Elegant Efficient e^3 Easy to Use

Sub-Harmonic Protection Relay

S-PRO 4000
Model 4001

Product Overview

The S-PRO sub-harmonic protection relay protects generators, wind turbines, and SVC equipment from uncontrollable sub-harmonics which cause:

- Sub-Synchronous Torsional Interaction (SSTI)
- Sub-Synchronous Control Interaction (SSCI) and
- Ferro-resonance

The S-PRO monitors potentially harmful Sub-Synchronous Oscillation (SSO) in real time & detects Sub-Synchronous Resonance (SSR) in transmission lines with power controller interactions such as FACTS or HVDC lines, particularly those lines with series compensation and interconnected with wind farms.

The easy-to-use S-PRO also provides control, automation, metering, monitoring, fault oscillography, dynamic swing recording and event logging with advanced communications.

Protect against sustained sub-harmonics in wind farm operations

Un-damped sub-harmonic current oscillations created by series capacitors interacting with the wind system can cause serious damage to wind turbine controllers and also to conventional generators. The wind turbine's own mechanical system interactions (tower-to-blade) can also generate sub-harmonics, which are detrimental to induction generators and transformers, and may cause resonance at the point of common coupling in the electrical grid.

The S-PRO relay detects these sub-harmonic oscillations and allows the utility to monitor and protect the power system by isolating the healthy grid from sub-harmonic generation sources.

dnp Distributed Network Protocol

10 Year WARRANTY

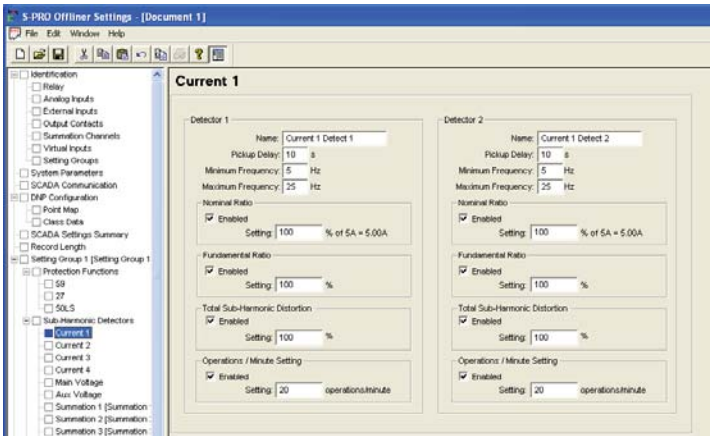
Protection & Control

- Real time processing of voltage and current signals
- Operating speed from 200 – 450 ms
- Sub-Harmonic Detector Frequency range
  - 5 – 55 Hz (60 Hz system)
  - 5 – 45 Hz (50 Hz system)
  - detection resolution of 0.2 Hz
- 2 sub-harmonic detectors for each 3-phase analog quantities each capable of alarming or tripping
- IEEE devices 59, 27 and 50LS protection at <1.5 cycles of fundamental frequency
- 2nd and 5th Harmonic Blocking for reliable operation under inrush conditions
- Sub-harmonic measurements communications via 61850 GOOSE, DNP 3 and Modbus
- ProLogic™ user-configurable logic which includes 24 control logic statements
- 8 setting groups with unique Group Logic Control Statements to create logic for setting groups switching
- Single and multi-breaker applications (i.e. ring bus and breaker-and-a-half capability)
- Total Sub Harmonic Distortion (TSHD) reporting
- Incident trending to protect against sustained above normal sub-harmonics
  - Operations per duration settable for durations from 1 – 60 minutes
  - cumulated events can be used to flag maintenance requirements
- Ethernet ports with 2 unique MAC addresses accommodate network access security needs

Features & Benefits

Ease of Use

- Easy-to-use, install, and maintain
- User-friendly, Windows®-based relay setting and record analysis software
- Setting software tool – relay specific application
- On-line setting tool – Relay Control Panel
- Flexible programmable logic for building customized schemes with ProLogic™ statements

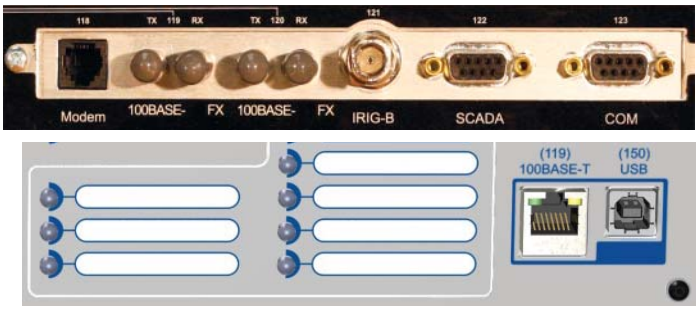


Reduce Installation and Operation Cost

- Product setting time – 240 x 128 LCD graphical user interface provides convenient means to check/change specific settings and parameters
- Front Panel Indicators – 11 user configurable LEDs, Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm

Flexible Communications

- 2 rear ports, 100BASE-TX RJ-45 or 100BASE-FX 1300 nm multimode optical with ST style connector
- Ethernet ports with 2 unique MAC addresses that easily accommodate network access security needs
- Front panel USB and 100BASE-TX RJ-45 Ethernet port interfaces
- Serial communication port
- Optional internal modem

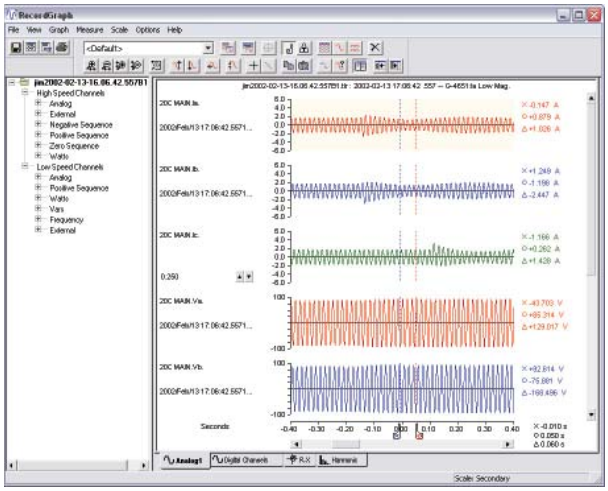


Substation Automation – Ethernet Ready

- Sub-harmonic measurements communications via 61850 GOOSE, DNP 3 and Modbus
- Reduce substation automation cost through IEC 61850 protocol
- Enhanced DNP3 SCADA communication protocol including user-selectable point lists, class support and multiple master station support
- Modbus SCADA communication protocol
- IRIG-B port (through BNC connector) for precise time stamping and sample synchronization
- 30 virtual inputs for local and remote control

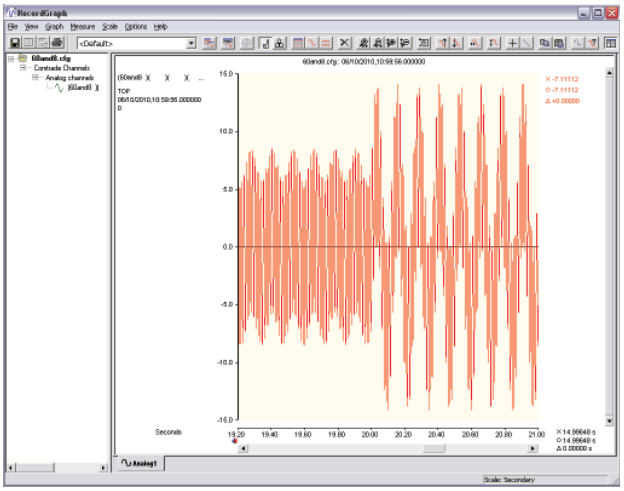
Multi-Functional Recording and Event Logging

- Exceptional fault recording capabilities (with 96 samples/cycle) and dynamic swing recording (at nominal frequency)
- User-configurable 0.2 to 10 second transient fault records and 60 to 120 second swing records. Combined record capacity of 75 records
- Metering functions for each input connection
- Sequence of Event Recorder – 250 events with 1 ms resolution
- Event auto save creates a compressed event records for every 250 events



RecordGraph™ and RecordBase View™

- Display multiple channels simultaneously and combine records
- Display multiple component voltage, current or summed channels
- Display THD, TSHD, harmonic and sub-harmonic magnitude
- Zoom, alignment, scaling, unit functions
- Record summaries including event lists
- COMTRADE, PTI and MS Excel export



Best in Class Human-Machine Interface

Large LCD display, allows for better metering display

Navigation controls allow for an easy experience through settings, maintenance, service and view menus

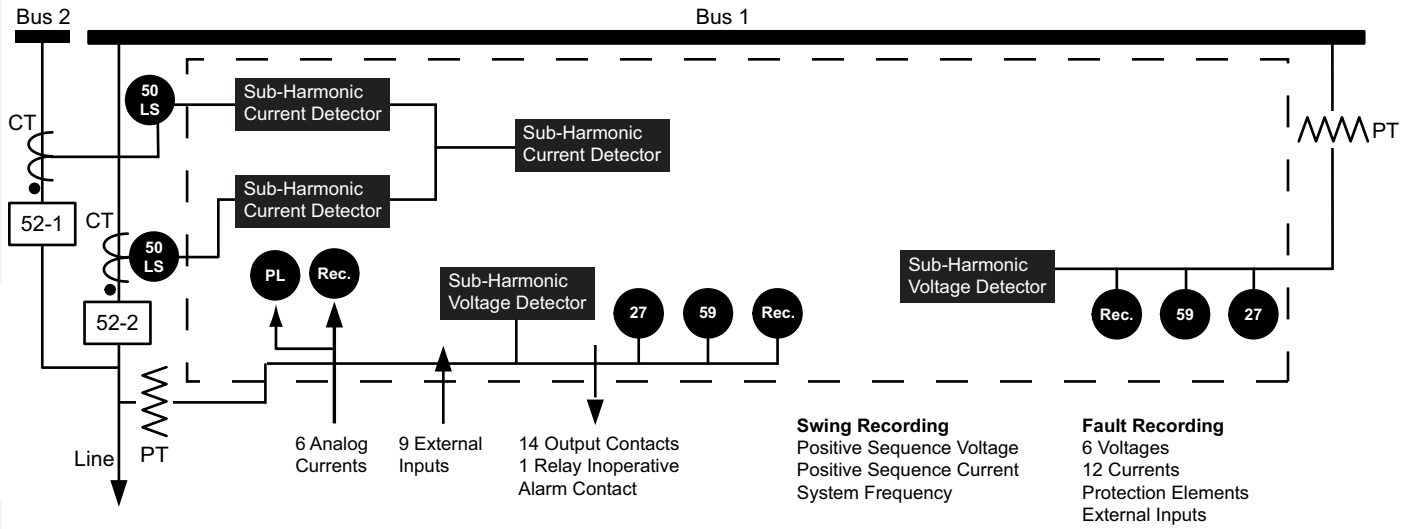
Programmable target LEDs provide tripping information to expedite response to system events

New faster processor and hardware platform

Rear optical ports ready for Ethernet connectivity

Unique front panel USB and Ethernet ports provide easy and fast access to settings and set up

Protection & Control Function Diagram



Detailed Specifications

S-PRO 4000: Model 4001 Sub-Harmonic Protection Relay for Transmission Systems

Item	Quantity/Specs	Notes
General		
Overvoltage Category	Overvoltage Category III	
Pollution Degree	Pollution Degree 2	
Insulation Class	Class I	
Ingress Protection	IP30 standard	Contact factory for IP50 on front panel
Nominal Frequency	50 or 60 Hz	
Operate Time for Normal Protection Functions (50LS, 27, 59)	Less than 1.5 cycles	Including output relay operation
Power Supply	Nominal supported:: 48 – 250 Vdc, 100 – 240 Vac Nominal for CE compliance: 48 – 125 Vdc, 100 – 120 Vac	Voltage tolerance: ±10% Maximum current: 0.7 A
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
Protection Functions		
IEEE Dev. 59, 27, 50LS Sub-harmonic detectors (2 voltages, 4 currents and 4 current summations)	2 x3-phase voltage inputs 4 x3-phase current inputs 4 x3-phase summation current inputs derived from current inputs	Suitable for ring bus configuration
ProLogic	24 statements per setting group	5 inputs per ProLogic™ statement
Group Logic	8 (16 group logic statements per setting group)	5 inputs per group logic statement
Recording:		
Transient (Fault)	96 s/c oscillography of all analog and external input channels	User-configurable 0.2 to 10.0 seconds Record length and 0.1 to 2 seconds prefault length
Dynamic Swing	1 s/c phasor measurements of line positive sequence V and I plus frequency	User-configurable 60 – 120 seconds. Pre-trigger time fixed at 30 seconds
Events	250 events circular log with 1ms resolution	When event auto save is enabled, a compressed event record is created every 250 events.
Record Capacity	75 records of a combination of transient, swing and optionally event records	
Input & Output		
Analog Voltage Inputs 2 sets of 3-phase voltage inputs (6 voltage channels total)	Nominal Voltage – across input channel Full Scale/Continuous Maximum Over-scale Thermal Rating	Vn = 69 Vrms (120 Vrms L-L) 2x Vn = 138 Vrms (240 Vrms L-L) 4x Vn = 276 Vrms (480 Vrms L-L) for 3 seconds 3x Vn = 207 Vrms (360 Vrms L-L) for 10 seconds
	Burden	<0.03VA @ Vn
Analog Current Inputs 4 sets of 3-phase current inputs (12 current channels)	Nominal Current Full Scale/Continuous Maximum full-scale rating Thermal rating	In = 1 Arms or 5 Arms 4x In = 4 Arms or 20 Arms 40x In for 1 second symmetrical 50x In for 3 seconds 100x In for 1 second
	Burden	<0.25 VA @ 5 Arms, <0.10VA @ 1 Arms

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Item	Quantity/Specs	Notes
Input & Output		
Amplitude measurement accuracy	+/-0.5% for 54 to 66 Hz (60 Hz nominal) +/-0.5% for 44 to 56 Hz (50 Hz nominal)	
Analog Sampling Rate	96 samples/cycle for recording 8 samples/cycle for protection	Records up to 25th harmonic
External Inputs	9 isolated inputs (3U chassis)	The 220/250 Vdc option is not available if CE compliance is required.
Isolation	2 KV optical isolation	
External Input Turn-on Voltage	48 Vdc range = 27 to 40 Vdc 125 Vdc = 75 to 100 Vdc 250 Vdc = 150 to 200 Vdc, 60% to 80% of nominal	Specified voltages are over full ambient temperature range.
Output Relays (contacts)		Externally wetted
Normal Contacts	3U: 14 programmable normal outputs and 1 relay inoperative normal output (normally closed)	Make: 30 A as per IEEE C37.90 Carry (all outputs active): 4 A continuous 6 A for 22 minutes 8 A for 13 minutes Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive
Virtual Inputs	30 Virtual Inputs	
Interface & Communication		
Front Display	240 x128 pixels graphics LCD	
Front Panel Indicators	16 LEDs: 11 programmable, 5 fixed	Fixed: Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm Target (11 programmable)
Front User Interface	USB port and 100BASE-T Ethernet port	Full Speed USB 2.0, RJ-45
Rear User Interface	LAN Port 1: 100BASE Copper or Optical 1300 nm LAN Port 2: 100BASE Copper or Optical	Copper: RJ-45, 100BASE-T Optical: 100BASE-FX, Multimode ST style connector
	Two Serial RS-232 ports to 115 kbd modem	Com port can support external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional internal modem
SCADA Interface	IEC61850 (Ethernet) or DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Time Sync	IRIG-B, BNC connector B003,B004,B123 and B124 Time Codes	Modulated or unmodulated, auto-detect
Self Checking/Relay Inoperative	1 contact	Closed when relay inoperative

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Item	Quantity/Specs	Notes
Environmental		
Ambient Temperature Range	-40°C to 85°C for 16 hours -40°C to 70°C continuous	IEC 60068-2-1, 2 LCD contrast impaired for temperatures below -20°C and above 60° C
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs, external inputs, output contacts at 2.0 kV, 50/60 Hz, 1 minute	IEC 60255-5, ANSI/IEEE C37.90
Electrical Fast Transient	Tested to level 4 - 4.0 kV 2.5/5 kHz on Power and I/O lines	ANSI/IEEE C37.90.1, IEC/EN 60255-22-4, IEC 61000-4-4
Oscillatory Transient	Test level = 2.5 kV	ANSI/IIEEE C37.90.1: 2.5 kV / IEC/EN 60255-22-1:IEC 61000-4-12): Level 3
RFI Susceptibility	10 V/m modulated, 35 V/unmodulated	ANSI/IEEE C37.90.2:/ (IEC 60255-22-3/ IEC61000-4-3): Level 3
Conducted RF Immunity	150 kHz to 80 MHz	IEC 60255-22-6 / IEC 61000-4-6 Level 3
Shock and Bump	5 g and 15 g	IEC60255-21-2,IEC/EN 60068-2-27, Class 1
Sinusoidal Vibration	1 g, 10 Hz to 150 Hz, 1.0 octave/min, 40 sweeps	IEC/EN 60255-21-1, IEC/EN 60068-26, Class 1
Voltage Interruptions	200 ms interrupt	IEC 60255-11 / IEC 61000-4-11
Physical		
Weight	3U chassis - 10.3 kg/22.6 lbs	
Dimensions	3U chassis: 13.2 cm height x 48.26 cm width rack mount x 32.8 cm depth	5.2 height x 19 width rack mount x 12.9 depth
Time Synchronization and Accuracy		
External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect	Upon the loss of an external time source, the relay maintains time with a maximum 160 seconds drift per year at a constant temperature of 25C. The relay can detect loss or re-establishment of external time source and automatically switch between internal and external time.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external)	
Overall S-PRO Accuracies		
Current (Fundamental)	±2.5% of inputs from 0.1 to 1.0 x nominal current (In) ± 1.0% of inputs from 1.0 to 40.0 x nominal current (In)	
Voltage (Fundamental)	± 1.0% of inputs from 0.01 to 2.0 x nominal voltage (Vn)	
Timers	±3 ms of set value	
Frequency	0.2 Hz	

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Detailed Environmental Tests

Test	Description		Test Level
	Type Test	**Test Points**	
FCC Part 15	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 60255-25	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 61000-3-2	Power line harmonics	ac power port	Class D: max.1.08, 2.3, 0.43, 1.14, 0.3, 0.77, 0.23 A.... for 2nd to nth harmonic
		dc power port	N/A
IEC/EN 61000-3-3	Power line fluctuations	ac power port	THD/ 3%; $P_{st} < 1$, $P_{lt} < 0.65$
		dc power port	N/A
IEC/EN 61000-4-2 IEC/EN 60255-22-2	ESD	Enclosure contact	+/- 6 kV
		Enclosure air	+/- 8 kV
IEEE C37.90.3	ESD	Enclosure contact	+/- 8 kV
		Enclosure air	+/- 15 kV
IEC/EN 61000-4-3 IEC/EN 60255-22-3	Radiated RFI	Enclosure ports	10 V/m: 80 – 1000 MHz
IEEE C37.90.2	Radiated RFI	Enclosure ports	35 V/m: 25 – 1000 MHz
IEC/EN 61000-4-4 IEC/EN 60255-22-4 IEEE C37.90.1	Burst (fast transient)	Signal ports	+/- 4 kV @2.5 kHz
		ac power port	+/- 4 kV
		dc power Port	+/- 4 kV
		Earth ground ports	+/- 4 kV
IEC/EN 61000-4-5 IEC/EN 60255-22-5	Surge	Communication ports	+/- 1 kV L-PE
		Signal ports	+/- 4 kV L-PE, +/-2 kV L-L
		ac power port	+/- 4 kV L-PE, +/-2 kV L-L
		dc power port	+/- 2 kV L-PE, +/-1 kV L-L
IEC/EN 61000-4-6 IEC/EN 60255-22-6	Induced (conducted) RFI	Signal ports	10 Vrms: 0.150 – 80 MHz
		ac power port	10 Vrms: 0.150 – 80 MHz
		dc power port	10 Vrms: 0.150 – 80 MHz
		Earth ground ports	10 Vrms: 0.150 – 80 MHz
IEC/EN 60255-22-7	Power frequency	Binary input ports: Class A	Differential = 150 Vrms
			Common = 300 Vrms
IEC/EN 61000-4-8	Magnetic field	Enclosure ports	40 A/m continuous, 1000 A/m for 1 s

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Detailed Environmental Tests

Test	Description		Test Level
	Type Test	**Test Points**	
IEC/EN 61000-4-11 IEC/EN 61000-4-29	Voltage dips & interrupts	ac power port (120 Vac)	Up to 70% for 10/12 cycles (50/60 Hz)
			100% for 5/6 cycles (50/60 Hz)
		dc power port (48 Vdc)	30% for 1 s, 60% for 30 ms, 100% for 30 ms
IEC 60255-11	Voltage dips & interrupts	dc power port	100% reduction for up to 200 ms
IEC/EN 61000-4-12 IEC/EN 60255-22-1	Damped oscillatory	Communication ports	1.0kV Common, 0 kV Diff
		Signal ports	2.5kV Common, 1 kV Diff
		ac power port	2.5kV Common, 1 kV Diff
		dc power port	2.5kV Common, 1 kV Diff
IEEE C37.90.1	Oscillatory	Signal ports	2.5kV Common, 0 kV Diff
		ac power port	2.5kV Common, 0 kV Diff
		dc power port	2.5kV Common, 0 kV Diff
IEC/EN 61000-4-16	Mains frequency voltage	Signal ports	30V continuous, 300V for 1s
		ac power port	30V continuous, 300V for 1s
IEC/EN 61000-4-17	Ripple on dc power supply	dc power port	10%

NOTE:

The S-PRO 4000 is available with 5 or 1 amp current input. All current specifications change accordingly.

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