# ELECTRICAL PROTECTION FOR SMART INSTRUMENTS & DUSTIQ

There are a number of circumstances where the electronics inside Kipp & Zonen Smart instruments may be damaged by voltage surges or spikes on power, serial data or analog signal connections. These may be either directly on the wires (for example from a power supply) or induced by electrostatic discharge (such as lightning) or by a very strong electric field.

The SMP series pyranometers, SHP pyrheliometer, SGR pyrgeometers, SUV ultraviolet radiometers and RT1 Rooftop Monitoring system share the same set of electronics. This has analog-to-digital conversion for monitoring the detector signal, external power supply voltage and internal temperature (PV module temperature for the RT1). Digital signal processing is carried out by a microprocessor with firmware and non-volatile memory.

The digital output is available as 2-wire RS-485 with Modbus® RTU protocol. A digital-to-analog converter provides a 0-1 V output for the -V versions, or a 4-20mA output for -A versions. A single 8-wire shielded cable carries all the power and signal output connections.

Due to space restrictions within the housings, these instruments have limited protection against surges and spikes and electro-static discharge (ESD).

The new SMP12 pyranometer has no analog output and the internal construction is different. This makes space available for class-leading built-in surge protection.

The Dust IQ Soiling Monitoring System has a different set of electronics and no analog outputs. The DustIQ with PV module temperature sensor and tilt angle sensor has surge protection built in.

This document provides advice on steps that can be taken to minimise the probability of damage occurring to the Smart instruments and to the DustIQ.

## DC Power Supply

Kipp & Zonen Smart instruments and DustIQ are typically operated from a (nominally) 12 VDC or 24 VDC power supply. Usually, this is an industrial type AC-DC switched mode type device with a ‘soft-start. However, it could be from a solar panel with batteries and a charger/regulator. It is advised not to use unregulated power supplies that have a switch-on surge. All the products have reverse polarity protection on the DC power input.

## DC Power Input Surge Protection

Except for SMP12 and DustIQ, the Smart instruments do not have internal surge protection and may also be damaged by inserting or removing the cable connector with the power switched on. It is strongly advised to use an industrial surge protection device (SPD), installed as close as is practical to the instrument to minimise pick-up on long cables.

## RS-485 Modbus® RTU Data Connection

Modbus® RTU normally operates over 2-wire (semi-duplex) RS-485 and the relevant requirements of the EIA-485 standard should be adhered to for reliable communication. A part of the RS-485 standard that is not often used, but is specified for Modbus®, is the requirement for a data common wire that is isolated from the shield or 0 V, to reduce ground potential issues between the two ends of the cable that might be outside the common-mode range of the line-drivers.

This means that for Modbus you should have a 3-wire RS-485 compliant cable (a twisted pair plus extra wire) with shield. The RS-485/Modbus® ‘common’ wire of the instrument connects to this. This ‘common’ wire in the cable should not normally be connected to the cable shield or a ground; if it is, only do so at the data acquisition end.

RS-485 requires that a 120 Ohm termination resistor is fitted across the data lines at the data acquisition port, this I because the impedance of a twisted pair data cable is typically in the range of 100-150 Ohms.

Whether pull-up and pull-down bias resistors are required depends on the cable length and the bus topography (number of devices connected and in what layout) and the ideal resistor value depends upon the data line voltages. 470 Ohms or 680 Ohms are typically used. These resistors are connected between each data line and the RS-485 'common'. For more than about 50 m of cable, it is usually necessary to have the correct bias resistors at the data acquisition port end and a 120 Ohm termination resistor at the instrument.

With the correct configuration, as above, communication should work reliably at 19,200 baud up to 1000 m with one device connected. It might be necessary to lengthen the poll/response delay timeout limit at the data acquisition. If multiple devices (with different addresses, of course) are connected to one RS-485 data acquisition input settings depend upon the topography of the network (how the devices are connected) and it may be necessary to reduce the baud rate and increase the polling interval.

## RS-485 Modbus® RTU Surge Protection

SMP12 and DustIQ, with PV module temperature sensor and integrated tilt angle sensor, have surge protection built-in for both RS-485 lines, but they are not electrically isolated. The best protection is to provide an isolation module as close as is practical to the instrument.

The other Smart instruments have only common mode voltage protection for the line driver; up to 70 VDC. It may be damaged by accidentally applying power to the connections. It is strongly advised to use an industrial surge protection device (SPD), installed as close as is practical to the instrument. Ideally, this should be electrically isolated.

## Analog Output

The analog outputs of the Smart instruments only have short-circuit protection, accidentally applying power to the connections will damage the voltage or current output amplifier.

It is strongly advised to use an industrial surge protection device (SPD), installed as close as is practical to the instrument, ideally with electrical isolation.

## Grounding

ESD and surge protection depends upon a good earth/ground connection to conduct away the induced current. In many cases there is not a good connection through the instrument mounting as the aluminium housing parts are anodised. The cable shield is connected to the housing internally and this needs to be grounded close to the instrument. Note that shield is the thick black wire in the yellow instrument cable.

Ideally, the shield would be grounded through an earth spike close to the mounting point or field wiring junction box. This is also where any surge protection devices should be located and grounded. Do not also connect the shield at the data acquisition end.

If the shield is only connected at the data acquisition end, ensure that the connection point is a protective earth/ground and not a '0 V' or power supply '-' terminal.

Note: If there is a longer cable than needed it is better to shorten it (leaving a loop for water to drip off) than to coil it up. This will minimise electrical pick-up.

## Example of SPD Components

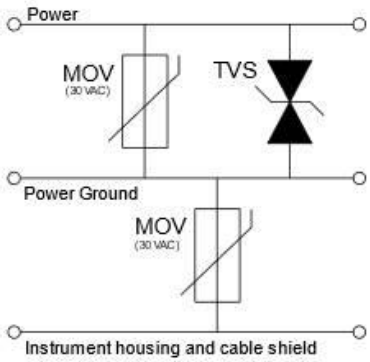
Shown below is the surge protection implementation within the new SMP12 pyranometer.
***This complies with the requirements of the EN IEC 61000-6-2 industrial standard for measurement, control and laboratory use.***

### 8.5. SMP12 EMC and Surge protection details

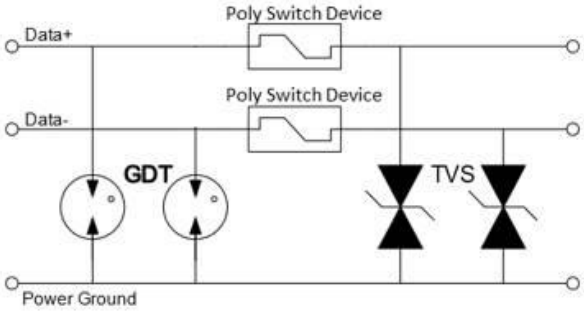
The SMP12 passes the most-stringent tests for Immunity & Emissions it conforms to all the EMC requirements for Commercial, Residential, Light Industrial, Industrial, Scientific & Medical Equipment, as well as Measurement Control & Laboratory Use.

In order to pass the above mentioned standards the SMP12 offers the following internal electronics protection:

**Power input with 2-stage protection**




**RS-485 with 3-stage data line protection**




| **Power Supply Surge Protection VDC+ and VDC-** | TVS Diode and Metal Oxide Varistor |
|---|---|
| Power supply surge standoff voltage | 36V |
| Power supply surge protection peak pulse capacity | 1500W |
| Power reverse protection | Included |
| **RS485 Surge Protection Data+/Data- to signal ground** | Gas Discharge Tube, TVS Diode and Poly Switch Device |
| Gas Discharge Tube standoff voltage | 90V |
| Surge protection peak pulse current, 8x20µs 300 Hits (150 Hits Each Polarity) | 100A |
| Poly Switch Device | 200mA, 400V |
| TVS diode standoff voltage | 12V |

The function of the Poly Switch Device is to switch off the entire RS485 when a surge pulse is applied on the input

Each line (Data+ and Data-) has its own Poly Switch Device

A small resistor of 47 Ohm is placed in-line with the Poly Switch Device protection

**Note :** For external surge protection the SMP12 is seen as "a varistor".

**Note :** For proper surge protection it is vital to use the double wire connection for Power Ground.