperature
6504C	Wind Speed/Direction, Ambient Temperature and Global Radiation
6504D	Wind Speed/Direction, Ambient Temperature, Global Radiation and Relative Humidity
6504E	Wind Speed/Direction, Ambient Temperature and Relative Humidity

APPENDIX D
The Model 6505 Weather Instruments

The superseded Model 6505 Weather Instruments have some performance differences from the Model 6501 described in this supplement. They also have a different printed circuit board and are calibrated differently.

The performance differences are:

- the temperature range is -10°C to 60°C
- the humidity range is 0% to 100% R.H.

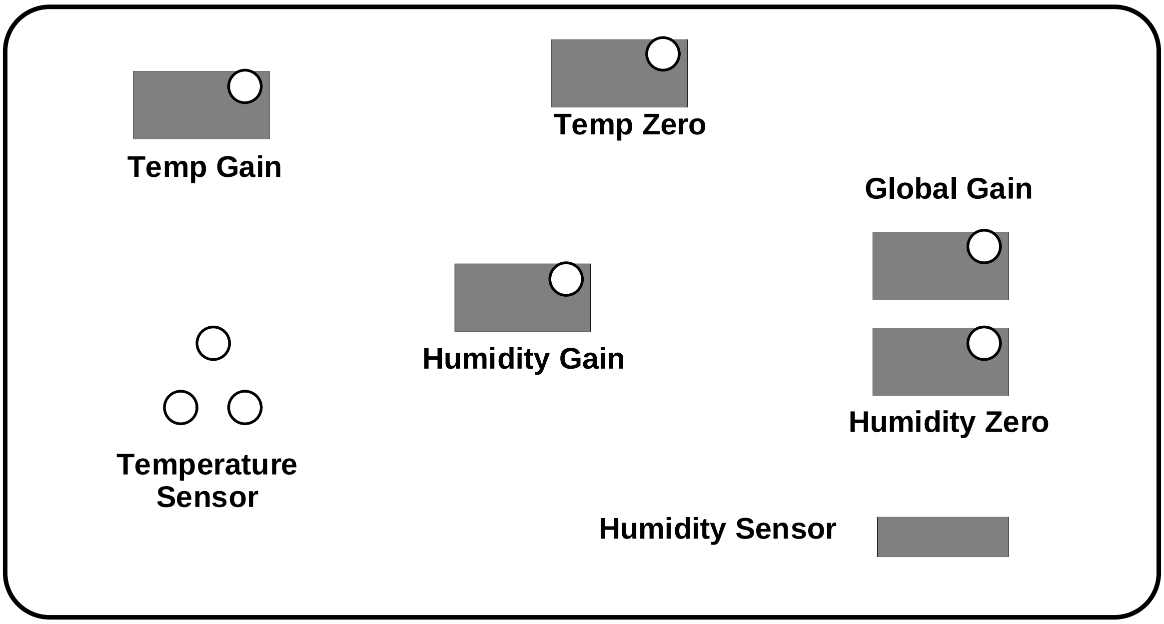
The superseded models are:

–	Model 6505B	ambient temperature
–	Model 6505C	ambient temperature and global radiation
–	Model 6505D	ambient temperature, global radiation and relative humidity
–	Model 6505E	ambient temperature and relative humidity

The calibration differences described in this appendix are:

- different PCB for calibration
- ambient temperature servicing
- relative humidity servicing

D.1. MODEL 6505 WEATHER INSTRUMENTS PCB LAYOUT



D.2. AMBIENT TEMPERATURE SERVICING

To recalibrate the temperature (required after circuit components replacement):

1. Remove the electronic PC Board from the shade housing.
2. Remove the temperature sensor and connect an accurate voltage source in its place.
3. Use a Test Mode to read the signal measurement and adjust the zero and gain trimmers to read [1 or 2] with 263.15 millivolt signal and [253 or 254] with a 333.15 millivolt signal. Other calibrations can be set by using reference voltages which relate to setpoint temperatures of 1 millivolt per degree absolute (0°C = 273.15 °K [absolute]).
4. Reinstall the sensor and adjust the zero trimmer so that the temperature measured fullscale is the same as the temperature measured by an accurate (0.1°)thermometer (stabilised and in contact with the AD590 sensor).

The PCB should be recoated with lacquer when any components are replaced. This provides protection against corrosion and moisture.

D.3. RELATIVE HUMIDITY SERVICING

The following procedure applies to Models 6505 and 6504 Instruments.

1. Remove Humidity Sensor terminals from the PCB and connect a 136.2pF ceramic capacitor in place of the transducer (use a 56pF + 56pF + 2.2pF + 22pF).
2. Use Test Mode (with no scaling) to adjust the Humidity Zero trimmer to read 200 (78%).
3. Remove the 22pF capacitor (leaving 114.2pF in circuit) and adjust the Humidity Gain trimmer to read 60 (23.5%).
4. Re-check with 136.2pF then 114.2pF until readings are stable. Note: a capacitance of 144 pF (56 + 56 + 22 + 10 pF) is equivalent to a humidity of 90% or a reading of 230.
5. Replace the Humidity Sensor onto the PCB and place the complete assembly in a humidity calibration jar of approximately 50% relative humidity and adjust the Zero trimmer to read the correct humidity. (This should not be more than 10% out, otherwise replace the Humidity Sensor).

APPENDIX E
Previous Versions of Model 6501

Differences in early versions of the Model 6501D Weather Instrument are:

- Connections from one six core cable
- Location of calibration trimmers and terminals
- Scaling, calibration and servicing of the humidity sensor

E.1. CONNECTIONS 6501B/C/D/E (6 core cable)

Various Instruments		STARLOGGER & PDL		MACRO Data Logger		«SQL»
Colour	**Function**	**Pin**	**Term**	**Pin**	**Term**	**Pin**
red	+5V	13	15, 16 or 17	18	49	1
green	common	23	41	1	40	7
yellow	temperature	1	39	20	39	2
blue	solar radiation	2	36	2	36	6
black	humidity	8	18	5	18	3
white	not used					

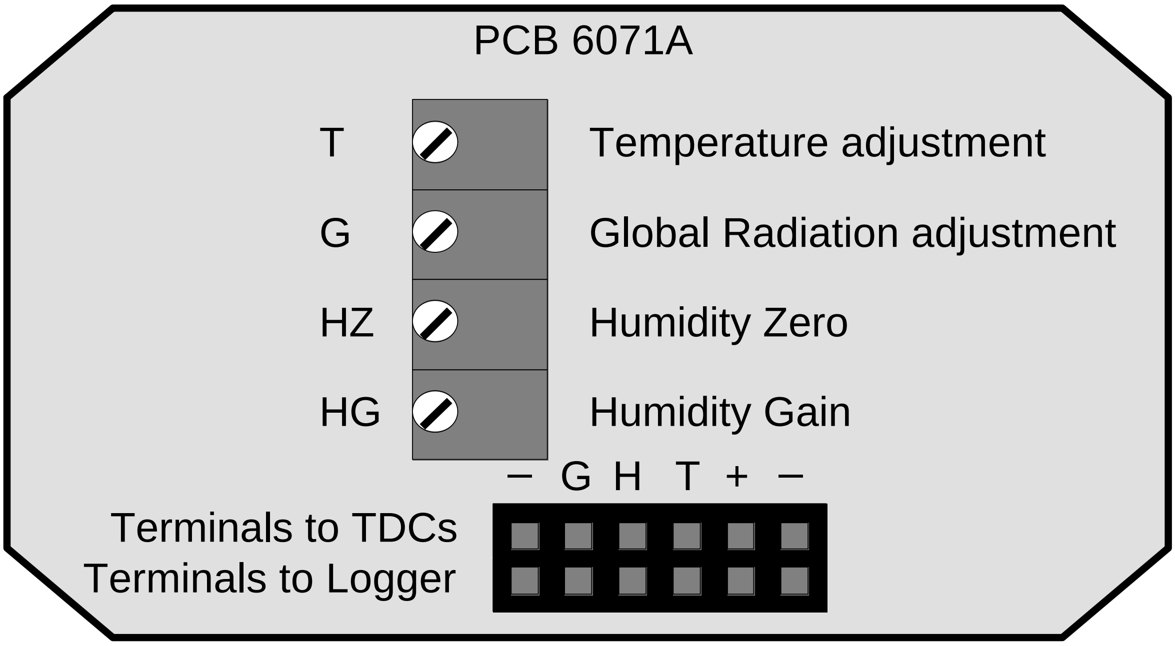
In the table above, Pin refers to the pins of the INPUT SIGNALS connector on a Logger, while Term is an abbreviation for numbered screw terminals on a Field Termination Strip. SQL refers to the weatherproof socket pin number. Refer to the supplement included with your Logger or Field Termination Strip for more information about these connections.

WARNING ! If you have a 12-core cable supplied for earlier products (6504A–E) see connection details in Appendix B.

E.2. CALIBRATION TRIMMERS & TERMINALS LOCATIONS

Early versions of the Model 6501D Weather Instrument included a printed circuit board inside the junction box within the white radiation screen. On this board were mounted the terminals for connecting the instruments to a Logger and the calibration trimmers for temperature, humidity and solar radiation.

If you have an early version which includes this board, the positions of the calibration trimmers and terminals are shown below.



E.3. HUMIDITY SCALING (serial #913 – 1099)

Humidity transducers from serial #913 to #1099 have been calibrated from 10% R.H. to 110% R.H. To correct for the non-linearity of the transducer, the following formula must be used. If you are using a Software Package up to Rev 2.024 you will want to add this formula to the PDLOUT.FOR file using an editor. (Refer to the STARLOG Users Manual.)

The formula to obtain correct Relative Humidity readings is:

```
:hum
pushv
pushv
mul
–0.000809
mul
pushv
0.6
mul
add
end
```

This formula is a definition of the following equation.

```
Relative Humidity = –0.000809v2  + 0.6 v
```

where v is the 8-bit representation of the voltage from the humidity sensing circuit.

The Relative Humidity transducer definition needed to use the formula once it is contained in PDLOUT.FOR is shown below:

Transducer Range/mV	**0 to 2550**
Transducer Scaling/Formula	**hum**

or

Transducer Range/mV	**0 to 2550**
Transducer Scaling/Formula	**10 to 110**

E.4. RELATIVE HUMIDITY SERVICING (from #913 to 1099)

The following procedure describes how to calibrate a Humidity Probe using saturated solutions of Sodium Chloride (NaCl) and Magnesium Chloride ($MgCl_2$).

An accurately calibrated humidity sensor will output 1.600V for the NaCl solution (75.3% humidity) and 0.598V for the $MgCl_2$ solution (33%) at 25°C. (For use with STARLOG formula hum.)

1. Suspend probe above NaCl in a sealed beaker and leave for 1 hour to establish equilibrium. Ensure that no liquid touches the probe.

2. With the Humidity Gain trimpot (labelled HG) fully counter clockwise, adjust the Humidity Zero trimpot (labelled HZ) so that the output voltage is approximately 2.5V. Once set, it is important that the HZ trimpot is not readjusted – any change will affect results.
3. Record the output voltage as value "A".
4. Now, wind HG fully clockwise and record the output voltage as value "B".
5. Suspend probe above MgCl2 in a sealed beaker and again leave suspended above the solution for 1 hour.
6. With HG fully clockwise, record the output voltage as "C".
7. Now, wind HG fully counter clockwise and record the output voltage as value "D". (If the output voltage is very close to zero, eg., <10mV, then the initial HZ setting was too low – start again.)
8. Calculate "E" using the formula below.
9. With the probe still above the MgCl2 solution, adjust HG so that the output voltage is "E".
10. Still above MgCl2, adjust HZ so that the output voltage is 0.598V.
11. The probe should now be calibrated, however, it is worthwhile checking it in the NaCl solution (the output voltage should be 1.600V ±0.050V.) Once again, allow 1 hour before taking a reading.

- Formulas for Calibrating Humidity Probe

$$M_x = \frac{A - D}{42.3} \qquad M_n = \frac{B - C}{42.3}$$

$$E = 0.99 \times \left[\frac{C - D}{M_x - M_n} \times (M_x - 0.0237) + D \right]$$

Typical Values (V): A=2.480, B=2.377, C=1.596, D=0.834, E=1.393.

APPENDIX F
Using Version 2 Software

F.1. CONNECT WIND SPEED TO c2, LOG ON c1

When logging wind speed using the Model 6504-FS Wind Speed and Wind Direction Instrument with a STARLOGGER or MACRO Data Logger, you use log buffer channel c1 (Counter 1), even though you will connect the wind speed transducer to C2 (Counter 2).

F.2. LOGGING WIND DIRECTION

If you want to log wind direction, you must add both components (x and y) to the **Log Buffer** , i.e.,

a2	Wind dirn X component
a3	Wind dirn Y component

Then, in order to print or plot the resulting wind direction, you would select the following when creating a Report:

Dirn	Wind direction result

It is possible to log maximum, minimum and average for wind direction, but you must ensure that you log both components using the same log action.

The wind direction, in general, should be averaged over the log interval or a sub interval. This gives a more meaningful value of wind direction over a period of time. Use the **Log Buffer** window to indicate that you wish to log averages: **AVE** is over the log interval and **ave** is over the sub interval.

F.2.1. The Extended Wind Package

To understand your wind data more fully, you may want to log Sigma Theta and Wind Vectors (speed and direction). The Extended Wind Package enables you to obtain this information and appears in the Instrument List as EWP (or Model 6504X in Version 2 Software).

Using Version 2, instead of adding a 6504-FS (or 6504N/A–D), you need to add the 6504X to your scheme.

WARNING : When using other instruments in addition to the Extended Wind Package, you must add the EWP last. Otherwise, an error will occur when saving (assembling) the scheme.

WARNING: In order to use the standard Extended Wind Package, the wind direction instrument must use the default channels: c1, a2 and a3.

Additional calculations are necessary in order to get Sigma Theta and Wind Vector data. This is automatically included in the Logger Program when the EWP is chosen and psuedo channels x, y, vx and vy are added to the Instrument List. Similar to Wind Direction, x and y are components used to calculate both speed and direction Wind Vectors. These calculations are done after the data has been unloaded from the data logger. In order to obtain valid Sigma Theta and Wind Vector information, these components must be logged as average values over the log or sub interval, ie.,

AVE_x	Sigma Theta X component
AVE_y	Sigma Theta Y component
AVE_vx	Wind Vector X component
AVE_vy	Wind Vector Y component

F.3. USING A MACRO DATA LOGGER

If you want to use a high resolution channel:

1. Add the instrument to the Scheme.
2. Edit the transducer to assign it to a hi-resolution channel (h0 to h15). You don’t need to change the **Transducer Range** (mV) nor the **Transducer Scaling**.

If you use a MACRO Configuration Table, then verify that the **Input Channel Range** in the Table is 0 to 5000 millivolts.

If you do not use the Configuration Table (e.g., the word none appears in the **Hardware Details: Data Logger** menu for this Scheme) the range for high resolution channels h0 to h15 defaults to 0 to 5000 millivolts.