TET3600-48-069xA

3600 W AC-DC Front-End Power Supply

Bel Power Solutions **TET3600-48-069xA** series is a 3600 Watt AC-DC power-factor-corrected (PFC) and DC-DC power supply that converts standard AC mains power or high voltage DC bus voltages into a main output of 54.5 VDC for supplying 48 VDC power distribution in high performance and reliability data center equipment, servers, routers, and network switches.

The TET3600-48-069xA meets international safety standards and displays the CE-Mark for the European Low Voltage Directive (LVD).

Key Features & Benefits

- Best-in-class efficiency of up to 97% at half load
- Wide input voltage range: full power at 200 - 277 VAC or 240 - 380 VDC, reduced output power at 90-180 VAC
- AC input with power factor correction, usable also with high voltage DC
- 3600 W main output
- Standby output 12 VDC / 30 W
- Golden fingers for incoming source connection and DC output connection (in double decked configuration)
- Parallel operation with active current sharing
- Hot-plug capable
- High density design: 44.4 W/in^3
- Small form factor (W x H x L): 68 x 40 x 490 mm (2.68 x 1.57 x 19.29 in)
- Full digital controls for improved performance
- I2C communication interfaces for control, programming and monitoring
- Over temperature, output overvoltage and overcurrent protection
- Status LED with fault signaling
- Black Box recorder
- Safety to UL/CSA 62368-1 and IEC/EN 62368-1
- RoHS Compliant

RoHS Compliant

Applications

- High Performance Servers
- Routers and Switches
- Data Center
- Industrial Power Supplies

1. ORDERING INFORMATION

TET	3600	-	48	-	069	x	A	Option Code
Product Family	**Power Level**	**Dash**	**V1 Output**	**Dash**	**Width**	**Airflow**	**Input**	
TET Front-Ends	3600 W		48 V		69 mm	N: Normal R: Reverse[1)]	A: AC	Blank: Standard model

[1)] Front to Rear

2. OVERVIEW

The TET3600-48-069xA is a fully DSP controlled, highly efficient front-end power supply. It incorporates resonant-soft-switching technology and highly integrated conversion stages to reduce component stresses, providing increased system reliability, very high efficiency and high-power density. With a wide input operating voltage range and minimal linear derating of output power with respect to ambient temperature, the TET3600-48-069xA maximizes power availability in demanding server, switch, and router applications. The power supply is fan cooled and ideally suited for server integration with a matching airflow path.

The PFC stage is digitally controlled using a state-of-the-art digital signal processing algorithm to guarantee best efficiency and unity power factor over a wide operating range when using AC input voltage. When operated with high voltage DC the PFC circuit is still in operation, but input current is controlled to be DC.

The DC-DC stage uses soft switching resonant techniques in conjunction with synchronous rectification. An active OR-ing device on the output ensures no reverse load current and renders the supply ideally suited for operation in redundant power systems.

The optional always-on +12V standby output provides power to external power distribution and management controllers. Its protection with an active OR-ing device provides for maximum reliability.

Status information is provided with front-panel LED. In addition, the power supply can be monitored and controlled (i.e. fan speed setpoint) via the I2C bus. It allows full monitoring of the supply, including input and output voltage, current, power, and inside temperatures. The bus supports the bootloader to allow field update of the firmware in the DSP controllers.

Cooling is managed by a fan, controlled by the DSP controller. The fan speed is adjusted automatically depending on the actual power demand and supply temperature and can be overridden through the I2C bus.

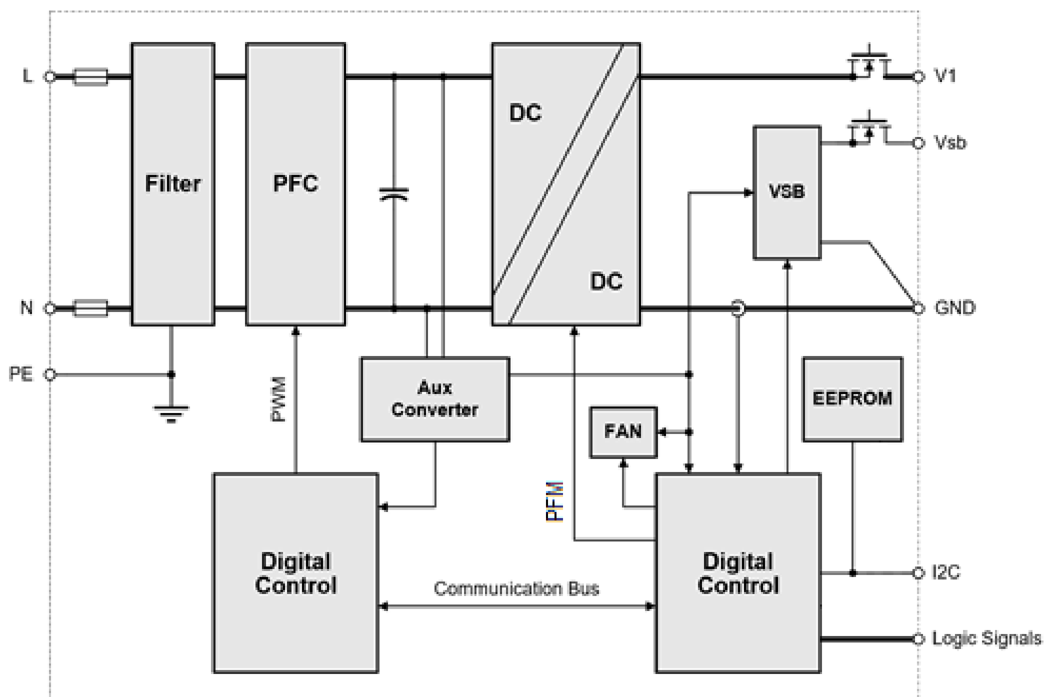

Figure 1. TET3600-48-069xA Block Diagram

3. ABSOLUTE MAXIMUM RATINGS

Stresses in excess of the absolute maximum ratings may cause performance degradation, adversely affect long-term reliability, and cause permanent damage to the power supply.

PARAMETER		CONDITIONS / DESCRIPTION	MIN	MAX	UNIT
$V_{i\ maxc}$	Maximum Input	Continuous		305 400	VAC VDC

4. INPUT

General Condition: T_A = 0…50 °C unless otherwise specified.

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
$V_{i\ AC\ nom}$	Rated AC Input Voltage	Rated AC Input Voltage	100	230	277	VAC
$V_{i\ AC\ operating}$	AC Input Voltage Range	Operating AC Input Voltage ($V_{i\ AC\ min}$ to $V_{i\ AC\ max}$)	90		305	VAC
$V_{i\ AC\ HL}$	High line AC Input Voltage	AC Input Voltage Range with full output power	180		305	VAC
$V_{i\ AC\ Red}$	Derated AC Input Voltage	AC Input Voltage Range with reduced output power	90		180	VAC
$V_{i\ DC\ nom}$	Rated DC Input Voltage	Rated DC Input Voltage	240		380	VDC
$V_{i\ DC\ operating}$	DC Input Voltage range	Operating DC Input Voltage ($V_{i\ DC\ min}$ to $V_{i\ DC\ max}$)	192		400	VDC
$I_{i\ max}$	Max Input Current	$V_{i\ AC}$ > 200 VAC or $V_{i\ DC}$ > 200 VDC			21	A_{rms}
$I_{i\ p}$	Inrush Current Limitation	$V_{i\ AC\ min}$ to $V_{i\ AC\ max}$ or $V_{i\ DC\ min}$ to $V_{i\ DC\ max}$			50	A_p
F_i	Input Frequency		47	50/60	63	Hz
PF	Power Factor	$V_{i\ AC\ nom}$, 50Hz, I_1 ≥0.1 $I_{1\ nom}$ $V_{i\ AC\ nom}$, 50Hz, I_1 ≥0.2 $I_{1\ nom}$ $V_{i\ AC\ nom}$, 50Hz, I_1 ≥ 0.5 $I_{1\ nom}$ $V_{i\ AC\ nom}$, 50Hz, I_1 =100% $I_{1\ nom}$	0.90 0.95 0.98 0.99			W/VA W/VA W/VA W/VA
THD	Total Harmonic Distortion on Input Current	$V_{i\ AC\ HL}$, > 50 % $P_{1\ nom}$		3	5	%
$V_{i\ AC\ on}$	Turn-on AC Input Voltage[2]	Ramping up	86	88	90	VAC
$V_{i\ AC\ off}$	Turn-off AC Input Voltage	Ramping down	80	83	86	VAC
$V_{i\ DC\ on}$	Turn-on DC Input Voltage	Ramping up	183	186	188	VDC
$V_{i\ DC\ off}$	Turn-off DC Input Voltage	Ramping down	176	181	185	VDC
η	Efficiency[3]	V_i = 230 VAC, 0.1·$I_{x\ nom}$, $V_{x\ nom}$, T_A = 25°C V_i = 230 VAC, 0.2·$I_{x\ nom}$, $V_{x\ nom}$, T_A = 25°C V_i = 230 VAC, 0.5·$I_{x\ nom}$, $V_{x\ nom}$, T_A = 25°C V_i = 230 VAC, $I_{x\ nom}$, $V_{x\ nom}$, T_A = 25°C		92 95.2 96.5 95.6		%
T_{hold}	Hold-up Time	After last AC zero crossing, V_1 > 45 V, $V_{i\ AC\ nom}$, $P_{1\ nom}$ After last AC zero crossing, V_1 > 45 V, $V_{i\ AC\ nom}$, 50% $P_{1\ nom}$	12 20			ms ms
$T_{hold-up,\ vsb-to-vo1}$	Time from Vo1 to Vsb Leaving Regulation	All hold-up conditions	40			ms

[2] The Front-End is provided with a minimum hysteresis of 3 V during turn-on and turn-off within the ranges
[3] Efficiency measured without fan loss included in PSU losses

4.1. INPUT FUSE

Fast-acting 30 A input fuses in series with both the L- and N-line inside the power supply protect against severe defects. The fuses are not accessible from the outside and are therefore not serviceable parts.

4.2. INRUSH CURRENT

The power supply exhibits an X capacitance of 6.6 µF, resulting in a low and short peak current, when the supply is connected to the mains. The internal bulk capacitors will be charged through NTC resistors which will limit the inrush current.

NOTE:

Do not repeat plug-in / out operations below 30 sec interval time, or else the internal in-rush current limiting device (NTC) may not sufficiently cool down and excessive inrush current may result.

4.3. INPUT UNDER-VOLTAGE

If the input voltage is reduced below the input under-voltage lockout threshold $V_{i\ AC\ off}$ or $V_{i\ DC\ off}$, the supply will be inhibited. Once the input voltage rises above $V_{i\ AC\ on}$ or $V_{i\ DC\ on}$, the supply will return to normal operation again.

4.4. POWER FACTOR CORRECTION

Power factor correction (PFC) is achieved by controlling the input current waveform synchronously with the input voltage. A fully digital controller is implemented giving outstanding PFC results over a wide input voltage and load range. The input current will follow the shape of the input voltage. If, for instance, the input voltage has a trapezoidal waveform, then the current will also show a trapezoidal waveform.

4.5. EFFICIENCY

The high efficiency is achieved by using state-of-the-art silicon power devices in conjunction with soft-transition topologies minimizing switching losses and a full digital control scheme. Synchronous rectifiers on the output reduce the losses in the high current output path. The rpm of the fan is digitally controlled to keep all components at an optimal operating temperature regardless of the ambient temperature and load conditions. *Figure 2* shows the measured efficiency with AC input voltage applied, while *Figure 3* represents the efficiency when operating with high voltage DC input.

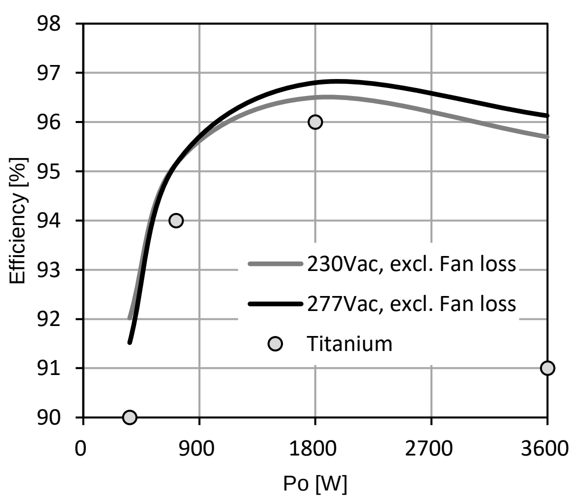

Figure 2. Typical Efficiency vs. Load Current at AC Input

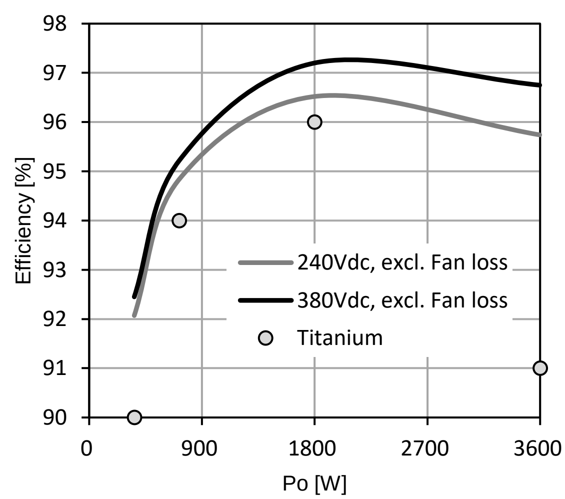

Figure 3. Typical Efficiency vs. Load Current at HVDC Input

5. OUTPUT

General Condition: T_A = 0…50 °C unless otherwise noted.

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
Main Output V1						
$V_{1\ nom}$	Nominal Output Voltage	$0.5 \cdot I_{1\ nom}$, $T_a \leq 50°C$		54.5		VDC
$V_{1\ set}$	Output Setpoint Accuracy	$0.5 \cdot I_{1\ nom}$, $T_a \leq 50°C$	-0.5		+0.5	% $V_{1\ nom}$
$dV_{1\ tot}$	Total Regulation	$V_{i\ AC\ min}$ to $V_{i\ AC\ max}$ or $V_{i\ DC\ min}$ to $V_{i\ DC\ max}$, 0 to 100% $I_{1\ nom}$, $T_{a\ min}$ to $T_{a\ max}$	-3		+3	% $V_{1\ nom}$
$P_{1\ nom}$	Nominal Output Power	$V_{i\ AC\ HL}$ or $V_{i\ DC\ operating}$, $T_a \leq 50°C$		3600		W
$I_{1\ nom}$	Nominal Output Current	$V_{i\ AC\ HL}$ or $V_{i\ DC\ operating}$, $T_a \leq 50°C$		66		ADC
		$V_{i\ AC\ HL}$ or $V_{i\ DC\ operating}$, T_a = 60 °C		53.2		ADC
$P_{1\ red}$	Available Output Power at V_i < 180 VAC	$V_{i\ AC\ Red}$, $T_a \leq 50°C$		21Arms*Vin – 400W[4]		W
$P_{1\ red}$	Low Line Output Power	V_i = 120 VAC, $T_a \leq 50°C$		2120		W
$I_{1\ ol}$	Short Time Over Load Current, Maximum duration 10 ms	$V_{i\ AC\ Red}$, $V_{i\ AC\ HL}$, $V_{i\ DC\ operating}$, relative to static output current available			110	%
$v_{1\ pp}$	Output Ripple Voltage	20 MHz BW with min Capacitive load			500	mVpp
$dV_{1\ Load}$	Load Regulation	$V_i = V_{i\ AC\ nom}$ or $V_{i\ DC\ nom}$, 0 - 100 % $I_{1\ nom}$		-12		mV/A
$dV_{1\ Line}$	Line Regulation	$V_{i\ AC\ min}$ to $V_{i\ AC\ max}$ or $V_{i\ DC\ min}$ to $V_{i\ DC\ max}$		0		mV
dI_{share}	Current Sharing	Deviation from $I_{1\ tot}$ / N, I_1 > 20% $I_{1\ nom}$	-3		+3	ADC
dV_{dyn}	Dynamic Load Regulation	ΔI_1 = 50% $I_{1\ nom}$, I_1 = 10 … 100% $I_{1\ nom}$, dI_1/dt = 1A/µs, f = 2 ... 50 Hz.	-2		2	V
T_{rec}	Recovery Time	Within 1% of V_1 final steady state I_1 = 10 … 100% $I_{1\ nom}$			2	ms
$t_{AC\ V1}$	Start-up Time from AC	Time from V_i in range to V_1 in regulation, T_A > 10 °C			2[5]	sec
$t_{V1\ rise}$	Rise Time	V_1 = 10 … 90% $V_{1\ nom}$	1		100	ms
C_{V1}	Maximum Capacitive Load		2.2		15	mF

[4] Example: At nominal grid 120 VAC the max. output power is 2120 W.
[5] At low ambient temperature T_A < 10 °C this time can rise to max 10 s.

5.1. STANDBY OUTPUT

A standby output is available, delivering 12 V with up to 2.5 A, to provide power to system management controls.

The output is always enabled if the input voltage is within operating range, and provides over current, over voltage and over temperature protections. Current share on standby output is provided by passive droop sharing.

General Condition: T_A = 0…50 °C unless otherwise noted.

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
Standby output VSB						
$V_{SB\ nom}$	Nominal Output Voltage	I_{SB} = 1.25 A, T_A = 25 °C		12		VDC
$V_{SB\ set}$	Output Setpoint Accuracy		-0.5		+0.5	% $V_{SB\ nom}$
$dV_{SB\ tot}$	Total Regulation	$V_{i\ min}$ to $V_{i\ max}$, 0 to 100 % $I_{SB\ nom}$, $T_{A\ min}$ to $T_{A\ max}$	-5		+3	% $V_{SB\ nom}$
$P_{SB\ nom}$	Nominal Output Power			30		W
$I_{SB\ nom}$	Nominal Output Current			2.5		ADC
$V_{SB\ pp}$	Output Ripple Voltage	20 MHz BW			150	mVpp
$dV_{SB\ Load}$	Load Regulation	0 - 100 % $I_{SB\ nom}$		200		mV
$dV_{SB\ Line}$	Line Regulation	V_i = $V_{i\ AC\ min}$ … $V_{i\ AC\ max}$ or $V_{i\ DC\ min}$ ... $V_{i\ DC\ max}$		0		mV
dI_{share}	Current Sharing	Deviation from $I_{SB\ tot}$ / N			2	ADC
dV_{dyn}	Dynamic Load Regulation	ΔI_{SB} = 50% $I_{SB\ nom}$, I_{SB} = 5 … 100% $I_{SB\ nom}$, dI_{SB}/dt = 1A/µs, f = 2 ... 50 Hz.	-600		600	mV
T_{rec}	Recovery Time	Within 1% of V_{SB} final steady state			2	ms
$t_{AC\ VSB}$	Start-up Time from AC	Time from V_i in range to V_{SB} in regulation, T_A > 10°C			1.5[6]	sec
$t_{VSB\ rise}$	Rise Time	V_{SB} = 10 … 90% $V_{SB\ nom}$	2		20	ms
C_{VSB}	Maximum Capacitive Load		100		3100	µF

5.2. OUTPUT VOLTAGE RIPPLE

The internal output capacitance at the power supply output (behind OR-ing element) is minimized to prevent disturbances during hot plug. To provide low ripple voltage at the application, external capacitors (a parallel combination of 10 µF low ESR capacitor in parallel with 0.1 µF ceramic capacitors) should be added at the input of the connected load circuits.

5.3. OVERSUBSCRIPTION

The main output has the capability to allow a load current of up to 10 A above the nominal output current rating for a maximum duration of 5 ms. This allows the system to consume extended power for short time dynamic processes. Oversubscription can be used with maximum 10% duty cycle. If the output current is less than 10 A above nominal output current, then the oversubscription time can be longer.

5.4. OUTPUT GROUND

The main output return path serves as main power return, the standby has a separate return path as standby power output return, and all signals are referenced to signal ground SGND. But they are non-isolated inside the PSU.

Signal ground SGND may be connected to power ground GND within the application, shown as dotted lines in *Figure 4*, allowing powering of system communication and logic from VSB output.

[6] At low ambient temperature T_A < 10 °C this time can rise to max 10s

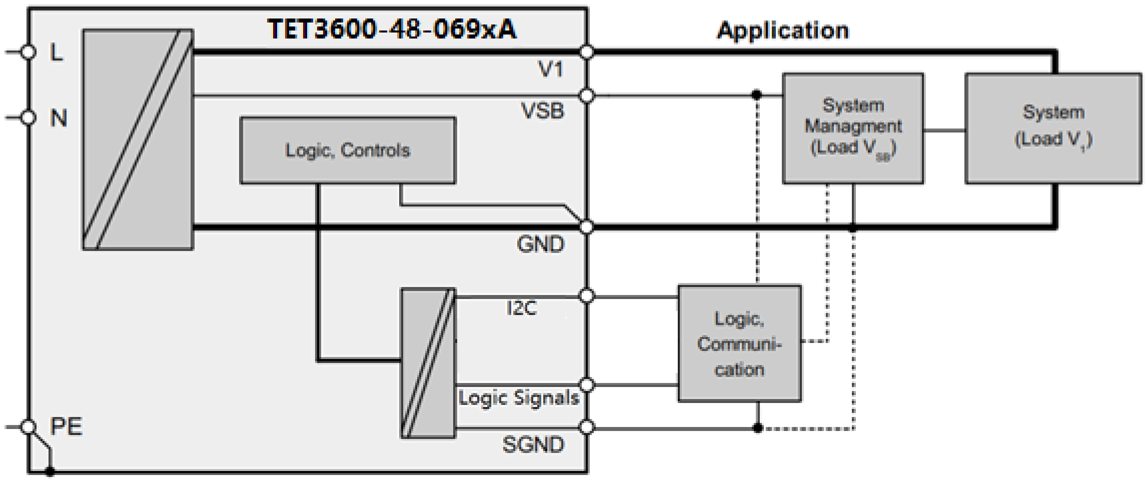

Figure 4. Output connection

6. PROTECTION

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
F	Input Fuses (L+N)	Not user accessible, fast-acting (F)		30		A
$V_{1\ OV}$	OV Threshold V_1	Latch-off Type	57		61	VDC
$t_{V1\ OV}$	OV Latch Off Time V_1				1	ms
$P_{1\ lim}$	Nominal Power Limitation	$V_{i\ AC\ HL}$, $T_a \leq 50°C$		3600		W
		$V_{i\ AC\ HL}$, $T_a = 60°C$		2900		W
$I_{1\ lim}$	Nominal Current Limitation	$V_{i\ AC\ HL}$, $T_a \leq 50°C$	69	72	75	ADC
		$V_{i\ AC\ HL}$, $T_a = 60°C$	56	59	62	ADC
I1 ol lim	Current Limit during short time over load V1	$V_{i\ AC\ HL}$, $T_a \leq 50°C$, Maximum duration 10ms	73	76		ADC
t1 SC off	Short Circuit Latch off time	Time to latch off when in short circuit or output under voltage ($V_1 < V_{1\ UV}$)		10		ms
$V_{1\ UV}$	Output Under Voltage Protection		39	40	41	VDC
$t_{1\ UV}$	Output Under Voltage Protection Delay time	$V_1 < V_{1\ UV}$		250		ms
TSD	Over Temperature on critical points	Inlet Ambient Temperature Secondary Sync Mosfet Temperature		75 120		°C °C
$V_{SB\ OV}$	OV Threshold V_{SB}		13		14.5	VDC
$V_{SB\ UV}$	Output Under Voltage Protection Standby		11.1	11.2	11.3	VDC
$I_{SB\ Lim}$	Standby Over Current Limit		3		4	ADC

6.1. PROTECTION BEHAVIOR

Main Output: A fault on the main output will turn off only the main output. For all faults, the output is turned off and auto restart after 1sec, except:

- OVP – output will latch off.
- SCP – output will latch off.
- OTP – once the temperature cools down to recovery point, the output will restart.

Standby Output: A fault on the standby output will turn off both the standby output and main output. The outputs are turned off and auto restart after 1sec, except:

- OTP_VSB – once the temperature cools down to recovery point, the output will restart.

The latch off can be cleared by:

- Recycle PSON
- Recycle Input Voltage (at least 1sec off-time)
- Send 0x00 to OPERATION command and then send 0x80 to OPERATION command through I2C communication.

6.2. OVER VOLTAGE PROTECTION

For both Main and Standby outputs, the over voltage protection is implemented with a comparator. Once an OV condition is triggered, the output is turned off. Refer to Section 6.1 for protection behavior.

6.3. UNDER VOLTAGE DETECTION

For both Main and Standby outputs, the under voltage protection is implemented in firmware. Once a UV condition is triggered, the output is turned off. Refer to Section 6.1 for protection behavior.

6.4. CURRENT LIMITATION MAIN OUTPUT

Two different over current protection features are implemented on the main output.

The 1st protection is a static over current protection will shut down the output, if the output current is increased slowly and exceeds $I_{1\ lim}$ for more than 50ms, this protection will shut down the supply.

The 2nd protection is a substantially rectangular output characteristic controlled by a software feedback loop. This protects the power supply and system during the 50 ms blanking time of the static over current protection. If the output current is rising fast and reaches $I_{1\ ol\ lim}$, the supply will immediately reduce its output voltage to prevent the output current from exceeding $I_{1\ ol\ lim}$. When the output current is reduced below $I_{1\ ol\ lim}$, the output voltage will return to its nominal value. In case the output voltage drop below the under-voltage level $V_{1\ UV}$ the output will turn off after 10 ms, signaling an under-voltage fault.

The main output current limitation level $I_{1\ lim}$ and $I_{1\ ol\ lim}$ are decreased if the ambient (inlet) temperature increases beyond 50°C (see *Figure 6*). See also *Figure 5* for output characteristic and current limitation.

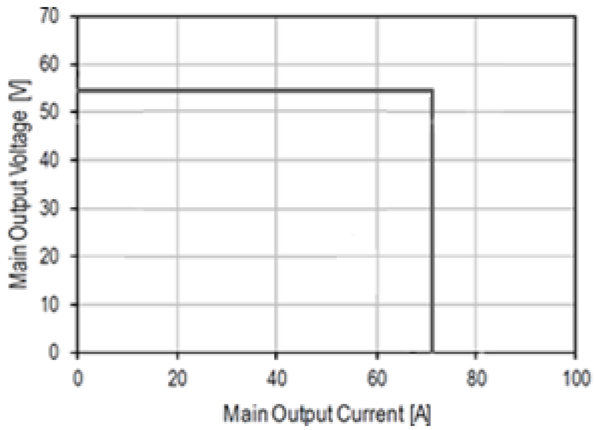

Figure 5. Output characteristics V_1

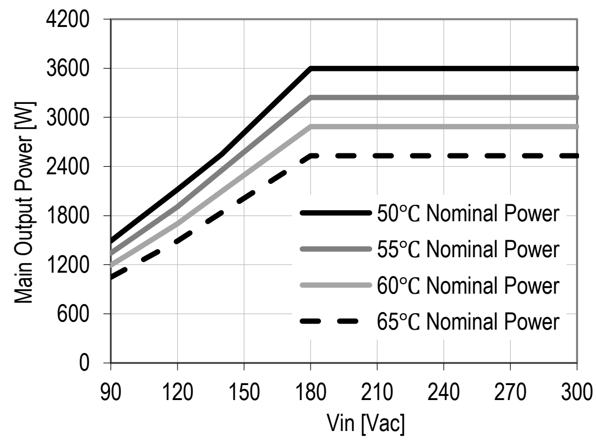

Figure 6. Derating on V1 vs Ta & Vin

6.5. CURRENT LIMITATION STANDBY OUTPUT

The standby output has a hiccup current limitation implemented. If the standby current exceeds $I_{SB\ Lim}$ the standby converter switches off and retries automatically after 1 second off time.

7. MONITORING

The power supply provides information about operating conditions through its I2C bus interface. Details can be found in the I2C Communication Manual BCA.00313. Accuracy of sensors within PSU is given in following table.

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
$V_{i\ mon}$	Input RMS Voltage	$V_{i\ min} \leq V_i \leq V_{i\ max}$	-3		+3	V_{rms}
$I_{i\ mon}$	Input RMS Current		-1		+1	A
$P_{i\ mon}$	True Input Power		-150		+150	W
$V_{1\ mon}$	V_1 Voltage	V_1 > 40 VDC	-1		+1	%
$I_{1\ mon}$	V_1 Current	I_1 > 25 A	-3		+3	%
		$I_1 \leq 25$ A	-1		+1	A
$V_{SB\ mon}$	V_{SB} Voltage	I_{SB} = 0 … 2.5A	-0.25		+0.25	V
$I_{SB\ mon}$	V_{SB} Current	I_{SB} = 0 … 2.5A	-0.5		+0.5	A
$P_{1\ mon}$	P_1 Output Power	P_1 > 1000W	-3		+3	%
		$P_1 \leq 1000$W	-30		+30	W
$T_{a\ mon}$	Inlet air temperature	T_a = 0 ... 50°C	-5		+5	°C

8. SIGNALING AND CONTROL

8.1. ELECTRICAL CHARACTERISTICS

PARAMETER	DESCRIPTION / CONDITION		MIN	NOM	MAX	UNIT
PSKILL/ PSON_L / Inputs						
V_{IL}	Input Low Level Voltage (Main output enabled)		-0.2		0.8	V
V_{IH}	Input High Level Voltage(Main output disabled)		2.4		3.5	V
$I_{IL,\ H}$	Maximum Input Sink or Source Current		0		1	mA
$R_{puPSKILL\_H}$	Internal Pull Up Resistor on PSKILL to internal 3.3V			10		kΩ
R_{puPSON_L}	Internal Pull Up Resistor on PSON_L to internal 3.3V			4.7		kΩ
PWOK_H Output						
V_{OL}	Output Low Level Voltage	I_{sink} < 4 mA	-0.2		0.4	V
V_{OH}	External pull up voltage				13	V
R_{puPWOK_L}	No internal pull up resistor, Recommended external pull up resistor on PWOK_L at V_{puACOK_L} = 3.3V			10		kΩ
High level output	Output voltage within regulation limits					
Low level output	Output voltage out of regulation limits					
VINOK_H Output						
V_{OL}	Output Low Level Voltage	I_{sink} < 4 mA	-0.2		0.4	V
V_{OH}	External pull up voltage				13	V
$R_{puVINOK\_L}$	No internal pull up resistor, Recommended external pull up resistor on VINOK_L at $V_{puVINOK\_L}$ = 3.3V			10		kΩ
High level output	Input voltage within operating range					
Low level output	No input voltage, or low input voltage					
SMB_ALERT_L Output						
V_{OL}	Output Low Level Voltage	I_{sink} < 4 mA	-0.2		0.4	V
V_{OH}	External pull up voltage				13	V
$R_{puSMB\_ALERT\_L}$	No internal pull up resistor, Recommended external pull up resistor on SMB_ALERT_L at $V_{puSMB\_ALERT\_L}$ = 3.3V			10		kΩ

8.2. PSKILL INPUT

The PSKILL input is active-high and is located on a recessed pin on the connector and is used to disconnect the main output as soon as the power supply is being plugged out. This pin should be connected to SGND in the power distribution unit. The standby output will remain on regardless of the PSKILL input state.

8.3. PSON_L OUTPUT

The PSON_L is an input signal to enable/disable the main output V1 of the front-end. With low level input the main output is enabled. This active-low pin is also used to clear any latched fault condition.

8.4. PWOK _H OUTPUT

The PWOK_H is an isolated open drain output referred to SGND. It requires an external pull-up resistor. PWOK_H is a power OK signal and will be pulled high by the power supply to indicate that all the outputs are within the regulation limits of the power supply. When any output voltage falls below regulation limits or when AC power has been removed for a time sufficiently long so that power supply operation is no longer guaranteed, PWOK_H will be de-asserted to a low state. The start of the PWOK_H delay time shall inhibited as long as any power supply output is in current limit.

8.5. SMB_ALERT_L OUTPUT

The SMB_ALERT _L is an isolated open drain output referred to SGND. It requires an external pull-up resistor. The SMB_ALERT_L signal indicates that the power supply is experiencing a problem that the system agent should investigate. This is a logical OR of the Shutdown and Warning events. It is asserted (pulled Low) at Shutdown or Warning events such as reaching temperature warning/shutdown threshold of critical component, general failure, over-current, over-voltage, under-voltage or low-speed of failed fan. This signal may also indicate the power supply is operating in an environment exceeding the specified limits.

8.6. VINOK_H OUTPUT

The VINOK_H is an isolated open drain output referred to SGND. It requires an external pull-up resistor. A high voltage on this pin reflects input voltage to be within operating range.

8.7. TIMING REQUIREMENTS

These are the timing requirements for the power supply operation. All outputs must rise monotonically.

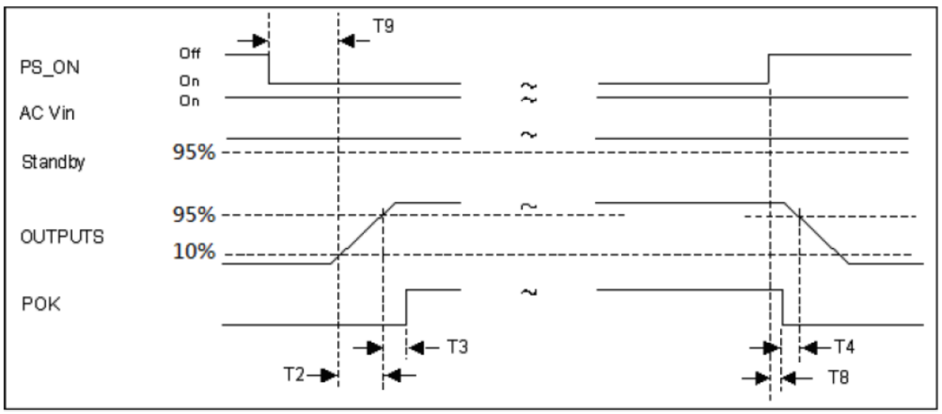

Figure 7. PS_ On/Off Timing

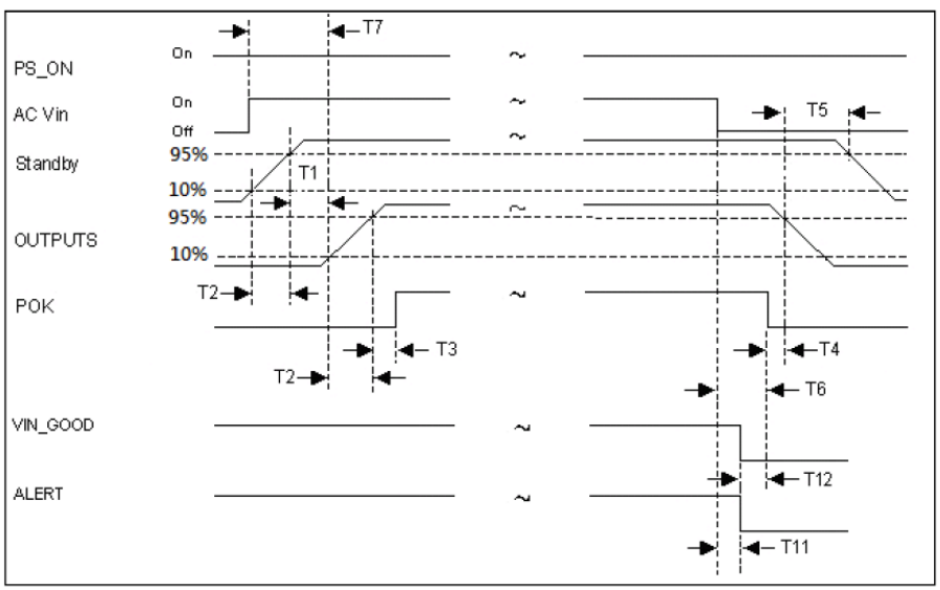

Figure 8. Turn On/Off Timing

PARAMETER	DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
T1	Delay from 12VSB regulation to 54VDC output turn on.	5		500	ms
T2A	Main 54VDC rise time	1		100	ms
T2B	12VSB rise time	2		20	ms
T3	Delay from Main 54VDC output within regulation to PWOK assertion at turn on	100		500	ms
T4	Delay from PWOK de-assertion to Main 54VDC dropping out of 45V	1			ms
T5	Delay from Main 54VDC out of regulation to 12VSB turn off.	40			ms
T6	Delay from loss of INPUT to PWOK de-assertion	10			ms
T7	Delay from application of INPUT on to Main 54VDC turn on			2000	ms
T8	PS_ON negation (PSU off) to PWOK negation			2	ms
T9	PS_ON (PSU on) to output established			350	ms
T11	Delay from VIN drop out to VIN_GOOD negation & SMBALERT assertion			2	ms
T12	Delay from VIN GOOD to PWOK	1			ms

Table 1. Timing Requirements

8.8. SENSE INPUTS

The 54 VDC main output shall be able to compensate for up to 1V of voltage drop to the remote load sense point. This value is a combined voltage drop both in positive and negative lines. In the event of loss of remote sense, all outputs shall revert to internal sensing.

Outputs shall be protected against reversal of sense leads.

8.9. ADDRESSING

The address for I2C communication can be configured by pulling address input pins A0, A1 and A2 either to SGND (Logic Low) or leave them open (Logic High). An internal pull up resistor will cause the A0, A1 and A2 pin to be in High Level if left open. A fixed addressing offset exists for the Controller.

A2	A1	A0	I2C Address	
			Controller	EEPROM
0	0	0	0xB0	0xA0
0	0	1	0xB2	0xA2
0	1	0	0xB4	0xA4
0	1	1	0xB6	0xA6
1	0	0	0xB8	0xA8
1	0	1	0xBA	0xAA
1	1	0	0xBC	0xAC
1	1	1	0xBE	0xAE

Table 2. Address and Protocol Encoding

8.10. FRONT LED

The front-end has one front LED showing the status of the supply. The LED is bi-colored: green and yellow and indicates AC and DC power presence and warning or fault conditions. *Table 3* lists the different LED status.

OPERATING CONDITION	LED STATE
Output ON and OK	Solid GREEN
No AC power to all power supplies	OFF
AC present / Only 12VSB on (PS off)	0.5 Hz Blink GREEN
Standby power failed, OCP, SC, OVP and UVP. Auto-recovery when the abnormal condition is removed.	Solid YELLOW
+54VDC Fault causing a shutdown; failure, (OCP, SC, OVP/UVP), OTP, Fan Fail, Input OVP	Solid YELLOW
Power supply in FW upload mode	2 Hz Blink GREEN

Table 3. LED Status

8.11. CURRENT SHARE

The front-end has an active current share scheme implemented for V1. All the ISHARE current share pins need to be interconnected in order to activate the sharing function. If a supply has an internal fault or is not turned on, it will disconnect its ISHARE pin from the share bus. This will prevent dragging the output down (or up) in such cases.

The standby output uses a passive current share method (droop output voltage characteristic).

Due to non-ideal current share the maximum total output power of paralleled power supplies is less than the theoretical maximum and is defined in Table 4.

No of paralleled PSUs	Maximum available power on main output V		Maximum available power on standby output (optional)	
	without redundancy	n+1 redundancy	without redundancy	n+1 redundancy
1	3600 W	-	30 W	-
2	7000 W	3600 W	47 W	30 W
3	10400 W	7000 W	65 W	47 W
4	13800 W	10400 W	83 W	65 W
5	17200 W	13800 W	101 W	83 W
6	20600 W	17200 W	119 W	101 W

Table 4. Power available when PSU in redundant operation

9. TEMPERATURE AND FAN CONTROL

To achieve best cooling results sufficient airflow through the supply must be ensured. Do not block or obstruct the airflow at the rear of the supply by placing large objects directly at the output connector. The TET3600-48-069RA is provided with a reverse airflow, which means the air enters through the front of the supply and leaves at the rear.

9.1. FAN CONTROL

The average speed of the two individual fans within the dual-axis-fan is controlled to meet the reference. The reference is given by the maximum of following 3 items:

- Load depending on Fan Speed curve, see *Figure 9*.
- Fan Speed depending ambient temperature.
- System commanded Fan Speed through I2C bus.

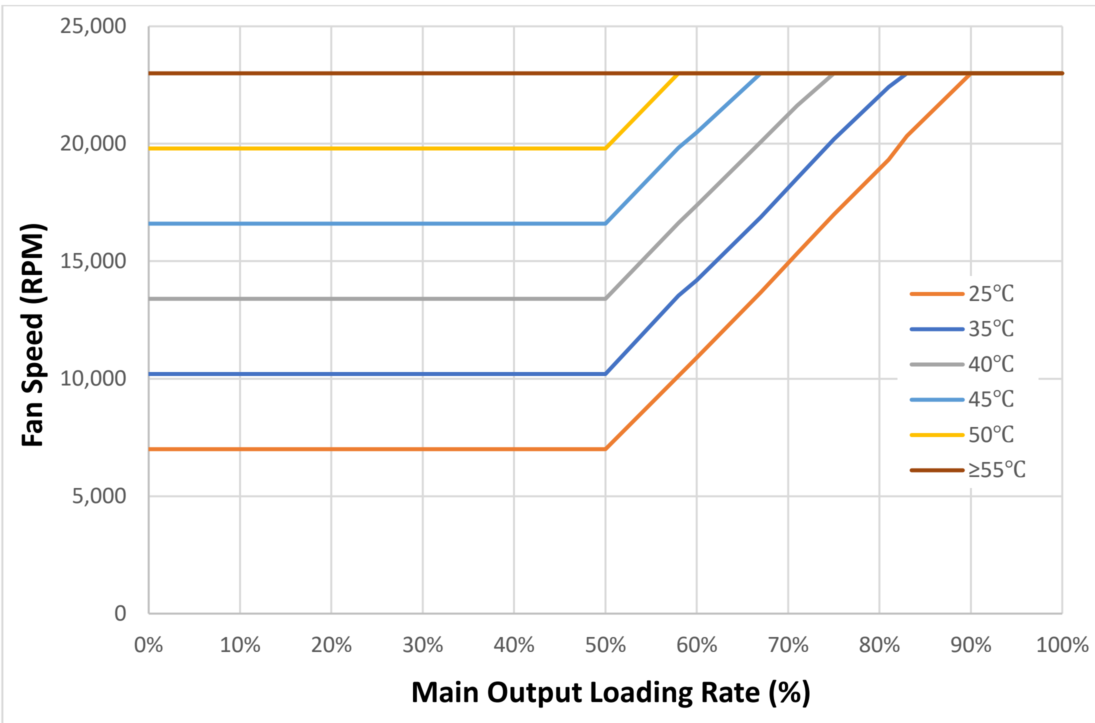

Figure 9. Fan speed versus main output load

10. ELECTROMAGNETIC COMPATIBILITY

10.1. IMMUNITY

NOTE: Most of the immunity requirements are derived from EN 55035.

PARAMETER	DESCRIPTION / CONDITION	CRITERION
ESD Contact Discharge	IEC / EN 61000-4-2, ±8 kV (metallic case, LEDs, connector body)	A
ESD Air Discharge	IEC / EN 61000-4-2, ±15 kV (non-metallic user accessible surfaces)	A
Radiated Electromagnetic Field	IEC / EN 61000-4-3, 10 V/m, 1 kHz / 80% Amplitude Modulation, 80 MHz to 1 GHz	A
EFT / Burst	IEC / EN 61000-4-4, Level 2 AC port ±2 kV, 1 minute	A
Surge	IEC / EN 61000-4-5, Level 3 Line to earth: ±2 kV Line to line: ±2 kV @	A
RF Conducted Immunity	IEC / EN 61000-4-6, Level 3, 10 Vrms	A
Magnetic Field Immunity	IEC / EN 61000-4-8, 3 A/m	B
Voltage Dips and Interruptions	IEC / EN 61000-4-11 1: Vi 230 Volts, 100% Load, Phase 0 °, Dip 100%, Duration 10 ms 2: Vi 230 Volts, 50% Load, Phase 0 °, Dip 100%, Duration 20 ms 3. Vi 230 Volts, 100% Load, Phase 0 °, Dip 100%, Duration > 20 ms	 A V1: B, VSB: A B

10.2. EMISSION

PARAMETER	DESCRIPTION / CONDITION	CRITERION
Conducted Emission	EN 55032 / CISPR 32: 0.15 … 30 MHz, QP and AVG	Class A
Radiated Emission	EN 55032 / CISPR 32: 30 MHz … 1 GHz, QP	Class A
Harmonic Emissions	IEC 61000-3-12, Vin = 230 VAC, 50 Hz, 100% Load	Class A
Audible Noise LpA	$V_{i\ nom}$, 50% $I_{o\ nom}$, T_A = 25°C, at the bystander position	65 dBA
Voltage Fluctuation and Flicker	IEC / EN 61000-3-11	PASS

11. SAFETY / APPROVALS

Maximum electric strength testing is performed in the factory according to UL / CSA 62368-1, IEC / EN 62368-1. Input-to-output electric strength tests should not be repeated in the field. Bel Power Solutions will not honor any warranty claims resulting from electric strength field tests.

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
	Agency Approvals	Approved to the latest edition of the following standards: UL / CSA 62368-1, IEC / EN 62368-1		Approved		
	Isolation Strength	Input (L/N) to case (PE) Input (L/N) to output Output to case (PE)		Basic Reinforced Functional		
d_C	Creepage / Clearance	Primary (L/N) to protective earth (PE) Primary to secondary		According to UL/CSA62368-1, IEC/EN 62368-1		
	Electrical Strength Test	Input to case Input to output (tested by manufacturer only) Output to case	2500 5000 500			VDC

12. ENVIRONMENTAL

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
T_A	Ambient Temperature	$V_{i\,min}$ to $V_{i\,max}$, $I_{1\,nom}$, $I_{SB\,nom}$ at 3000 m	0		+45	°C
		$V_{i\,min}$ to $V_{i\,max}$, $I_{1\,nom}$, $I_{SB\,nom}$ at 2000 m	0		+50	°C
T_{Aext}	Extended Temp. Range	Derated output	+50		+65	°C
T_S	Storage Temperature	Non-operational	-40		+70	°C
	Operating humidity	Non-condensing	5		95	%
	Storage humidity	Non-condensing	5		95	%
	MTBF	Per Telcordia SR-332 issue 3, M1C3 @ 50°C & 230 VAC	387K			hrs

13. MECHANICAL

PARAMETER		DESCRIPTION / CONDITION	MIN	NOM	MAX	UNIT
	Dimensions	Width		68		mm
		Heigth		40		mm
		Depth		490		mm
m	Weight			1.89		kg

NOTE: A 3D step file of the power supply casing is available on request.

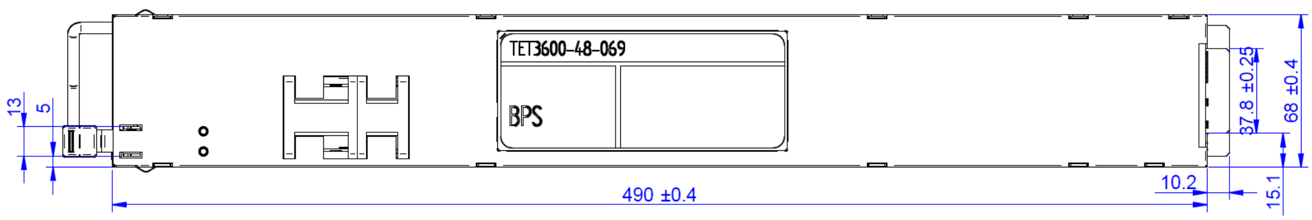

Figure 10. Top view

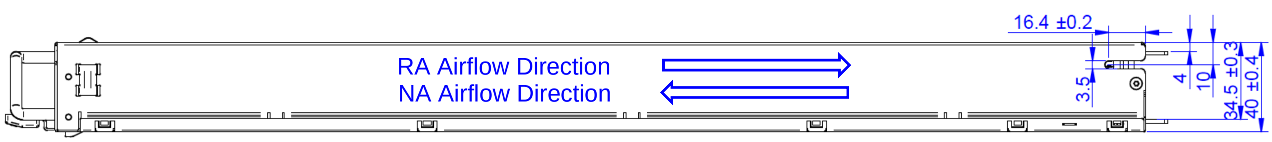

Figure 11. Side view

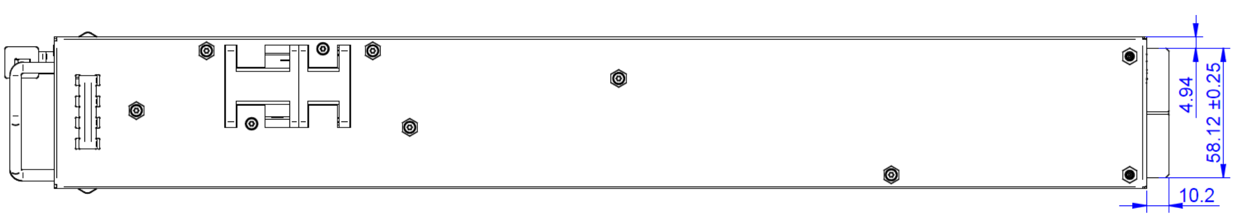

Figure 12. Bottom view

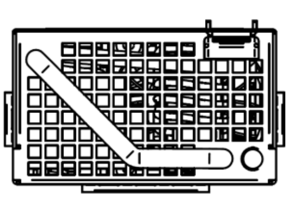

Figure 13 A. Front view

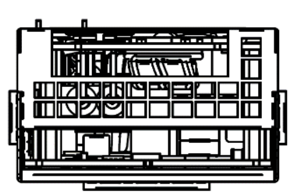

Figure 13 B. Rear view

14. CONNECTORS

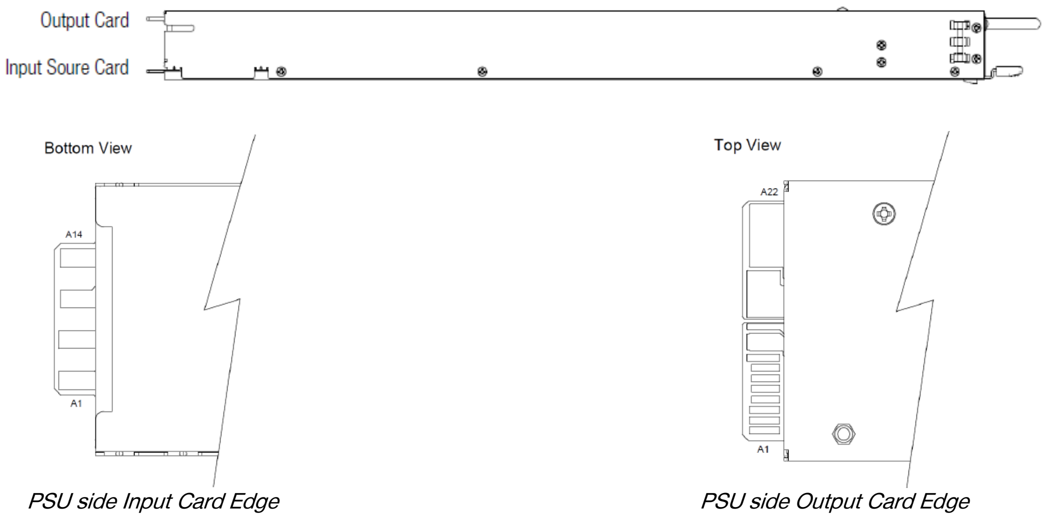

Figure 14. PSU rear side gold fingers

14.1 INPUT POWER INTERFACE CARD EDGE “GOLD FINGER” PIN ASSIGNMENT

PIN NUMBER	SIGNAL NAME	COMMENTS
A13-A14 / B13-B14	NEUTRAL	AC Input neutral / DC Input negative
A9-A10 / B9-B10	INPUT LIVE	AC Input live / DC Input positive
A1, 2, 5, 6 / B1, 2, 5, 6	EARTH	Protective earth; connects to enclosure/chassis

Table 5. Pin assignment

14.2 OUTPUT, SIGNAL INTERFACE CARD EDGE “GOLD FINGER” PIN ASSIGNMENT

PIN NUMBER	SIGNAL NAME	COMMENTS
A17-A22 B17-B22	+54.5V	+54.5V Main Output
A11-A16 B11-B16	+54.5V Return	+54.5V Main return
A9, A10	12VSB_RTN	12VSB return
B9, B10	12VSB	12VSB Output
B8	+54.5V_REMOTE_SENSE	+54.5V Main output remote sense +VE lead;
B7	RETURN_SENSE	+54.5V Main output remote sense -VE lead;
B6	I_SHARE	Main 54.5V Output Current Share Signal (bus), 8V at full load
B5	PS_A0	Address A0
B4	PS_A1	Address A1
B3	PS_A2	Address A2
B2	SMBALERT_L	Active low; I²C alert signal (interrupt)
B1	N/C	Reserved
A8	SIGNAL_RETURN	Signal GND for all signals, long connection
A7	SCL	I²C / SMBus / Power Management Bus Clock Line
A6	SDA	I²C / SMBus / Power Management Bus Data Line
A5	PRESENT	Power Supply Present, passive signal to Signal Return
A4	PSKILL	Power module kill pin, shortest sequenced pin.
A3	PS_ON_L	Active low; 54.5VDC main output on/off control
A2	VIN_GOOD	Indicate input voltage is present and within operational limits
A1	PWOK	Active high; indicates 54.5 VDC Main is valid and within operational limits

Table 6. Pin assignment

15. ACCESSORIES

ITEM	DESCRIPTION	ORDERING PN	SOURCE
	**Evaluation Board** Connector board to operate TET3600-48-069xA. Includes an onboard USB to I2C converter (use I2C Utility as desktop software)	YTM.G4901.0	Bel Power Solutions

16. REVISION HISTORY

REV	DESCRIPTION		PSU PRODUCT VERSION	DATE	AUTHOR
1	Initial Draft.		V001	08-Aug-2022	GT
A	Release to A	Update the spec based on final test results	A	04-Sep-2023	GT
B	Update safety spec	Update the creepage/ clearance at section 11	B	06-Nov-2023	Jason

For more information on these products consult: tech.support@psbel.com