Heated Pitot-Static Probe HPS-1

HPS-1 of Simtec is a lightweight pitot-static probe with an integrated and regulated heating system and drainage system that prevents aggregation of ice, water and moisture.

The HPS-1 is the optimal solution if precise pitot and static pressure is needed on unmanned aerial vehicles (UAV), remotely piloted aircraft (RPA) or other flight vehicles. It can be used together with the ADC-10 Air Data Computer or with any other air data system.

HPS-1 L-Shape

HPS-1 Detached Heater Controller

HPS-1 Standard Version

The integrated heating electronics regulates the temperature of the probe within a narrow band of temperature. Using pulse width modulation of varying duty cycle, a stable probe temperature is achieved. At 100% duty cycle at least 40W of heating power is available. Both the maximum temperature and the maximum duty cycle are configurable by the factory and by the user. A status output signal indicates system normal operation. A discrete input signal allows the flight control computer (or autopilot) to switch the heater on and off during the flight. This is used to conserve power during a long flight.

The static holes are located in the stainless-steel part of the probe for highest accuracy and best heating performance as well as mechanical and chemical resistance.

Key Features

– Small size and lightweight, very small probe diameter of only Ø9 mm
– Made of stainless steel, aircraft grade aluminum and carbon fiber tube
– Best solution for UAVs, RPAs and other flight vehicles
– Integrated and regulated heater
– 9-32 VDC Power Input (min. 40 Watt at 28VDC, 100% power)
– High accuracy
– Designed and tested in the wind-tunnel

Key Advantages

– Heated static holes
– Drainage system
– Small probe diameter and regulated temperature for lowest power consumption
– On/off function via 5V logic level
– Status indication via 5V logic level
– Electrical connector for easy installation and detachment
– Connector and pressure fitting in line with aircraft axis, allows slim fuselage design
– Reverse polarity protection

Specifications

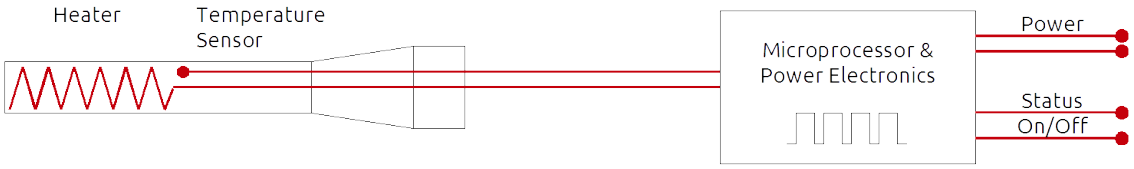
	40 W Version	60 W Version
Supply Voltage	9 V … 32 V	9 V … 28 V, Surge (<1 s) up to 32 V
Supply Current (100% Duty Cycle, 28V)	1.4 A ... 2.0 A	2.1 A … 2.9 A
	The supply current I_{VS} at a given supply voltage V_S is calculated as: $I_{VS} = I_{28\,V} \times V_S / 28\ V$	
Heater Temperature	The probe temperature is regulated by a microprocessor and a temperature sensor. Standard tip temperature is 80°C. The tip temperature is configurable via the status pin.	
Heater Power (100% Duty Cycle, 28V)	At 100% duty cycle a minimum of 40W of heating power is provided. The heating power is automatically reduced when the targeted probe temperature is reached.	At 100% duty cycle a minimum of 60W of heating power is provided. The heating power is automatically reduced when the targeted probe temperature is reached.
	The heater power P_{VS} at a given supply voltage V_S is calculated as: $P_{VS} = P_{28\,V} \times (V_S / 28\ V)^2$	
Electrical Connector	Binder 711 Female 4-Pole (09 0082 32 04) – Pin-1: 9 .. 32VDC (28VDC) – Pin-2: Ground – Pin 3: 5V On/Off (RX for configuration) – Pin 4: 5V Status Indication (TX for configuration)	
Accuracy	Calibrated in wind-tunnel, see aerodynamic properties for details.	

Materials	Stainless steel, aviation grade aluminum, carbon fiber tube
Operating Temp.	-55°C .. +80°C (-40°C .. +80°C start-up))
Mounting	Two to four M4 screws (M3 for L-Shape)
Mass	0.095kg @ 300mm

Function

The total pressure port is protected internally with a settling chamber so that no water and ice can enter the pressure lines. A drainage system drains water to the outside. The static pressure ports are drilled in the stainless steel tube to guarantee accurate static pressure.

The integrated electronic circuit board holds the microprocessor, the sensor electronics and the power electronics. The temperature in the probe tip is regulated with the help of a small temperature sensor. The power to the heater is regulated by a sophisticated control algorithm. To provide fine grained heater regulation and to minimize power fluctuation on the power system of the aircraft pulse-width modulation (PWM) is used to adjust the required power. Maximum power and maximum temperature is configurable by the factory or the user. As maximum power is configurable, the system can be used on smaller aircraft with limited maximum power capabilities.



Functional diagram of the HPS-1 heater system

Available Probe Models

To be able to meet all customers needs, there are several different models available:

Standard *SIM-D8C-4FE*	Probe mounted on carbon tube. Heater controller box directly attached to carbon tube.
Mount *SIM-CC1-09A*	Probe mounted on carbon tube with aluminum mount. Heater controller box detached.
L-Shape *SIM-304-695*	Probe mounted on L-shaped mast. Heater controller box detached. Pig-tail cable with Binder connector.

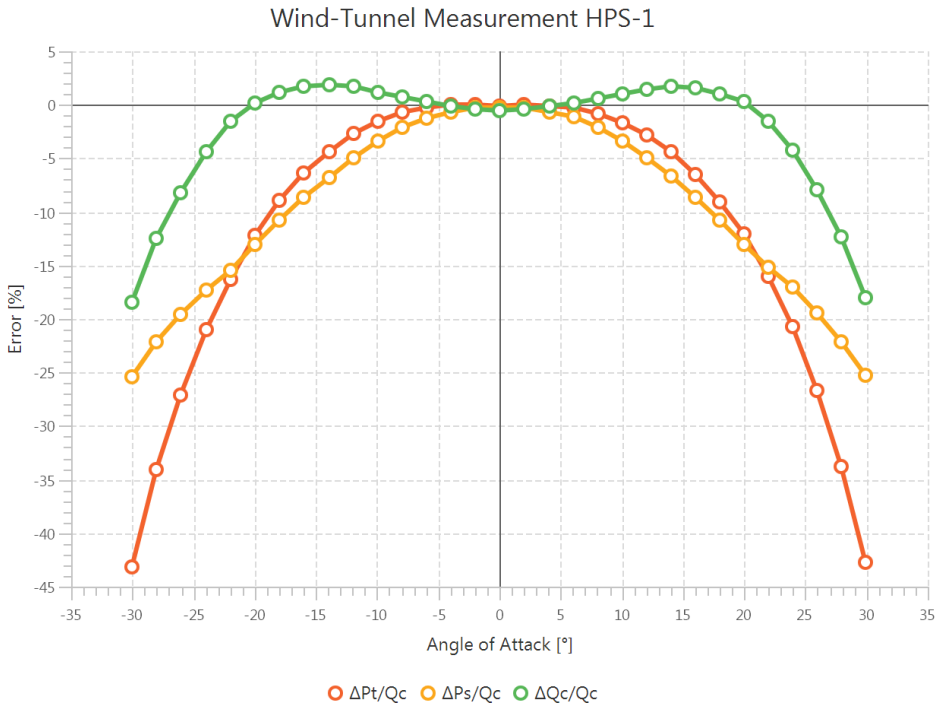
Available Probe Configurations & Options

Heater Power	The heater power can be increased to 60W instead of 40W. *Note that the current consumption is increased by a factor of 1.5. If this option is chosen, the supply voltage must be limited to 28VDC maximum. Short duration surges up to 32V are acceptable.*
Boom Length	Length of carbon tube for Standard and Mount version
Installation Orientation	For the L-Shape probe the orientation of installation must be specified such that the drainage hole can be aligned accordingly.
Power Optimized Probe (PO)	On the power optimized probe, the shape of the tip is optimized to reduce power consumption, which is important in particular for high airspeed. In return, the accuracy of the pitot measurement is reduced at AoA and AoS above 18°.
Long Cable (LC)	The L-Shape probe can be ordered with an extended cable length of 1000mm instead of 250mm.

For guidelines on how to customize your part-number please refer to the drawings of the respective probe model.

Pitot and Static Pressure

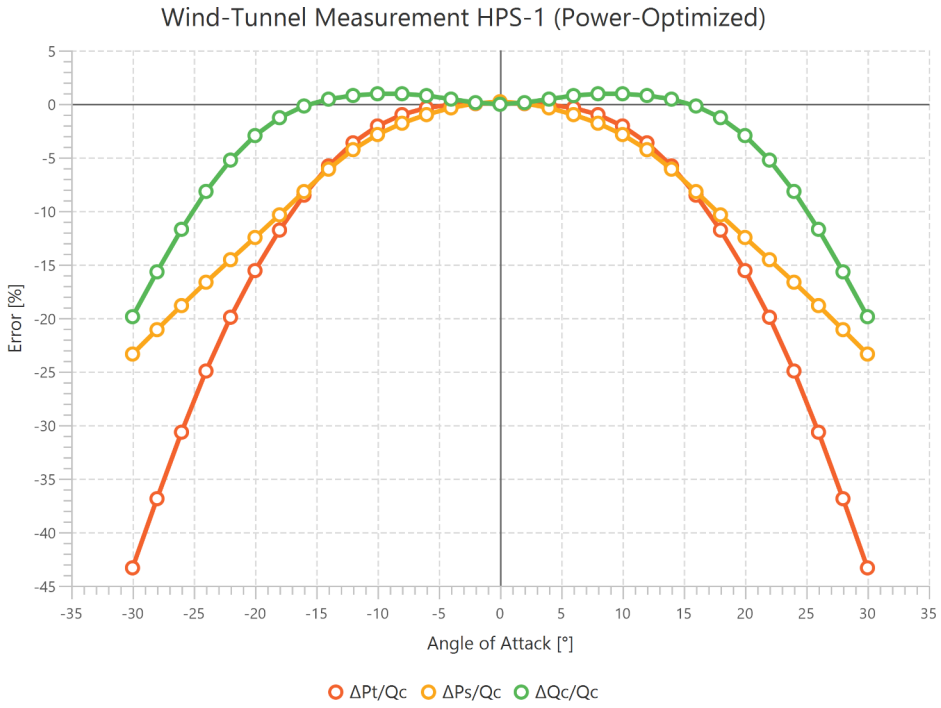
The following diagram depicts the aerodynamic errors at large flow angles in relation to the true dynamic pressure Qc (correct reference pressure) for the standard version:



Aerodynamic properties of HPS-1 standard version as measured in the wind-tunnel

The probe is designed to have small errors in dynamic pressure Qc which is important to get small errors in airspeed even at large angle of attack (AoA) and angle of side-slip (AoS). This is especially important for slow moving vehicles where gusts and crosswind have a strong effect.

The windtunnel calibration for the Power Optimized (-PO) version is shown below.



Aerodynamic properties of HPS-1-PO Version as measured in the wind-tunnel

The power optimized (PO) version is optimized to reduce the required heater power at the cost of slightly reduced accuracy of the dynamic pressure Qc at AoA and AoS above 18°.

The probe has a symmetric behavior in all directions (AoA and AoS). On request Simtec can provide probes that are optimized in a certain direction (e.g. small errors at positive AoA).

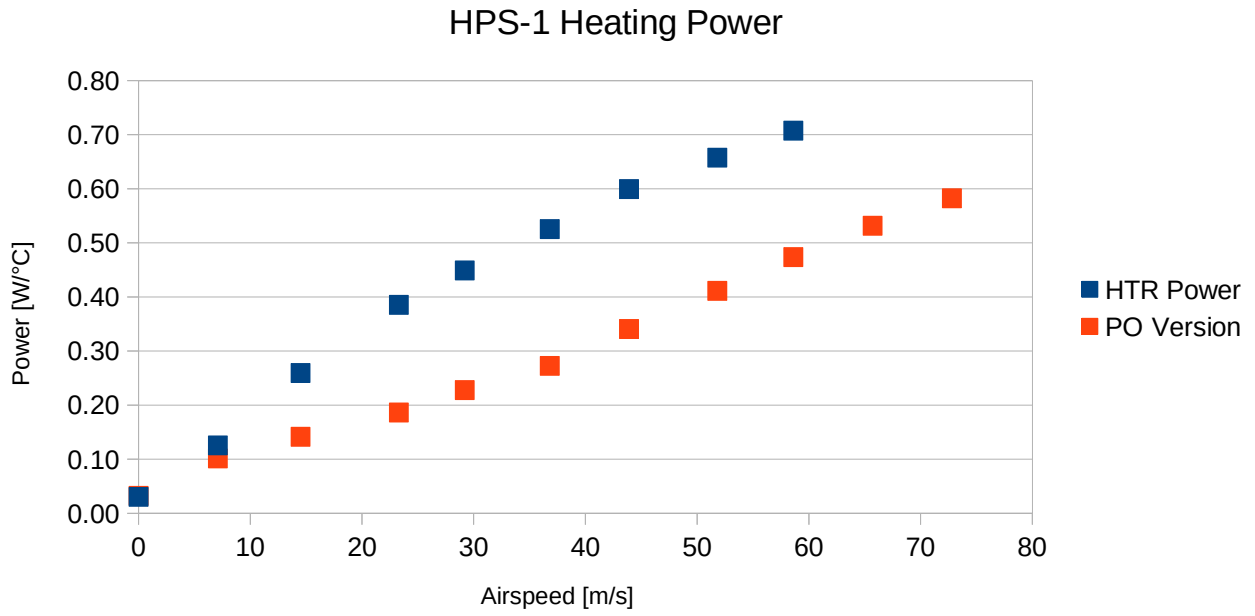
Heater Temperature and Power

The maximum temperature of the tip and maximum available power is configurable via the status pin. Standard tip temperature is factory-preset to 80°C. The heater of the 40W version is not designed to be operated above 30 VDC for a prolonged time. The 60W version must not be operated above 28 VDC.

The average power consumption during the flight depends on the airspeed, outside air temperature and the tip temperature and can be calculated from the formula below:

$$P_{tot} = p\,[T_{tip} - T_{oat}] + K$$

p has been measured in Simtec's windtunnel, where the results are shown in the graph below. An additional margin K should be accounted for melting and heating the water impacting the probe. Contact Simtec for additional information regarding the required margin K.



Example Calculation:

CAS	30	m/s	airspeed of UAV
p	0.23	W/°C	power per °Celsius according to diagram at 30 m/s (PO version)
Toat	-15	°C	ambient temperature at altitude
Ttip	80	°C	tip temperature according to configured value
Ptot	26.9	W	$P_{tot} = 0.23 \times [80 + 15] + K \approx 21.9\ W + K$

Status Indication

The status pin provides information concerning the probe temperature with a 5V TTL signal. As of revision **R4 of the Heater Controller Box (SIM-B04-03A) and revision R7 of the HPS-1 Standard Version (SIM-D8C-4FE), there are two user-configurable manners of indicating the heater temperature: legacy or PWM. For older versions, only the legacy status indicator is available. Note that the revision is clearly marked on the device for R4/R7 and above. Older versions do not have their revision marked on the device.**

Legacy status indicator

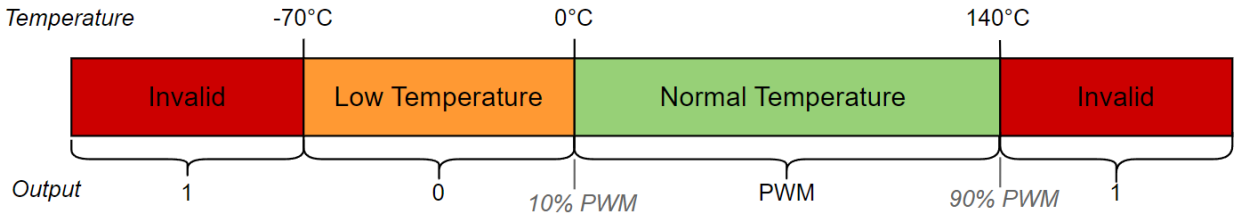
If the HPS-1 Heater Controller Box is configured with the legacy status indicator, the probe temperature is indicated with three distinct states.

LOW-TEMP	5	VDC	The tip is below reference temperature. There are three reasons the LOW-TEMP warning can happen: 1. during power-up until the heater reaches the correct temperature 2. Due to low outside temperature and high airspeed, the heater power becomes insufficient. 3. if the heater is not working correctly or broken and the correct tip temperature is not reached at all
HIGH-TEMP	0/5	VDC	The tip temperature is above the reference temperature of the tip. The status indication alternates between 0 and 5 VDC at a rate of about 2 Hz. There are two reasons the HIGH-TEMP warning can happen: 1. at power-up or during a fast temperature change the heater can overshoot the reference temperature for a small amount of time 2. if the heater is not working correctly
NORMAL-OP	0	VDC	The system is working properly. The heater works at the configured temperature.

PWM status indicator

This option is only available on revision R4 of the Heater Controller Box (SIM-B04-03A) and revision R7 of the HPS-1 Standard Version (SIM-D8C-4FE) or above.

There are three distinct states: Invalid, Low Temperature or Normal Temperature.



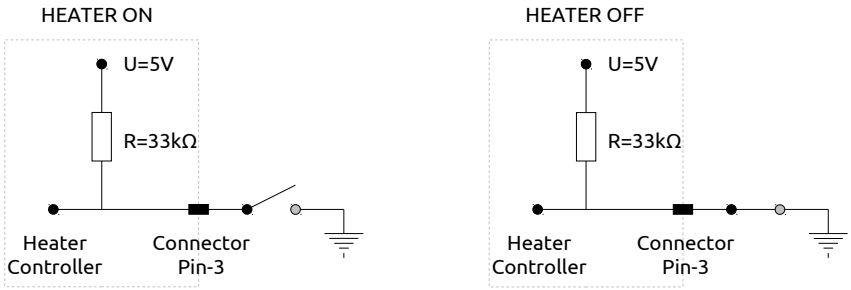
INVALID	5	VDC	The tip temperature is below -70°C or above +140°C. This is due to a temperature sensor failure or a heater failure.
LOW TEMPERATURE	0	VDC	The tip temperature is between -70°C and 0°C. In this state the tip of the probe will get clogged when flying in icing conditions. There are three reasons the LOW-TEMP warning can happen: 1. during power-up until the heater reaches the correct temperature 2. Due to low outside temperature and high airspeed, the heater power becomes insufficient. 3. if the heater is not working correctly or broken and the correct tip temperature is not reached at all
NORMAL TEMPERATURE	5V PWM		The tip temperature is between 0°C and 140°C. In this case, the PWM duty cycle is proportional to the tip temperature. Thus, the user can read the temperature with the following formula: $Temp = (Duty - 10\%) \times 175$ Where *Temp* is the probe temperature in °C and *Duty* is the duty cycle of the PWM in %. Here are some example of duty cycle and corresponding temperature: 10% → 0°C 28% → 31.5°C 72% → 108.5°C 90% → 140°C The frequency of the PWM can be 0.2Hz or 100Hz depending on the configuration. Please note that the frequency is not very accurate, however the duty cycle is precise.

On/Off Function

The heater can be shut off and on via the on/off pin:

ON	5	VDC	If the on/off pin is not connected the heater works
OFF	0	VDC	If 0 VDC is applied to the on/off pin the heater will be shut off.

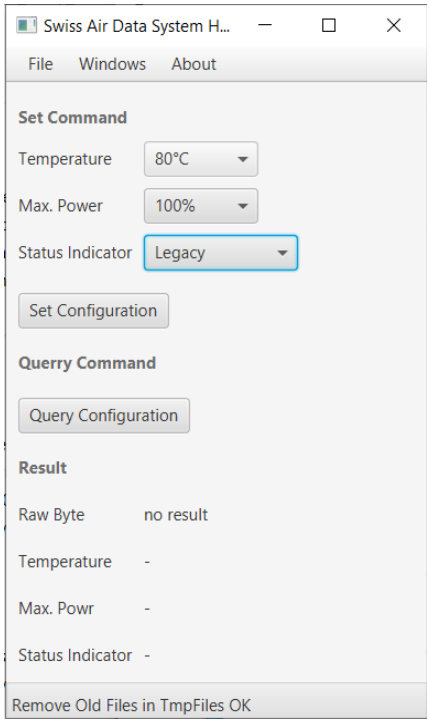
The on/off-pin on the HPS-1 is at 5VDC. If nothing is connected to the pin, the heater will be in the ON state (heater controller on). If the pin is connected to ground, the heater will be in the OFF state (heater off). The following diagram clarifies this behavior:



If the on/off functionality is not needed the on/off pin can be left unconnected. The heater starts working as soon as power is provided on the power pins.

In dry air and if no ice is anticipated the flight control computer (FCC) may decide to shut down the heater to conserve power. However it is recommended to keep the heater in the on state during all critical flight phases to prevent the accumulation of moisture and ice crystals.

Software Configuration



The heater can be configured via connector pin 3 and pin 4. A 5 VDC TTL signal at 1'200 baud is used to configure the heater. To re-program the tip temperature and the power, pin 4 is used as the TX-pin and pin 3 is used as the RX-pin. A USB TTL Serial cables (e.g. from http://www.ftdichip.com) can be used together with the HPS-1 configuration software. USB cables and the PC-software is available from Simtec on request.

A single command byte of data with the below bit-format has to be sent to the RX-pin of the HPS-1 to configure the heater. On success the heater stores the new values in non-volatile EEPROM and answers with a response byte of the same format on the TX-pin.

Byte Format (8 bits):	Description
"0pppttt1"	ppp: Max. Power Setting, values 0..7 ttt: Tip Temperature, values 0..7
"1xxxsss1"	xxx: Reserved bytes, not used sss: Status Indicator Configuration

Max. Power Setting (ppp)

000:	Querry power
001:	10%
010:	25%
011:	40%
100:	55%
101:	70%
110:	85%
111:	100%

Tip Temperature (ttt)

000:	Querry temperature
001:	5°C
010:	20°C
011:	35°C
100:	50°C
101:	65°C
110:	80°C
111:	110°C

Status Indicator (sss)

000:	Querry status
001:	Legacy status
010:	PWM 0.2Hz
011:	PWM 100Hz
100:	Stop status (always “5V”)
101:	Start status indicator
110:	Reserved for future used
111:	Reserved for future used

If the heater receives “0b00000001” it returns the configured temperature and power values.

If the heater receives “0b10000001” it returns the configured status indicator.

Warnings

The electronics features a reverse polarity protection to prevent the damage of the internal electronics like the microprocessor or the temperature circuitry. Note however that during reverse polarity operation the heater is not controlled and full power is applied to the heater. The probe can get very hot and operation for more than a few seconds will destroy the probe!

The 60W version must not be operated above the nominal voltage of 28 VDC. Short surges (<1s) up to 32V are acceptable.

Do not apply pressure above 1500 hPa. Overpressure can destroy the internal tubing.

The tip of the probe can get very hot.

Part-Numbers Probes

SIM-D8C-4FE	**HPS-1 Heated Pitot-Static Probe (Standard)** Heated pitot-static probe, L=200/300/400mm. Includes probe, mount, heater controller and Binder-connector 4pole. Assembled and leakage tested
SIM-CC1-09A	**HPS-1 Heated Pitot-Static Probe Mount** Heated pitot-static probe mount excl. detached heater controller. Includes probe, carbon tube, mount and connector mounted on pig-tail cable. Assembled and leakage tested. Heater controller *SIM-B04-03A* must be ordered separately.
SIM-304-695	**HPS-1 Heated Pitot-Static Probe L-Shaped** L-shaped heated pitot-static probe excl. detached heater controller . Includes probe, mast and connector mounted on pig-tail cable. Assembled and leakage tested. Heater controller *SIM-B04-03A* must be ordered separately.

The following options are available (eg. *SIM-D8C-4FE-60W-400mm-PO*):

-40W *-60W*	**Heater Power** Optionally the heater power can be increased to 60W instead of 40W.
-200mm *-300mm* *-400mm*	**Probe Length** For *SIM-D8C-4FE* and *SIM-CC1-09A*, different lengths are available. Standard lengths are 200mm/300mm/400mm. Custom lengths are available on request.
-TOP / -BTM *-RGT / -LFT*	**Installation Orientation** For SIM-304-695, the orientation of installation must be specified such that the drainage hole can be aligned accordingly.
-PO	**Power Optimized Version (PO)** For this version, the shape of the probe tip is optimized to reduce power consumption, which is important in particular for high airspeed. In return, the accuracy of the pitot measurement is reduced at AoA and AoS above 18°.
-LC	**Long Cable (LC)** For *SIM-304-695* the cable length can be extended to 1000mm.

For guidelines on how to customize your part-number please refer to the drawings of the respective probe part-number. If the kit is ordered, please add the configuration/option to the kit part-number following the guidelines presented for the corresponding probe part-number.

Part-Numbers Heater Controller

SIM-B04-03A **HPS-1 Heater Controller**

Detached Heater Controller Box required for *SIM-CC1-09A* and *SIM-304-695*.

Part-Numbers Kits

SIM-4C8-02D **HPS-1 Heated Pitot-Static Probe Mount - Kit**

Heated pitot-static probe mount with detached heater controller. Includes probe, carbon tube, mount, heater controller and Binder-connectors 4pole. Assembled and leakage tested.

SIM-A4E-675 **HPS-1 Heated Pitot-Static Probe L-Shaped - Kit**

L-shaped heated pitot-static probe, detached heater controller. Includes probe, mast, controller and Binder-connectors 4pole. Assembled and leakage tested.

Part-Numbers Ground Support Equipment (GSE)

SIM-97B-130 **HPS-1 Tip Cover**

Used to protect HPS-1 pitot-static probe on ground. Includes "Remove Before Flight" flag.

SIM-4E1-7B8 **HPS-1 Pressure Test-Adapter Ps/Pt**

Pressure test adapter which can be used for all HPS-1 base part-numbers.

SIM-EFD-E2B **TTL-to-USB Converter Cable**

Includes Binder connector, USB-connector and open-ended power cable, approx. 1.8m.

RoHS and REACH

RoHS: Simtec's safety critical aerospace products are excluded from the scope of the RoHS Directive.

REACH: Simtec PCBs (printed circuit boards) are soldered with leaded solder. Lead (CAS-No. 7439-92-1) is listed as a substance of very high concern (SVHC). When used as intended, these products are not hazardous to health.

Service and Repair

Should any damage occur during shipping, handling, or misuse by the user, Simtec is able to service it. Technical consultation can be obtained from Simtec if expertise is needed for the integration of the air data system into the aircraft, during flight-testing or post processing of data.

About Simtec AG

Simtec develops and manufactures high-quality and fully self-contained, heated and unheated multi-hole air data systems, air data computers, air data units, pitot-static probes and flow vanes. The products sense static and dynamic pressure, angle of attack, angle of side-slip and air temperature. Simtec's products are all Swiss Made. Simtec operates its own wind-tunnels and calibration laboratories. Swiss Air Data Systems are used on unmanned aerial vehicles (UAV), remotely piloted aircraft (RPA), drones, aircraft, helicopters and for flight testing.

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