

SIPROTEC 5 protection relays use deadband mechanisms to reduce the volume of SCADA traffic that would otherwise occur with small changes in reported analogue values. There are two different mechanisms (which are somewhat protocol-dependent).

This 'Quick Note' will explain the mechanism(s), and provide information not found in existing manuals. It is written considering only DNP and IEC 61850 protocols and firmware 7.9 (or lower). It is anticipated that firmware 8.x will introduce a new deadband mechanism for frequency (only) which will be covered in a new or updated document.

The SIPROTEC 5 series are native IEC 61850 relays and, as illustrated in Figure 1, also provide a DNP capability. This figure shows that DNP data is derived from MMS data processed with 'Deadband for magnitude' (which uses an accumulated sum method later described in this document). This 'IEC 61850 SCADA data' is then made available for conversion to the DNP map which has its own 'traditional' 'Threshold' (deadband) mechanism that can also be applied.

Figure 1 is provided to highlight the point that DNP data is affected by both the 'Deadband for magnitude' setting and the 'Threshold' setting.

This 'Quick Note' also provides important information on the minimum values used in the 'Deadband for magnitude' algorithm – which is not apparent from the values that can be set in the software, nor is apparent from information within the manual.

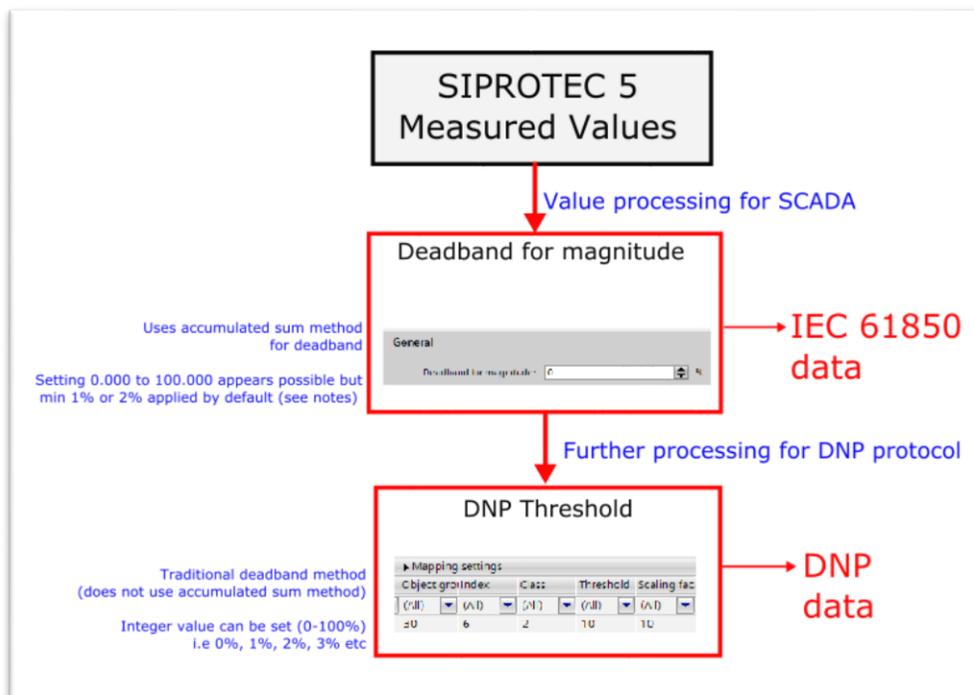


Figure 1. Conceptualisation of measured value processing for SCADA.

QUICK GUIDE TO: Locating the settings

DNP 'Threshold' can be found in the Communication Mapping window. When using the Communication Mapping screen, you need to select the desired Protocol (e.g. DNP) in the 'Show Protocol' drop-down menu (arrowed in Figure 2). The 'All Entries' drop-down menu (also arrowed) allows the list of signals to be filtered, showing (for example) just measured values or device I/O (binary points).

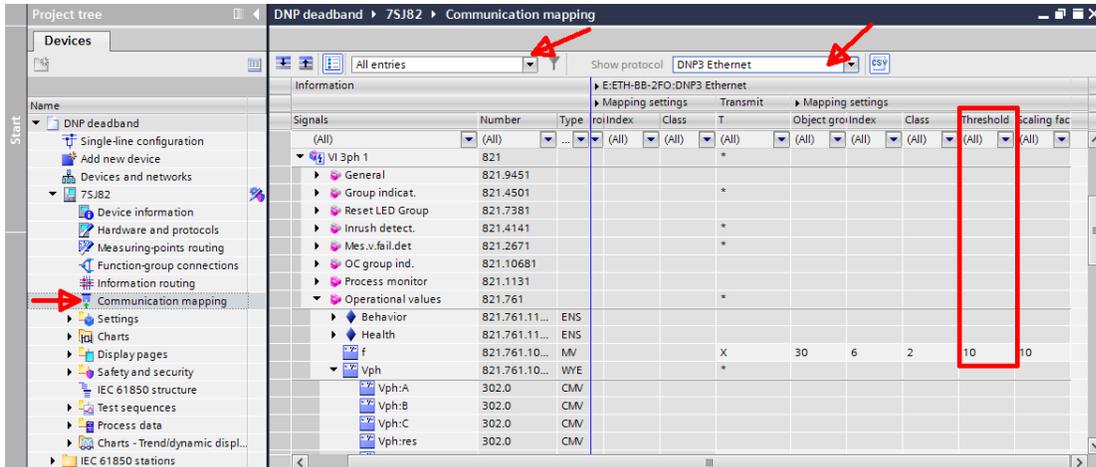


Figure 2. DNP 3 Communication Mapping Screen, 'Threshold' setting.

If IEC 61850 protocol is enabled, the 'Deadband for magnitude' can be located via the 'IEC 61850 structure' entry in the Project Tree. Navigate to the desired node in the tree, and 'Deadband for magnitude' is shown in the Properties tab.

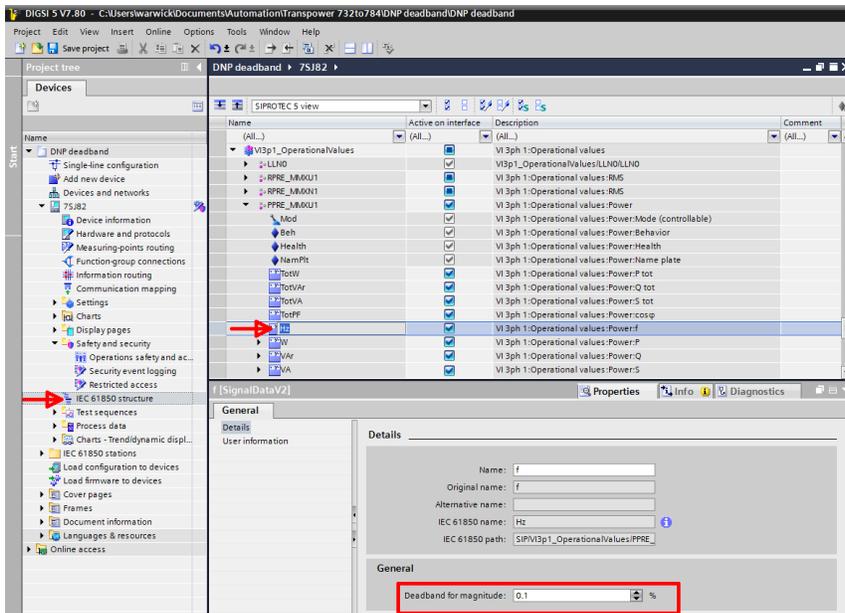


Figure 3. IEC 61850 Structure, values and 'Deadband for magnitude' properties.

In some cases (such as if the point is both a DNP and IEC 61850 point), the properties for the DNP point also provide the IEC 61850 name and the 'Deadband for magnitude' setting value – where for your convenience the 'Deadband for magnitude' can be edited from that location (see example in Figure 4).

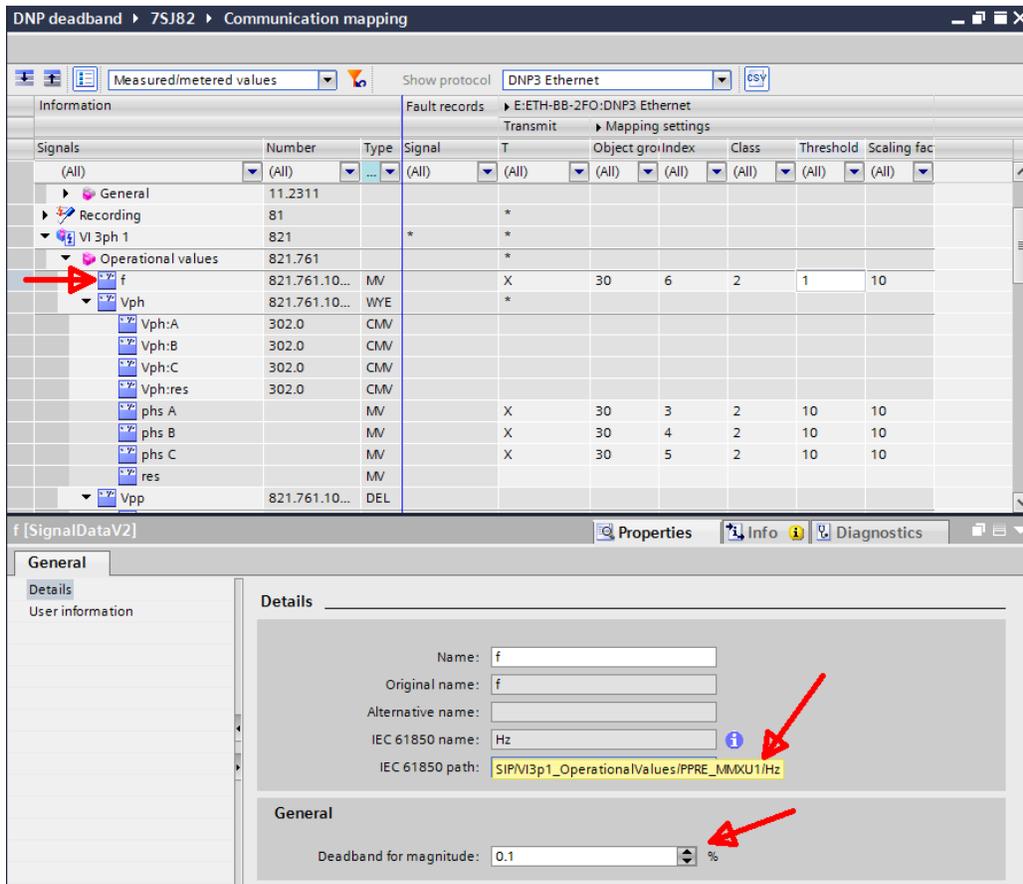


Figure 4. Example DNP 3 point showing also IEC 61850 and 'Deadband for magnitude' setting.

CMV vs MV signal types

Another observation can be made in the 'Communications mapping' screen. This shows all measured values types (see the TYPE column), but not all types are supported by the DNP protocol. For example 'CMV' type (Complex Measured Values) will not allow a DNP point to be assigned in the mapping screen, as the DNP protocol does not support this 'phasor' type measurement. Only MV (Measured Values) types can be assigned as DNP analogue points. Where a measured value has versions with both a CMV and MV type, then the 'Deadband for magnitude' is only shown on the CMV type (for example, Phase voltage, current and three-phase power measurements). For measurements like Frequency, neutral values (VN, IN) and three phase totals P tot, Q tot, S tot, where only a MV type is provided, 'Deadband for magnitude' settings are provided.

'Deadband for magnitude' settings affect DNP MV values

Testing confirms that even without IEC 61850 protocols enabled, the MMS 'Deadband for magnitude' settings will affect DNP MV values. For example, with the DNP frequency 'Threshold'

set to zero, the 'Deadband for magnitude' setting has an effect and frequency values can be found to be updated according to the accumulated sum method.

The following is not immediately obvious, but does occur

Measurements such as '(voltage) phs A', which is a DNP MV point, does not have a 'Deadband for magnitude' setting in the Properties window, so you may expect there would be no 'Deadband for magnitude' 'summation' effect. This is not the case. The relay processes MMS signals in the CMV space, which are then converted to MV type to support the DNP protocol. Testing has confirmed that, for example, the DNP 'phs A' point is affected by the 'Vph:A CMV' 'Deadband for magnitude' setting.

Method of Operation – 1) 'Deadband for magnitude'

This mechanism is not a simple percentage change (where a change greater than the threshold setting causes the point value to be updated/published). **In SIPROTEC 5 relays, an accumulated change is monitored.** For a small step change even 'within a deadband', this results in the point being updated (after a period of time based on the amount accumulated).

For the full 'Siemens' explanation of 'Deadband for magnitude' refer to the SIPROTEC 5 Communication Protocols Manual:

- 'Mapping of Data Types'. *Section 1.8.2 of manual for firmware V7.80*
- 'Measured Values and Measured-Value Description'. *Section 2.6.7 of manual for firmware V7.80*

The mechanism:

At each interval, if the instantaneous measured value (instMag) deviates from the last published value (mag), then the **absolute difference** between these two values is added to a running sum. Over time the summed value will accumulate to a point where it exceeds the deadband (db) setting. At that point the published value 'mag' is updated with the current 'instMag' value and the accumulated sum value is reset to zero.

Measured value processing takes place at 0.5 second intervals, and all measured values are processed in primary values.

Note that it is the absolute difference that is accumulated, so using voltage as an example – an increase of 2% above nominal for one processing step followed by a decrease of 2% below nominal for one processing step would accumulate a summed value of 4% change.

Example 1.

Assuming a step change from 50.00 Hz to 50.02 Hz occurs and the ‘Deadband for magnitude’ setting is 2%.

Deadband (in primary units) = 1 Hz (2% of 50 Hz)

On each measuring interval, a delta of 0.02 Hz is accumulated, till the deadband trigger threshold of 1 Hz is reached.

End of Measuring Interval	instMag	Mag	Delta	Accumulated Sum	Trigger threshold
prior	50.00 Hz	50.00 Hz	0.00 Hz	0.00	1 Hz
1	50.02	50.00	0.02	0.02 Hz	1
2	50.02	50.00	0.02	0.04	1
.....					1
49	50.02	50.00	0.02	0.98	1
50	50.02	50.02	0.00	1.00	1
51	50.02	50.02	0	0	1 Hz

Table 1

That is, after 50 intervals (of 0.5 seconds each) the accumulated sum reaches the deadband trigger threshold and a new measured value is updated in the IEC SCADA map.

This example shows that even though the ‘Deadband for magnitude’ is set at 2%, a change smaller than that value (0.04%) will eventually update the published value. This method has the advantage of updating the SCADA published points to track (slow-moving) changes within the ‘deadband’.

To keep this Quick Note simple we only consider polled/unbuffered data points. Unsolicited/buffered reporting has further settings that can withhold point updates to reduce network traffic.

Method of Operation – 2) Threshold

This DNP-specific setting works per the normal industry deadband; that is, it does not use an accumulated sum method. The magnitude of the signal change must equal or exceed the threshold before the DNP point will update.

For example, with an initial 63.5 V secondary voltage, a 1% ‘Threshold’ setting and an increasing ramp of voltage, the DNP point will update only when the voltage reaches 64.135 V (63.5 + 1%), then 64.77 V (63.135 + 1%), etc.

A threshold of 0% is accepted, but recall that the DNP point is derived from the internal value that has had the ‘Deadband for magnitude’ method applied, so even with 0% ‘Threshold’ set, the accumulated sum method is still being applied.

Setting limits

Settings for DNP are set via the 'Threshold' column in the Communication Routing screen. Integer values of 0–100% are possible. 0% is acceptable.

For 'Deadband for magnitude' settings, while DIGSI 5 settings appear to allow very small setting values (e.g. 0.02%), **the algorithm uses a minimum of 1%**. For example, voltage with any 'Deadband for magnitude' setting value less than 1% is treated as 1%. This includes a setting of 0%.

Measurement (some exceptions apply)	DNP default 'Threshold' setting	DNP 'Threshold' setting resolution	DNP 'Threshold' setting range	'Deadband for magnitude' default setting	'Deadband for magnitude' setting resolution	'Deadband for magnitude' actual minimum setting
Frequency [1]	10%	1%	0–100%	0.1%	0.001%	1%
Voltage	10%	1%	0–100%	2.0%	0.001%	1%
Current	10%	1%	0–100%	10%	0.001%	1%
Power	10%	1%	0–100%	10%	0.001%	1%
Angle [1]	No default	1%	0–100%	1.0%	0.001%	1%
Others (not fully tested)	No default	1%	0–100%	10%	0.001%	1%

Table 2. DIGSI setting values compared to those used in the algorithm.

[1] For most values the percentage (change) is evaluated against the last published value (mag). However, for frequency and angle the percentage is always evaluated against a constant being 50 Hz and 360 degrees respectively.

While 'Deadband for magnitude' cannot be 'turned off' with a 0% setting to get 'raw data', remember that due to the accumulated sum function (even with the minimum 1% setting), changes much smaller than that will be reported – just after some time taken for the sum to accumulate to the 1% value. While the minimum value of 1% may seem limiting to those used to a 0.1% voltage deadband, as the accumulated difference is used, a deadband sensitivity far greater than 1% is achieved. However, the time for such changes to be reported does depend upon the magnitude of the change.

Other considerations:

If the deadband value is set differently for different phases of the same measurement, then the values for all phases will be updated upon any phase reaching a deadband change.

For example, if L1 voltage is set to 2%, L2 voltage set to 5% and L3 voltage to 10%:

- L2 and L3 will be updated at each 2% change of L1
- L1 and L3 will be updated at each 5% change of L2
- L1 and L2 will be updated at each 10% change of L3

Further examples of accumulated sum method

Calculating the time to change

Assuming a change of 11,000 to 11,100 volts occurs (0.9%), and 'Deadband for magnitude' is set to 2%
 Delta change = 100V
 Threshold = 2% of 11,000 = 220V
 Number of steps for Delta to reach 220 = $220/100 = 2.2$. Round this up (to 3)
 Three steps are required for Delta to reach/exceed the threshold. At 0.5 seconds per step the DNP point would update in **1.5 seconds**

Example 2

A step change of 3% occurs on a nominal 11 kV, with a 'Deadband for magnitude' setting of 2%

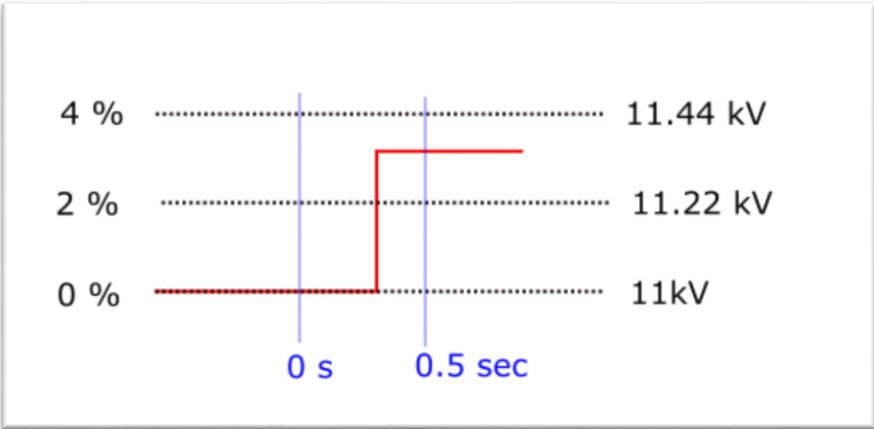


Figure 5. Example 2. 3% step change

At the first measuring interval following the change, the Delta voltage would be 330 V. This is greater than the deadband threshold of 220 V, thus the published magnitude would be updated to 11.33 kV. In comparison a traditional 2% deadband algorithm would simply report 11.22 kV, as the voltage has exceeded the 2% value threshold.

Example 3

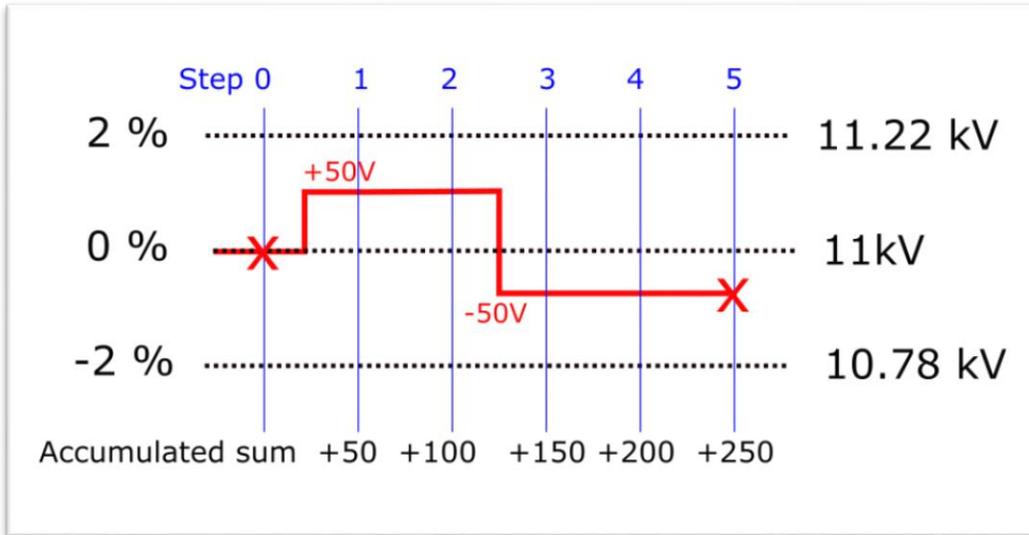


Figure 6. Example 3. Provides a reminder that sum accumulated is the absolute value.

At or prior to, step 0, the published SCADA point was 11 kV. At step one, the measured value is 50 V different, thus 50 is added to the Accumulated Sum. This also occurs at step 2. At steps 3, 4 and 5, fifty volts is still added – as it is the absolute change from the last published value which is used. Assuming a 2% ‘Deadband for magnitude’ setting at step 5, the accumulated sum (250V) will be greater than the trigger threshold (220V), thus point is updated and published as 10.95 kV.

In comparison, a traditional 2% deadband algorithm would report no change from 11 kV, as the voltage has not exceeded the 2% threshold.

Example 4

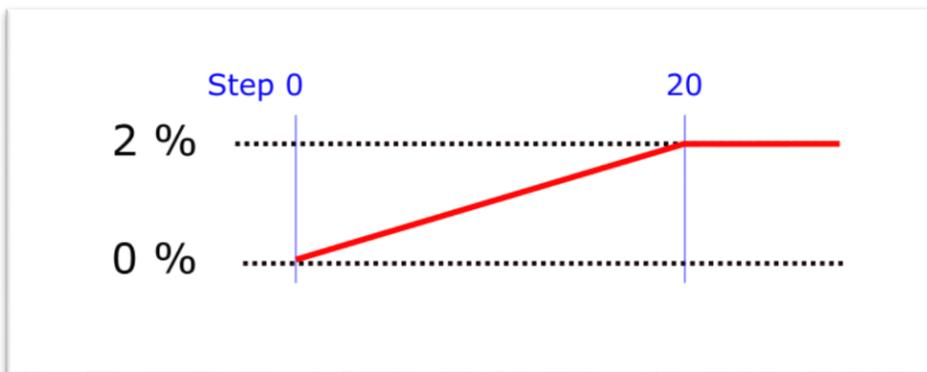


Figure 7. Example 4. Slow ramp change

While values are processed in primary units, analysis can be undertaken in percentage, as is the case in this example. A ramp from ‘nominal value’ to +2% occurs over a 10-second period (20 measuring steps). ‘Deadband for magnitude’ is set to 2%. Table 3 shows the Accumulated sum building till the trigger level (2%) is reached/exceed. At the point the DNP point will update, such as at step 6 (+0.6% nominal value



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reported at 3-second mark), step 18 (+ 1.2% nominal value reported at 9-second mark) and step 29 (+2% nominated value reported at 14.5-second mark). *In comparison, a 'traditional' deadband would report +2% value at the 10-second mark.*

Step	Delta	Sum
1	0.1	0.1
2	0.2	0.3
3	0.3	0.6
4	0.4	1.0
5	0.5	1.5
6	0.6	2.1
7	0.1	0.1
8	0.2	0.3
9	0.3	0.6
10	0.4	1.0
11	0.5	1.5
12	0.6	2.1
13	0.1	0.1
14	0.2	0.3
15	0.3	0.6

Step	Delta	Sum
16	0.4	1.0
17	0.5	1.5
18	0.6	2.1
19	0.1	0.1
20	0.2	0.3
21	0.2	0.5
22	0.2	0.7
23	0.2	0.9
24	0.2	1.1
25	0.2	1.3
26	0.2	1.5
27	0.2	1.7
28	0.2	1.9
29	0.2	2.1
30	0	0

Table 3. Step sequence for Example 4.

This document has been written by observing behaviour of a SIPROTEC 5 relay using a limited number of test sequences with typical nominal values. We are satisfied that this reverse engineering support the general methods described in this document. However, we have not tested all ranges, conditions, points and values. Undoubtedly there are other settings, limits and behaviour that will have an effect. If you are using this general advice for an application that is critical, we urge you to undertake your own testing to confirm behaviour for that application.