TECHNICAL REFERENCE NOTE

Advanced Energy

SL POWER TF3000 SERIES

3000 Watts Single Output Industrial Grade

PRODUCT DESCRIPTION

Advanced Energy's SL Power TF3000 series of industrial grade AC-DC fan-cooled power supply comprises seven output models. All models feature industrial safety approvals and accept a universal input of 90 to 264 Vac. These compact switch-mode power supplies feature output over voltage, over temperature, over load, and short circuit protections. The TF3000 series power supplies provide up to 3000 watts of output power with remote setting and global control function.

AT A GLANCE

Total Power

3000 Watts

Input Voltage

90 to 264 Vac

127 to 370 Vdc

# of Outputs

Single

RoHS

SPECIAL FEATURES

- 3000 watts fan-cooled (load & temperature controlled)
- Programmable output voltage (0% to 105%)
- Programmable output current (0% to 105%)
- Forced current sharing at parallel operation
- Constant current limit
- Selectable 5V/0.5A or 9V/0.3A auxiliary output
- Remote setting multiple PSU via RS232, RS485 & I^2C
- Protection: OVP, OLP, OTP, SCP, fan failure
- Conformal coating applied
- Three-year warranty

COMPLIANCE

- EMI Class A, with 6db margin
- EN 61000 Immunity
- RoHS compliant
- REACH compliant

SAFETY

- CSA/IEC/EN/UL 62368-1
- CB certificate and report
- TUV
- CE (LVD + EMC)
- UKCA Mark

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SECTION 1 MODEL NUMBERS

Model	Output Voltage	Maximum Output Current	Output Power	Auxiliary Output
TF3000A12K	12Vdc	200A	2400W	+5V/0.5A or +9V/0.3A
TF3000A15K	15Vdc	160A	2400W	+5V/0.5A or +9V/0.3A
TF3000A24K	24Vdc	125A	3000W	+5V/0.5A or +9V/0.3A
TF3000A30K	30Vdc	100A	3000W	+5V/0.5A or +9V/0.3A
TF3000A36K	36Vdc	83.3A	3000W	+5V/0.5A or +9V/0.3A
TF3000A48K	48Vdc	62.5A	3000W	+5V/0.5A or +9V/0.3A
TF3000A60K	60Vdc	50A	3000W	+5V/0.5A or +9V/0.3A

Options

No Options

Family Comparison

Model Number	Output Voltages	Output Power	Auxiliary Output	Dimension
TF800 Series	12V, 15V, 24V, 30V, 36V,48V, 60V	800W	+5 V/0.5 A or +9 V/0.3 A selectable	5.0” x 1.6” x 9.80”
TF1500 Series	12V, 15V, 24V, 30V, 36V,48V, 60V	1500W	+5 V/0.5 A or +9 V/0.3 A selectable	5.0” x 2.5” x 11.02”
TF3000 Series	12V, 15V, 24V, 30V, 36V, 48V, 60V	3000W	+5 V/0.5 A or +9 V/0.3 A selectable	6.7” x 2.5” x 11.02”
TF3000HV Series	150V, 200V, 250V,300V, 400V	3000W	+5 V/0.5 A or +9 V/0.3 A selectable	6.69” x 2.5” x 11.02”

SECTION 2 ELECTRICAL SPECIFICATIONS

2.1 Absolute Maximum Ratings

Stress in excess of those listed in the “Absolute Maximum Ratings” may cause permanent damage to the power supply. These are stress ratings only and functional operation of the unit is not implied at these or any other conditions above those given in the operational sections of this TRN. Exposure to any absolute maximum rated condition for extended periods may adversely affect the power supply’s reliability.

Table 1. Absolute Maximum Ratings

Parameter	Model	Symbol	Min	Typ	Max	Unit
Input Voltage AC continuous operation DC continuous operation	All models	$V_{IN,AC}$ $V_{IN,DC}$	90 127	- -	264 370	Vac Vdc
Maximum Output Power[1] $V_{IN,AC}$ > 180Vac	12V, 15V models Other models	$P_{O,max}$	- -	- -	2400 3000	W W
Isolation Voltage - AC Voltage Input to output Input to ground Outputs to ground	All models		- - -	- - -	3000 1500 500	Vac Vac Vac
Isolation Voltage - DC Voltage Input to output Input to ground Outputs to ground	All models		- - -	- - -	4242[2] 2121 707	Vdc Vdc Vdc
Isolation Resistance 500Vdc	All models		-	-	100	Mohm
Ambient Operating Temperature	All models	T_A	-25	-	+60[3]	°C
Storage Temperature	All models	T_{STG}	-40	-	+85	°C
Humidity (non-condensing) Operating Non-operating	All models		20 10	- -	90 95	% %
Altitude Operating Non-operating	All models		- -	- -	3000 3000	meters meters
MTBF	Certified MIL-HDBK-217F		112	-	-	KHours

Note 1 - Refer to derating curve for the max output power with input voltage lower than 180Vac.
Note 2 - This input to output 4242Vdc is done without enclosure. If with enclosure, the input to output isolation voltage is 2121Vdc.
Note 3 - Output power is derated 50% linearly from 50°C to 60°C.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.2 Input Specifications

Table 2. Input Specifications

Parameter		Condition	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, AC[1]		All	$V_{IN,AC}$	90	115/230	264	Vac
Operating Input Voltage, DC		All	$V_{IN,DC}$	127	-	370	Vdc
Input AC Frequency		All	f_{IN}	47	50/60	63	Hz
Maximum Input Current		$V_{IN,AC}$ = 115Vac[2] $V_{IN,AC}$ = 230Vac[3]	$I_{IN,max}$	- -	- -	19.7 14.5	A
No Load Input Current (V_O = On, I_O = 0A, I_{AUX} = 0A)		$V_{IN,AC}$ = 115/230Vac	$I_{IN,no\text{-}load}$	-	0.3	-	A
No Load Input Power (V_O On, I_O = 0A, I_{AUX} = 0)		$V_{IN,AC}$ = 115/230Vac	$P_{IN,no\text{-}load}$	-	10	-	W
Standby Input Current (V_O Off, I_{AUX} = 0)		$V_{IN,AC}$ = 115/230Vac	$I_{IN,Standby}$	-	0.2	-	A
Standby Input Power (V_O Off, I_{AUX} = 0)		$V_{IN,AC}$ = 115/230Vac	$P_{IN,Standby}$	-	6.0	-	W
Harmonic Line Currents		All	THD	IEC 61000-3-2			
Power Factor		I_O = $I_{O,max}$ $V_{IN,AC}$ = 115Vac $V_{IN,AC}$ = 230Vac	PF	0.98 0.95	- -	- -	- -
Startup Surge Current (Inrush) @ 25°C		$V_{IN,AC}$ = 115Vac $V_{IN,AC}$ = 230Vac	$I_{IN,surge}$	- -	- -	33 65	A_{PK}
Leakage Current to Safety Ground		V_{IN} = 240Vac f_{IN} = 60Hz	$I_{IN,leakage}$	-	-	3.5	mA
Input Fuse		Internal, 250Vac rated		-	25	-	A
Efficiency (T_A = 25°C, forced air cooling)	TF3000A12K	$V_{IN,AC}$ = 230Vac I_O = $I_{O,max}$	η	-	88	-	%
	TF3000A15K			-	89	-	
	TF3000A24K			-	91	-	
	TF3000A30K			-	91	-	
	TF3000A36K			-	92	-	
	TF3000A48K			-	92	-	
	TF3000A60K			-	93	-	

Note 1 - Derating is applied in low input voltage. Check the derating curve for details.
Note 2 - Test with 2000W output power (1600W for 12V, 15V models).
Note 3 - Test with 3000W output power (2400W for 12V, 15V models).

SECTION 2 ELECTRICAL SPECIFICATIONS

2.3 Output Specifications

Table 3. Output Specifications

Parameter		Condition	Symbol	Min	Typ	Max	Unit
Factory Set Voltage	TF3000A12K	$V_{IN,AC}$ = 180Vac $I_O = I_{O,max}$	$V_{O,factory}$	11.94	12.00	12.06	Vdc
	TF3000A15K			17.91	18.00	18.09	
	TF3000A24K			23.88	24.00	24.12	
	TF3000A30K			29.85	30.00	30.15	
	TF3000A36K			35.82	36.00	36.18	
	TF3000A48K			47.76	48.00	48.24	
	TF3000A60K			71.64	72.00	72.36	
Output Current, continuously	TF3000A12K	$V_{IN,AC}$ > 180Vac	$I_{O,max}$	0	-	200	A
	TF3000A15K			0	-	160	
	TF3000A24K			0	-	125	
	TF3000A30K			0	-	100	
	TF3000A36K			0	-	83.3	
	TF3000A48K			0	-	62.5	
	TF3000A60K			0	-	50	
	5V aux output 9V aux output		$I_{AUX,max}$	0 0	- -	0.5 0.3	
Output Ripple, pk-pk	TF3000A12K	Measured at 20MHz bandwidth by a 12” twisted pair-wire terminated with a 0.1µF and a 47µF in parallel capacitor	V_O	-	-	150	mV
	TF3000A15K			-	-	150	
	TF3000A24K			-	-	240	
	TF3000A30K			-	-	300	
	TF3000A36K			-	-	360	
	TF3000A48K			-	-	480	
	TF3000A60K			-	-	600	
Capacitive Load	TF3000A12K	$V_{IN,AC}$ = 230Vac C_O = 1000µF x $I_{O,max}$	C_O	-	-	200000	µF
	TF3000A15K			-	-	160000	
	TF3000A24K			-	-	125000	
	TF3000A30K			-	-	100000	
	TF3000A36K			-	-	83300	
	TF3000A48K			-	-	62500	
	TF3000A60K			-	-	50000	

SECTION 2 ELECTRICAL SPECIFICATIONS

2.3 Output Specifications

Table 3. Output Specifications con't

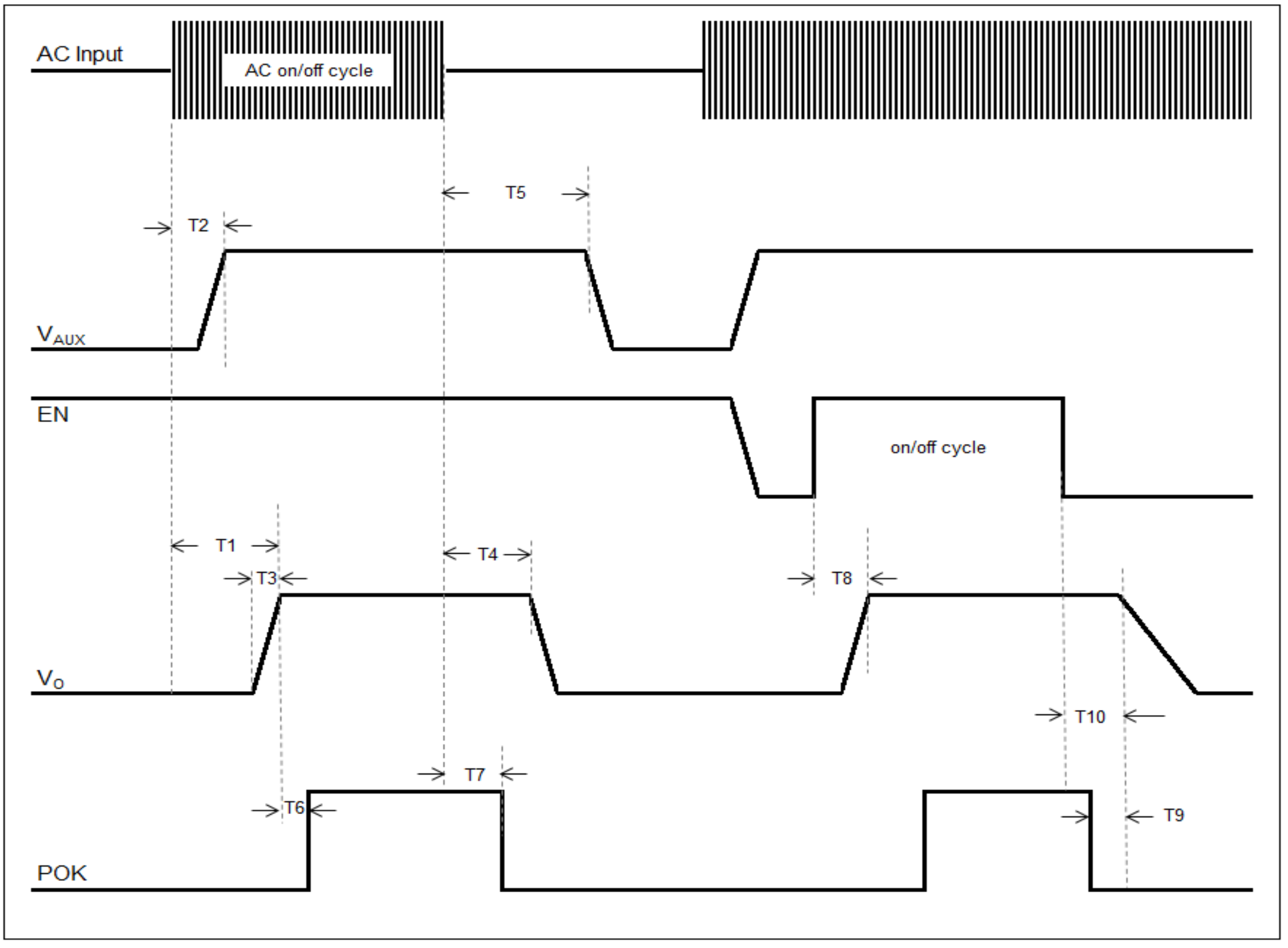
Parameter	Condition	Symbol	Min	Typ	Max	Unit
Output Voltage Adjustment Range	By potentiometer VR1 By VCI programming	$\%V_O$	-5 0	- -	+5 105	%
Line Regulation	All models	$\%V_O$	-1	-	+1	%
Load Regulation	All models	$\%V_O$	-1	-	+1	%
Total Regulation	Inclusive of setup time tolerance, line, load regulation	$\%V_O$	-2	-	2	%
Number of Parallel Units[1]	PAR pins connected		-	-	8	Units
V_O Dynamic Response Peak Deviation Settling Time	50% load change, slew rate = 1A/µS	$\%V_O$ t_s	-3.5 -	- -	3.5 300	% µS
Turn On Overshoot	$I_O = I_{O,max}$	$\%V_O$	-	-	5	%
V_O Over Voltage Protection	Latch off	$\%V_O$	113	120	127	%
V_O Over Load Protection	Constant current	$\%I_O$	-	105	-	%
Over Temperature Protection	Measured on NTC Auto-recovery	T_{NTC}	80	85	90	^{O}C
Short Circuit Protection	All		Constant Current Mode, Auto Recovery			

Note 1 - In parallel connection only one unit will operate if the total output load is less than 5% of the rated power.

SECTION 2 ELECTRICAL SPECIFICATIONS

2.4 System Timing Specifications

Label	Parameter	Min	Typ	Max	Unit
T1	Turn-on delay - V_O	-	-	800	ms
T2	Turn-on delay - V_{AUX}	-	-	100	ms
T3	Rise time, 10% V_O to 90% V_O from 230Vac input at 100% load	-	-	100	ms
T4	Hold up time - All outputs stay within regulation after loss of AC. Measured at 230Vac, full load.	14	-	-	ms
T5	Hold up time - V_{AUX} stays within regulation after loss of AC	100	-	-	ms
T6	Delay from output voltages within regulation limits to POK asserted at turn on.	-	100	-	ms
T7	Delay from loss of AC to de-assertion of POK (full load).	-	30	-	ms
T8	Delay from EN active to output voltage within regulation limits.	-	80	-	ms
T9	Delay from POK de-asserted to output voltages out of regulation limits.	-	15	-	ms
T10	Delay from EN deactive to output voltage out of regulation.	-	15	-	ms



SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A12K Performance Curves

Figure 1: TF3000A12K Turn-on delay via AC mains

V_{IN} = 90Vac Load: Io = 100A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

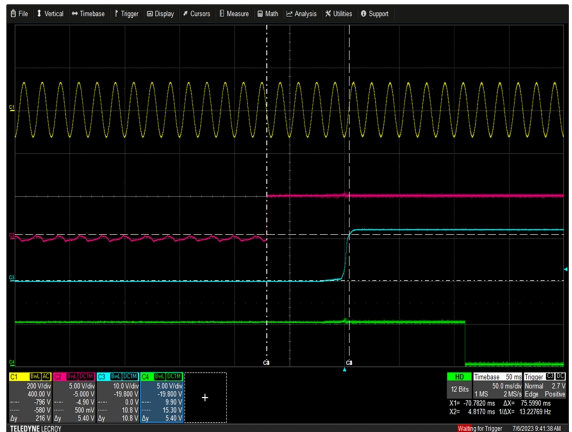


Figure 2: TF3000A12K Turn-on delay via EN

V_{IN} = 90Vac Load: Io = 100A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

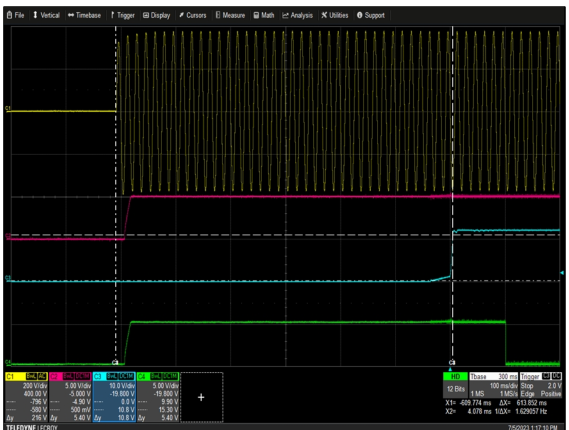


Figure 3: TF3000A12K Turn-on delay via AC mains

V_{IN} = 264Vac Load: Io = 200A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

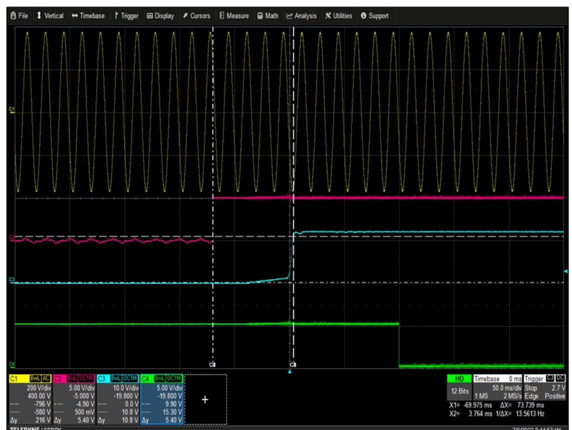


Figure 4: TF3000A12K Turn-on delay via EN

V_{IN} = 264Vac Load: Io = 200A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

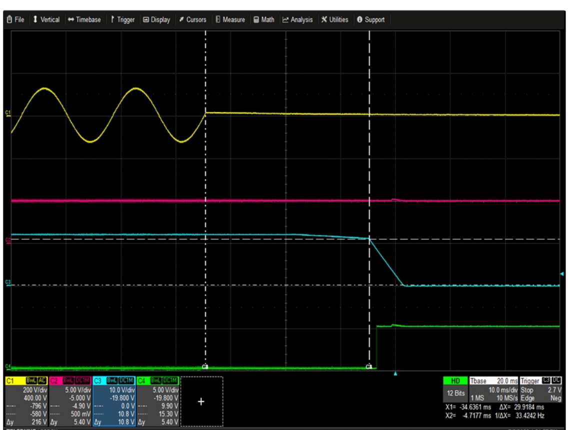


Figure 5: TF3000A12K Hold-up Time

V_{IN} = 90Vac Load: Io = 100A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

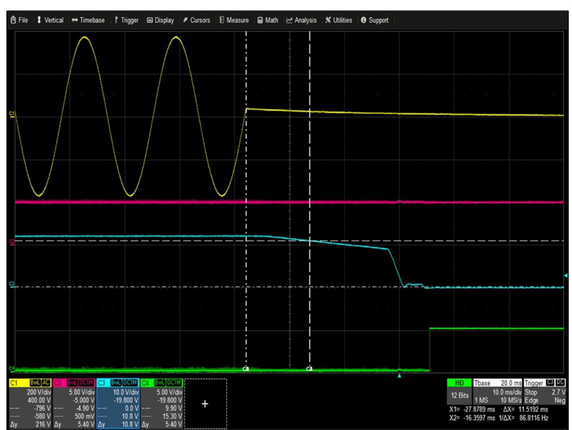


Figure 6: TF3000A12K Hold-up Time

V_{IN} = 264Vac Load: Io = 200A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A12K Performance Curves

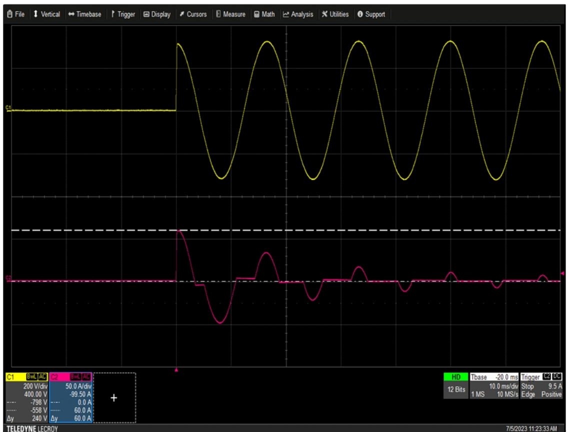


Figure 7: TF3000A12K Inrush Current
V_{IN} = 230Vac   Load: Io = 0A, Turn on at 90 deg
Ch 1: V_{IN} Ch 2: I_{IN}

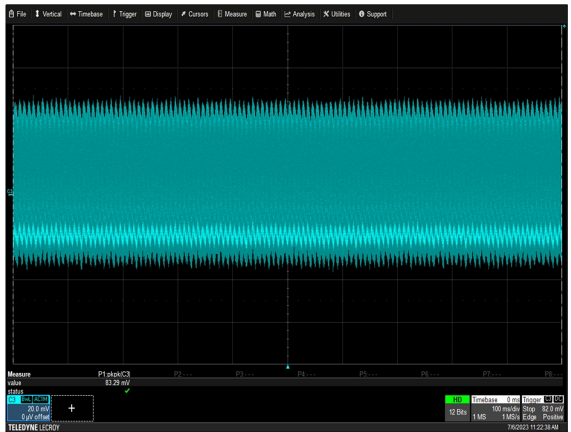


Figure 8: TF3000A12K Ripple and Noise Measurement
V_{IN} = 230Vac   Load: Io = 200A
Ch 3: Vo

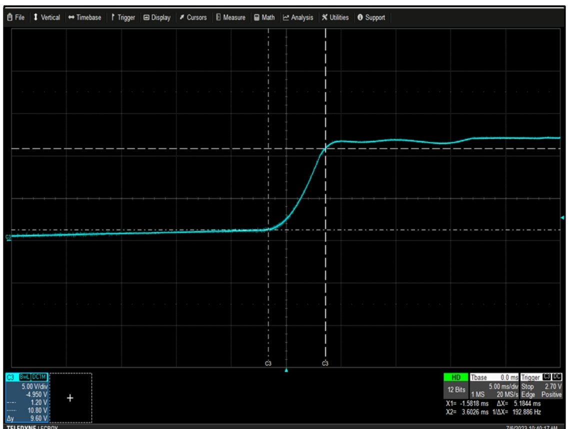


Figure 9: TF3000A12K Output Voltage Startup
V_{IN} = 230Vac   Load: Io = 200A
Ch 3: Vo

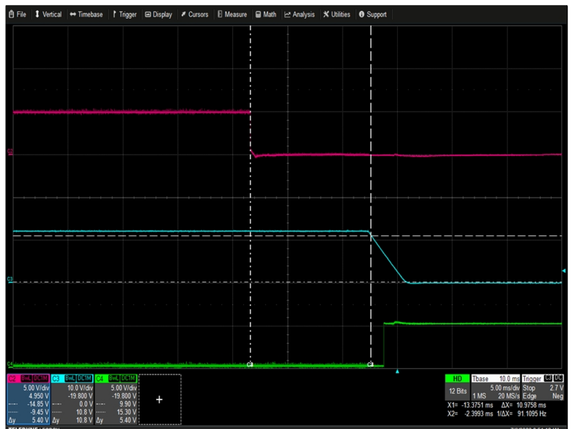


Figure 10: TF3000A12K Turn Off Characteristic via EN
V_{IN} = 230Vac   Load: Io = 200A
Ch 2: EN   Ch 3: Vo   Ch 4: POK

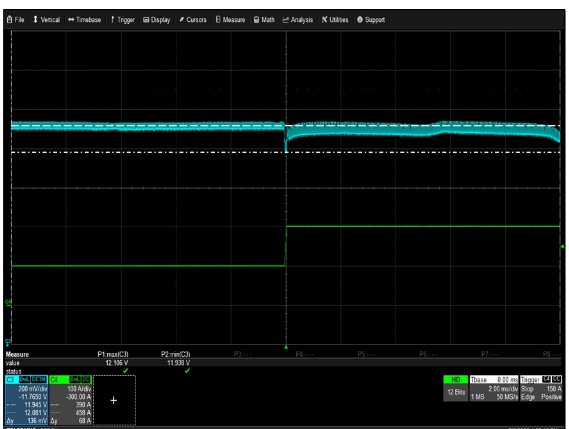


Figure 11: TF3000A12K Transient Response - Vo Deviation
50% to 100% load change   1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo   Ch 4: Io

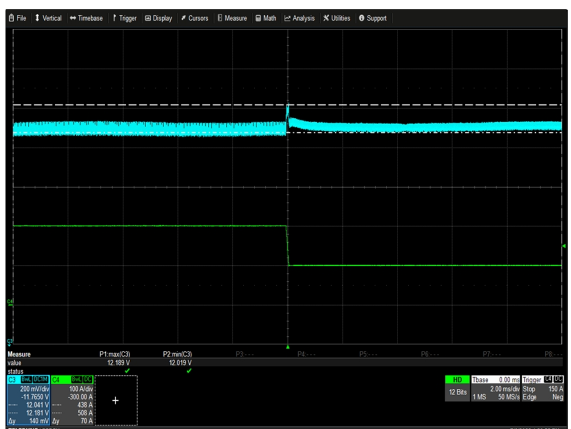


Figure 12: TF3000A12K Transient Response - Vo Deviation
100% to 50% load change   1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo   Ch 4: Io

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A12K Performance Curves

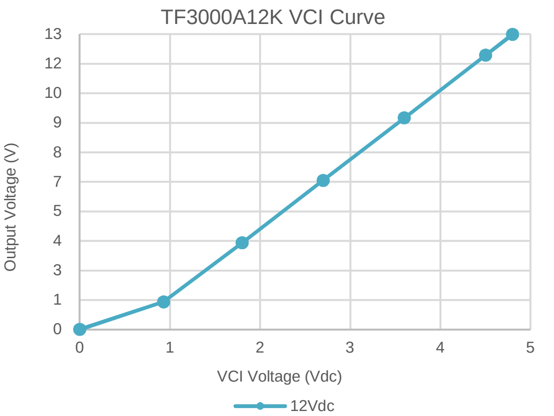


Figure 13: TF3000A12K Output Voltage Adjustment by VCI @ 25°C

Io = 0A

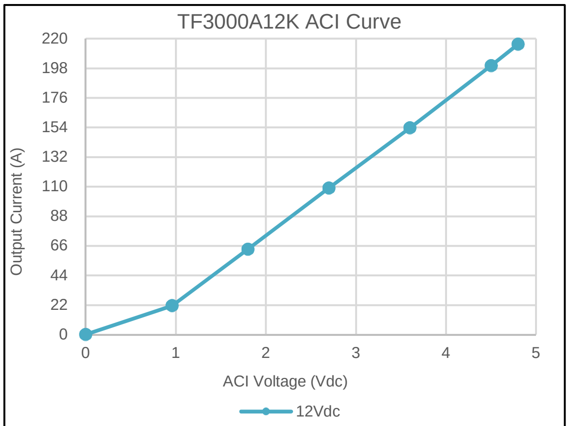


Figure 14: TF3000A12K Output Current Adjustment by ACI @ 25°C

Vo = 12V

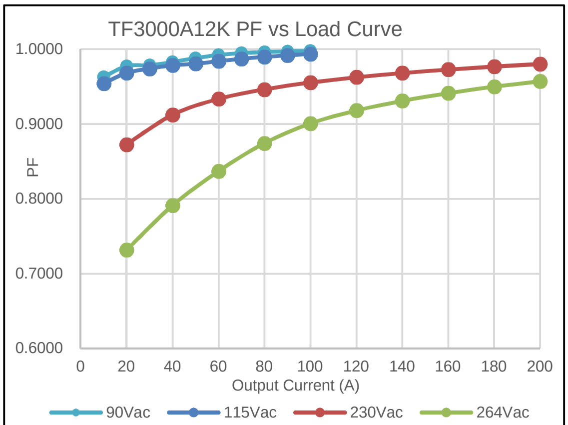


Figure 15: TF3000A12K PF vs Load Curve

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

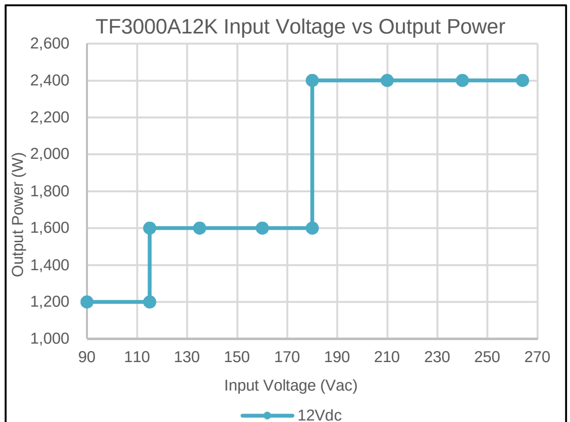


Figure 16: TF3000A12K Input Voltage vs Output Power Curve

Loading: I_{o_main} = $I_{o,max}$

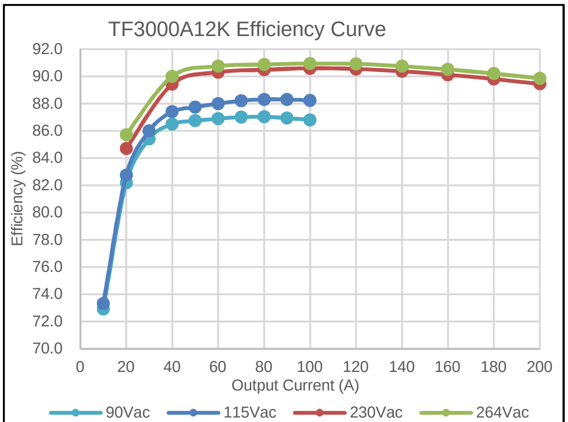


Figure 17: TF3000A12K Efficiency Curve @ 25°C

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

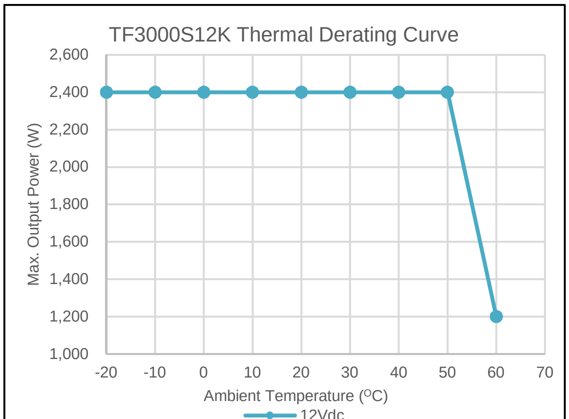


Figure 18: TF3000A12K Thermal Derating Curves

V_{IN} = 230Vac

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A24K Performance Curves

Figure 19: TF3000A24K Turn-on delay via AC mains

V_{IN} = 90Vac Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

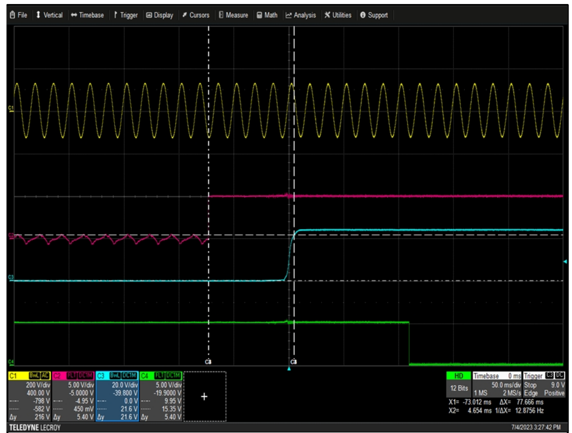


Figure 20: TF3000A24K Turn-on delay via EN

V_{IN} = 90Vac Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

Figure 21: TF3000A24K Turn-on delay via AC mains

V_{IN} = 264Vac Load: Io = 125A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

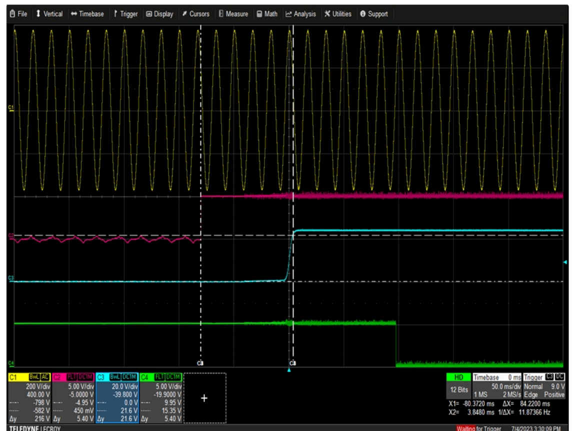


Figure 22: TF3000A24K Turn-on delay via EN

V_{IN} = 264Vac Load: Io = 125A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

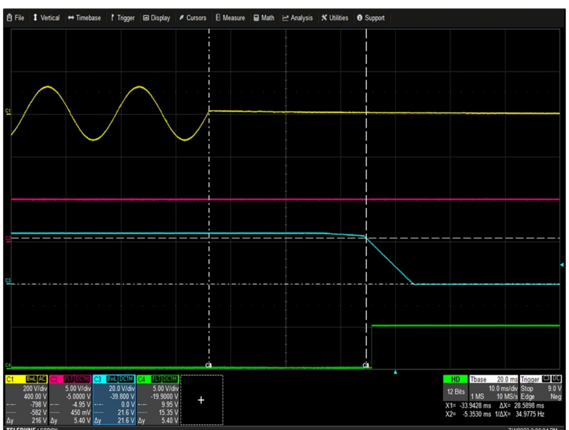


Figure 23: TF3000A24K Hold-up Time

V_{IN} = 90Vac Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

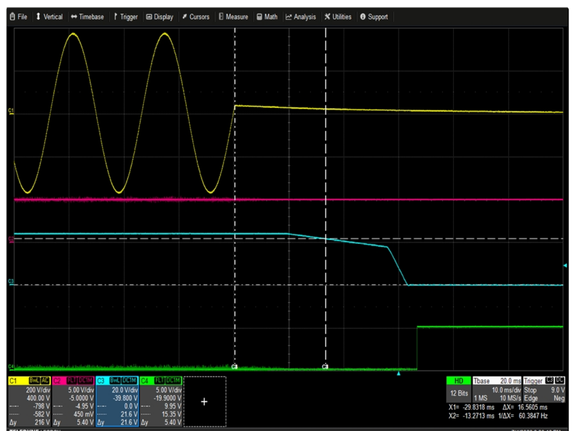


Figure 24: TF3000A24K Hold-up Time

V_{IN} = 264Vac Load: Io = 125A, V_{AUX} = 5V, I_{AUX} = 0.5A

Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A24K Performance Curves

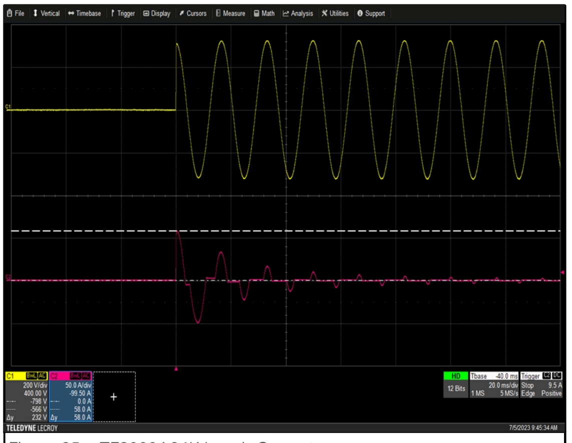


Figure 25: TF3000A24K Inrush Current
V_{IN} = 230Vac Load: Io = 0A, Turn on at 90 deg
Ch 1: V_{IN} Ch 2: I_{IN}

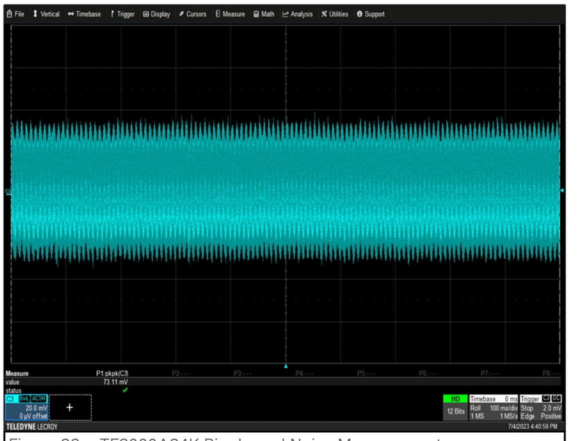


Figure 26: TF3000A24K Ripple and Noise Measurement
V_{IN} = 230Vac Load: Io = 125A
Ch 3: Vo

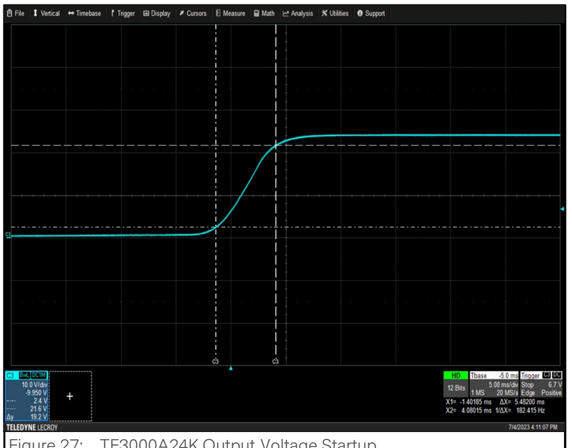


Figure 27: TF3000A24K Output Voltage Startup
V_{IN} = 230Vac Load: Io = 125A
Ch 3: Vo

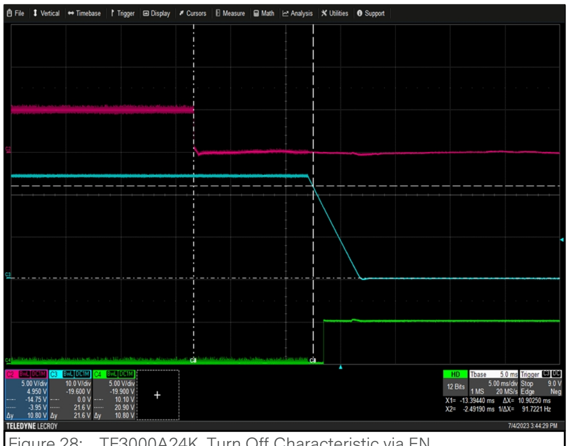


Figure 28: TF3000A24K Turn Off Characteristic via EN
V_{IN} = 230Vac Load: Io = 125A
Ch 2: EN Ch 3: Vo Ch 4: POK

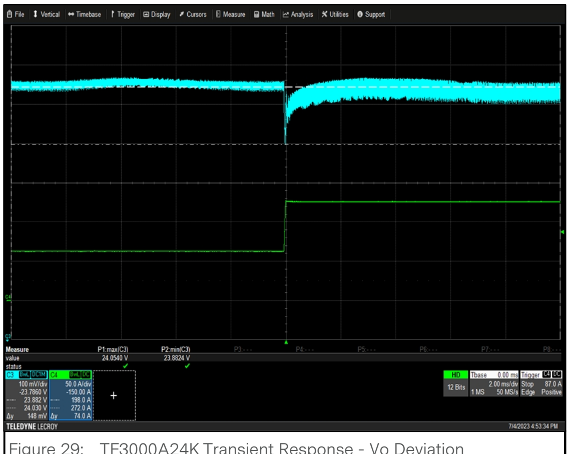


Figure 29: TF3000A24K Transient Response - Vo Deviation
50% to 100% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo Ch 4: Io

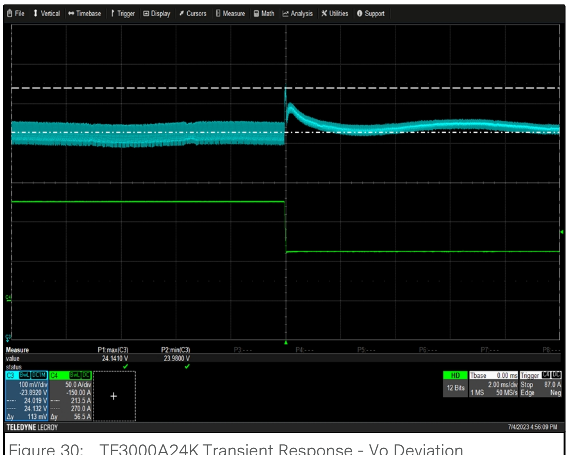


Figure 30: TF3000A24K Transient Response - Vo Deviation
100% to 50% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo Ch 4: Io

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A24K Performance Curves

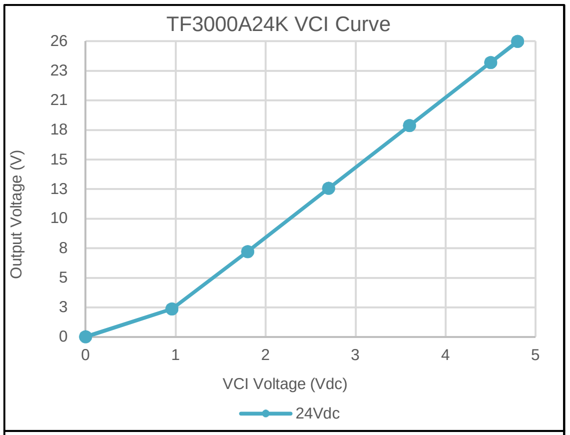


Figure 31: TF3000A24K Output Voltage Adjustment by VCI @ 25°C

Io = 0A

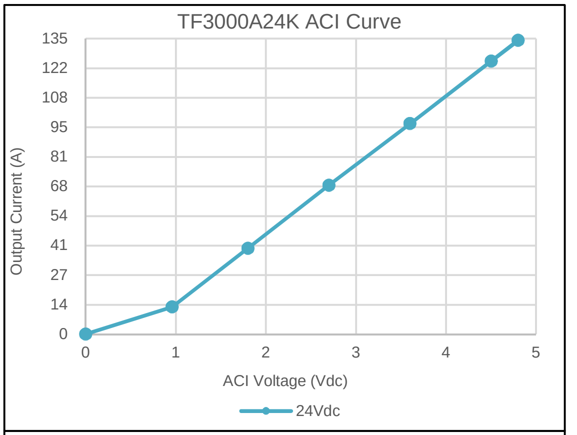


Figure 32: TF3000A24K Output Current Adjustment by ACI @ 25°C

Vo = 24V

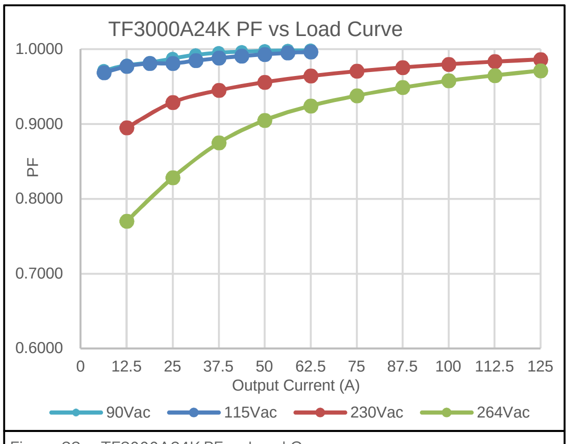


Figure 33: TF3000A24K PF vs Load Curve

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

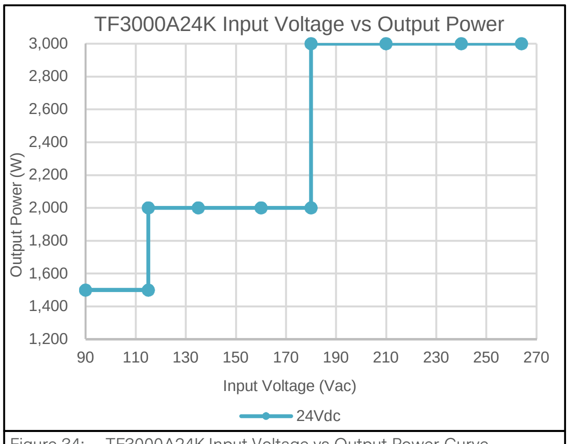


Figure 34: TF3000A24K Input Voltage vs Output Power Curve

Loading: I_{o_main} = $I_{o,max}$

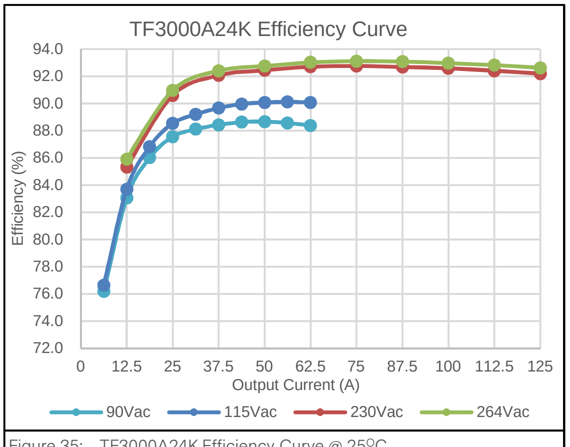


Figure 35: TF3000A24K Efficiency Curve @ 25°C

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

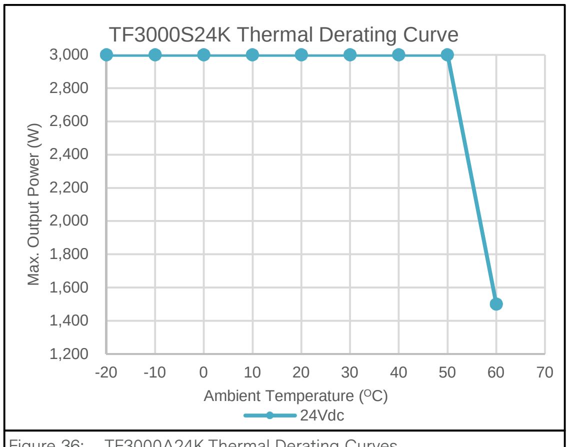


Figure 36: TF3000A24K Thermal Derating Curves

V_{IN} = 230Vac

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A48K Performance Curves

Figure 37: TF3000A48K Turn-on delay via AC mains
V_{IN} = 90Vac   Load: Io = 31.25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo   Ch 4: POK

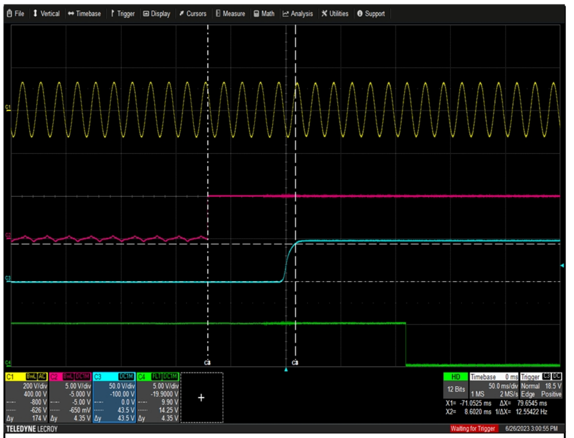


Figure 38: TF3000A48K Turn-on delay via EN
V_{IN} = 90Vac   Load: Io = 31.25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: EN   Ch 3: Vo   Ch 4: POK

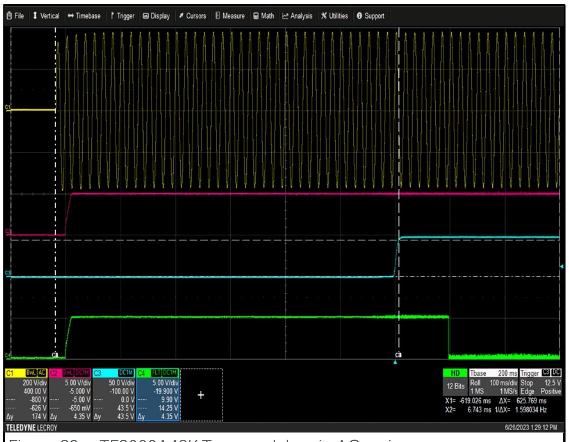


Figure 39: TF3000A48K Turn-on delay via AC mains
V_{IN} = 264Vac   Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo   Ch 4: POK

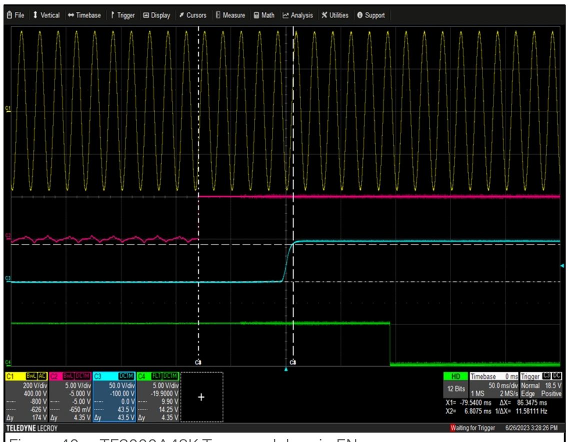


Figure 40: TF3000A48K Turn-on delay via EN
V_{IN} = 264Vac   Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: EN   Ch 3: Vo   Ch 4: POK

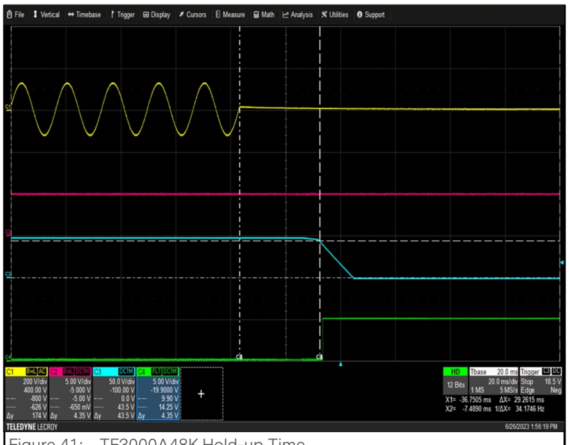


Figure 41: TF3000A48K Hold-up Time
V_{IN} = 90Vac   Load: Io = 31.25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo   Ch 4: POK

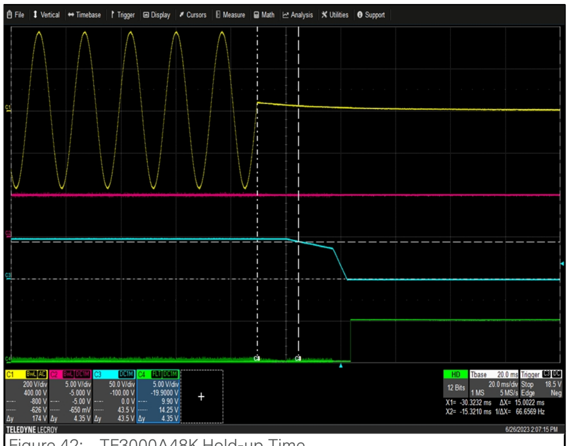


Figure 42: TF3000A48K Hold-up Time
V_{IN} = 264Vac   Load: Io = 62.5A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo   Ch 4: POK

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A48K Performance Curves

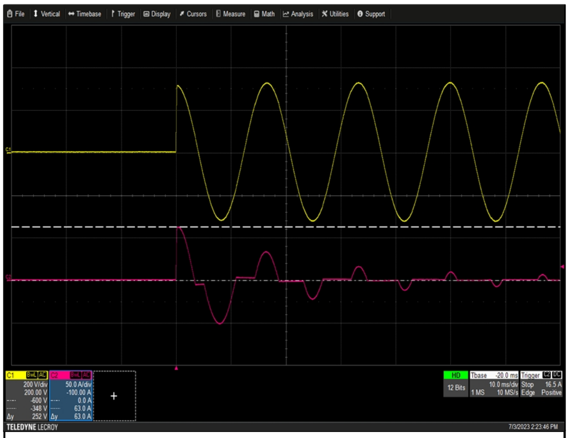


Figure 43: TF3000A48K Inrush Current
V_{IN} = 230Vac Load: Io = 0A, Turn on at 90 deg
Ch 1: V_{IN} Ch 2: I_{IN}

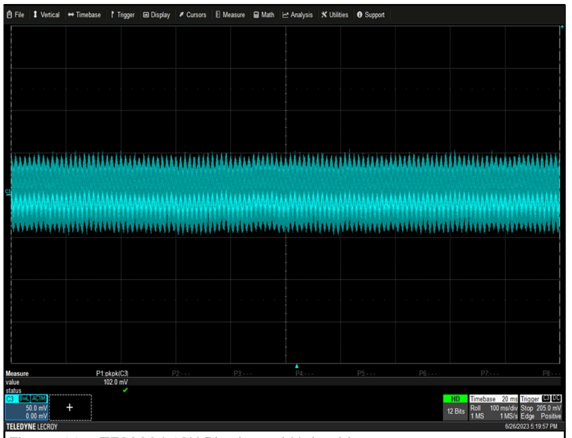


Figure 44: TF3000A48K Ripple and Noise Measurement
V_{IN} = 230Vac Load: Io = 62.5A
Ch 3: Vo

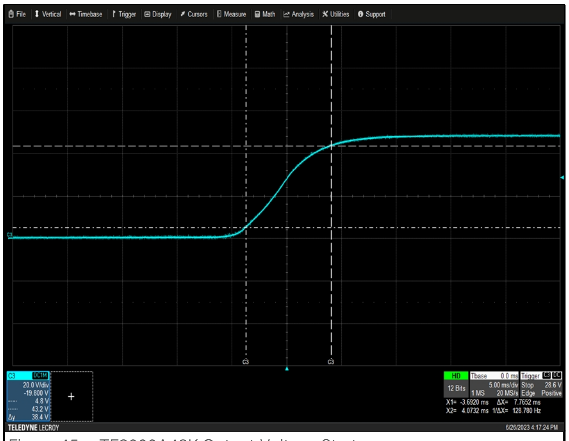


Figure 45: TF3000A48K Output Voltage Startup
V_{IN} = 230Vac Load: Io = 62.5A
Ch 3: Vo

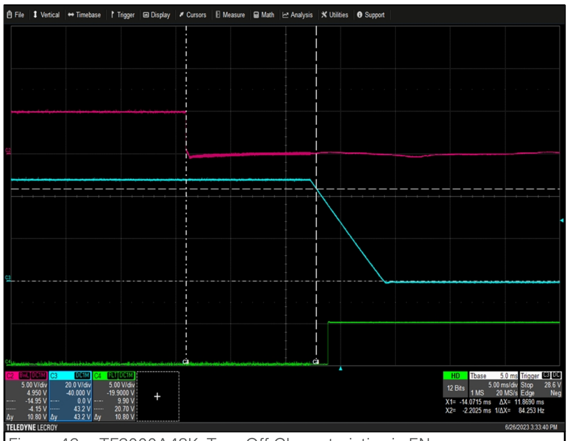


Figure 46: TF3000A48K Turn Off Characteristic via EN
V_{IN} = 230Vac Load: Io = 62.5A
Ch 2: EN Ch 3: Vo Ch 4: POK

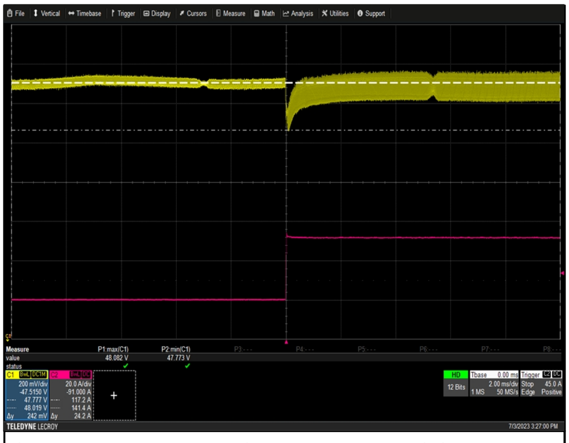


Figure 47: TF3000A48K Transient Response - Vo Deviation
50% to 100% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 1: Vo Ch 2: Io

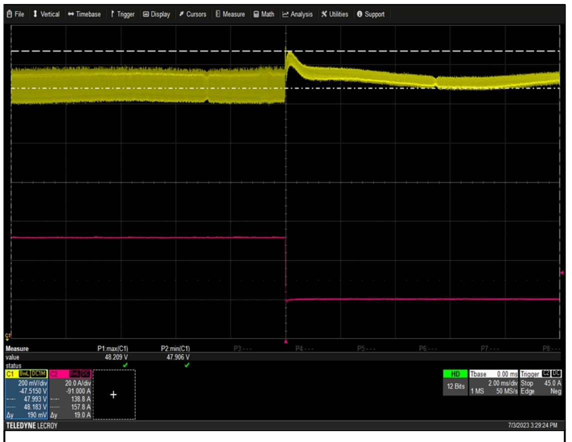


Figure 48: TF3000A48K Transient Response - Vo Deviation
100% to 50% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 1: Vo Ch 2: Io

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A48K Performance Curves

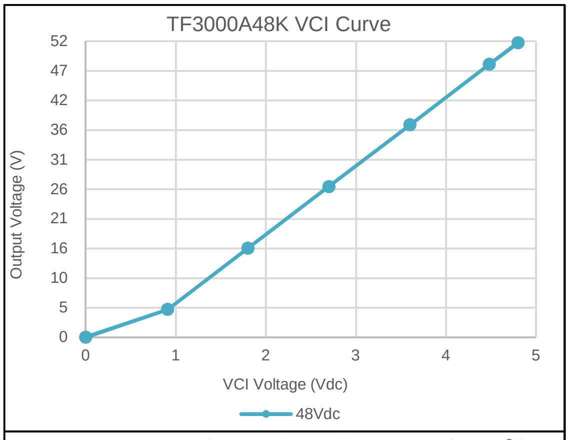


Figure 49: TF3000A48K Output Voltage Adjustment by VCI @ 25°C

Io = 0A

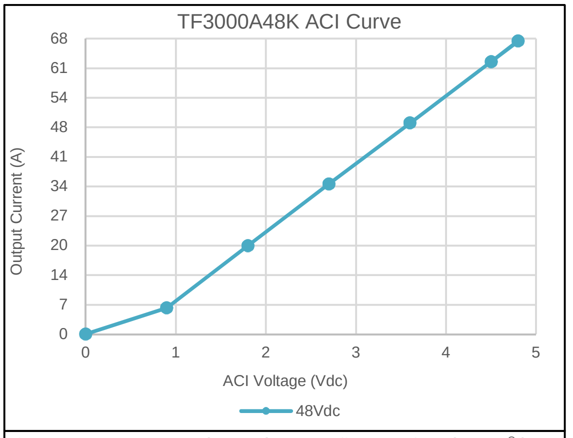


Figure 50: TF3000A48K Output Current Adjustment by ACI @ 25°C

Vo = 48V

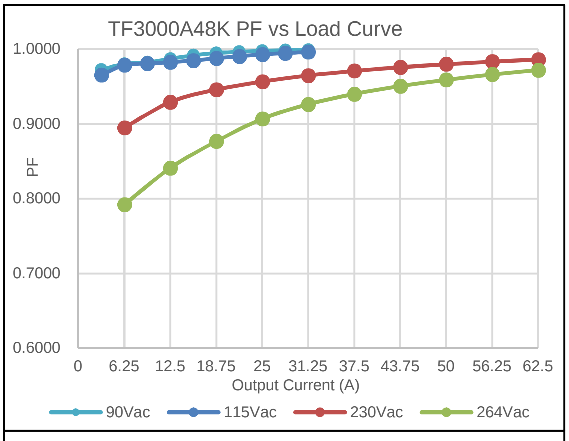


Figure 51: TF3000A48K PF vs Load Curve

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

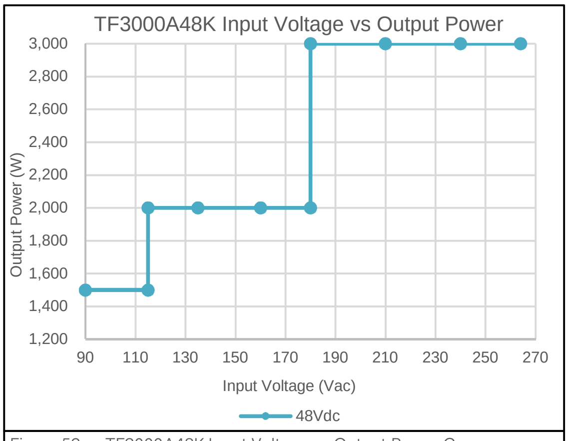


Figure 52: TF3000A48K Input Voltage vs Output Power Curve

Loading: I_{o_main} = $I_{o,max}$

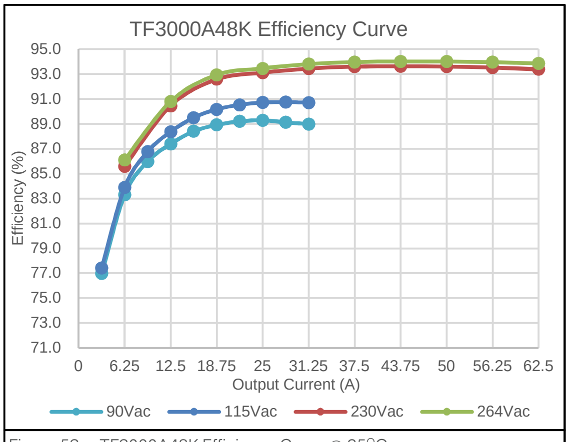


Figure 53: TF3000A48K Efficiency Curve @ 25°C

Loading: I_{o_main} = 10%$I_{o,max}$ increment to $I_{o,max}$

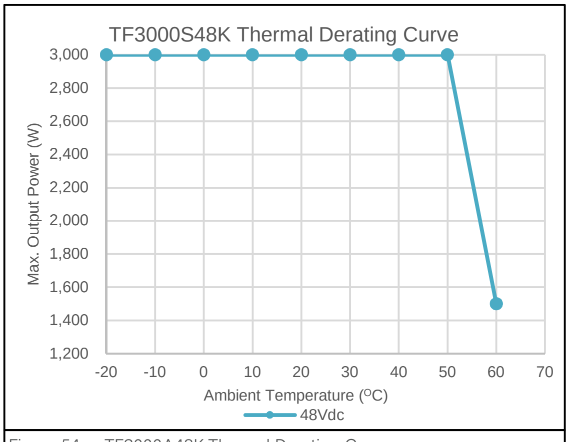


Figure 54: TF3000A48K Thermal Derating Curves

V_{IN} = 230Vac

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A60K Performance Curves

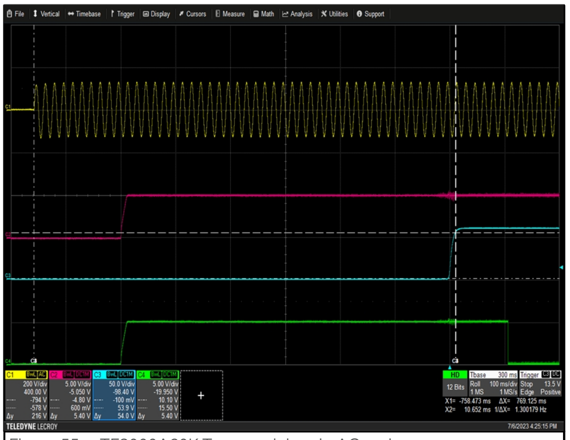


Figure 55: TF3000A60K Turn-on delay via AC mains
V_{IN} = 90Vac Load: Io = 25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

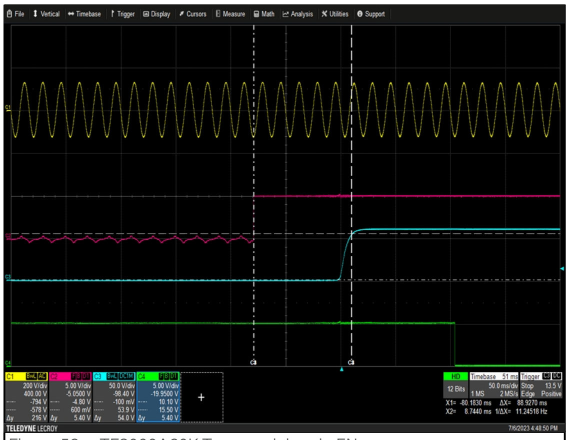


Figure 56: TF3000A60K Turn-on delay via EN
V_{IN} = 90Vac Load: Io = 25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

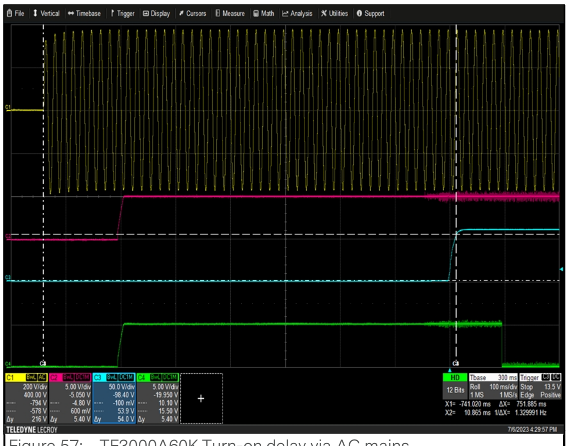


Figure 57: TF3000A60K Turn-on delay via AC mains
V_{IN} = 264Vac Load: Io = 50A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

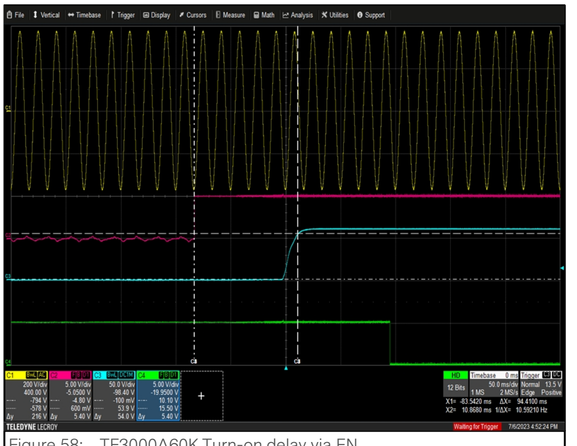


Figure 58: TF3000A60K Turn-on delay via EN
V_{IN} = 264Vac Load: Io = 50A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: EN Ch 3: Vo Ch 4: POK

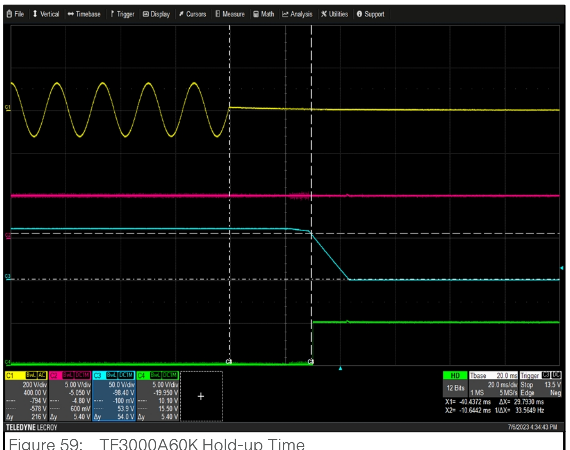


Figure 59: TF3000A60K Hold-up Time
V_{IN} = 90Vac Load: Io = 25A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

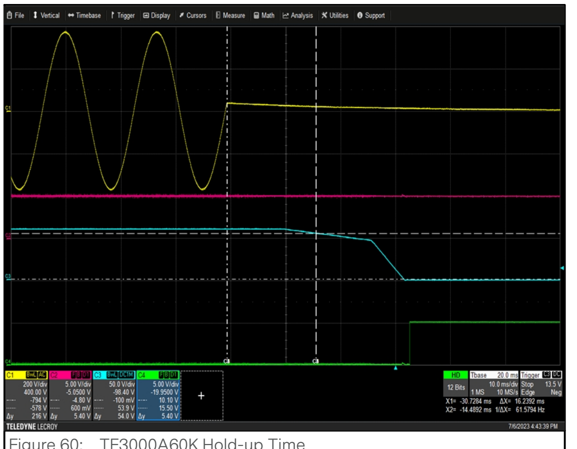


Figure 60: TF3000A60K Hold-up Time
V_{IN} = 264Vac Load: Io = 50A, V_{AUX} = 5V, I_{AUX} = 0.5A
Ch 1: V_{IN} Ch 2: V_{AUX} Ch 3: Vo Ch 4: POK

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A60K Performance Curves

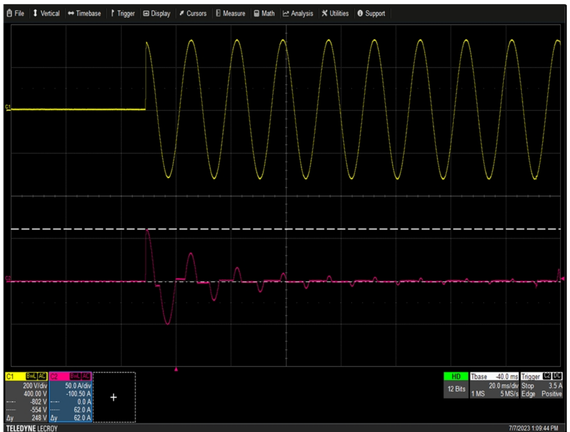


Figure 61: TF3000A60K Inrush Current
V_{IN} = 230Vac Load: Io = 0A, Turn on at 90 deg
Ch 1: V_{IN} Ch 2: I_{IN}

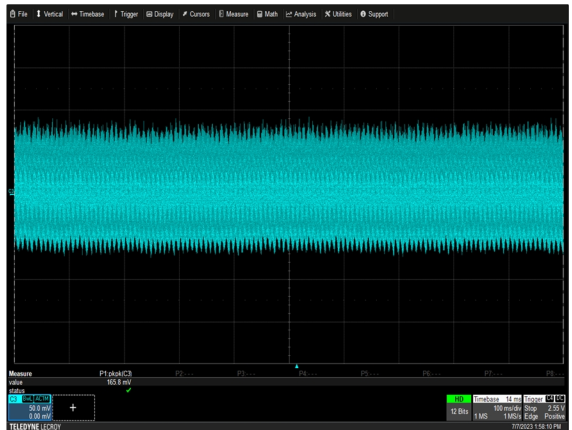


Figure 62: TF3000A60K Ripple and Noise Measurement
V_{IN} = 230Vac Load: Io = 50A
Ch 3: Vo

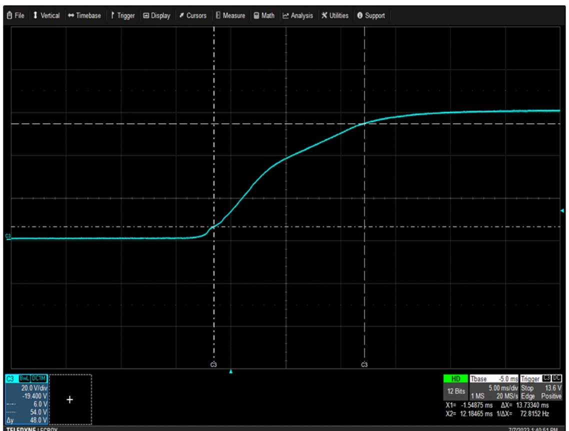


Figure 63: TF3000A60K Output Voltage Startup
V_{IN} = 230Vac Load: Io = 50A
Ch 3: Vo

Figure 64: TF3000A60K Turn Off Characteristic via EN
V_{IN} = 230Vac Load: Io = 50A
Ch 2: EN Ch 3: Vo Ch 4: POK

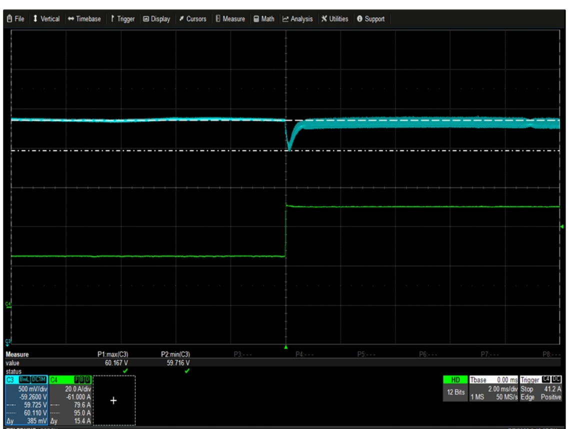


Figure 65: TF3000A60K Transient Response - Vo Deviation
50% to 100% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo Ch 4: Io

Figure 66: TF3000A60K Transient Response - Vo Deviation
100% to 50% load change 1A/µS slew rate V_{IN} = 230Vac
Ch 3: Vo Ch 4: Io

SECTION 2 ELECTRICAL SPECIFICATIONS

2.5 TF3000A60K Performance Curves

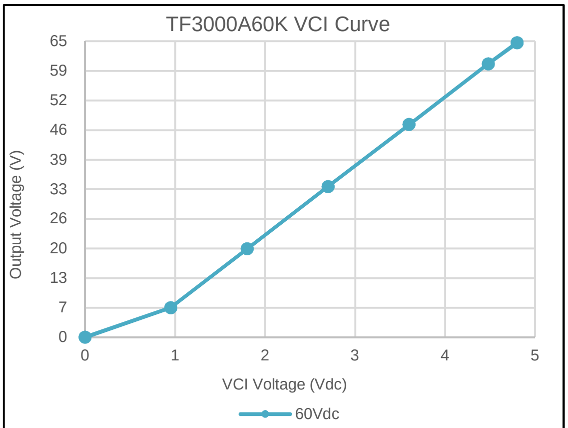


Figure 67: TF3000A60K Output Voltage Adjustment by Vprog @ 25°C

Io = 0A

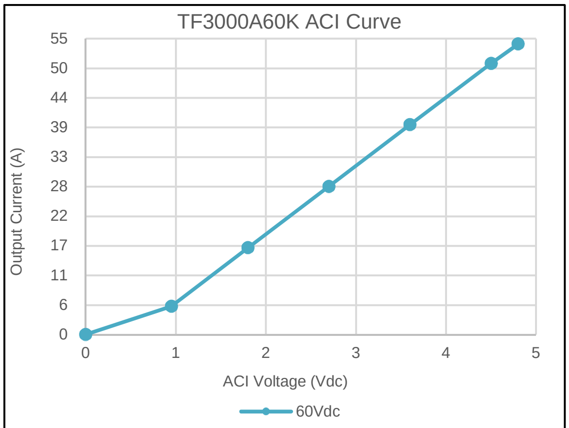


Figure 68: TF3000A60K Output Current Adjustment by ACI @ 25°C

Vo = 60V

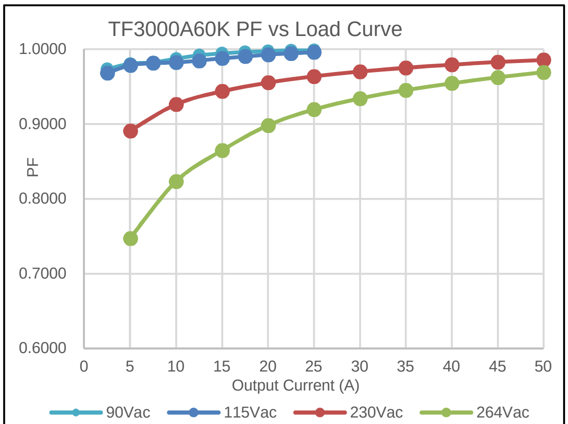


Figure 69: TF3000A60K PF vs Load Curve

Loading: $I_{o\_main} = 10\% I_{o,max}$ increment to $I_{o,max}$

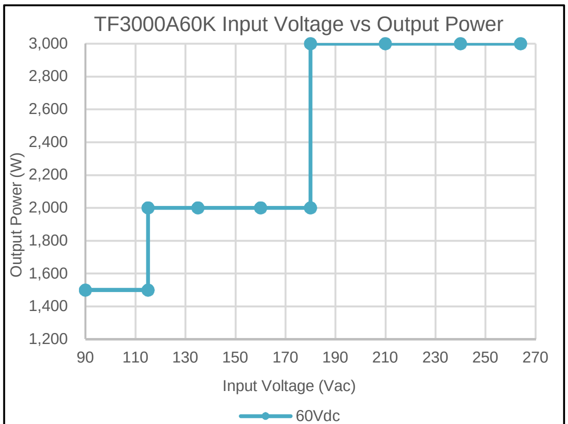


Figure 70: TF3000A60K Input Voltage vs Output Power Curve

Loading: $I_{o\_main} = I_{o,max}$

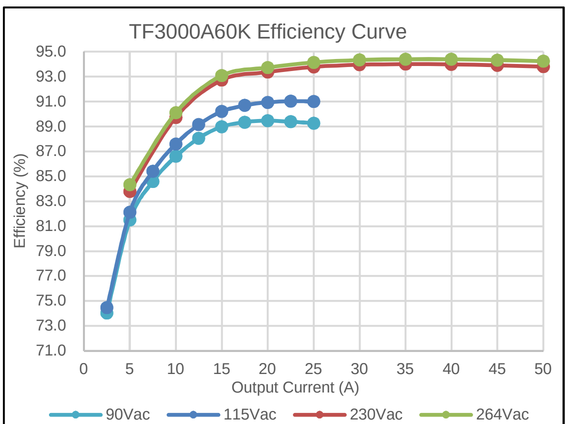


Figure 71: TF3000A60K Efficiency Curve @ 25°C

Loading: $I_{o\_main} = 10\% I_{o,max}$ increment to $I_{o,max}$

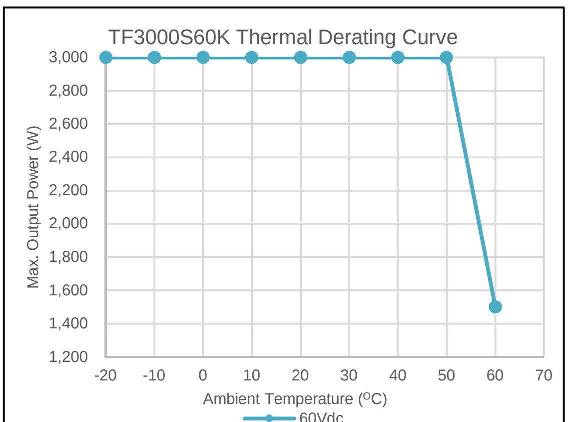


Figure 72: TF3000A60K Thermal Derating Curves

V_{IN} = 230Vac

SECTION 2 ELECTRICAL SPECIFICATIONS

2.6 Protection Function Specifications

Input Fuse

TF3000 series power supply is equipped with internal non user serviceable 25 A, 250 Vac fuse for fault protection in the Line of the AC input.

Over Voltage Protection (OVP)

The power supply main output will latch off during output overvoltage (120%±7% of rated output voltage) with the AC line recycled or inhibit to reset the latch.

When the output voltage is programmed by VCI to 105% of rated output voltage, the OVP trigger point is decreased to 114% of the output voltage.

While the output voltage is programmed by VCI to 6.25% of rated output voltage, the OVP trigger point is increased to 196% of the output voltage.

TF3000A12K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	13.56	14.40	15.24	V

TF3000A15K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	16.95	18.00	19.05	V

TF3000A24K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	27.12	28.80	30.48	V

TF3000A30K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	33.90	36.00	38.10	V

TF3000A36K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	40.68	43.20	45.72	V

TF3000A48K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	54.24	57.60	60.96	V

TF3000A60K

Parameter	Min	Typ	Max	Unit
V_O Output Overvoltage	67.80	72.00	76.20	V

SECTION 2 ELECTRICAL SPECIFICATIONS

Over Load Protection (OLP)

TF3000 series power supply includes internal current limit circuitry to prevent damage in the event of overload or short circuit. In the event of overloads (105% of rated power), the output voltage will enter constant current type, and may deviate from the regulation band but recovery is automatic when the load is reduced to within specified limits.

TF3000A12K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	210	/	A

TF3000A15K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	168	/	A

TF3000A24K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	131.25	/	A

TF3000A30K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	105.00	/	A

TF3000A36K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	87.465	/	A

TF3000A48K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	66.625	/	A

TF3000A60K

Parameter	Min	Typ	Max	Unit
V_O Output Overcurrent	/	52.5	/	A

Short Circuit Protection (SCP)

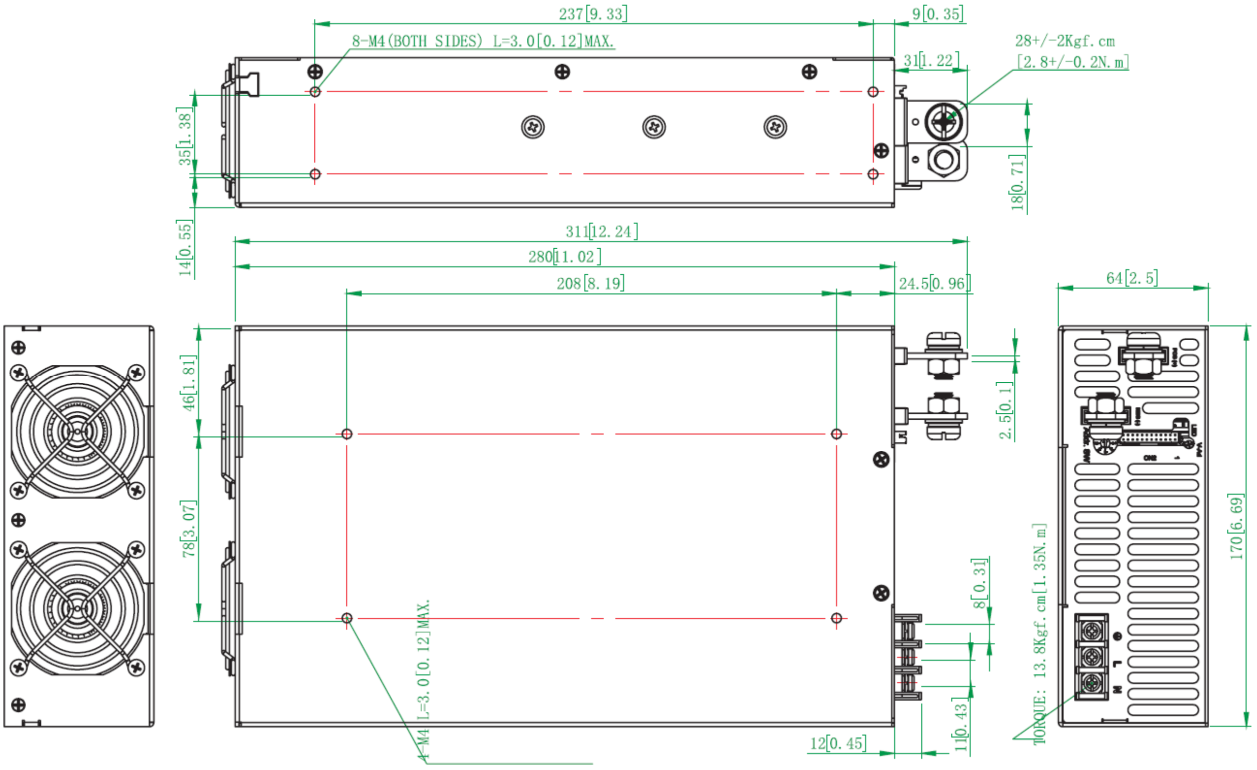
The power supply will withstand a continuous short circuit with no permanent damage. The power supply will enter constant current mode and automatically restart when the short circuit is removed. A short is defines as impedance less than 50 milliohms.

Over Temperature Protection (OTP)

The power supply shuts down during over temperature (85$\pm$5^{O}C) and automatically returns back to normal operation when the power supply is cooled down. The power supply might experience OTP conditions during a persistent overload on the output. Overload conditions can be caused by external faults. OTP might also be entered due to a loss of control of the environmental conditions, e.g. an increase in the converter's ambient temperature due to a failing fan or external cooling system etc.

SECTION 3 MECHANICAL SPECIFICATIONS

3.1 Mechanical Outlines unit: mm [inch]



3.2 Mechanical Data

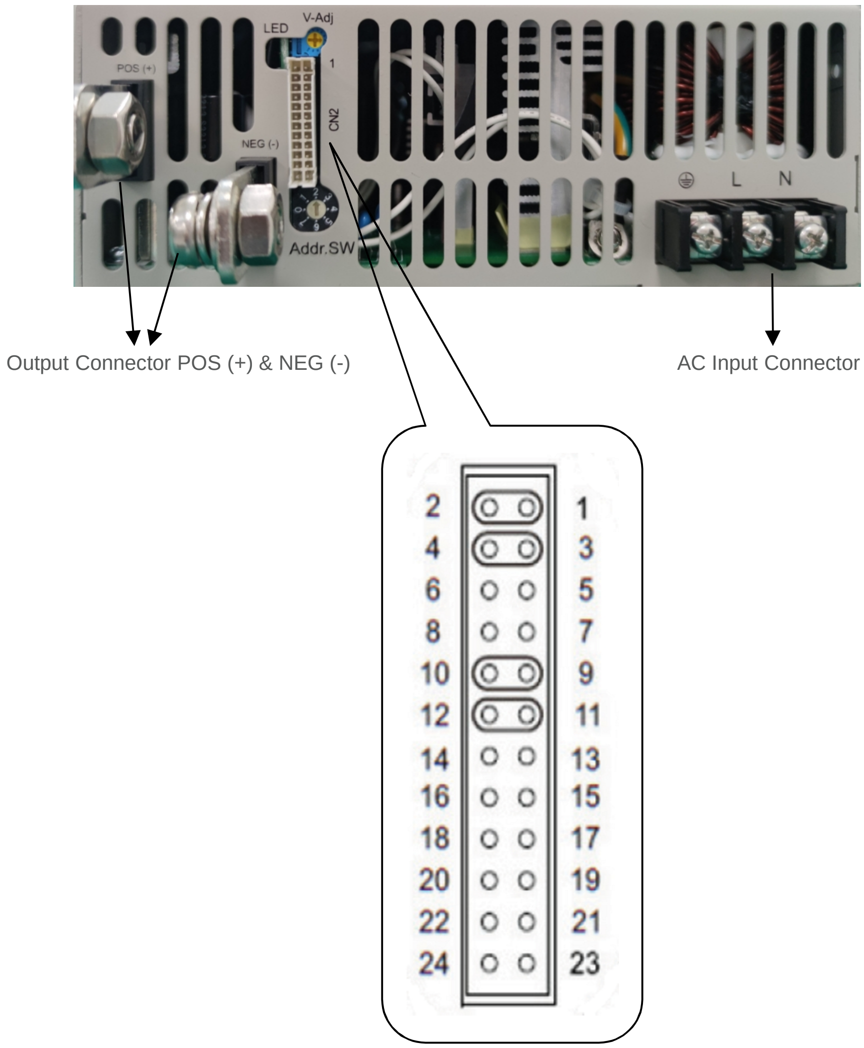
Table 4. Mechanical Data	
Dimensions (W x D x L)	170 x 64 x 280 mm (6.69” x 2.52” x 11.02”)
Weight	3.9kg (8.6lbs)
Cooling	Built in fan
3D Model Link	https://slpower.com/product-detail?IdProduct=366

3.3 Unit Packaging Requirement

Table 5. Unit Packaging Requirement	
Packing Quantities	6pcs / Carton
Packaging Weight	25.9kg / 2.48ft^3

SECTION 3 MECHANICAL SPECIFICATIONS

3.4 Connector Definitions



AC Input Connector

⏚	–	Ground
L	–	Line
N	–	Neutral

Output Connector

POS (+)	–	Main Output (Vo)
NEG (-)	–	Main Output Return

Signal Connector – CN2

Pin 1	–	VS+
Pin 2	–	VO+
Pin 3	–	VS-
Pin 4	–	VO-
Pin 5	–	POK
Pin 6	–	GND
Pin 7	–	PAR
Pin 8	–	VSET
Pin 9	–	EN-
Pin 10	–	GND
Pin 11	–	EN+
Pin 12	–	AUX
Pin 13	–	ACI
Pin 14	–	GND
Pin 15	–	VCI
Pin 16	–	GND
Pin 17	–	AUX
Pin 18	–	GND
Pin 19	–	SCL
Pin 20	–	SDA
Pin 21	–	AUX
Pin 22	–	GND
Pin 23	–	RX
Pin 24	–	TX

SECTION 3 MECHANICAL SPECIFICATIONS

3.5 Power / Signal Mating Connectors and Pin Types

Table 6. Mating Connectors for TF3000 Series		
Reference	On Power Supply	Mating Connector or Equivalent
AC Input Connector	Terminal line, neutral and ground	#10 wire lugs
Output Connector	Terminal POS (+) & NEG (-)	1/4-20 wire lugs
Signal Connector	CN2 24pin connector	Connector: JST PHDR-24VS or equivalent Pins: JST SPHD-002T-P0.5 or equivalent

3.6 LED Indicator Definitions

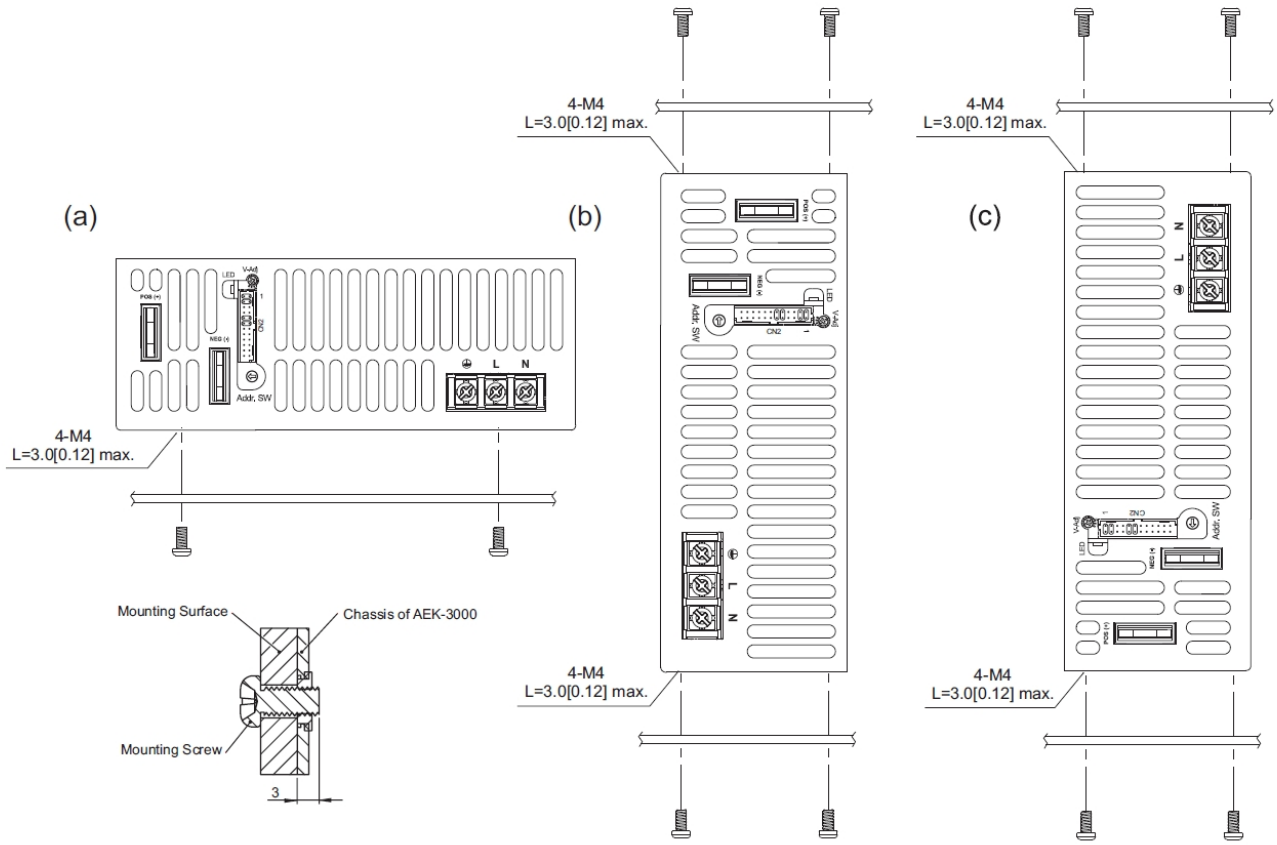
A user-friendly LED for status and diagnostics show status of input power, output power and alarm condition valuable troubleshooting aid to reduce system downtime.

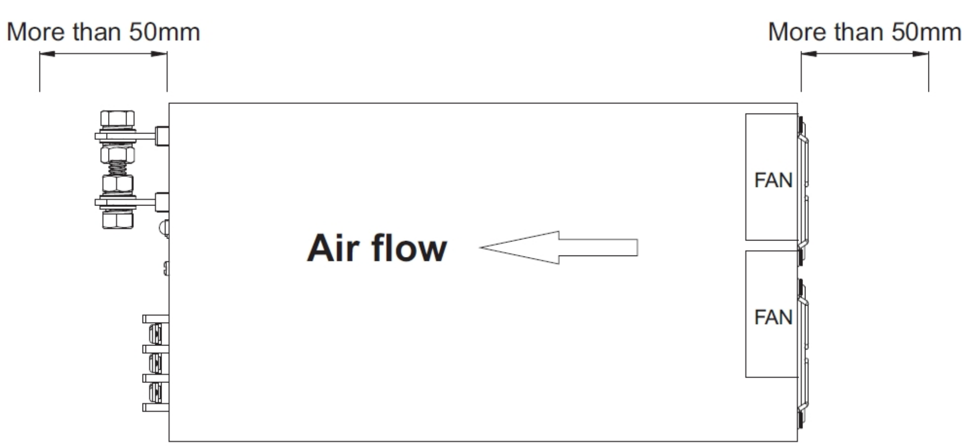
LED	LED Signal	Status
Solid (Green)		Power OK (Local Mode)
Solid (Orange)		Power OK (Remote Mode)
Slow Blink (Green)		Power Standby (Local Mode)
Slow Blink (Orange)		Power Standby (Remote Mode)
Fast Blink (Red)		Over Voltage Protection (OVP)
Solid (Red)		Over Load Protection (OLP)
Slow Blink (Red)		Over Temperature Protection (OTP)
Intermittent Blink (Red)		Fan Failure
Interlace Blink (Red)		Power Failure

SECTION 3 MECHANICAL SPECIFICATIONS

3.7 Mounting Instructions

Recommended standard mounting methods:





Note 1 - Recommended screw length is measured from the power supply surface.
Note 2 - There are ventilating holes on the front and back side panels, do not obstruct; allow 50mm at least for air flow.
Note 3 - The Maximum allowable penetration of screw is 3mm. Incomplete threading should not be penetrated.
Note 4 - Recommended the torque of mounting screw: M4 screw: 1.27N · m (13.0kgf · cm)

SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.1 EMC Immunity

TF3000 series power supply is designed to meet the following EMC immunity specifications.

Table 7. Environmental Specifications

Test Item	Standard	Test Level	Criteria
Conducted Emissions	EN 55032: 2015 / AC: 2016, CISPR 32: 2015 (Ed 2.0) / C1:2016	Class A	-
Radiated Emissions	EN 55032: 2015 / AC: 2016, CISPR 32: 2015 (Ed 2.0) / C1:2016	Class A	-
Harmonic Current Emissions	EN 61000-3-2: 2014	Class A	-
Voltage fluctuations & Flicker	EN 61000-3-3: 2013	-	-
Electro Static Discharge (ESD) Immunity	EN 55024: 2010 + A1: 2015 IEC 61000-4-2: 2008	±4kV contact, ±8kV air	A
Radiated RF EM Fields Susceptibility	EN 55024: 2010 + A1: 2015 IEC 61000-4-3: 2006 + A1: 2007 + A2: 2010	3V/m, 80MHz to 1GHz, 80% AM at 1kHz	A
Electrical Fast Transients (EFT) / Bursts	EN 55024: 2010 + A1: 2015 IEC 61000-4-4: 2012	±1kV, 5Khz rep rate	A
Surges - Line to Line (DM) and Line to GND (CM)	EN 55024: 2010 + A1: 2015 IEC 61000-4-5: 2014 + A1: 2017	±1kV DM, ±2kV CM	A
Conducted Disturbances Induced by RF Fields	EN 55024: 2010 + A1: 2015 IEC 61000-4-6: 2013	3Vrms, 0.15Mhz to 80Mhz, 80% AM at 1KHz	A
Rated Power Frequency Magnetic Fields	EN 55024: 2010 + A1: 2015 IEC 61000-4-8: 2009	1A/m, 50Hz	A
Voltage Interruptions, Dips, Sags & Surges[1]	EN 55024: 2010 + A1: 2015 IEC 61000-4-11: 2014 + A1: 2017	Voltage Dips: >95% reduction, 10ms (0.5 cycles) 30% for 500ms (25 cycles) Voltage Interruptions >95% for 5000ms (250 cycles)	 A A B

Note 1 - Performance criteria are based on EN55024. According to the standards, performance criteria are defined as following:
- A - Normal performance during and after the test
- B - Temporary degradation, self-recoverable
- C - Temporary degradation, operator intervention required to recover the operation
- D - Permanent damage

SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.2 Safety Certifications

The TF3000 series are intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a standard alone product.

Table 8. Safety Certifications for TF3000 Series Power Supply System

Standard	Agency	Description
UL/CSA62368-1	UL + CSA	US and Canada Requirements
EN62368-1	TUV	European Requirements
IEC62368-1	CB Scheme	International Electrotechnical Commission
CE Mark	-	European Requirements
UKCA Mark	-	UK Requirements

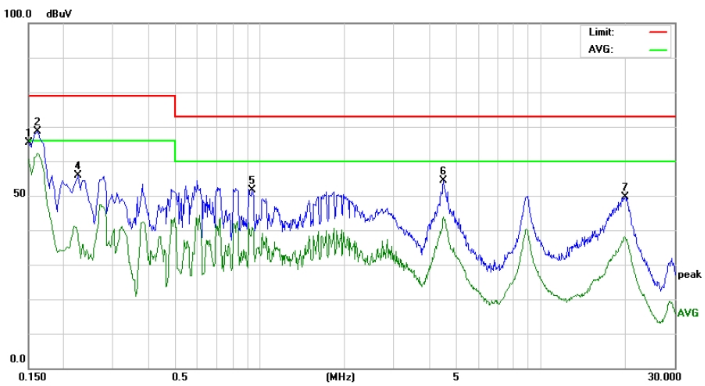
SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.3 EMI Emissions

The TF3000 series has been designed to comply with the Class A limits of EMI requirements of EN55032 (FCC Part 15) and CISPR 32 (EN55032) for emissions and relevant sections of EN61000 (IEC 61000) for immunity. The unit is enclosed inside a metal box, tested at 3000W using resistive load with cooling fan.

Conducted Emissions

The applicable standard for conducted emissions is EN55032 (FCC Part 15). Conducted noise can appear as both differential mode and common mode noise currents. Differential mode noise is measured between the two input lines, with the major components occurring at the supply fundamental switching frequency and its harmonics. Common mode noise, a contributor to both radiated emissions and input conducted emissions, is measured between the input lines and system ground and can be broadband in nature.



The TF3000 series have internal EMI filters to ensure the convertors' conducted EMI levels comply with EN55032 (FCC Part 15) Class A.

The EMI measurements are performed with resistive loads at maximum rated loading Sample of EN55032 Conducted EMI Measurement at 230Vac input.

Note: Red Line refers to Quasi Peak margin, which is 6dB below the CISPR international limit. Green Line refers to the Average margin, which is 6dB below the CISPR international limit.

Conducted EMI emissions specifications of the TF3000 series:

Parameter	Model	Symbol	Min	Typ	Max	Unit
FCC Part 15, class A	All	Margin	6	-	-	dB
CISPR 32 (EN55032), class A	All	Margin	6	-	-	dB

Radiated Emissions

Unlike conducted EMI, radiated EMI performance in a system environment may differ drastically from that in a stand-alone power supply. The shielding effect provided by the system enclosure may bring the EMI level from Class A to Class B. It is thus recommended that radiated EMI be evaluated in a system environment. The applicable standard is EN55032 Class A (FCC Part 15). Testing ac-dc convertors as a stand-alone component to the exact requirements of EN55032 can be difficult, because the standard calls for 1m leads to be attached to the input and outputs and aligned such as to maximize the disturbance. In such a set-up, it is possible to form a perfect dipole antenna that very few AC-DC convertors could pass. However, the standard also states that an attempt should be made to maximize the disturbance consistent with the typical application by varying the configuration of the test sample.

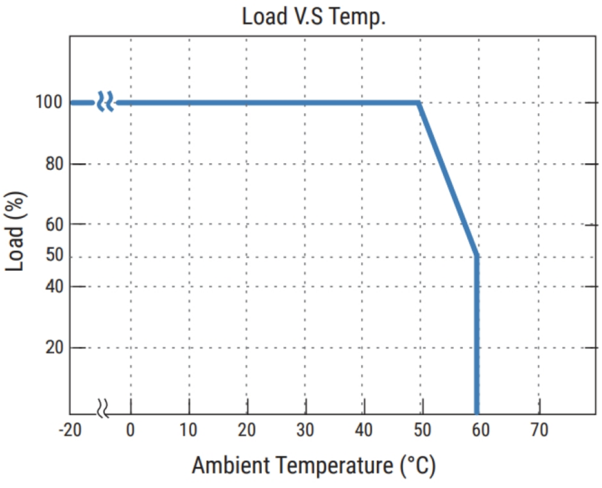
SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.4 Operating Temperature

The TF3000 series maximum output power can be loaded up to an ambient temperature of +50°C.

Only 50% of the maximum output power can be loaded at ambient temperature of +60°C. Linear derating to 50% nominal output power starts from +50°C to +60°C.

Output Power vs Operating Temperature



4.5 Forced Air Cooling

The TF3000 series power supplies include internal cooling fan as part of the power supply assembly to provide forced air cooling to maintain and control temperature of devices and ambient. The standard direction of airflow is from the fan to the input/output connectors of the power supply.

The cooling fan is a variable speed fan. Fan will be smart based on output current and internal temperature.

4.6 Storage and Shipping Temperature

The TF3000 series can be stored or shipped at temperatures between -40°C to +85°C and relative humidity from 10% to 95% non-condensing.

4.7 Altitude

The TF3000 series will operate within specifications at altitudes up to 1000 feet (3000 meters) above sea level. The power supply will not be damaged when stored at altitudes of up to 3000 meters above sea level.

4.8 Humidity

The TF3000 series will operate within specifications when subjected to a relative humidity from 20% to 90% non-condensing. The TF3000 series can be stored in a relative humidity from 10% to 95% non-condensing.

SECTION 4 ENVIRONMENTAL SPECIFICATIONS

4.9 Vibration

The TF3000 series comply to IEC68-2-6 and IEC68-2-64, and pass the following vibration specifications:

Non-Operating Random Vibration

Acceleration	2.0		gRMS
Frequency Range	10 to 500		Hz
Duration	60		Mins
Direction	3 mutually perpendicular axis		
PSD Profile	FREQ (Hz)	SLOPE (db/oct)	PSD (g^2/Hz)
	10	/	0.04
	80	/	0.04
	500	/	0.0198

Operating Random Vibration

Acceleration	2.0		gRMS
Frequency Range	10 to 500		Hz
Duration	60		Mins
Direction	3 mutually perpendicular axis		
PSD Profile	FREQ (Hz)	SLOPE (db/oct)	PSD (g^2/Hz)
	10	/	0.04
	80	/	0.04
	500	/	0.0198

4.10 Shock

The TF3000 series power supply will pass the following shock specifications:

Non-Operating Half-Sine Shock

Acceleration	30	G
Duration	36	mSec
Pulse	trapezoidal	
Number of Shock	3 shock on each of 6 faces	

Operating Half-Sine Shock

Acceleration	40	G
Duration	6	mSec
Pulse	Half-Sine	
Number of Shock	3 shocks in each of 6 faces	

SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

5.1 AC Input Connector

This connector supplies the AC Mains to the TF3000 series power supply.

⏚ – Ground
L – Line
N – Neutral

5.2 Output Connectors

These terminals provide the main output for the TF3000 series. The POS (+) and NEG (-) terminals are the positive and negative rails, respectively, of the V_O main output of the TF3000 series power supply.

POS (+) – +Main Output (V_O)
NEG (-) – Main Output Return

5.3 Signal Connector - CN2

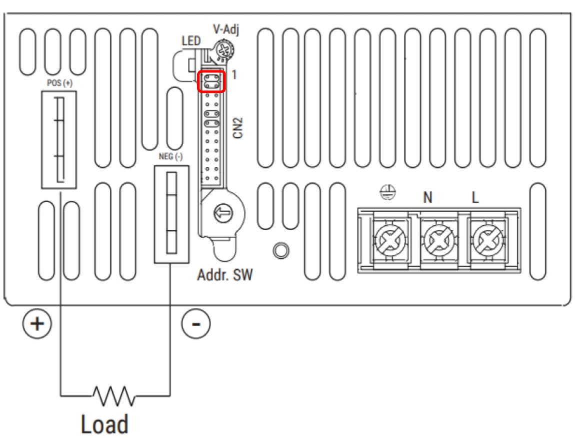
The TF3000 series CN2 contains 24 pins control signal header providing analogy control, auxiliary output and I²C interface.

VS+, VS- - (Pin 1, Pin 3)

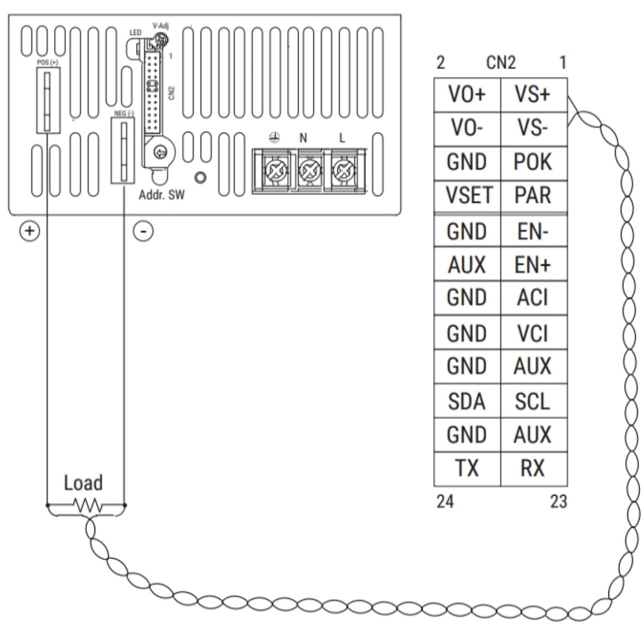
The default remote sense setting is to connect the VS+ & VS- to the VO+ (pin 2) & VO- (pin 4) directly as local sensing.

As remote sensing, these pins can also be connected as close to the loading as possible. This remote sense circuit will be designed to compensate for a power path drop up to 0.5V.

Local Sense (Default Setting)



Remote Sense



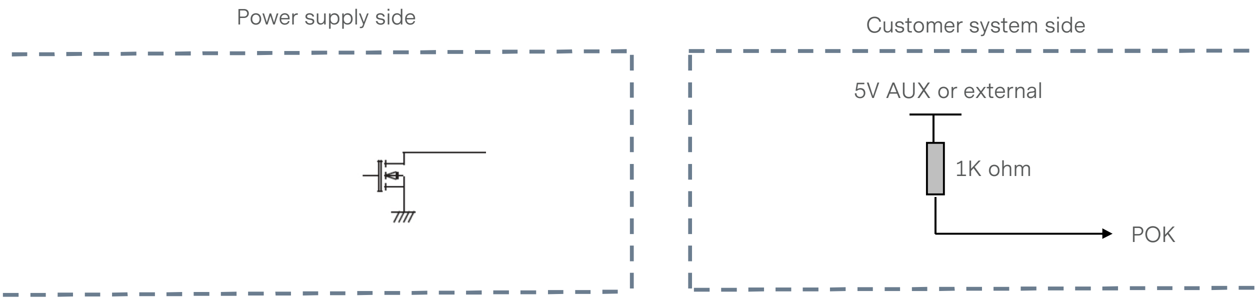
VO+, VO- - (Pin 2, Pin 4)

They are positive output voltage and negative output voltage rails connected with POS (+) and NEG (-) respectively.

SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

POK - (Pin 5)

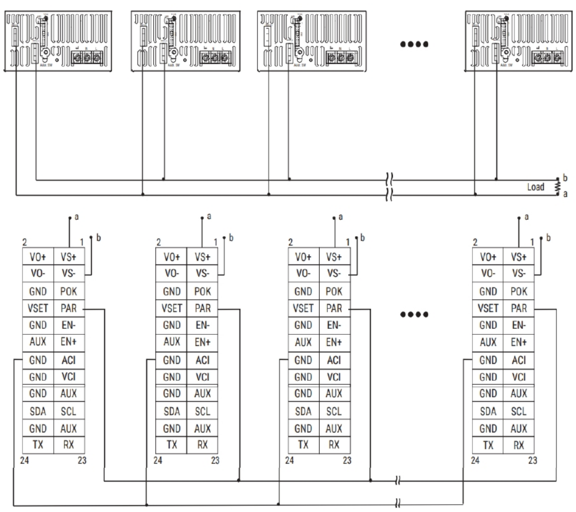
POK is an open drain power OK signal. When the PSU turns on, the POK signal goes to low logic. The maximum sink current is 20mA, and the max drain voltage is 40V. Recommended pull-up resistor to 5V AUX or external source is 1K ohm.



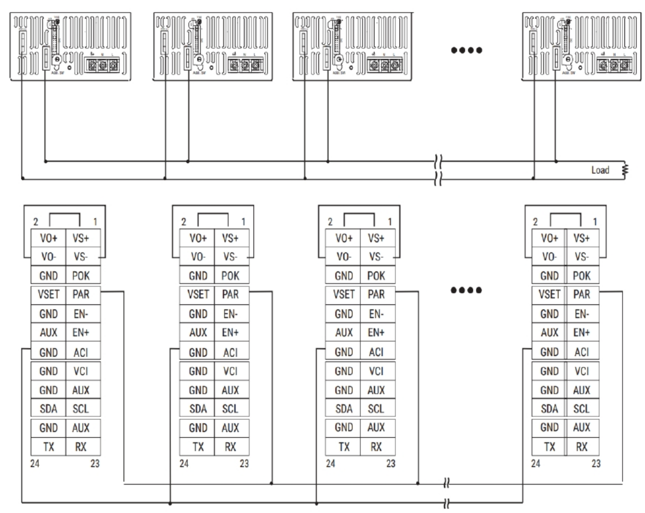
PAR - (Pin 7)

The main output has active current sharing. All current sharing functions are implemented internal to the power supply by making use of the PAR signal. The system connects all the PAR lines between the power supplies for parallel operation current sharing.

Current Sharing with Remote Sensing



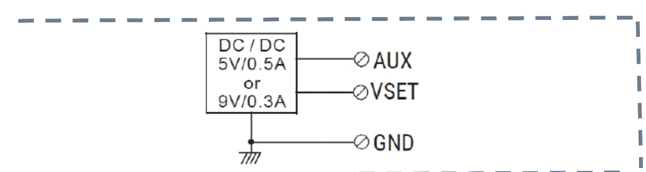
Current Sharing with Local Sensing

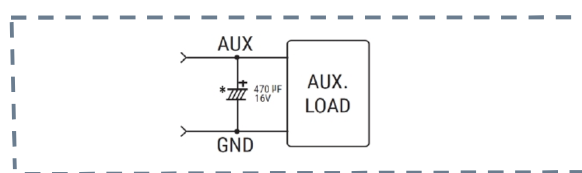


VSET - (Pin 8)

The VSET signal is to set the optional AUX output voltage. The default setting is 5V AUX output when VSET pin is left open. Shorting VSET to GND of CN2 can set a 9V AUX output.

Place an additional capacitor to have a better performance of auxiliary power operation.



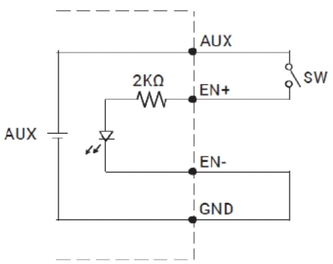


SECTION 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

EN-, EN+ - (Pin 9, Pin 11)

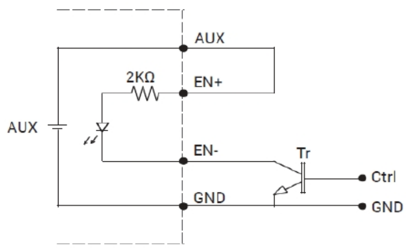
There’re three methods to use these EN- & EN+ signals to turn ON/OFF the main output voltage. The default setting is to use internal 5V AUX source.

(A) Using Internal 5V AUX Source



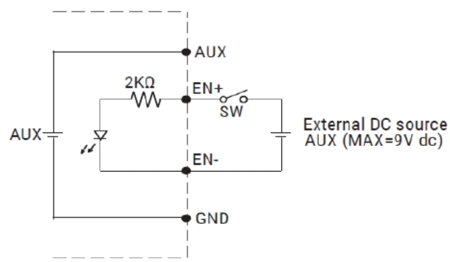
SW	OFF	Power OFF
	ON	Power ON

(B) ON/OFF Control by NPN Transistor



Ctrl	L	Power OFF
	H	Power ON

(C) Using External Voltage Source



SW	OFF	Power OFF
	ON	Power ON

AUX - (Pin 12, Pin 17, Pin 21)

The TF3000 series provides an optional auxiliary power 5V/0.5A or 9V/0.3A. The AUX option can be set by the VSET signal.

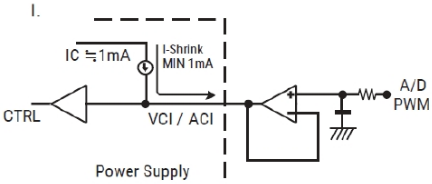
ACI, VCI - (Pin 13, Pin 15)

The ACI is the I program signal to program the output current from 0% to 105%.

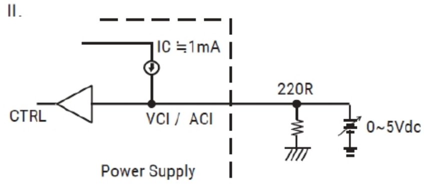
The VCI is the V program signal to program the output voltage from 0% to 105%.

Connecting an external voltage or resistor between the ACI or VCI can both adjust the output current or output voltage. To ensure the power supply output voltage and current could be accurately adjusted, please make sure to adjust the output voltage and current > 10% vs. the rated voltage and current. (ex. for a 24V unit, adjust the DC output voltage above 2.4 V to ensure accuracy; same applies to the output current)

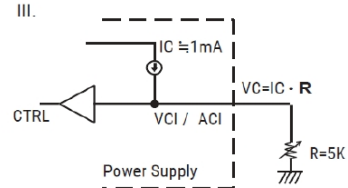
I.



II.



III.



SCL, SDA - (Pin 19, Pin 20)

Please refer to “Communication Descriptions” section.

GND - (Pin 6, Pin 10, Pin 14, Pin 16, Pin 18, Pin 22)

They are all the same signal ground referred to the signals of CN2 connector.

RX, TX - (Pin 23, Pin 24)

These pins are for RS232 receiver and transmission function. Refer to “Communication Protocol User Manual”.

SECTION 6 COMMUNICATION DESCRIPTIONS

6.1 I²C Bus Signals

The TF3000 series contains enhanced monitor and control functions implemented via the I²C bus. The TF3000 series I²C functionality can be accessed via the control signals' connector. The I²C interface is designed to run with a serial clock speed of 100KHz.

SCL (I²C Serial Clock Signal) - (pin 19)

This input signal is used to strobe all data in and out of the unit. It should be connected to +5V via a pull-up resistor of 2K ohm.

SDA (I²C Serial Data Signal) - (pin 20)

This bi-directional signal is used to transfer data in or out of the unit. It is an open drain output that may be wire-ORed with other open drain or open collector signal on the bus. A pull-up 2K ohm resistor must be connected from SDA to +5V.

E0, E1, E2 (I²C Address)

There are three address lines internally to address the eight units by I²C bus. To address the units, adjust the address switch on the front panel of the power supply directly.

I²C Bus Protocol

The I²C bus option of unit are provided with I²C type EEPROM device protocol (24C02).

Write mode sequences:

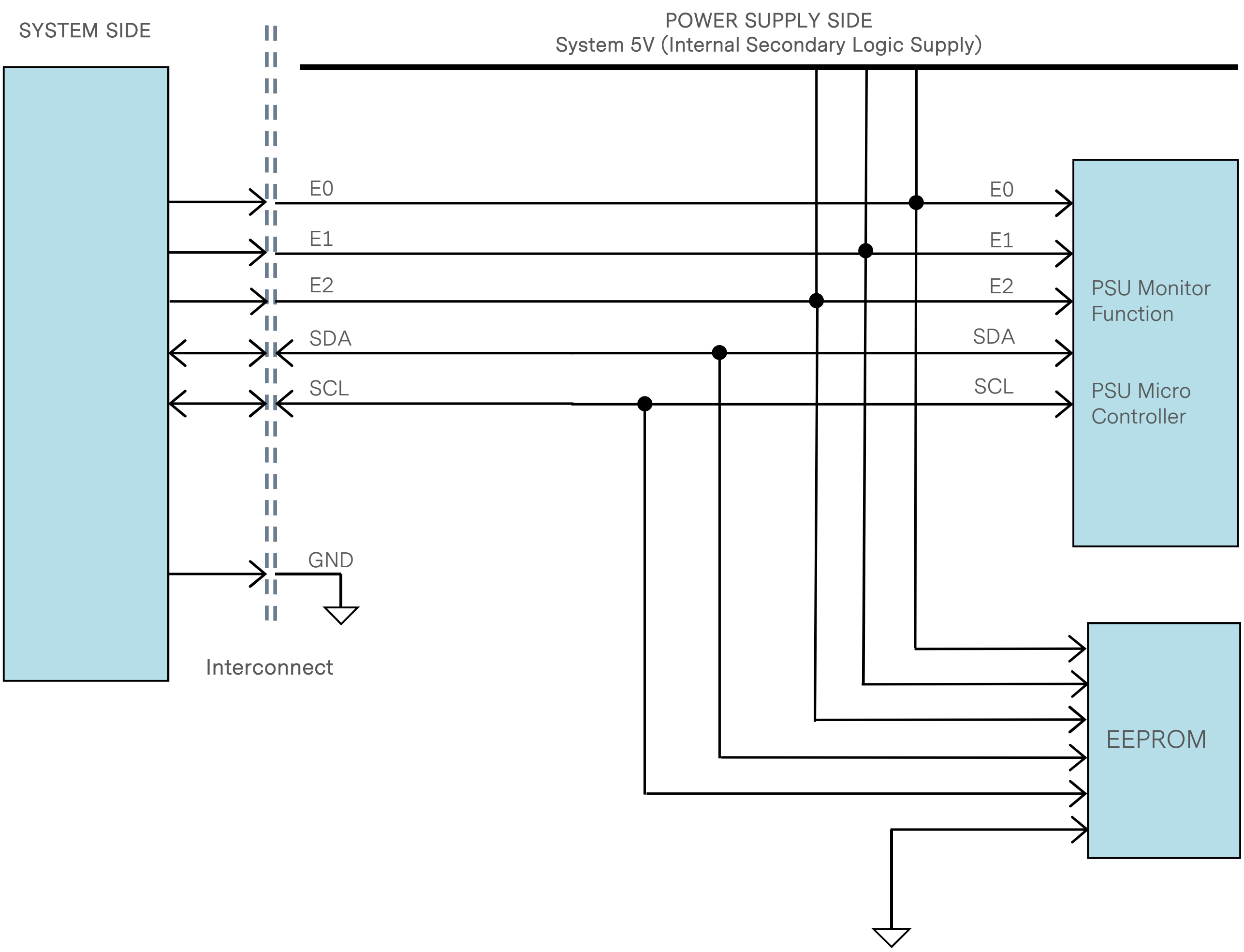
S	1 0 1 0 E2-E0 0	A	A7-A0	A	D7-D0	A	P

Read mode sequences:

S	1 0 1 0 E2-E0 0	A	A7-A0	A	S	1 0 1 0 E2-E0 1	A	D7-D0	A	P

SECTION 6 COMMUNICATION DESCRIPTIONS

I^2C Bus Internal Implementation, Pull-ups and Bus Capacitances



I^2C Bus - Recommended external pull-ups

Electrical and interface specifications of I^2C signals (referenced to standby output return pin, unless otherwise indicated):

Parameter	Condition	Symbol	Min	Type	Max	Unit
SDA, SCL Internal Pull-up Resistor		R_{int}	-	-	-	Kohm
SDA, SCL Internal Bus Capacitance		C_{int}	-	-	-	pF
Recommended External Pull-up Resistor	1 to 8 PSU	R_{ext}	-	2	-	Kohm

SECTION 6 COMMUNICATION DESCRIPTIONS

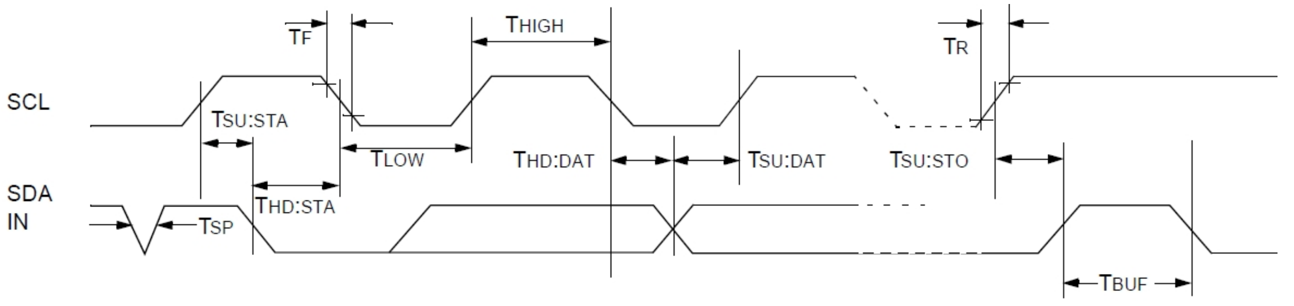
6.2 Logic Levels

TF3000 series power supply I²C communication bus will respond to logic levels as per below:

Logic High: 5V nominal (Spec is 4.5V to 5.5V)
Logic Low: 500mV nominal (Spec is 800mV max)

Note: Advanced Energy 73-769-001 I²C adapter and USB to I²C GUI software was used.

Timings



Parameter	Symbol	Standard-Mode Specs[1]		Actual Measured		Unit
		Min	Max			
Clock frequency	F_{CLK}	-	400	205		KHz
Hold time (repeated) START condition	$t_{HD;STA}$	0.6	-	4.72		µS
LOW period of SCL clock	t_{LOW}	1.3	-	4.45		µS
HIGH period of SCL clock	t_{HIGH}	0.6	-	3.45		µS
Setup time for repeated START condition	$t_{SU;STA}$	0.6	-	5.45		µS
Data hold time	$t_{HD;DAT}$	0	-	488		nS
Data setup time	$t_{SU;DAT}$	100	-	3780		nS
Rise time	t_r	-	300	SCL = 250	SDA = 250	nS
Fall time	t_f	-	300	SCL = 140	SDA = 180	nS
Setup time for STOP condition	$t_{SU;STO}$	0.6	-	5.92		µS
Bus free time between a STOP and START condition	t_{BUF}	1.3	-	63378		µS

Note 1 - Spec is based on ambient temperature -40°C ≤ T_A ≤ +85°C.

SECTION 6 COMMUNICATION DESCRIPTIONS

6.3 Device Addressing

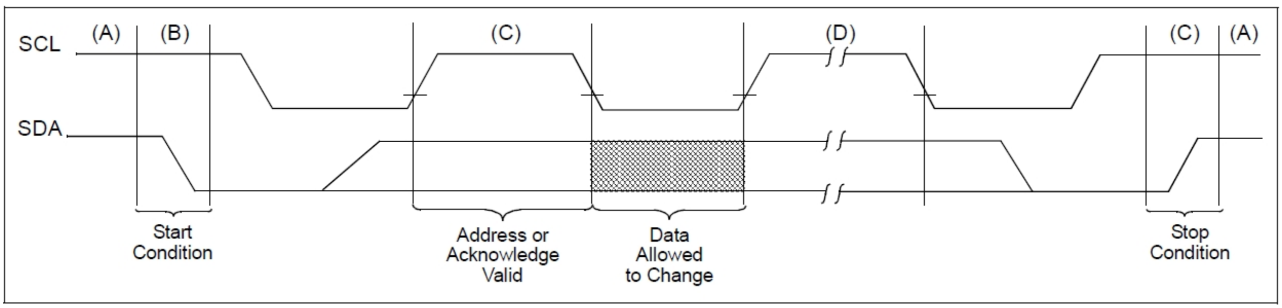
Slave device address is a 7-bit device address, and can be configurable via the address switch on the front panel. The first four bits are fixed 1010 as device type identifier. When 0 is selected on the front panel, it is 0x50 write address. Below is the table of the possible addresses that can be used via the address switch configuration.

PSU Slot			Address Switch Location	Write Address	Read Address
E2	E1	E0			
0	0	0	0	0x50	0x51
0	0	1	1	0x51	0x52
0	1	0	2	0x52	0x53
0	1	1	3	0x53	0x54
1	0	0	4	0x54	0x55
1	0	1	5	0x55	0x56
1	1	0	6	0x56	0x57
1	1	1	7	0x57	0x58

6.4 Bus Characteristics

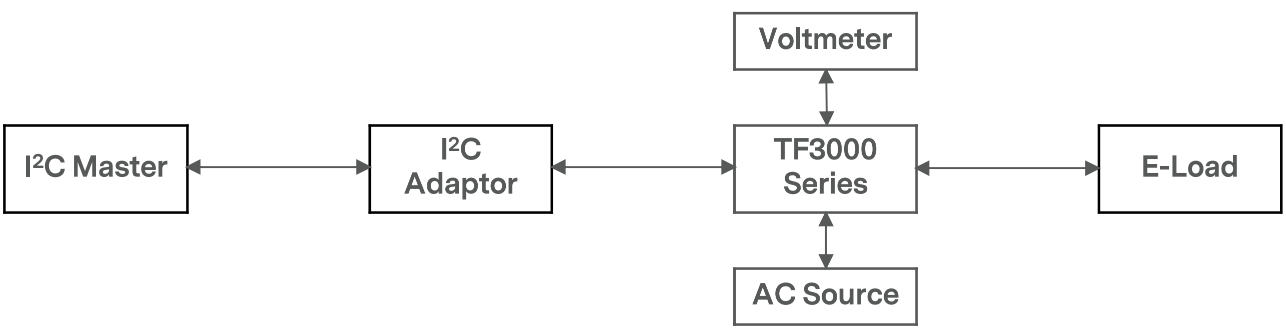
Data transfer may be initiated only when the bus is not busy.

During data transfer, the data line must remain stable whenever the clock line is high. Changes in the data line while the clock line is high will be interpreted as a Start or Stop condition.



6.5 Equipment Setup

The TF3000 series is compliant with the I²C EEPROM device 24C02 protocol for monitoring and control of the power supply via the I²C interface port. The following is typical I²C communication setup:



SECTION 6 COMMUNICATION DESCRIPTIONS

6.6 TF3000 Series Supported I²C Command List

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
00h-0Fh	Manufacture	SL Power,	R	16	ASCII	Default: SL Power, (0x53 4C 20 50 6F 77 65 72 2C 20 20 20 20 20 20 20)
10h-1Fh	Model name	TF3000AxxK	R	16	ASCII	Default: TF3000AxxK (0x54 46 33 30 30 30 41 x x 4B 20 20 20 20 20 20) xx varies based on models with different voltage. Ex: TF3000A12K, TF3000A24K, TF3000A48K, etc.
20h-23h	Output voltage	-	R	4	ASCII	
24h-27h	Revision	-	R	4	ASCII	
28h-2Fh	Manufacture date	-	R	8	ASCII	
30h-3Fh	Serial number	-	R	16	ASCII	
40h-4Fh	Country of manufacture	TAIWAN	R	16	ASCII	Default: TAIWAN (0x54 41 49 57 41 4E 20 20 20 20 20 20 20 20 20 20)
50h-51h	Rated output voltage	-	R	2	Direct	
52h-53h	Rated output current	-	R	2	Direct	
54h-55h	Max. output voltage	-	R	2	Direct	
56h-57h	Max. output current	-	R	2	Direct	
60h-61h	Output voltage[1]	-	R	2	Direct	60h – Low byte, 61h – High byte Multiplier – 100
62h-63h	Output current[2]	-	R	2	Direct	62h – Low byte, 63h – High byte Multiplier – 100
68h	Internal temperature[3]	-	R	1	Direct	Multiplier – 1
6Ch	Status: 0	00	R	1	Bitmapped	Returns the summary of critical faults
	b7 – AC input failure					0 – Normal AC input 1 – AC input < 85Vac, power off
	b6 – AC input power down					0 – AC input ≥ 180Vac, normal output 1 – AC input < 180Vac, output power down
	b5 – HI-TEMP alarm					0 – Internal temperature normally 1 – Internal temperature > 75°C
	b4 – AUX or SMPS fail					0 – Unit normal working 1 – Unit fail, power is shutdown
	b3 – FAN failure					0 – FAN normal working 1 – FAN fail, power is shutdown
	b2 – OTP shutdown					0 – Normal internal temperature 1 – Internal temperature > 85°C, power is shutdown
	b1 – OLP shutdown					0 – Normal 1 – Overload shutdown
	b0 – OVP shutdown					0 – Normal 1 – Overvoltage shutdown

Note 1 - To ensure the reading data accuracy, read 0x60 at 1st priority and then 0x61 at 2nd. Ex. the hex value of [0x60] = 0x74, [0x61] = 0x09. Convert 0x0974 into decimal is 2420, to divide 2420 by 100 equals 24.20, Vo = 24.20V.

Note 2 - To ensure the reading data accuracy, read 0x62 at 1st priority and then 0x63 at 2nd. Ex. the hex value of [0x62] = 0xC6, [0x63] = 0x11. Convert 0x11C6 into decimal is 4550, to divide 4550 by 100 equals 45.50, Io = 45.50A.

Note 3 - To read the values of the addresses of [0x68], convert the value into decimal to receive the internal temperature (centigrade). Ex. the hex value of [0x68] = 0x37. Convert 0x37 into decimal is 55, the internal temperature is 55°C.

SECTION 6 COMMUNICATION DESCRIPTIONS

The TF3000L-T Series Supported I²C Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
6Fh	Status: 1	12	R	1	Bitmapped	Summary of units fault and warning status
	b7 – Remote control status					0 – Control by VCI, ACI, INHI 1 – Control by software (I²C or RS232/RS485)
	b6:5 – Not used					Not supported
	b4 – ON/OFF status					0 – Power off 1 – Power on
	b3:2 – Not used					Not Supported
	b1 - Inhibit by control register (7Ch bit7=1)					0 – Unit normal working 1 – Inhibit by 7Ch bit0
	b0 – Inhibit by VCI/ACI or INHI (7Ch bit7=0)					0 – Unit normal working 1 – Inhibit by VCI/ACI/INHI signal
70h-71h	O/P voltage setting[1,3]	00	R/W	2	Direct	70h – Low byte 71h – High byte Multiplier – 100
72h-73h	O/P current setting[2,3]	00	R/W	2	Direct	72h – Low byte 73h – High byte Multiplier – 100
7Ch	Control	00	R/W	1	Bitmapped	Temperature related faults and warnings
	b7 – Remote control					0 – Control by VCI, ACI, INHI 1 – Control by software (I²C or RS232/RS485)
	b6 – Reserved					Reserved
	B5:4 – Not used					Not supported
	b3 – Command error					0 – Valid 1 – Error
	b2 – Command update					0 – Control by VCI, ACI, INHI 1 – Control by software (I²C or RS232/RS485)
	b1 – Note used					Not supported
	b0 – Power control					0 – Power off 1 – Power on

Note 1 - Multiply the setting voltage of 100 and convert the value into hex code, then write high byte and low byte on the addresses of 0x71, 0x70. Ex: The output voltage setting is 24.25V, to multiply 24.25 of 100 and convert 2425 into hex 0x0979. Write hex code 0x09, 0x79 into the addresses of 0x71, 0x70.

Note 2 - Multiply the setting current of 100 and convert the value into hex code, then write high byte and low byte on the addresses of 0x73, 0x72. Ex: The output current setting is 45.75A, to multiply 45.75 of 100 and convert 4575 into hex 0x11DF. Write hex code 0x11, 0xDF into the addresses of 0x73, 0x72.

Note 3 - After setting voltage and current stores in buffer the setting parameters will not be updated immediately. The parameters will present after checking procedure of writing 1 on the bit2 of control register 0x7C will be done.

1) The setting will be denied when the setting value is over limits, the output will remain the default value. The reading of bit3 of control register (0x7C) command is 1 as error.
2) The setting will be effective when the setting value is in limits, the output setting will be updated. The reading of bit3 of control register (0x7C) command is 0 as valid.

After writing 1 into the bit2 of control register (0x7C), the bit will be clear to “0” no matter if the setting is valid. To verify the command is running successfully by evaluating the values of bit3 and bit2 of the control register (0x7C).

SECTION 7 APPLICATION NOTES

7.1 Current Sharing and Parallel Operation

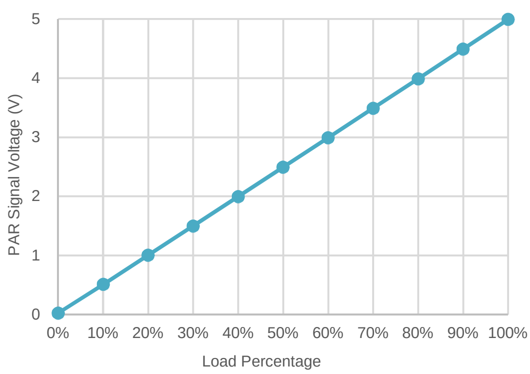
The TF3000 series OR'ing diode has the built-in active sharing function to support maximum of 8 power supplies connected in parallel condition to support higher output power application.

To perform the parallel connection, make sure all the PAR pins connected for current sharing function, and the output voltage difference of each PSU < 0.2Vdc (set via V-adj from the front panel). To ensure current share balance, output current of each unit must be > 10% vs. the rated output current.

The table below shows the derated maximum power capacity when units are in parallel configuration.

Number of Units in Parallel (N)	Maximum Output Power (Rated output power per unit x N x 0.9)
Stand-alone	3000W
2	5400W
3	8100W
..	..
....	....
8	21600W

PAR signal voltage of the TF3000 series power supply:



SECTION 7 APPLICATION NOTES

7.2 Output Voltage and Current Setting by I²C Command

Leave the EN+ & EN- signals disconnected to make sure the power supply is inhibited as stand-by mode.

Read the command 0x60, 0x61. Get the original output voltage 0V.

Must set both the output voltage and output current.

For example set the output voltage to 24.5V (multiply 24.5 of 100 and convert 2450 decimal to 0x0992), and output current to 125A (multiply 125 of 100 and convert 12500 decimal to 0x30D4).

Write the command 0x70 (low byte) and 0x71 (high byte) with 0x92 and 0x09 respectively.

Write the command 0x72 (low byte) and 0x73 (high byte) with 0xD4 and 0x30 respectively.

After the voltage and current setting, the voltage and current stores in the buffer of power supply. The parameters will present after writing 1 on the bit2 of Control Register 0x7C, that is to write 0x7C with 0x85 (1000 0101).

Read the output voltage with command 0x60, 0x61 again to verify the new output voltage.

Script examples:

Seq#	Enable	Start	Address	R/W	Data	Stop?	Delay(ms)	Description	Status
1	☑	S	A0	WRITE	60	☐	0		No Error
2	☑	S	A0	READ	00	☑	0	Read original voltage, it's 0V	No Error
3	☑	S	A0	WRITE	61	☐	0		No Error
4	☑	S	A0	READ	00	☑	0		No Error
5	☑	S	A0	WRITE	70,92	☑	0	Set voltage to 0x0992, 24.5V	No Error
6	☑	S	A0	WRITE	71,09	☑	0		No Error
7	☑	S	A0	WRITE	72,D4	☑	0	Set current to 0x30D4, 125A	No Error
8	☑	S	A0	WRITE	73,30	☑	0		No Error
9	☑	S	A0	WRITE	7C,85	☑	2000	Command update and power on	No Error
10	☑	S	A0	WRITE	60	☐	0		No Error
11	☑	S	A0	READ	92	☑	0	Read new voltage	No Error
12	☑	S	A0	WRITE	61	☐	0		No Error
13	☑	S	A0	READ	09	☑	0		No Error

7.3 Remote On/Off by I²C Command

Set the specific output voltage and output current according to the procedures in section 7.2.

To power off, write "0" into the bit0 of control Register 0x7C.

To Power on, write "1" into the bit0 of control Register 0x7C.

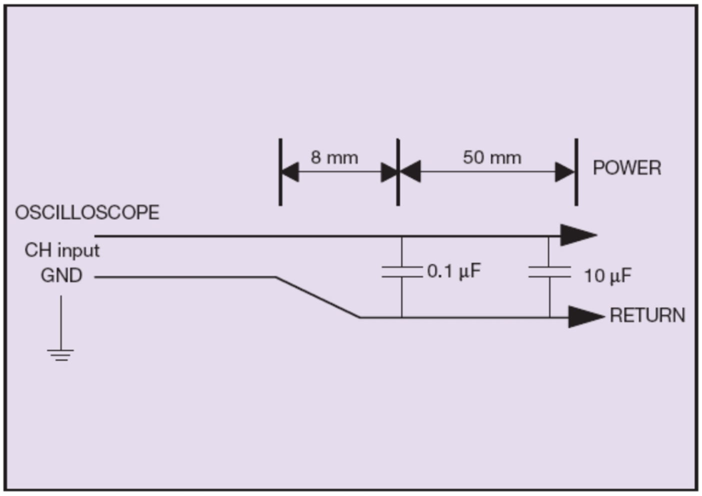
Script examples:

Seq#	Enable	Start	Address	R/W	Data	Stop?	Delay(ms)	Description	Status
1	☑	S	A0	WRITE	7C,84	☑	20000	Power off	No Error
2	☑	S	A0	WRITE	60	☐	0		No Error
3	☑	S	A0	READ	41	☑	0	Read voltage, decrease to 5.32V (0A load)	No Error
4	☑	S	A0	WRITE	61	☐	0		No Error
5	☑	S	A0	READ	02	☑	0		No Error
6	☑	S	A0	WRITE	7C,85	☑	2000	Power on	No Error
7	☑	S	A0	WRITE	60	☐	0		No Error
8	☑	S	A0	READ	95	☑	0	Read voltage, 24.53V	No Error
9	☑	S	A0	WRITE	61	☐	0		No Error
10	☑	S	A0	READ	09	☑	0		No Error

SECTION 7 APPLICATION NOTES

7.4 Output Ripple and Noise Measurement

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the TF3000 series. When measuring output ripple and noise, a scope jack in parallel with a 0.1 µF ceramic chip capacitor, and a 10 µF tantalum capacitor should be used. Oscilloscope should be set to 20 MHz bandwidth for this measurement.



SECTION 8 RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	09.12.23	First Issue	A. Zhang

Note – If you have any feedback for this document, feel free to contact kathy.wang@aei.com.

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