



USER MANUAL **VU01**

Ventilation unit for SR20 and
SR22 pyranometers and IR20 pyrgeometers



Warning statements



Always power off the ventilation unit when conducting maintenance or installing VU01.



VU01 may be used with SR20, SR20-D2, SR22, SR25, SR25-D1, IR20 & IR20WS sensors. VU01 is not meant to be used with other pyranometers and pyrgeometers.



Accidentally exchanging the VU01 cable and sensor cable will not damage the sensor, but the instrument and ventilation unit will not function.



In case of cable replacement or extension beyond 5 metres by the user, please note that the voltage drop across the regular VU01 cable becomes significant and that a cable with a lower electrical resistance must be used. Otherwise VU01 may not get a sufficient amount of power supply. The ventilator needs a supply between 10.8 and 13.2 VDC, otherwise it may cause damage to the fan.

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List of symbols

Quantities	Symbol	Unit
Voltage output	U	V
Electrical resistance	R	Ω
Current	I	A
Time in seconds	t	s
Rotation rate	N	1/min
Supply voltage	U_{supply}	V
Voltage drop over cable	U_{drop}	V
Fan voltage supply	U_{fan}	V
Cable resistance	R_{cable}	Ω
Wire resistance per meter	R_{ewire}	Ω/m
Cable length	L_{cable}	m
Fan current draw	I_{fan}	A
Fan status signal high	$U_{\text{S,high}}$	V
Fan status signal low	$U_{\text{S,low}}$	V
Rotation rate treshold	N_{g}	1/min

Introduction

VU01 is a high-quality ventilation unit for use with SR20 and SR22 pyranometers and IR20 pyrgeometers. Its purpose is to improve the dependability of the measurement. Measurement accuracy improves because offsets are reduced. Reliability benefits from prevention of dew and frost formation and quick evaporation and sublimation of water and snow. ISO/TR 9901 "Solar Energy - Field Pyranometers - Recommended practice for use" recommends use of ventilators where high accuracy and reliability are required.

VU01 provides an airflow over the instrument body and dome and has two heaters on board to heat the air. The use of heating (5W or 10W) is optional. The VU01 ventilation unit runs on 12 VDC voltage. VU01 may be used in combination with Hukseflux' SR20, SR20-D2, SR22, SR25 and SR25-D1 secondary standard pyranometers and IR20 and IR20WS research grade pyrgeometers.

Ventilation promotes thermal equilibrium between all components of radiometers, and thereby reduces zero offsets. Dew and frost formation is prevented. Additional heating will promote evaporation of water droplets and sublimation of snow. It should be noted that heating in combination with pyranometers will lead to increased thermal offsets, so heating is only recommended if necessary.

Using VU01 is easy. The ventilator is generally used continuously; the heater is typically controlled by the datalogger. ISO/TR 9901 "Solar Energy - Field Pyranometers - Recommended practice for use" recommends use of ventilators where high accuracy and reliability are required. More details can be found in paragraph 5.2.2 and annex A. The Baseline Surface Radiation Network, BSRN, recommends ventilation for radiometers in its BSRN operations manual v2.1.



Figure 0.1 *VU01 ventilation unit with SR20 secondary standard pyranometer*

VU01 is designed, using high-quality materials, in agreement with the recommendations of ISO/TR 9901 and BSRN. The footprint of VU01 is small, which prevents accumulation of snow. The ventilator power is relatively high in order to increase the airflow. The heaters should be activated using external relays. A fan status signal (high / low) may be used by the user to monitor rotation of the fan.

For specifications of pyranometers and pyrgeometers and general considerations concerning site selection and maintenance for such instruments, please consult the SR20, SR20-D2, SR22, SR25, SR25-D1 and IR20 manuals.

1 Ordering and checking at delivery

1.1 Ordering VU01

The standard configuration of VU01 is with 5 metres cable. Options are: longer cable (in multiples of 5 m and a pack of 5 dust filters. Consult Hukseflux for cable options. One dust filter and one spare dust filter are included with VU01.

1.2 Included items

Arriving at the customer, the delivery should include:

- ventilation unit VU01
- cable of the length as ordered
- sensor mounting hardware (affixed to VU01):
 - (1 x) sensor mounting plate and gasket
 - (4 x) M5x10 screw
- torx key T25 (1 x)
- VU01 mounting hardware:
 - (2 x) M5x60 screw
 - (2 x) M5 retaining torque nut
 - (4 x) $\varnothing 5 \times 10^{-3}$ m washer
- spare filter (1 x)
- product certificate
- any other options as ordered

1.3 Options

- longer cable, in multiples of 5 metres. Specify total cable length. Please consult Hukseflux.
- pack of 5 filters. Specify order number VU01F.

1.4 Quick instrument check

A quick test of the ventilation unit can be done by using a simple hand held multimeter and a 12 VDC power supply, using the wiring diagram in chapter 5 of this manual.

1. Check the electrical resistance of the two heaters; 27Ω each
2. Connect fan wires to a 12 VDC power supply: the fan should run
3. When running, the status of the fan can be monitored by measuring a fan status signal (see chapter 5 for the optional status monitoring configuration instructions).

2 Instrument principle and theory

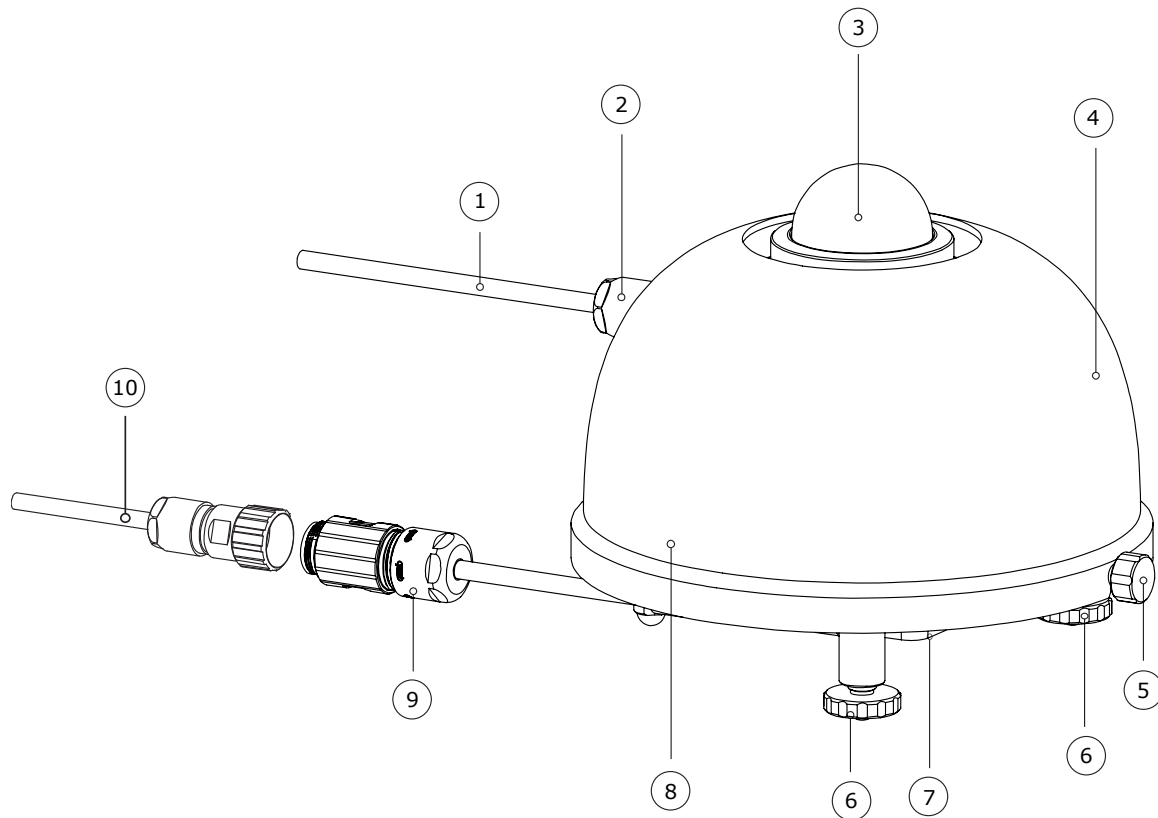


Figure 2.1 Overview of VU01 with SR20:

- (1) SR20 cable
- (2) SR20 connector
- (3) SR20 dome
- (4) VU01 cover
- (5) VU01 fixation of cover
- (6) VU01 levelling feet
- (7) VU01 filter retainer
- (8) VU01 ventilator, heaters and filter replacement system (below cover)
- (9) VU01 connector
- (10) VU01 cable and cable connector

Ventilation promotes thermal equilibrium between all components of radiometers, and thereby reduces zero offsets. Dew and frost formation is prevented. Additional heating will promote evaporation of water droplets and sublimation of snow. It should be noted that heating in combination with pyranometers will lead to increased thermal offsets, so heating is only recommended if necessary.

3 Specifications of VU01

3.1 Specifications of VU01

VU01 is a high-quality ventilation unit that may be used with pyranometer models SR20, SR20-D2, SR22, SR25 and SR25-D1, and pyrgeometer models IR20 and IR20WS. Its purpose is to improve the dependability of the measurement. Measurement accuracy improves because offsets are reduced. Reliability benefits from prevention of dew and frost formation and quick evaporation and sublimation of water and snow. For specifications of pyranometers and pyrgeometers, please consult the SR20, SR20-D2, SR22, SR25, SR25-D1 and IR20 manuals.

Table 3.1.1 *Specifications of VU01 (continued on next page)*

VU01 SPECIFICATIONS	
Compatible instruments	SR20, SR20-D2, SR22, SR25, SR25-D1, IR20, IR20WS
Compliance with standards	ISO/TR 9901
	BSRN operations manual
Rated operating power	7.8 W at 12 VDC (unheated)
Rated operating voltage range	10.8 to 13.2 V
Rated air flow	50 m ³ /hr
Rated operating temperature range	-40 to +70 °C
Fan status signal	2.5 VDC (optional use) High = fan OK = 2.5 V Low = fan NOT OK = ≤ 0.4 V
Heating	5 and 10 W at 12 VDC (optional use)
Increase of air temperature	0.5 °C at 0 W heating; 1.0 °C at 5 W heating; 1.5 °C at 10 W heating
Zero offset a SR20 ventilated	2.5 W/m ² at 0 W heating
Offset SR20 by heating	-2 W/m ² at 5 W heating
Offset SR20 by heating	-4 W/m ² at 10 W heating
Offset IR20 by heating	0 W/m ² at 5 W heating
Offset IR20 by heating	0 W/m ² at 10 W heating
Cable resistance	0.3 Ω/m (2 x 0.15 Ω/m)
Voltage drop at 7.8 W ventilation	0.2 V/m
Voltage drop at 10 W heating power	0.12 V/m
Footprint diameter	0.17 m
Fan rotation rate	5050 to 5400 1/min at 12 VDC
Standard cable length (see options)	5 m
Cable diameter	5.3 x 10 ⁻³ m
VU01 connector	M16 straight connector, male thread, 10-pole
VU01 connector type	HUMMEL AG 7.820.400.000 straight connector, male thread, for cable 5 to 9 x 10 ⁻³ m
Cable connector	M16 straight connector, female thread, 10-pole
Cable connector type	HUMMEL AG 7.810.300.00M straight connector, female thread, for cable 3 to 6 x 10 ⁻³ m, special version
Connector protection class	IP67 / IP69K per EN 60 529 (connected)
Cable replacement	replacement cable with cable connector can be ordered separately from Hukseflux
IP protection class VU01	IP54

Table 3.1.1 Specifications of VU01 (continued)

Gross weight including 5 m cable	1.55 kg
Net weight including 5 m cable	1.35 kg
Packaging	box of (330 x 250 x 220) mm
VERSIONS / OPTIONS / ACCESSORIES	
Longer cable, in multiples of 5 metres	option code = total cable length; consult Hukseflux see chapter 5.5 on installation design considerations
Pack of 5 dust filters	order code = VU01F

3.2 Dimensions of VU01

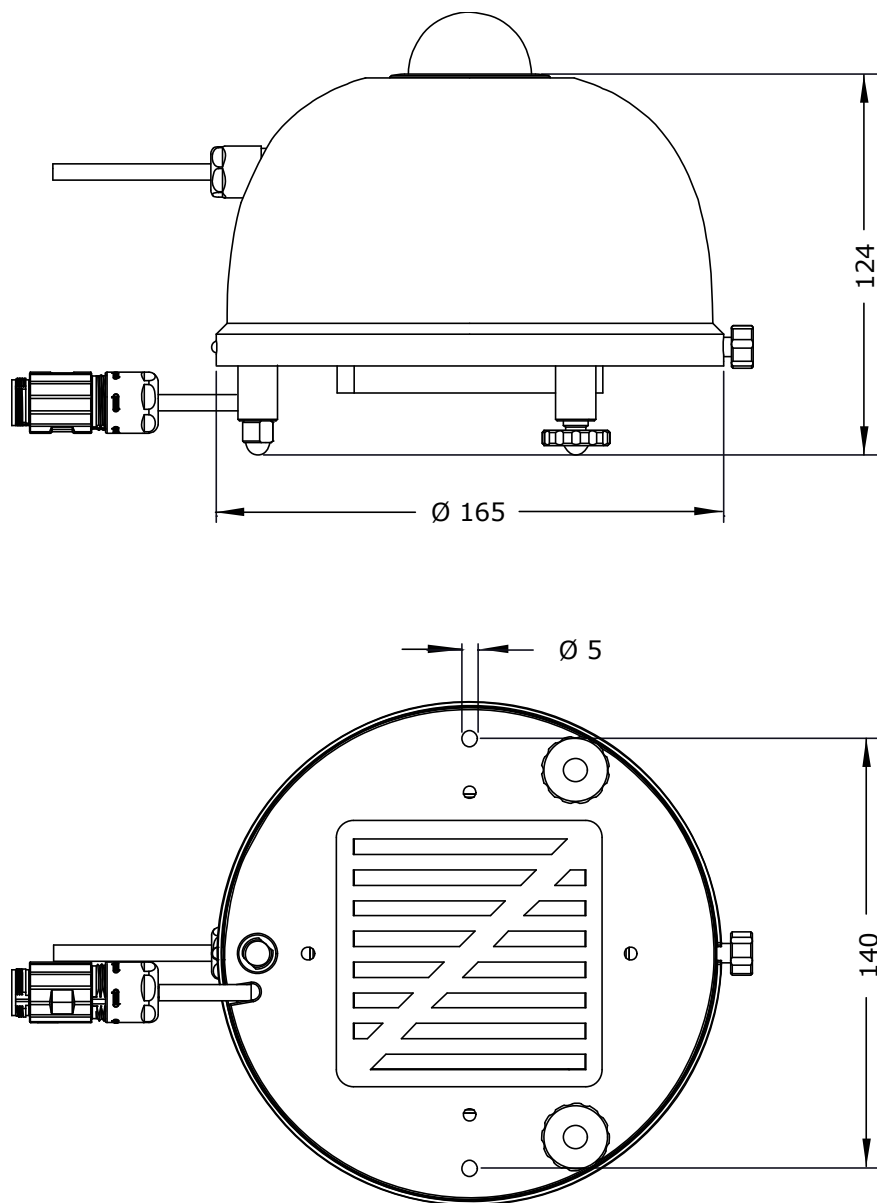


Figure 3.2.1 Dimensions of VU01 in 10^{-3} m.

4 Standards and recommended practices for use

Pyranometers are classified according to the ISO 9060 standard and the WMO-No. 8 Guide. In any application the instrument should be used in accordance with the recommended practices of ISO, IEC, WMO and / or ASTM.

Pyrgeometers are not subject to standardisation. The World Meteorological Organization (WMO) is a specialised agency of the United Nations. It is the UN system's authoritative voice on the state and behaviour of the earth's atmosphere and climate. WMO publishes WMO-No. 8; Guide to Meteorological Instruments and Methods of Observation, in which paragraph 7.4 covers "measurement of total and long-wave radiation". For ultra high accuracy measurements, the following manual may serve as a reference: Baseline Surface Radiation Network (BSRN) Operations Manual, Version 2.1, L. J. B. McArthur, April 2005, WCRP-121, WMO/TD-No. 1274. The BSRN manual also includes chapters on pyrgeometer installation and calibration.

Table 4.1 *Standards with recommendations for instrument ventilation*

STANDARDS FOR INSTRUMENT USE FOR SOLAR AND LONGWAVE RADIATION		
ISO STANDARD	EQUIVALENT ASTM STANDARD	WMO
ISO/TR 9901:1990 Solar energy -- Field pyranometers -- Recommended practice for use	ASTM G183 - 05 Standard Practice for Field Use of Pyranometers, Pyrheliometers and UV Radiometers	WMO-No. 8; Guide to Meteorological Instruments and Methods of Observation, chapter 7, measurement of radiation, 7.3 measurement of global and diffuse solar radiation, 7.4 measurement of total and long-wave radiation BSRN Operations Manual, Version 2.1, April 2005

5 Installation of VU01

5.1 Installation of the ventilation unit

Once the VU01 cover is removed, the ventilation unit can be mounted to a flat mounting surface using the supplied VU01 mounting hardware.

Optionally a large hole can be made by the user in the mounting surface under VU01 if obstruction of the airflow from the sides is expected, for example by snow buildup. The hole diameter should not exceed 120×10^{-3} m.

5.2 Installation of the sensor

- Remove the pyranometer's or pyrgeometer's sun screen.
- Attach the sensor mounting plate to the bottom of the sensor using two M5x10 screws (See Figure 5.2.1). A T25 torx key to do so is included with VU01.
- Affix the sensor with the sensor mounting plate to the ventilation unit using two M5x10 screws (See Figure 5.2.1 for placement of the gasket).
- The sensor cable connector should be positioned alongside the engraved "cable" marking on the VU01 base.
- The VU01 levelling feet can be used to fine-tune the sensor levelling. Even with the VU01 cover installed (see next page), the sensor can still be levelled since the instrument's bubble level is still visible below the VU01 cover.

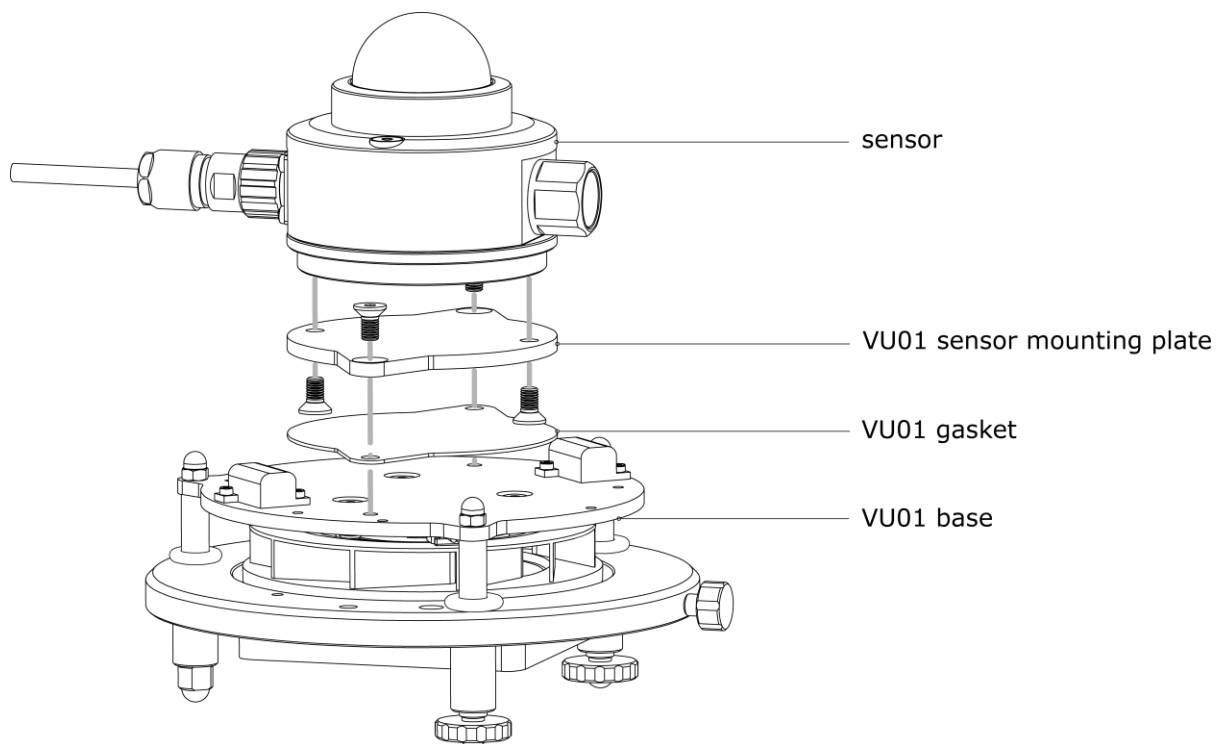


Figure 5.2.1 VU01 base with gasket, sensor mounting plate and SR20 pyranometer: the instrument is affixed to VU01 using four M5x10 screws.

5.3 Installation of the VU01 cover

To install:

- Connect the sensor cable connector (3) to the sensor, guiding the connector through the designated hole in the VU01 cover
- Position the cover (2) at an angle on positioning pin (5)
- Close the cover using positioning pin (5) as swivel point
- Affix the cover using thumbscrew (1)
- Connect the VU01 cable connector to the VU01 connector (4)

To remove cover:

- Loosen thumbscrew (1) by turning counterclockwise until the tapered part of the thumbscrew is ejected from the ventilation unit base
- Lift the cover, tilting around positioning pin (5)

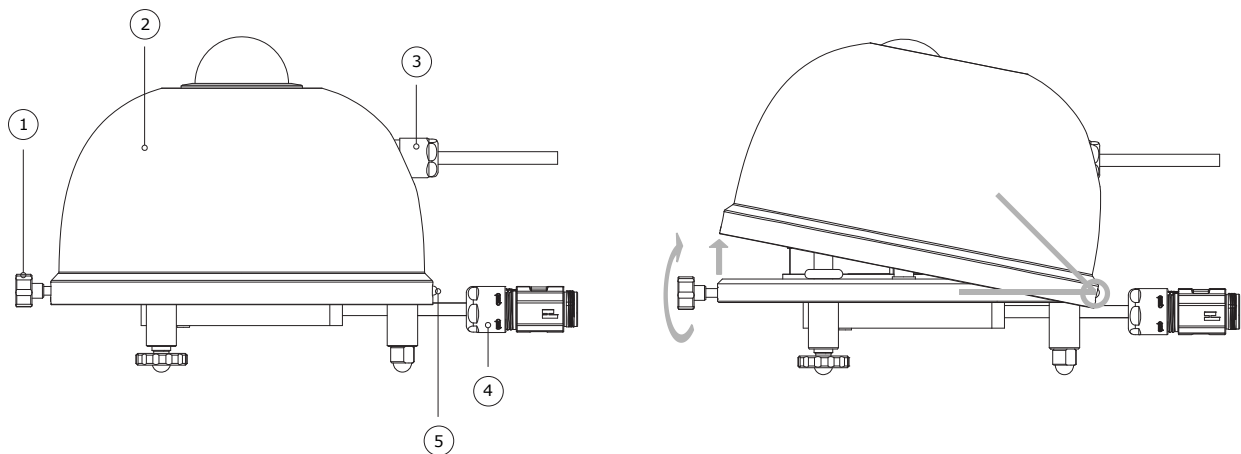


Figure 5.3.1 Installation and removal of ventilator cover: (1) VU01 thumbscrew, (2) VU01 cover, (3) sensor connector, (4) VU01 connector, (5) VU01 positioning pin.

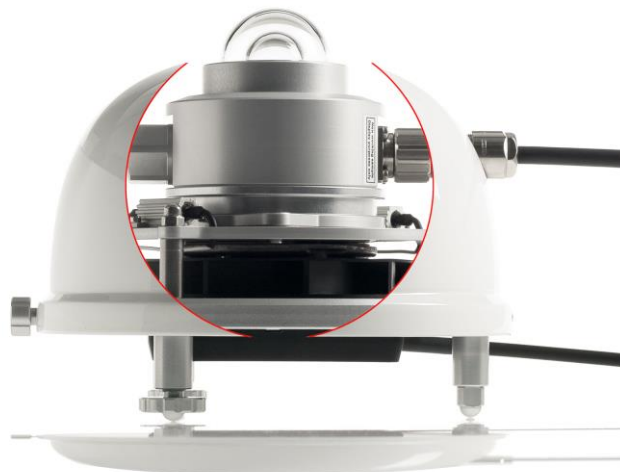


Figure 5.3.2 Cutaway of VU01 showing internal components and SR20 pyranometer.

5.4 Electrical connection of VU01

The cables of VU01 and Hukseflux secondary standard pyranometers and research grade pyrgeometers have an identical M16 straight connector. Do not connect the VU01 connector to the SR20 / SR22 / SR25 / IR20 cable and do not connect the SR20 / SR22 / SR25 / IR20 connector to the VU01 cable; both VU01 and the sensor will not function.

Cables generally act as a source of distortion, by picking up capacitive noise. We recommend keeping the distance between VU01 and a power supply as short as possible. For cable extension, see the next paragraph and appendix on this subject.

Table 5.4.1 *The electrical connection of VU01. The heaters and fan status signal are not necessarily used; their use is optional.*

PIN	WIRE	VU01	CONNECTION
1	Brown	fan [+]	12 VDC [+]
4	Yellow	fan [-]; fan status signal [-]	common [-]
6	Blue	fan status signal [+]	2.5 VDC [+]
2	Red	heater 1 [+]	12 VDC [+]
8	Grey	heater 1 [-]	common [-]
3	Pink	heater 2 [+]	12 VDC [+]
5	Green	heater 2 [-]	common [-]
7	White	not connected	not connected
9	Black	shield	ground

Optionally the user can measure a fan status signal to monitor the status of the fan as shown in the wiring diagram in figure 5.6.2. See paragraph 5.6 in this manual on using the fan status signal.

5.5 Power supply and cable length

Standard VU01 is delivered with a cable length of 5 m. Longer cable lengths, in multiples of 5 metres, are offered by Hukseflux. Please consult Hukseflux.

In case of cable replacement or extension beyond 5 m, please note that the voltage drop across the regular VU01 cable becomes significant and that a cable with a lower electrical resistance must be used. Otherwise VU01 may not get a sufficient amount of power supply. The ventilator needs a supply between 10.8 and 13.2 VDC.

Voltage drop is the part of the power supply voltage that is lost along the circuit leading to the equipment. In this case the voltage drop is caused by the electrical resistance of the cable. The voltage drop is proportional to the current and to the the electrical resistance of the 2 wires in the cable leading to the ventilator; a high cable resistance casuses a high voltage drop. VU01 power consumption is 7.8 W at a low voltage (12 VDC). The current that is needed, 0.66 A, causes a significant voltage drop.

Using a 12 VDC power supply and a cable of 5 m, the voltage drop is around 1 V and the VU01 ventilator will effectively run on 11 VDC.

To prevent VU01 from receiving an supply voltage that is too low, the user can choose between the following options:

1. Move the power supply closer to VU01, thereby reducing cable length;
2. Use a cable with lower electrical resistance per meter;
3. Use a combination of the above

Cable resistance and voltage drop can be calculated using the ventilator current draw:

$$U_{\text{drop}} = I_{\text{fan}} \cdot R_{\text{cable}}$$

$$R_{\text{cable}} = 2 \cdot (R_{\text{ewire}} \cdot L_{\text{cable}})$$

$$U_{\text{fan}} = U_{\text{supply}} - U_{\text{drop}}$$

Table 5.5.1 *Power supply variables*

SYMBOL	QUANTITY	VALUE
U_{supply}	Supply voltage [V]	
U_{drop}	Voltage drop over cable [V]	
U_{fan}	Fan voltage supply [V]	10.8 to 13.2 VDC (12 V nominal)
R_{cable}	Cable resistance [Ω]	
R_{ewire}	Wire resistance per meter [Ω/m]	
L_{cable}	Cable length [m]	
I_{fan}	Fan current draw [A]	590 to 660 mA (655 mA nominal)

The table below shows the voltage drop for several cable lengths and AWG (American wire gauge). Different AWG wires differ in wire diameter and electrical resistance. The table may be used to estimate the right type of wiring for installations using up to 50 metres of cable; i.e. 100 m of internal wire. Check your cable distributor for actual resistance values. Acceptable voltage drops, when using a 12 VDC power supply, are indicated by grey shading.

Table 5.5.2 Voltage drop for different cable lengths and AWG wires. Wires length is 2 times cable length. Resistance values are retrieved from ASTM B258-14.

	AWG 26	AWG24	AWG 22	AWG 20	AWG 18	AWG 16	AWG 14
Cable length	U_{drop}	U_{drop}	U_{drop}	U_{drop}	U_{drop}	U_{drop}	U_{drop}
[m]	[V]	[V]	[V]	[V]	[V]	[V]	[V]
1	0.2	0.1	0.1	0.0	0.0	0.0	0.0
5	1	0.5	0.3	0.2	0.1	0.1	0.1
10		1.1	0.7	0.4	0.3	0.2	0.1
15			1.0	0.6	0.4	0.3	0.2
20				0.9	0.5	0.3	0.2
30					0.8	0.5	0.3
40						0.7	0.4
50						0.9	0.5

Examples: For a cable length of 50 metres, the resistance of AWG16 is low enough to deliver 11.1 V to VU01 when using a 12 VDC power supply. For a cable length of 15 metres, AWG 26 and AWG 24 cabling should not be used because the voltage drop prohibits VU01 from receiving a sufficient amount of power.

Warning: Voltage supply to VU01 must be between 10.8 and 13.2 VDC, higher voltages may cause damage to the fan. The voltage supplied to VU01 should be measured when VU01 is connected.

Combinations of different cable lengths, AWG sizes and voltage supply are also possible, but have to be calculated for each case.

Standard VU01 is delivered with a cable length of 5 m. Longer cable lengths, in multiples of 5 metres, are offered by Hukseflux. Please consult Hukseflux.

5.6 Using the status signal for monitoring

VU01 provides users with a fan status signal which may be used to monitor rotation of the fan. Using the fan status signal is optional. The fan status signal is either high (OK) or low (not OK). The VU01 status signal emits a high, continuous signal during trouble-free operation of the fan. When the fan is running too slowly or not at all, a low signal is provided. When opting for using the signal, please read this chapter and see paragraph 5.4 for the electrical connection of VU01.

A signal, $U_{S,high}$, is provided when the fan rotation rate N is above the fan rotation rate threshold, N_g , of 1500 rotations per minute. The signal is 2.5 V. When the fan is running too slowly or not at all, a low signal $U_{S,low}$ is provided. The fan status signal will only function when VU01 itself is powered.

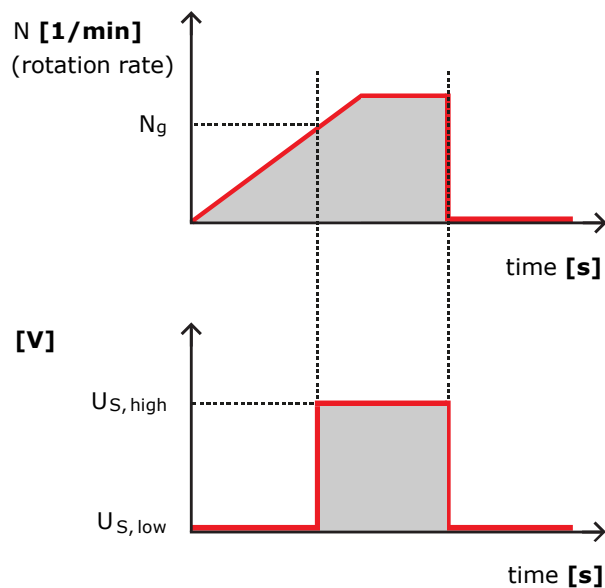


Figure 5.6.1 A fan status signal, $U_{S,high}$, is provided when the fan rotation rate N is above the fan rotation rate threshold N_g . The fan status signal emits a high, continuous signal during trouble-free operation of the fan. When the fan is running too slowly or not at all, a low signal $U_{S,low}$ is provided. Using the fan status signal is optional.

Table 5.6.1 Fan status signal variables

SYMBOL	QUANTITY	VALUE	STATUS
$U_{S,high}$	Fan status signal high [V]	2.5 V	OK
$U_{S,low}$	Fan status signal low [V]	≤ 0.4 V	not OK
N	Fan rotation rate [1/min]		
N_g	Fan rotation rate threshold [1/min]	1500 / min \pm 100 /min	
t_2	Fan status signal start-up interval [s]	< 15 s	

VU01 includes an internal load resistor, allowing direct use of the fan status signal. To use the optional status signal, the user has to measure the signal between the blue (fan status signal [+]) and yellow (fan status signal [-]) wire, as shown in Figure 5.6.2.

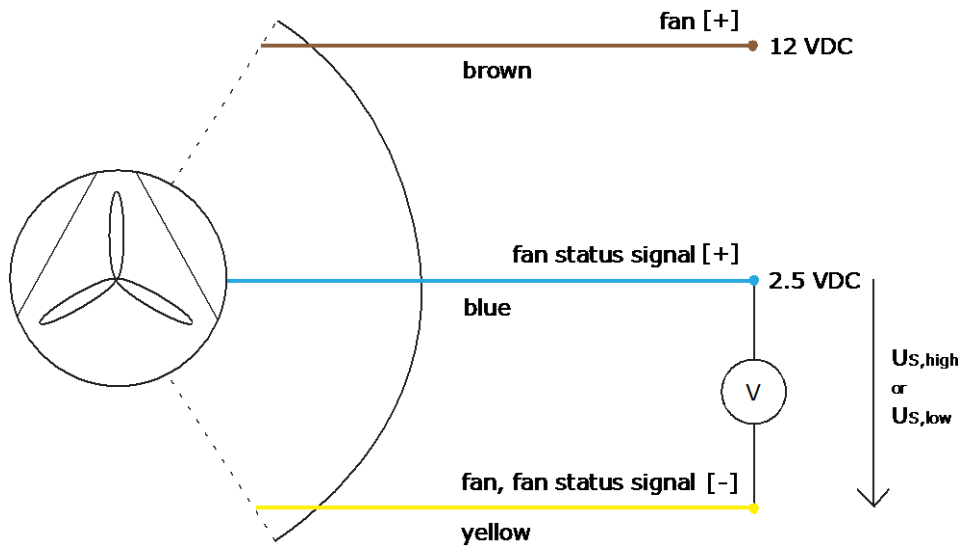


Figure 5.6.2 Wiring diagram required to use VU01's fan status signal. To use the optional status signal, the user has to measure the signal between the blue and yellow wire. The use of the fan status signal is optional. See table 5.4.1 for the electrical connection of VU01.

6 Maintenance and trouble shooting

6.1 Recommended maintenance

For maintenance and trouble shooting of pyranometers or pyrgeometers consult the SR20, SR20-D2, SR22, SR25, SR25-D1 or IR20 manual.

When conducting maintenance on VU01, always power off the ventilation unit.

Powering off VU01 may be done by disconnecting the VU01 connector.

Table 6.1.1 *Recommended maintenance of VU01*

MINIMUM RECOMMENDED VENTILATION UNIT MAINTENANCE			
	INTERVAL	SUBJECT	ACTION
1	1 week	check	check the operational status of the ventilator and heaters by checking the optional fan status signal or by on-site inspection
2	1 week	cleaning	clean ventilator cover and ensure air inlet is free of obstructions such as leaves or snow buildup
3	6 months	filter	replace dust filter, as described in the appendix

6.2 Life expectancy

The life expectancy of the fan itself is more than 45.000 hours under normal operating conditions.

6.3 Trouble shooting

Table 6.3.1 *Trouble shooting for VU01*

PROBLEM	SOLUTION
Fan and / or heaters do not function	check wiring for correct connection of [+] and [-] check power supply
Fan does not work	check for obstructions of fan
Fan provides little airflow	check for obstructions of airflow replace dust filter if clogged check wiring connections

7 Appendices

7.1 Appendix on dust filter replacement

Dust filters have to be replaced manually. Filters may be re-used several times after cleaning with water and soap. Hukseflux offers a pack of 5 replacement dust filters as an option. The replacement interval depends on local conditions, and may vary from 1 week to 6 months.

To replace the dust filter:

- Power off the ventilation unit by disconnecting the VU01 connector
- Insert the tip of a flat screwdriver in the designated slot of the front side the filter retainer
- Turn the screwdriver 90 ° to detach the filter retainer from the finger guard
- Replace the used filter cloth with a fresh filter (spare part VU01F)
- Slide the filter retainer under the ventilation unit
- Lift and click the filter retainer in place

7.2 Appendix on tools for VU01

Table 7.2.1 *Specifications of tools for VU01*

tooling required for sensor mounting and removal	torx key T25 (included)
tooling required for fixing VU01 to platform	hex key 3
tooling required for filter replacement	screwdriver, flat

7.3 Appendix on spare parts for VU01

- levelling feet (set of 2)
- static foot
- cover
- pack of 5 dust filters
- cable with cable connector (specify length in multiples of 5 m). Consult Hukseflux.

7.4 Appendix on cable extension / replacement

When opting for cable extension or cable replacement please note the voltage drop in cabling. In case of cables longer than 5 metres, consult Hukseflux. See the specific paragraph in this manual about power supply and cable length.

The cable of VU01 is equipped with a M16 straight connector. In case of cable replacement, it is recommended to purchase a new cable with cable connector at Hukseflux. An alternative is to choose a Do-It-Yourself (DIY) approach; please ask for the DIY connector assembly guide. In case of cable extension, the user may choose between purchasing a new cable with cable connector at Hukseflux or extending the existing cable himself. Please note that Hukseflux does not provide support for DIY connector- and cable assembly.

Cables act as a source of distortion by picking up capacitive noise. Keep the distance between VU01 and power supply as short as possible.

VU01 connector, cable and cable connection specifications are summarised below.

Table 7.4.1 Preferred specifications for VU01 cable replacement and extension

General replacement	please order a new cable with connector at Hukseflux or choose a DIY approach. In case of DIY replacement by the user see connector specifications below and ask for the DIY connector assembly guide
General cable extension	please order a new cable with connector at Hukseflux or solder the new cable conductors and shield to the original sensor cable and make a connection, using adhesive-lined heat shrink tubing, with specifications for outdoor use. Always connect shield. See chapter 5.5.
Connectors used	VU01: M16 straight connector, male thread, 10-pole, HUMMEL AG 7.820.400.000 straight connector, for cable 5 to 9×10^{-3} m cable: M16 straight connector, female thread, 10-pole, HUMMEL AG 7.810.300.00M straight connector, for cable 3 to 6×10^{-3} m, special version
Cable	8-wire, shielded, with copper conductors (at Hukseflux 8-wire shielded cable is used, of which 2 wires are used to power the fan, 4 for heating and 1 for the alarm signal)
Wire resistance	$< 0.15 \Omega/\text{m}$. See chapter 5.5.
Length	cables should be kept as short as possible, in case of cables longer than 5 m, consult Hukseflux.
Outer sheath	with specifications for outdoor use (for good stability in outdoor applications)

7.5 EC declaration of conformity



We, Hukseflux Thermal Sensors B.V.
Delftechpark 31
2628 XJ Delft
The Netherlands

in accordance with the requirements of the following directive:

2004/108/EC The Electromagnetic Compatibility Directive

hereby declare under our sole responsibility that:

Product model: VU01
Product type: Ventilation unit

has been designed to comply and is in conformity with the relevant sections and applicable requirements of the directive.

A handwritten signature in black ink, appearing to read 'Kees Van den Bos', with a large, sweeping flourish underneath.

Kees VAN DEN BOS
Director
Delft
October 24, 2013

