Grid-Connected Photovoltaic Inverter

Technical Specification

Model:

SOLEIL 3F-TL 10K

SOLEIL 3F-TL 15K

SOLEIL 3F-TL 20K

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1. Introduction

This specification is regarding to a series of Photovoltaic Inverters (PV Inverter) developed by Siel S.p.A.. The inverter is used to convert DC power from solar array[1] to AC power fed to grid in distributed power applications.

1 The inverter is suitable for silicon module or Thim-Film without grounding.

2. Features

1. Transformerless design
2. Maximum efficiency ≧ 97.5%
3. Euro efficiency ≧ 97%
4. RCMU (GFCI) embedded
5. Lead-free, RoHS complied
6. DC switch embedded

3. Electrical & Power curve

3.1 Electrical specification

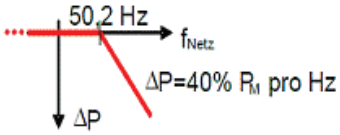
Model	SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Input (DC)			
Nominal DC voltage	720 V		
Max. PV open voltage	1000V		
System start-up voltage	260 V		
Initial feeding voltage	350 V		
Shutdown voltage	Typical 200V		
Working voltage range[2]	250 ~ 1000V		
MPPT Full rating voltage range	350 ~ 850 V	400 ~ 850 V	450 ~ 850 V
MPPT efficiency	> 99%		
Number of MPP tracker(s)	2		
Max. DC power	10500W	15750W	21000W
Max. DC current	16A×2	20A×2	23A×2
Max. number of parallel strings	2×2	2×2	3×2
DC insulation resistance[3]	> 1.2MΩ		
DC insulation	Transformerless design, input can't connect to ground. (Ungrounded photovoltaic power system)		
Output (AC)			
Nominal AC power	10kW/ 10kVA	15kW/ 15kVA	20kW/ 20kVA
Max. AC power	10kW/ 10kVA	15kW/ 15kVA	20kW/ 20kVA
Nominal AC current	14.5A	21.7 A	29 A
Max. AC current	16A	24A	30A
DC current injection (Max.)[4]	20mA	50mA	70mA
AC grid voltage / Range	230 / 400Vac, 3ψ4W+PE / ±20%, depending on country configuration (refer to 3.2)		
AC grid frequency / Range	50Hz / 60Hz / depending on country configuration (refer to 3.2)		
O/P current distortion (THD i)[5]	< 3%		
Phase shift (cosψ) at nominal output power (adjustable)	>0.99 (±0.8 on demand)		

[2] Which is the DC voltage range that inverter can feed power to grid.
[3] The DC resistance requirement for positive or negative terminal to chassis ground
[4] Average current in 5 minutes
[5] THDv < 1% condition

Model	SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Efficiency[6]			
Max. conversion efficiency	≧97.5%		
European efficiency	≧97.0%		
General Data			
Topology	Transformerless		
Power consumption: standby[7] / night	≦ 20W / ≦ 1W		
Protection degree	Outdoor / Chassis: IP65 / Fan: IP55		
Heat dissipation	Force air cooling, variable fan speed according to temperature on heatsink		
Acoustic noise level	≦ 55dB(A)		
Working temperature range	- 20 ~ + 60℃		
Continuous O/P power temperature range	- 20 ~ + 45℃		
Humidity	100%, condensing		
Altitude	Up to 2000m without power derating		
Hazard substance restriction	Lead free, complied with RoHS GP2		
Ground fault protection	Internal RCMU (GFCI) and Isolation detection function, in accordance with VDE0126-1-1		
DC disconnect (Optional)	EN/IEC standard approved DC Switch		
Communication	- Standard: USB B type, Modbus, RS485		
RS485 Protocol			
Front Bezel	Data logger - Display: 128 × 64 pixels - Function key × 5 - Standard: embedded - Optional: removable		
Normative references			
Market	Germany	Italy	England
Model Name	SOLEIL3F-TL10K/15K/20K		
Grid interface regulation	VDE-AR-N 4105 VDE0126-1-1/A1	CEI 0-21	G83/1-1 G59 Issue 2
Regular safety	IEC 62109-1: 2010, EN 62109-1: 2010 IEC 62109-2: 2011, EN 62109-2: 2012		
EMC	EN 61000-6-2: 2005 EN 61000-6-3: 2007/A1: 2011		
DC Switch	EN 60947-1 EN 60947-3		
CE	LVD: 2006/95/EC EMC: 2004/108/EC		

[6] According to EN61683-1991
[7] DC voltage 260~350V

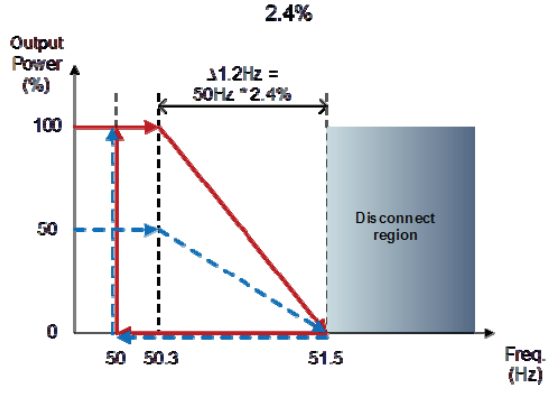
3.2 Country configuration

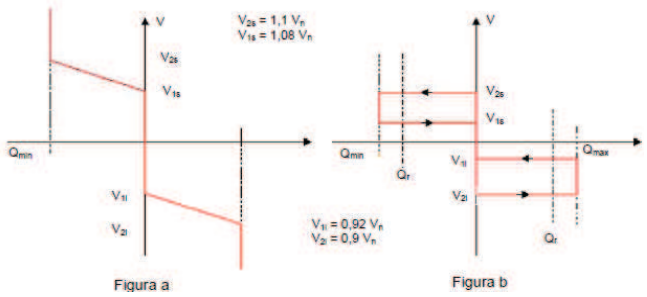
Model	SOLEIL 3F-TL10K SOLEIL 3F-TL15K SOLEIL 3F-TL20K			SOLEIL 3F-TL10K SOLEIL 3F-TL15K SOLEIL 3F-TL20K		
Grid Monitoring	**VDE-AR-N 4105**			**VDE0126-1-1/A1**		
Display model name	SOLEILT10 DE			SOLEILT15 / 20 DE		
limit of single phase	N/A			N/A		
Operational voltage range	230V / 400V, -20%+15%			230V / 400V, -20%+15%		
Disconnection time of excess operational voltage range[8]	-20%	+15%	+10%	-20%	+15%	+10%
	< 0.1s		< 0.1s	≦0.2s		≦0.2s
Voltage value setting in the firmware[9]	184V	264.5V	253V	187V	262V	250V
Power factor	0.9 lagging/leading			0.99		
Voltage tolerance	better than 1%			N/A		
Frequency tolerance	better than 0.1%			N/A		
Operational frequency range	 1. 47.5~51.5Hz , Disconnection within 0.2seconds 2. Back frequency point: The same as the red curve (Before disconnection)					
Frequency value setting in the firmware	47.5 Hz	51.5Hz		47.55 Hz	51.45Hz	
Reconnection time	1. 60s @ 85% ~ 110% voltage & 47.5Hz ~ 50.05Hz with 10% Power/min increment					
Reconnection time(FW setting)						
Disconnection time of excess DC current injection (sec.)	< 0.1s			< 0.2s		
DC-Injection	1A			1A		

[8] After calculating of the mean value of 10 minutes then it just can trip for +10%

[9] If only an integrated NS protection is used for power generation systems of up to 30 kVA, then the value of the rise-in-voltage protection U of 1.1 Un shall not be changed.

Model	SOLEIL 3F-TL10K		SOLEIL 3F-TL15K SOLEIL 3F-TL20K			
Grid Monitoring	**G83/1-1**		**G59 Issue 2**			
Display model name	SOLEILT10 UK		SOLEILT15 / 20 UK			
limit of single phase	< 16A/phase		> 16A/phase			
Operational voltage range	230V / 400V, -10%+14.7%		230V / 400V, -20%+15%			
Disconnection time of excess operational voltage range	-10%	+14.7%	-20%	-13%	+10%	+15%
	< 1.5 s		< 0.5s	< 2.5s	< 1s	< 0.5s
Voltage value setting in the firmware	210V	261V	184V	200.1V	253V	264.5V
Operational frequency range	47Hz	50.5Hz	47Hz	47.5Hz	51.5Hz	52Hz
	< 0.5s		< 0.5s	20s ~ 21s	90s ~ 91s	< 0.5s
Frequency value setting in the firmware	47.05 Hz	50.45Hz	47Hz	47.5Hz	51.5Hz	52Hz
Reconnection time	180s		180s			
Reconnection time (FW setting)						
Disconnection time of excess DC current injection (sec.)	NA		NA			
DC-Injection	< 20mA		< 0.25% of Nominal AC current			

Model	SOLEIL 3F-TL10K/15K/20K	
Grid Monitoring	CEI 0-21 *(1)	
Display model name	SOLEIL 3F-10 /15 / 20K **IT**	
limit of single phase	N/A	
Operational voltage range	230V / 400V,	
Power Factor Range	0.9 over or under excited	
S1 Voltage *(2)	46 ~230V	230 ~276.0V
FW default setting	184V (80%)	264.5V (115%)
S1 V Disconnection Time	0.05~5.00S	0.20~10.00S
FW default setting	0.5s	0.2s
S1 Frequency	47.0 ~50.0Hz	50.0 ~52.0Hz
FW default setting	47Hz	51Hz
S1 F Disconnection Time	0.05~5.00S	0.05~5.00S
FW default setting	4s	1s
S2 Voltage	0 ~230V	230 ~299.0V
FW default setting	0V	264.5V (115%)
S2 V Disconnection Time	0.05~5.00S	0.05~1.00S
FW default setting	0.2s	0.2s
S2 Frequency	47.0 ~50.0Hz	50.0 ~52.0Hz
FW default setting	47Hz	51Hz
S2 F Disconnection Time	0.10~5.00S	0.10~5.00S
FW default setting	4s	1s
Limitation curves of active power via frequency (2~5%Adjustable, 2.4% as Default, can be disable/enable)		

Reconnection time (FW Setting)	wait 300 sec with frequency inside "Value of frequency to reset the derating condition"	
Slow-Start after derating condition P(f)	20% per min to frozen load	
Value of frequency to reset the derating condition	49.90 - 50.10 Hz (settable for island)	
Reconnection voltage	195,5 V - 253 V	
Reconnection frequency	49,90 - 50,10 Hz default (settable from 49Hz to 51Hz by steps of 0,05Hz)	
Reconnection time	300s default (settable from 0s to 900s by steps 5s)	
Slow-Start after disconnection	20% per min to nominal Power (10kW)	
DC-Injection	> 1 sec @0.5% (72.5mA) & > 0.2sec @ 1A	
Reactive Power control		
1.Const.		
10kVA	Cosfi = 1 P=10KW Q = 0 VAR	Cosfi = 0.9 -> P = 9KW Q= (-)4358 Var ~ (+)4358 Var (48.43% P)
15kVA	Cosfi = 1 P=15KW Q = 0 VAR	Cosfi = 0.9 -> P = 13,5KW Q=(-)6537 Var ~ (+) 6537 Var (48.43% P)
20kVA	Cosfi = 1 P=20KW Q = 0 VAR	Cosfi = 0.9 -> P = 18KW Q=(-)8717 Var ~ (+) 8717 Var (48.43% P)
2. Const PF	(-)0.90 ~(+)0.90 pf	
3. Curve Q(U)with type A&B		

	P Lock-in: 20% Pn	*P Lock-out: 5% Pn*
Node1:	*90%*	*(+)43.6% Q/S*
Node2:	*92%*	*(+) 0% Q/S*
Node3:	*108%*	*(+) 0% Q/S*
Node4:	*110%*	*(-)43.6% Q/S*

4.Curve PF(P) Type A	*V Lock-in: 241.5 V*	*V Lock-out:230.0 V*
Node1:	*20%*	*(+) 1.00pf*
Node2:	*40%*	*(+) 1.00pf*
Node3:	*50%*	*(+) 1.00pf*
Node4:	*90%*	*(-) 0.90pf*
Curve PF(P) Type B		
Node1:	*0%*	*(+) 1.00pf*
Node2:	*5%*	*(+) 1.00pf*
Node3:	*5%*	*(-)0.90pf*
Node4:	*90%*	*(-) 0.90pf*

(1)CEI 0-21 LV (S1=S2) LV & MV has the same default setting :

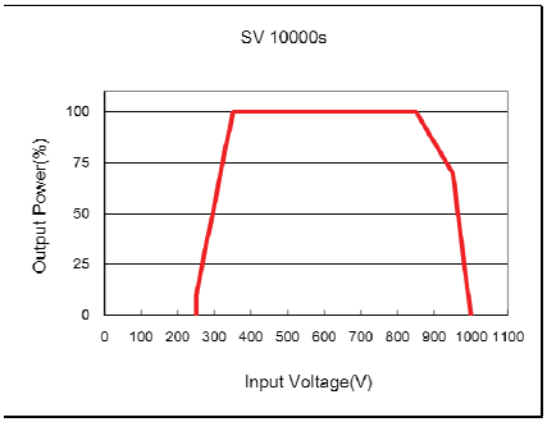
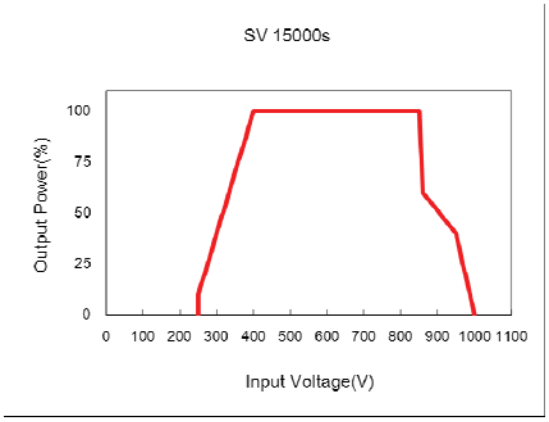
V↑ = 276V 0,5s, V↓ = 184V 1s, F↓ = 47Hz 4s, F↑ = 52Hz 1s, Slope:2.4%

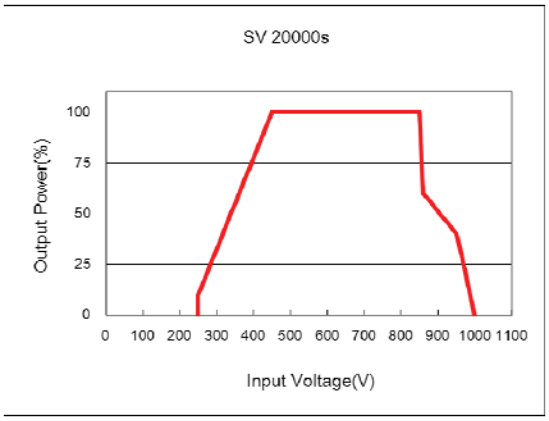
(2) In CEI 0-21, Voltage & Frequency operation range & disconnection time setting are adjustable.

S1 Voltage average value of the voltage measured on a time window of 10 min mode moving average

(3) The inverter must start in any case when the F & V are allocated in 49.9~50.1hz & 195.5 ~253V, (included the first start)

3.3 Power curve

Model	Formula	Curve
SOLEIL 10K	In case the input voltage is lower than 350Vdc and higher than 850Vdc, the output power can be handled by controller. The output power within the range of de-rating can be determined by the following equation: **Vpv: 250~350V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{V_{pv}-250}{100}\right)\times 90\%+10\%$ **Vpv: 850~950V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{950-V_{pv}}{100}\right)\times 30\%+70\%$ **Vpv: 950~1000V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{1000-V_{pv}}{50}\right)\times 70\%$	
SOLEIL15K	In case the input voltage is lower than 400Vdc and higher than 850Vdc, the output power can be handled by controller. The output power within the range of de-rating can be determined by the following equation: **Vpv: 250~400V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{V_{pv}-250}{150}\right)\times 90\%+10\%$ **Vpv: 850~860V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{860-V_{pv}}{10}\right)\times 40\%+60\%$ **Vpv: 860~950V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{950-V_{pv}}{90}\right)\times 20\%+40\%$ **Vpv: 950~1000V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{1000-V_{pv}}{50}\right)\times 40\%$	

SOLEIL 20K	In case the input voltage is lower than 450Vdc and higher than 850Vdc, the output power can be handled by controller. The output power within the range of de-rating can be determined by the following equation: **Vpv: 250~450V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{V_{pv}-250}{200}\right)\times 90\%+10\%$ **Vpv: 850~860V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{860-V_{pv}}{10}\right)\times 40\%+60\%$ **Vpv: 860~950V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{950-V_{pv}}{90}\right)\times 20\%+40\%$ **Vpv: 950~1000V** Power Limit $_{(Vpv)}$ (%) = $\left(\frac{1000-V_{pv}}{50}\right)\times 40\%$	

4. Mechanical requirements

4.1 Dimension

Model	SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Dimension W×H×D (mm)	548 × 565 × 268	548 × 565 × 268	548 × 565 × 268

4.2 Weight

Model	SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Net weight	46kg	52kg	57kg

4.3 Installation method

Model	SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Wall mounted	Yes		
Tower orientation	No		

4.4 Connection of wires

Model		SOLEIL 3F-TL10K	SOLEIL 3F-TL15K	SOLEIL 3F-TL20K
Input (DC side)	M4 connectors (pairs)	4	4	6
Output (AC side)	Terminal blocks	Terminal block labeled with L1, L2, L3, N and G		
	Maximum admissible conductor size	10 AWG	8AWG	8AWG

5. Controls

5.1 Internal control

To meet VDE 0126-1-1, redundancy and maximum safety, there are 2 controllers inside. Both controllers monitor the grid frequency, voltage and in the same time. In addition, each of them is responsible for its own output switch, the channel where the inverter feed power to grid.

5.2 Residual current monitoring unit (RCMU)

The specification of RCMU (GFCI) is based on VDE0126-1-1
The ground fault current (as known as residual current) is represented as I_G.
Once ΔI_G ≥30mA (+0%/-30%), inverter must stop feeding according to IEC/TR 60755/ A2: 1992 Type B requirements and following rules.

a) Before connecting, the insulation resistance in DC side has to be larger and equal than 1kΩ/V. This is proportional to DC input voltage. However, the minimum resistance must be larger than 500kΩ.
b) While feeding, once I_G ≥300mA, the feeding must be stopped in 300mS.
c) The disconnection criterion of ground fault current is based on the table below

ΔI_G (RMS)	Disconnection time
30mA	300mS
60mA	150mS
150mA	40mS

5.3 MPPT function

1. General: There are 2 MPP trackers inside. Each can track the maximum power of the PV panel connected to individually
2. Parallel operation: The multi-MPP trackers can work either individually or in parallel. That is, user can connect more than 1 MPP trackers to single PV array. The inverter will identify the connection and change to proper operation modes
3. In case the total power from PV array is larger than inverter demands in multi-MPPT operation, inverter shall distribute individual current as small as possible. This can reduce the wire loss as small as possible
4. In case one of the MPP trackers fails to operate, inverter should keeping feeding power if possible.

5.4 Self check

1. Sensing circuit: The inverter must check its internal sensing circuit including output DC sensor, GFCI circuit before connecting to grid.
2. Controller check: The unit must check the data consistence between 2 controllers all the time.