

PF maestro – SPF-21X Series Power Factor Controller







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PF maestro – SPF-21X Series is a high-performance, intelligent power factor correction controller designed for modern industrial power systems. It offers real-time, automatic power factor correction with precision up to three decimal places, optimizing energy efficiency and voltage stability. With support for 8+1 capacitor step control, advanced four-quadrant energy metering, and robust communication via MODBUS, this product series enables seamless integration into SCADA and energy management systems. It features built-in harmonic monitoring, capacitor health diagnostics without extra sensors. Engineered for flexibility and durability, it supports wide voltage ranges, operates reliably in harsh environments, and ensures safe, efficient capacitor switching through programmable delays and interleaving. This series is the ideal solution for industrial and commercial users seeking reliable, scalable, and intelligent power factor correction.

PRODUCT FEATURES

> Real-time Automatic Displacement Power Factor (D-PF) Correction

SPF-21X intelligently switches capacitor banks to maintain a programmable target PF up to three decimal places, ensuring optimal energy efficiency, improved voltage stability, and reduced utility penalties across dynamic industrial loads.

> 8+1 Capacitor Bank Step Control with Auxiliary Output

Capable of managing eight capacitor banks plus one auxiliary output for either an additional capacitor or alarm/trip function, providing flexible system expansion without hardware redesign.

- Four-Quadrant Energy Measurement with IEC-62053 Class 3.0 Compliance Accurately measures Active, Reactive, Apparent, and Distortion Power, supporting complex import/export systems and enabling precise energy audits and billing verification.
- Built-in RS-485 Communication Supporting MODBUS-RTU and MODBUS-ASCII Allows real-time remote monitoring and full configuration from SCADA, BMS, or energy management systems, streamlining centralized control and diagnostics.

> Wide Auxiliary Supply Range of 90-485V AC

The wide voltage range ensures the meter continues to function safely even during voltage fluctuations, preventing unexpected shutdowns or failures that could lead to electrical hazards, overheating, or damage to connected equipment.

> Easy Edit Mode for Quick Setup and Expert Edit Mode for Advanced Programming

Enables fast commissioning for standard systems while providing deep customization options such as CT correction, vector adjustment, step mapping, and generator management for complex installations.

> Automatic and Manual Current-Voltage Wiring Synchronization

Corrects CT polarity, phase sequencing, and vector configuration internally without requiring rewiring, reducing installation errors and commissioning time.

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> Dual Programmable Power Factor Targets for Grid and Generator Supply

Automatically adjusts PF targets based on detected supply type, protecting generators from leading PF damage and maintaining optimal network power factor during transitions.

- Capacitor Step Utilization Tracking (Switching Count and ON-Time Monitoring) Tracks each capacitor step's switching frequency and operating hours, calculates realistic usage levels, and enables predictive maintenance scheduling to prevent unplanned failures.
- Capacitor Health Monitoring Without Additional Current Sensors Analyzes VAR contribution per switching operation to detect faulty capacitors without needing extra CTs, saving installation costs while maintaining system integrity.
- Programmable Step Usage Limits Based on Capacitor Duty Cycles Configurable lifetime thresholds per capacitor step trigger timely maintenance alerts, optimizing asset lifespan and system reliability.
- > Capacitor Discharge Delay Control for Contact Protection

Applies programmable discharge delays between capacitor switching operations to ensure safe re-energization, protecting contactors from residual voltage damage and extending equipment life.

Interleaving Delay Between Capacitor Switching Events

Introduces adjustable delay between successive step activations, preventing simultaneous inrush surges and stabilizing network voltage levels.

Advanced Fault Monitoring with Over 47 Fault Types Detects and responds to various system faults with programmable fault reaction strategies,

ensuring full protection and uptime.

- Internal Data Logging and Event Recording Records energy usage, fault histories, and operational summaries, enabling data-driven preventive maintenance.
- Harmonic Monitoring for Voltage and Current up to the 31st Order Detects and helps mitigate harmonic-related power quality issues, protecting system components.
- Fully Configurable Relay and Auxiliary Outputs Supports custom assignment for alarms, fans, trips, and extended capacitor control, increasing system flexibility.
- User-Friendly 2-Line LCD Display with 7-Key Navigation Keypad Facilitates easy parameter viewing and device configuration even in poor lighting conditions.
- Robust Industrial Build with IP54 Front Protection and Fire-Retardant ABS Housing Ensures reliable, safe operation in harsh industrial environments.

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TECHNICAL SPECIFICATIONS

Function	Parameter	Condition	Minimum	Maximum			
		Measurement					
	Voltage (V) Sinusoidal	Phase & Neutral - fundamental Phase to Phase - fundamental	50V~ L-N 85V~ L-L	315V~ L-N 550V~ L-L			
	Current (I) Sinusoidal	5 Amp IN: - fund. Form fact = sqrt2 1 Amp IN: - fund. Form fact = sqrt2	75mA(cl- 2),25mA<0 15mA(cl- 2),05mA<0	7.5 Amp 1.5 Amp			
	Frequency	Frequency (Hz) (Fundamental Supply Voltage measurement of frequency)	47Hz (for 50Hz) 57Hz (for 60Hz) meas range 45Hz	53Hz (for 50Hz) 63Hz (for 60Hz) meas range 65Hz			
Supply	Power / Energy	IEC-62053 pt.21 & 23 4 quadrant measurement	5Amp range: Class 2: P & Q 1Amp range >0.2A: Class 2 P & Q				
	Maximum Demand	S (VA) 1 min sliding window P (W) (Window time user set)	Window time 5 - Minutes	Window time 60 - Minutes			
	Harmonics	Voltage - L-L & L-N Current - one of three phases	Spectrum: 2nd to 31st Harmonic. For Voltage and Current.				
	VA Burden	Voltage at 550V~ L-L Voltage at 415V~ L-L Voltage at 240V~ L-N Current at 7.5Amp~ S-CT Current at 5.0Amp~ S-CT Current at 1.0Amp~ S-CT	<0.15VA across 2 phases <0.10VA across 2 phases <0.65VA with 1ph & Neutral <1.0VA per ph. <0.5VA per ph. <0.05VA per ph.				
Capacitor Control							
PF Correction	Target PF	Displacement Power Factor setting	Inductive: 0.000	Capacitive: 0.000			
	VAR margin	Smallest capacitor bank VAR X	X 1.1	X 9.9			
	Offset to target	% above the target PF Setting	0%	100%			
ON/OFF control	Algorithm	Optimal value to target.	Single target PF with adjustable No action VAR tolerance band				
	Bank Utilization	Limit = (Number of switch ON / C) + (On duration in Minutes / T)	C = 01 (00 for Disb.) T = 01 (00 for Disb.)	C = 99 T = 99			
	Relay Contacts	8 - numbers of Relay "NO" contacts.	5Amp Resistive / 0.5Amp Inductive Amp~ 250V~ voltage contact rating.				

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Auxiliary Supply								
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> 68 Volt								
5Amp Resistive / 0.5Amp Inductive								
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Communication									
Communication	RS-485	Protocol	MODBUS-(RTU & ASCII), PC App (user settings)						
Temperature sensing									
Internal unit temperature	For Unit right functioning	Range within unit operating temperature	0°C	+65°C					
Environmental / Sa	afety - Type test	s							
IEC61326-1	EMC	Electromagnetic Compatibility	Compliance Compliance						
	EMI	Electromagnetic Interference							
IEC61010-1	Safety Standards	Safety Standards with Low Voltage instruments directive (category III)	Compliance						
RoHS	2002/95/EC RoHS 3.0	Regulation on Hazardous Substances usage.	Compliance						
CE			Compliance						
	Dry Heat	Storage condition +70°C for 72Hrs.	Compliance						
IEC60068-2	Cold Test	Storage condition -25°C for 72Hrs.	Compliance						
	Damp Heat Cyclic Test	Power-up condition At RH 93% +40°C & +25°C 12-12Hrs. cyclic 144Hrs.	Compliance						
Temperature	Operating	Surrounding Ambient temperature	0°C	+60°C					
remperature	Storage	Surrounding Ambient temperature	-10°C	+70°C					
Humidity	RH%	Relative Humidity	10%RH 95%RH (non- cond.)						

All specifications are typical and subject to change without notice due to ongoing product development and improvement.

WIRING TERMINALS



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MECHNICAL DIMENSIONS



WIRING RECOMMENDATIONS





4-Wire LV (160V~LL to 440V~LL / 3-ph) 3-Wire Capacitors





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	Features/Models	SPF-21)	SPF-21	SPF-21	SPF-21	SPF-21	SPF-21
	√ - Available	8/X	8/X	X/4	X/6	8/X	8/X
	• - Optional	K1	T1N	K1I	K1I	K1	11T
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	Steps	8	8	4	6	8	8
	Mounting dimensions 96 X 96		\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
	Step switching Relay (R)	\checkmark	Х	\checkmark	\checkmark	\checkmark	\checkmark
	Step switching Transistor (T)	Х		Х	Х	Х	Х
Hardware	Supply Current Measurement 1-CT	\checkmark		\checkmark	\checkmark	\checkmark	
	Communication port RS-485 MODBUS + PC-App	\checkmark	\checkmark	Х	Х	Х	Х
	Internal Temperature sensing within MCU	\checkmark		\checkmark	\checkmark	\checkmark	
	Auxiliary Dig. Inputs	\checkmark		\checkmark	\checkmark		\checkmark
	Auxiliary Digital Outputs	\checkmark		\checkmark	\checkmark	\checkmark	
	Supply freq. phase locked measurement	\checkmark		\checkmark	\checkmark		\checkmark
	Voltage meas. 4W, 3W, 2WLL, 2WLN	•	•	•	•	•	•
	Power meas. 3Watt-met, 2Watt-met, 1Watt-met	•	•	•	•	•	•
	Supply RMS Current & Voltage measurement	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Volt/Amp/Cap-ind. Volt & Amp fundamental values	•	•	•	•	•	•
	Power Distortion & Cross distortion values	\checkmark		\checkmark	\checkmark		\checkmark
	Minimum supply current sensitivity 0.001% of rated	\checkmark		\checkmark	\checkmark	\checkmark	
	Frequency range 45Hz to 65Hz	\checkmark		\checkmark	\checkmark	\checkmark	
	P,Q,S RMS 3-phase overall Values	\checkmark		\checkmark	\checkmark		\checkmark
	P,Q,S Fundamental 3-phase Overall Values	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
M	Ph,Qh,Sh + & - RMS Energy	\checkmark		\checkmark	\checkmark	\checkmark	
Measurement &	Ph1,Qh1,Sh1 + & - Fund. Energy	\checkmark		\checkmark	\checkmark	\checkmark	
Display	Maximum (+/-) values of various measured parameters	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Maximum Demand KVA & KW-user set sliding window	\checkmark		\checkmark	\checkmark	\checkmark	
	Supply Voltage harmonics THD-% & value	\checkmark		\checkmark	\checkmark		
	Supply current harmonics THD% & TDD%	\checkmark		\checkmark	\checkmark	\checkmark	
	Volt & Amp, C/I.Amp harmonic spectrum up to 31st	•	•	•	•	•	•
	Display on External PC/Laptop	\checkmark		Х	Х	Х	Х
	AC voltage meas. with aux.i/p (contactor coil)	\checkmark		\checkmark	\checkmark		\checkmark
	PFC internal operating temperature	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Capacitor steps VAR on-line detection (normalized)	\checkmark		\checkmark	\checkmark		\checkmark
	Capacitor steps Utilization (switching & time)	\checkmark		\checkmark	\checkmark		\checkmark
	PFC powering up/down counter	\checkmark		\checkmark	\checkmark		\checkmark
	PFC power voltage 90V~ to 485V~ (Max limit 600V~)	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	EMI filter for transient protection on PFC power supply	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Early Warning Power Fail detection for data loss	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
Reliability	Capability to work in Dusty & Conductive environment	\checkmark		\checkmark	\checkmark	\checkmark	
	Operability at -10°C to +60°C ambient temperature	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	S/c protected sourcing / sinking current Transistor o/ps	Х		Х	Х	Х	Х
	Galvanically isolated communication ports	\checkmark		Х	Х	Х	Х

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PRODUCT SELECTION AND FEATURES

	Features/Models √ - Available X - Not Available • - Optional	SPF-21X/8K1MO	SPF-21X/8T1MO	SPF-21X/4K1NO	SPF-21X/6K1NO	SPF-21X/8K1NO	SPF-21X/8T1NO
	Contactor coils voltage over / under value	\checkmark			\checkmark		\checkmark
	Over & Under Voltage on meas. Voltage	\checkmark					\checkmark
	PFC power shutoff protection for excess Over-voltage		V	N		N	
	Supply Voltage Over-frequency and Under-frequency	\checkmark	N	N		<u>م</u>	\checkmark
Fault Monitoring &	Capacitor step VAR health monitor & selective trip		N	N	N	N	N
Capacitor Tripping	Capacitor step user masking	N	N	N	N	N	N
	Supply Voltage, Current Over-harmonics	N	N	N	N	N	N
	Capacitor step over-utilization selective trip	N	N	N	N	N	N
	PFC electronics & memory self monitoring faults	N	N	N	N	N	N
	Over Temperature Internal to PFC unit	N	N	N	N	N	N
	Stan control by over temperature	N	N	N	N	N	N
A La	Step/s declared faulty & masked	N	N	N	N	N	N
Alarms &	Stop/s (1 or more) trip alarm	N	N	N	N	N	N
AUX.1 unction		N N	N N	N	N N		N
	Lipit functioning without any fault indicator	N N	N N	N N	N N	<u>v</u>	N N
	EASY EDIT settings for standard LV usage	N N	N N	N N	N N	<u>v</u>	N
	PC programmable EXPERT EDIT remote upload	N N	N N	X	X	X	X
		√			$\overline{\mathbf{A}}$	× √	$\overline{\mathbf{A}}$
	Steps Capacitor testing mode	- 	1	1		1	1
	Fixed capacitor banks step declaration by user	v √	v √	1	 √		 √
	Fixed or Proportionate Correction time - user set			1			 √
	User friendly Keyboard for front operations			1	ب	- - \	1
	Capacitor step status on front I CD			- - 	, √	1	
	Adjustable C/K:Offset & VAR band width to Target PF	√					√
	Automatic Supply V & A synchronization						
	Automatic step VAR detection						
	Manual wiring V & A synchronization						
Application	Expansion of steps by additional module	\checkmark			\checkmark		\checkmark
	Dual PF settings for Generator & Grid supply	\checkmark			\checkmark		\checkmark
	Voltage & Current sensing on 2 sides of transformer	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Remote communication for VAR compensation	\checkmark		Х	Х	Х	Х
	HV side sensing and LV side compensation	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	LV side sensing & compensation with HV side control	\checkmark			\checkmark	\checkmark	\checkmark
	4-quadrant operation for Solar/Wind generation	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	High speed cycle to cycle control with Thy.version	Х	\checkmark	Х	Х	Х	Х
	PC-Application program for data view & log	\checkmark	\checkmark	Х	Х	Х	Х
	Two X'mer with 2 APFC with bus coupler operation		\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
	Monthly auto reset of MD / Energy values	\checkmark	\checkmark		\checkmark		\checkmark
	Password protected user settings		\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
	"I AM OK" self-monitoring health indicator (LED / LCD)						\checkmark

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	Features/Models √ - Available X - Not Available • - Optional	SPF-21X/8K1MO	SPF-21X/8T1MO	SPF-21X/4K1NO	SPF-21X/6K1NO	SPF-21X/8K1NO	SPF-21X/8T1NO
Data Logging (PQ	Real time data availability on MODBUS (RS-485)	\checkmark		Х	Х	Х	Х
ANALYSIS) & IoT	User settings by PC-App "PFC_DATAVIEW"			Х	Х	Х	Х
(SCADA)	MODBUS declaration of any step masked or usable	\checkmark		Х	Х	Х	Х
	CE	\checkmark			\checkmark	\checkmark	\checkmark
	ROHS				\checkmark	\checkmark	
	EMC	\checkmark			\checkmark	\checkmark	\checkmark
	EMI	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
Turne Teet	SAFETY Voltage category III				\checkmark	\checkmark	\checkmark
Cortifications	Environmental – Fire retardant material housing				\checkmark	\checkmark	\checkmark
Certifications	IP Enclosure – Front IP54, Back IP30	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Pollution Degree III compliance	•	•	•	•	•	•
	Accuracy of Measurement as defined	\checkmark		\checkmark	\checkmark	\checkmark	\checkmark
	Galvanic isolation insulation standards	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark
	Storage & Handling Safety	•	•	•	•	•	•