PS1650

1650 Watts
High Availability Power Supply Units

Total Power: 1650 W
Input Voltage: 180-264 Vac (Signal Phase)
311-457 Vac (WHY)
187-228 Vac (Delta)
Main Output: 12.25 Vdc

PMBus

Special Features

- Fault mode resiliency
- Dynamic maximum input power limit (DMIPL)
- Inrush current control
- N+1 internal and external redundancy, up to four PSUs in a system
- PMBus® compliant
- Hot pluggable
- EMC Conducted/Radiated Class A
- EMC EN/IEC 61000
- RoHS

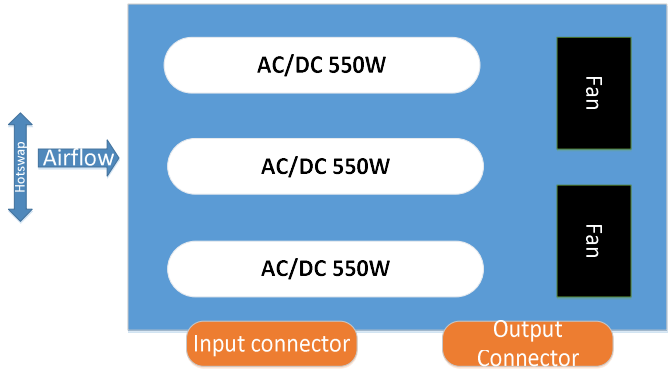
Safety

UL/CSA 60950 (UL recognized)
IEC 60950
CE Mark

Product Descriptions

The PS1650 series are high availability server power supply unit (PSU) developed for hyperscale cloud deployments. The PS1650 were designed to support an open source hardware development effort through Open Compute Project (OCP) collaboration. The PS1650 support a new standard building block model for OCP solution providers to develop hardware solutions from a common design.

The PS1650 consists of inputs of three single phases (3 total) and three 550W power supply units (PSU's) in parallel with a total maximum output of 1650W. Each PSU is powered by one of the three phases. The power supply is hot pluggable. Failure of a single Power Supply Module(PSM) or loss of a single phase will not affect system operation for loads 1100W and below. Power supplies are hot swappable for up to four in parallel. The power supply structure is below.



ARTESYN™
An Advanced Energy Company

Model Numbers

Standard	Output Voltage	Minimum Load	Maximum Load
PS1650	12.25Vdc	1A	134.7 A

Options

None

Electrical Specifications

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						
Single phase	All	$V_{IN,AC}$	180	-	264	Vac
WYE			311	-	457	Vac
Delta			187		228	Vac
Maximum Output Power	All	$P_{O,max}$	-	-	1650	W
Isolation Voltage						
Input to outputs	All		-	-	2121	Vdc
Input to safety ground	All		-	-	2121	Vdc
Ambient Operating Temperature	All	T_A	+10	-	+45	°C
Storage Temperature	All	T_{STG}	-40	-	+60	°C
Humidity (non-condensing)						
Operating	All		10	-	90	%
Non-operating	All		5	-	95	%
Altitude						
Operating	All		-	-	10,000	Feet
	All		-	-	(3050)	M
Non-operating	All		-	-	30,000	Feet
	All		-	-	(9144)	M

Input Specifications

Table 2. Input Specifications:

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, AC Single phase 3 phase - WYE 3 phase - Delta		$V_{IN,AC}$	 180 311 187	 230 400/415 208	 264 457 228	 Vac Vac Vac
Input AC Frequency		$f_{IN,AC}$	47	50/60	63	Hz
Maximum Input Current for each 550W module $I_O = I_{O,max}$	$V_{IN,AC} = V_{IN,min}$	$I_{IN,max}$	-	-	3.85	A
No Load Input Current (V_O =On, I_O = 0A)		$I_{IN,no-load}$	-	-	450	mA
Harmonic Line Currents		THD	Per IEC61000-3-2			
Input iTHD	I_O = 5 to 15%$I_{O,max}$ I_O = 15 to 30%$I_{O,max}$ I_O = 30 to 100%$I_{O,max}$			- - -	20 10 5	% % %
Power Factor	$V_{IN,AC}$ = 240Vac $I_O = I_{O,max}$		0.98	-	-	
Startup Surge Current (Inrush) for each 550W module		$I_{IN,surge}$	-	-	8	A
Input Fuse	Internal, L and N, CERAMIC, Quick Acting 5A, 250V		-	-	5	A
Leakage Current to earth ground for each 550W module	$V_{IN,AC}$ = 240Vac $f_{IN,AC}$ = 50/60 Hz		-	-	2	mA
Operating Efficiency @ 25^{O}C	I_O = 50%$I_{O,max}$ $V_{IN,AC}$ = 200Vac $V_{IN,AC}$ = 208Vac $V_{IN,AC}$ = 230Vac $V_{IN,AC}$ = 240Vac	η	 93 93 94 94	 - - - -	 - - - -	 % % % %
System Stability: Phase Margin Gain Margin			 45 -10	 - -	 - -	 Ø dB

Output Specifications

Table 3. Output Specifications:

Parameter		Condition	Symbol	Min	Typ	Max	Unit
Output Setpoint		I_O = 40.41A	V_O	12.305	12.320	12.335	Vdc
Output Regulation		Inclusive of set-point, all load and line voltages across the ambient temperature limits under steady state conditions	V_O	12.00	12.25	12.50	Vrms
Output Ripple, pk-pk		Measure with a 0.1µF ceramic capacitor in parallel with a 10µF tantalum capacitor, 20MHz bandwidth	V_O	-	-	120	mV_{PK-PK}
Common Mode Noise		10Hz to 20Hz bandwidth The measurement shall be made across a 100Ω resistor between each of DC outputs	V_O	-	-	350	mV_{PK-PK}
Output Current	1 module N+1(3 modules)	All	I_O	1 1	- -	44.9 134.7	A A
V_O Current Share Accuracy		P_O <660W 660W< P_O<1320W P_O> 1320W		- - -	- - -	8.1 15 10	$\%I_O$ $\%I_O$ $\%I_O$
Load Capacitance		Start up		2200	-	11000	µF
V_O Dynamic Response Peak Deviation		60% load change, 1% to 61% load C_O =3500uF +/-5% slew rate = 0.1-0.5A/us	V_O	11.7	-	12.8	Vdc
Number of Parallel Units[1]		Main Output Current Share connected		-	-	4	

Note 1 - V_{SB} output do not use active current sharing. On paralleled units, maximum current on V_{SB} output rail should not exceed the current of one unit.

System Timing Specifications

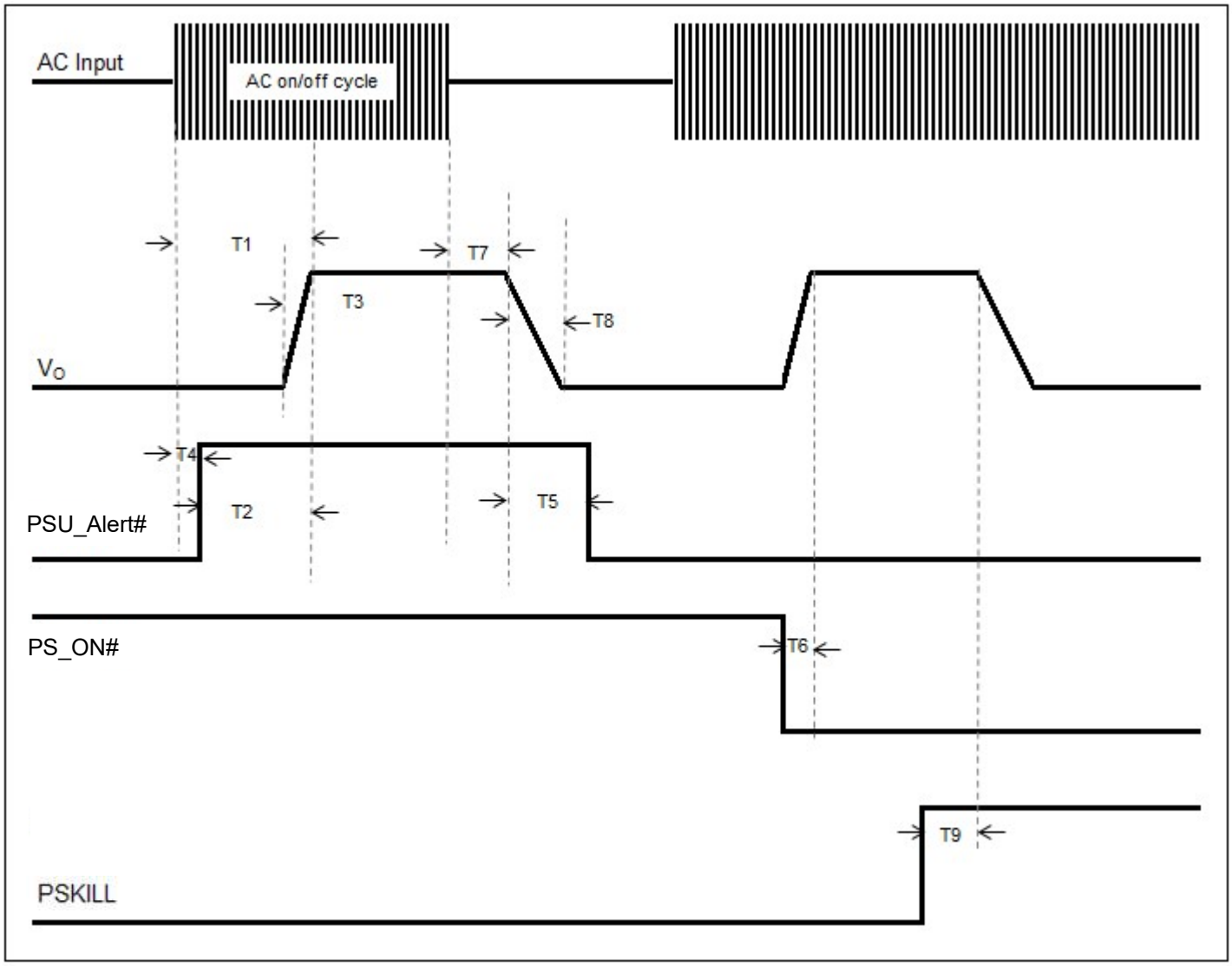
Table 4. System Timing Specifications:

Label	Parameter	Min	Typ	Max	Unit
T1	Delay from AC being applied to V_O output voltage being within regulation	500	1000	3000	mSec
T2	Delay from Alert to V_O output voltages being within regulation	-	100	-	mSec
T3	V_O rise time, 0V to V_O in regulation.	40	45	50	mSec
T4	Delay from AC being applied to Alert asserted high.	-	TBD	-	mSec
T5	Delay from Vo stay within regulation to Alert going to low	-	TBD	-	mSec
T6	Delay from PS_ON# active to output voltages within regulation limits.	80	100	120	mSec
T7	Hold up time - time output voltage stay within regulation after loss of AC.	20	-	-	mSec
T8	V_O fall time, V_O in regulation to 0V	-	60	-	mSec
T9	Delay from PSKILL to V_O stay within regulation[1]	-	5	-	mSec

Note 1 - Test at 50% loading.

System Timing Specifications

Figure 1: System Timing Diagram:

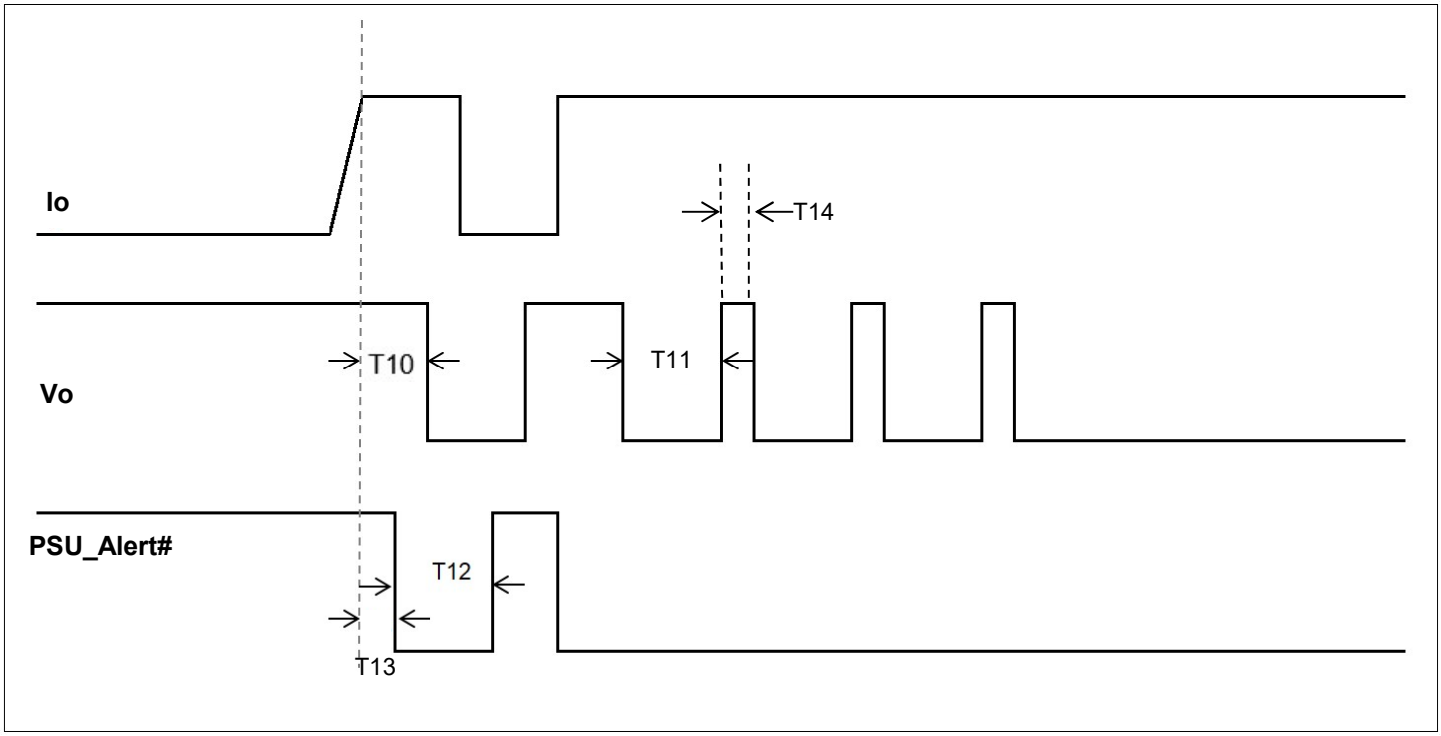


System Timing Specifications

Table 5. OCP Timing Specifications:

Label	Parameter	Min	Typ	Max	Unit
T10	OCP delay time	-	200	-	mSec
T11	OCP Turn off 2 seconds	-	2000	-	mSec
T12	Until clear fault command is received	20	-	-	mSec
T13	Alert signal assert once OCP threshold reached	-	-	10	mSec
T14	Vo comes back on for 200mS	-	200	-	mSec

Figure 2. OCP Timing Specifications

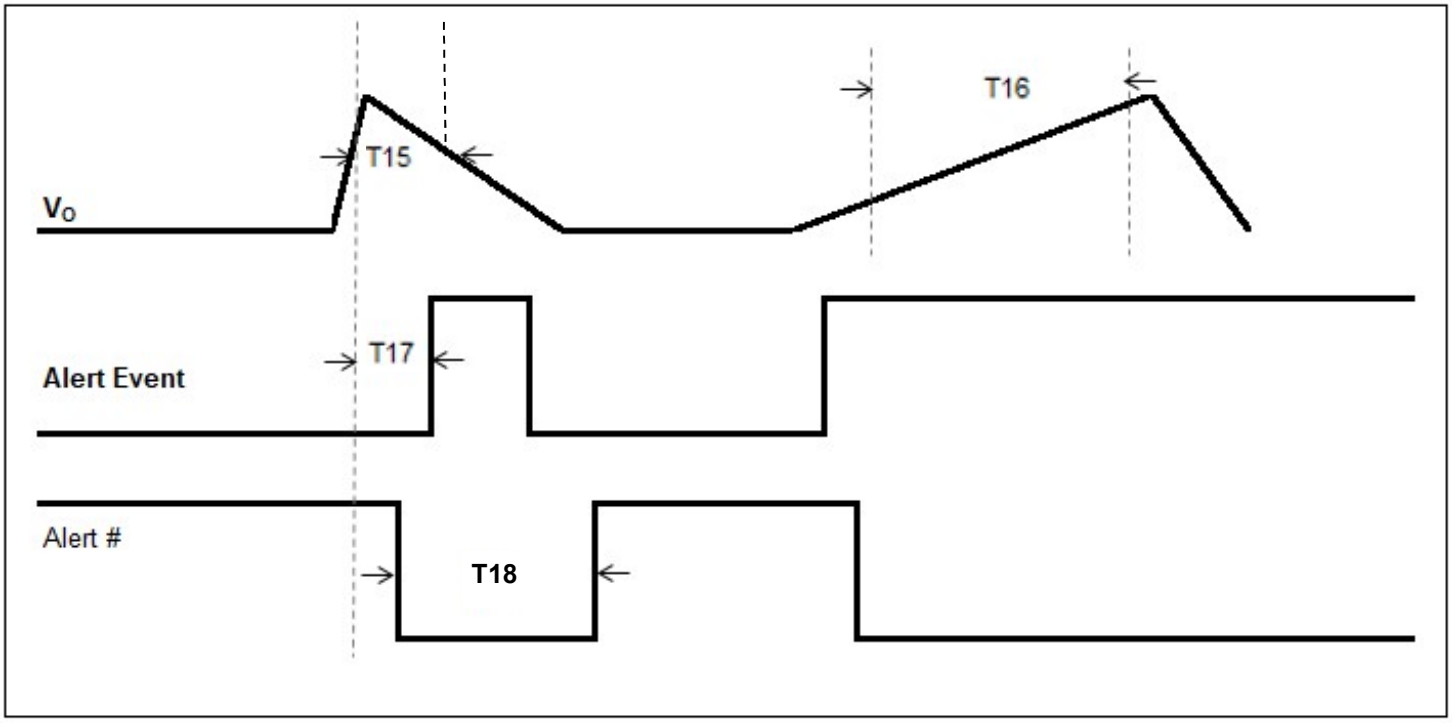


System Timing Specifications

Table 6. OVP Timing Specifications:

Label	Parameter	Min	Typ	Max	Unit
T15	Overvoltage condition time	-	-	15	mSec
T16	12V Shuts off and latched PS_ON#/AC cycle to reset	15	-	-	mSec
T17	Reached threshold Alert assert	-	-	5	mSec
T18	Alert signal assert time until clear fault send	20	-	-	mSec

Figure 3. OVP Timing Specifications

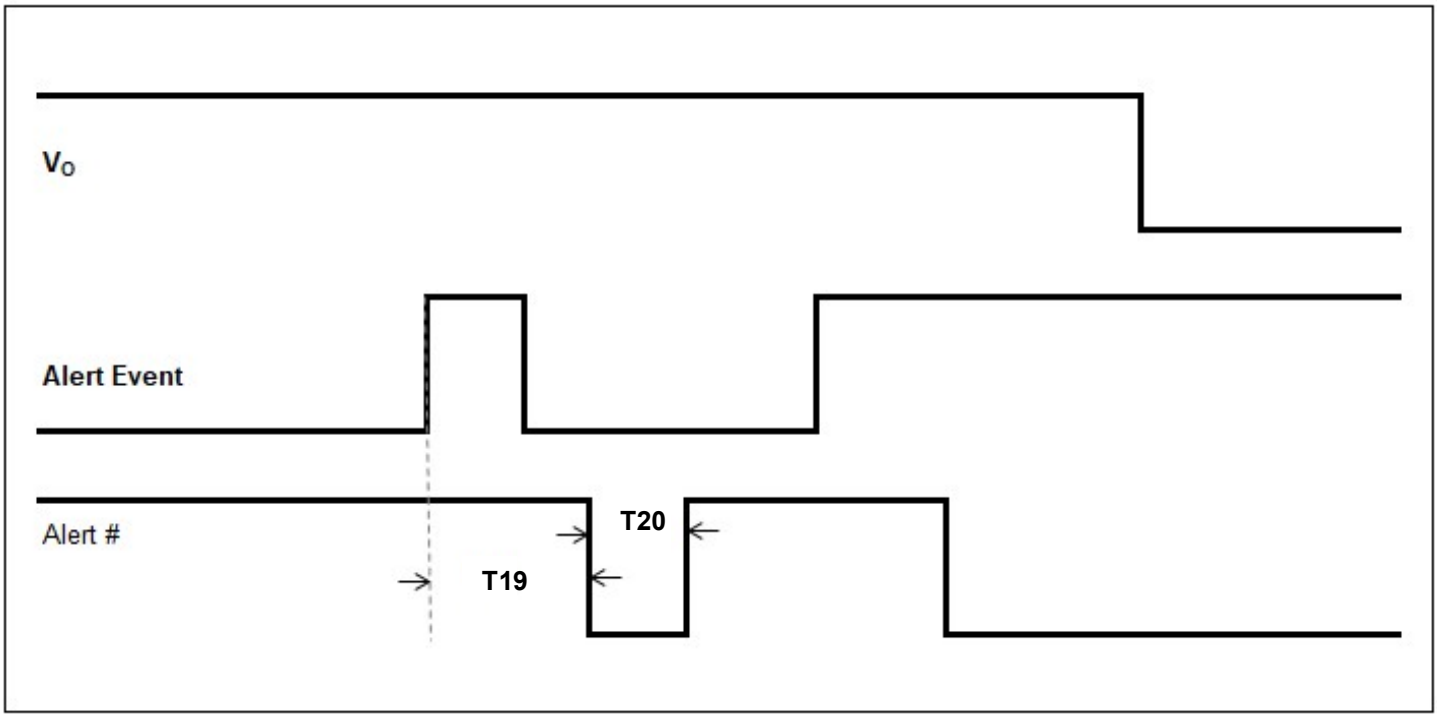


System Timing Specifications

Table 7. Alert Event Timing Specifications:

Label	Parameter	Min	Typ	Max	Unit
T19	Delay from Alert Event to Alert signal assert	5	10	15	mSec
T20	Until clear fault command is received	20	-	-	mSec

Figure 4. Alert Event Timing Specifications



Alert Event and masking/unmasking

Status_Vout (0x7A): 0xFF(1111 1111)

Status_Iout (0x7B):0x5F(0101 1111)

Status_Input(0x7C):0xFF(1111 1111)

Status_Temperature(0x7D): 0xFF(1111 1111)

Status_CML(0x7E): 0xFF(1111 1111)

PS1650 Performance Curves

Figure 5: PS1650 Turn-on delay via AC mains – V_{IN} = 180Vac
Full Load: I_O = 134.7A
Ch 1: AC Mains Ch 2: V_O Ch 3: PSU_Alert#

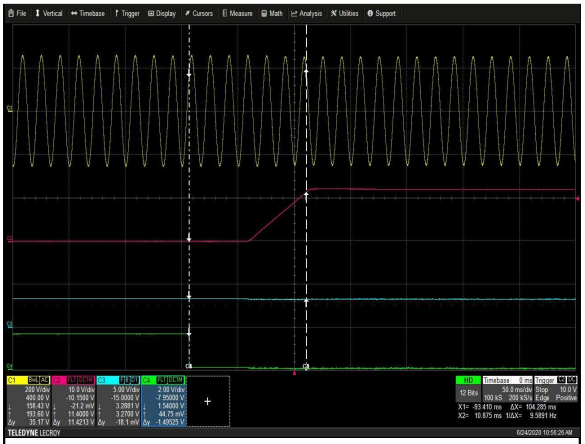


Figure 6: PS1650 Turn-on delay via PS_ON# – V_{IN} = 180Vac
Full Load: I_O = 134.7A
Ch 1: AC Mains Ch 2: V_O Ch 3: PSU_Alert# Ch 4: PS_ON#

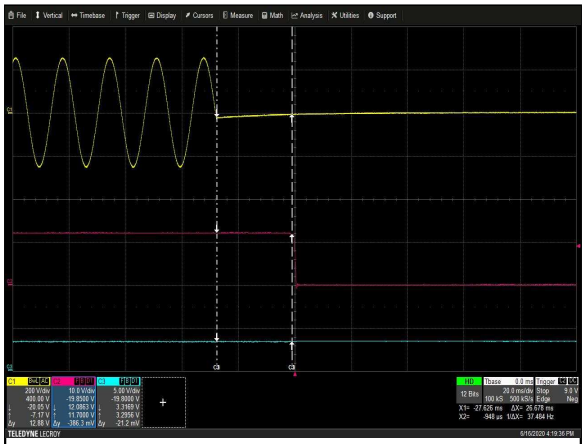


Figure 7: PS1650 Hold-up Time – V_{IN} = 180Vac / 60Hz / 0°
Full Load: I_O = 134.7A
Ch 1: AC Mains Ch 2: V_O Ch 3: PSU_Alert#

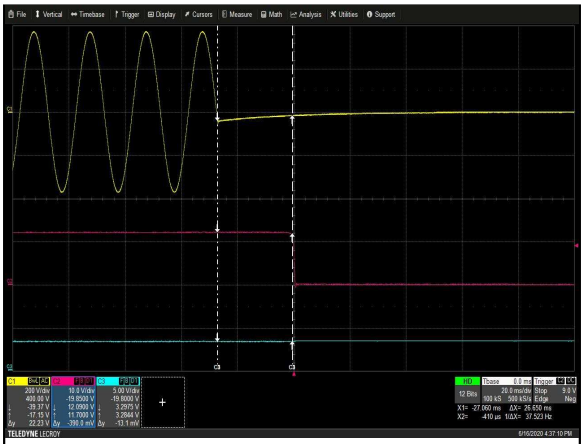


Figure 8: PS1650 Hold-up time – V_{IN} = 264Vac / 60Hz / 0°
Full Load: I_O = 134.7A
Ch 1: AC Mains Ch 2: V_O Ch 3: PSU_Alert#

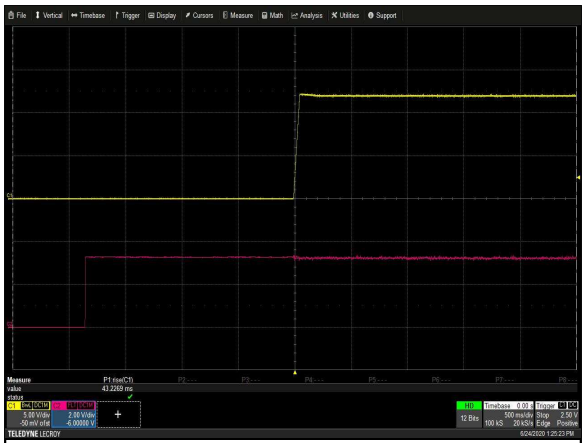


Figure 9: PS1650 Output Voltage Startup Characteristic – V_{IN}= 180Vac
Full Load: I_O = 134.7A
Ch 1: V_O Ch 2: PSU_Alert#

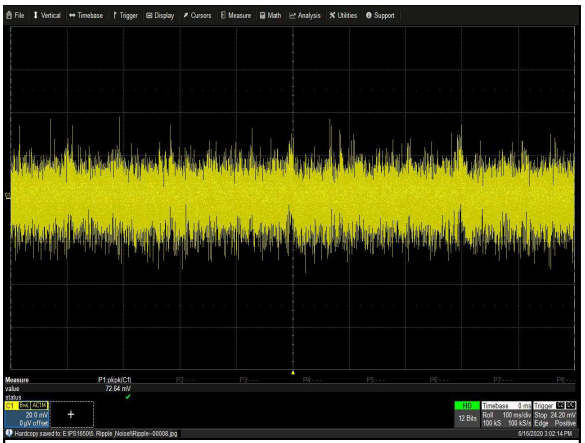


Figure 10: PS1650 Ripple and Noise Measurement – V_{IN} = 180Vac
Full Load: I_O = 134.7A
Ch 1: V_O

PS1650 Performance Curves

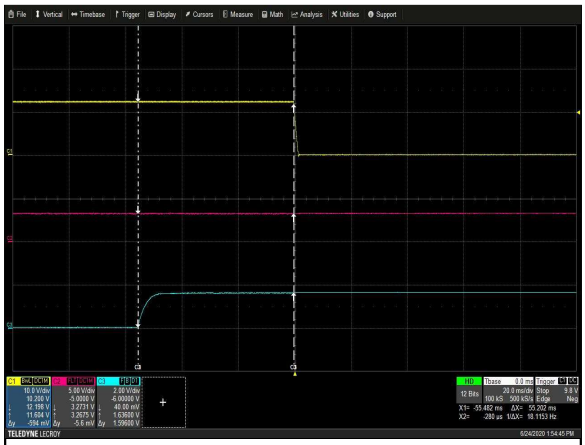


Figure 11: PS1650 Turn Off Characteristic via PS_ON#
V_{IN} = 180Vac, I_O = 67.35A
Ch 1: V_O Ch 2: PSU_Alert# Ch 3: PS_ON#

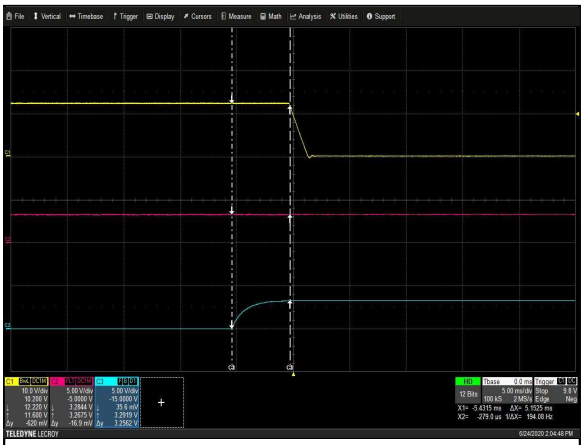


Figure 12: PS1650 Turn Off Characteristic via PSKill
V_{IN} = 180Vac, I_O = 67.35A
Ch 1: V_O Ch 2: PSU_Alert# Ch 3: PSKill

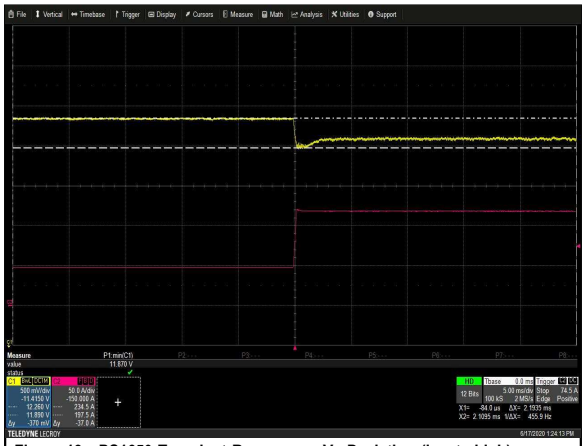


Figure 13: PS1650 Transient Response – Vo Deviation (low to high)
40% to 100% load change, 0.25A/µS slew rate, V_{IN} = 230Vac
Ch 1: V_O Ch 2: I_O

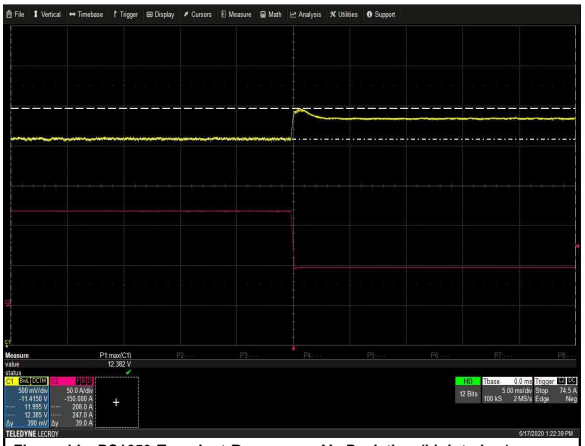


Figure 14: PS1650 Transient Response – Vo Deviation (high to low)
40% to 100% load change, 0.25A/µS slew rate, V_{IN} = 230Vac
Ch 1: V_O Ch 2: I_O

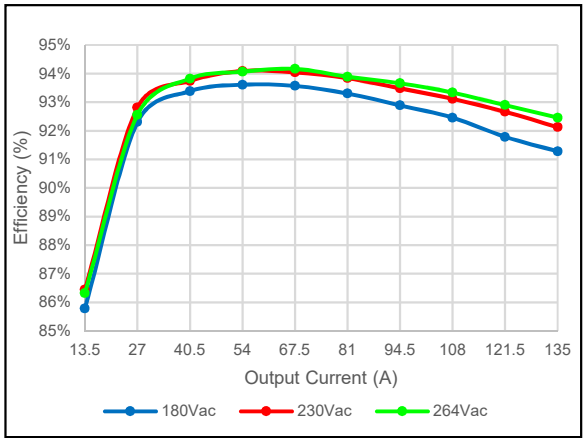


Figure 15: PS1650 Efficiency Curves @ 25 degC

Loading: I_O = 10% to 100% load

Protection Function Specification

Input Fusing

PS1650 series are equipped with an internal non user serviceable 5A fast acting 250 Vac fuse for fault protection in both the L1 and L2 lines input.

Over Voltage Protection (OVP)

The power supply over voltage protection should be shut down in a latch off mode upon an over voltage condition.

OVP

Parameter	Min	Nom	Max	Unit
V_O Output Over Voltage	13.6	/	15.0	V

Over Current Protection (OCP)

The power supply can provide limited output current to the load for protecting the power supply from damage under indefinite over load conditions. OCP point is set between 115% and 130% of rated output current. Under an overcurrent condition for over 200ms, the power supply will employ hiccup mode (200ms on and 2 seconds off) for 5 cycles and if overcurrent isn't cleared after the 5th cycle, the power supply will latch off (All timing accuracy above is +/- 20%). Over current events under 100ms will be ignored.

Parameter	Min	Nom	Max	Unit
V_O Output Over Current	115	/	130	$\%I_{O,max}$

Note - $I_{O,max}$=27.7A * working phase. eg: If 3 phases operating, $I_{O,max}$= 27.7A * 3 = 83.1A

Short Circuit Protection (SCP)

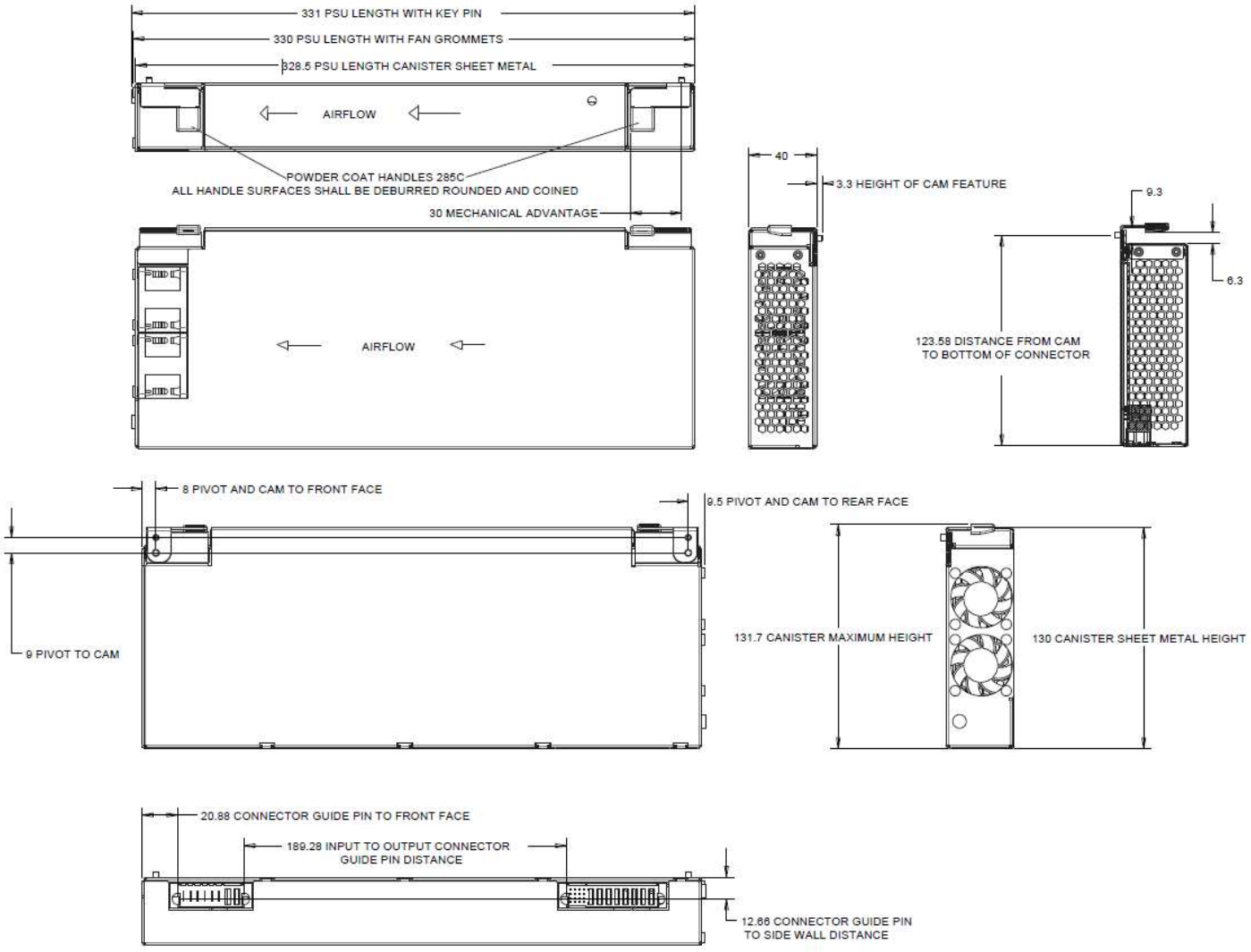
For short circuit situations, the power supply will latch off immediately to prevent damage.

Over Temperature Protection (OTP)

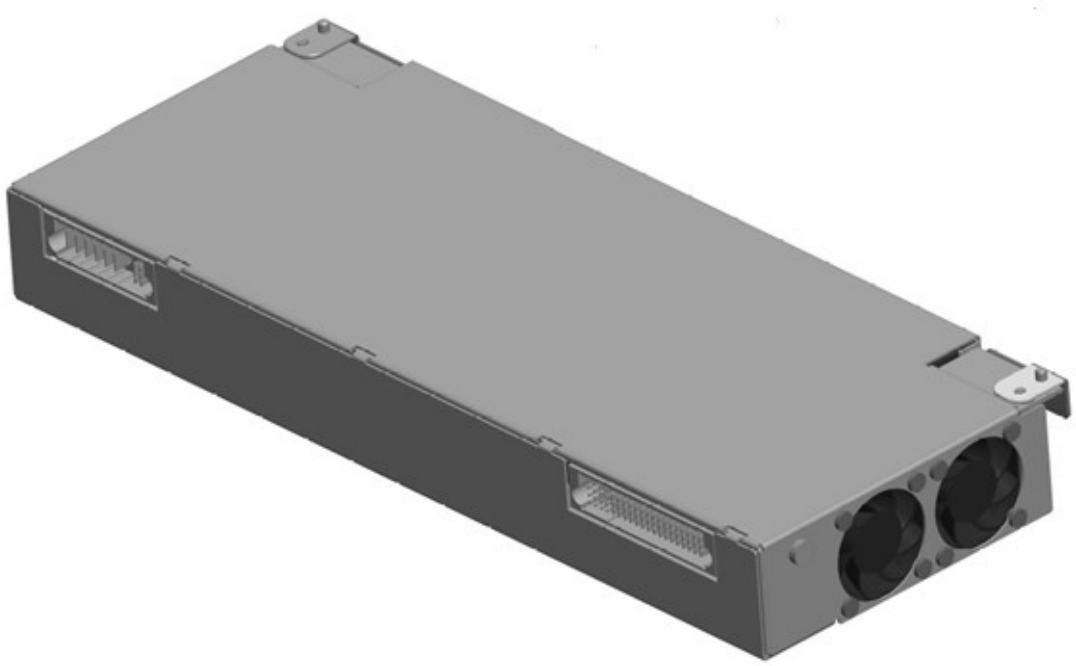
The power supply can be protected against over temperature conditions caused by loss of fan cooling or excessive ambient temperature which could cause internal part failures. In an over temperature condition the power supply will shutdown protecting itself. When the temperature drops to within safe operating limit for internal parts, the power supply will restore power automatically. The OTP circuit is incorporate built in hysteresis such that the power supply does not oscillate on and off due to temperature recovering condition. The OTP event will be reported as a fault condition.

Mechanical Specifications

Mechanical Outlines (Unit: mm)

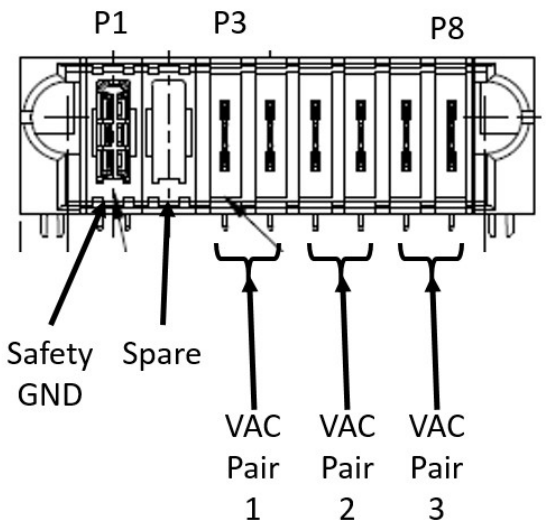


Mechanical Outlines



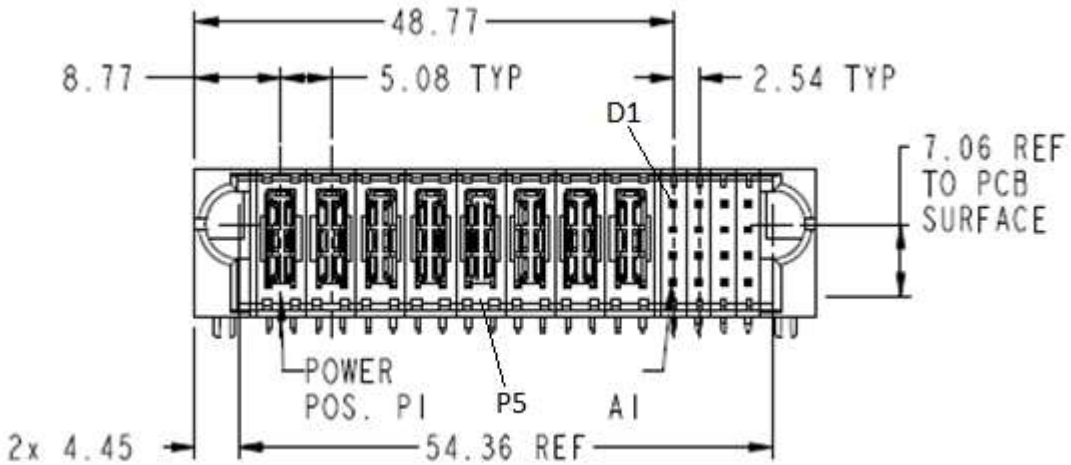
Connector Definitions

AC Input Connector



Pin Number	Description	
	WYE	Delta
P1	Safety Ground	Safety Ground
P2	Not Used	Not Used
P3	Neutral	Phase A
P4	Phase C	Phase C
P5	Neutral	Phase C
P6	Phase B	Phase B
P7	Neutral	Phase B
P8	Phase A	Phase A

Output Connector



Output Connector – Power Blades

P1 ~ P4 – + Main Output (V_O)
P5 ~ P8 – Main Output Return

Output Connector – Control Signals

A1 – SCL
A2 – Return
A3 – SDA
A4 – PSU_ALERT#
B1 – I^2C Address
B2 – Return
B3 – I-Share (0-7V)
B4 – PSU_PRESENT#
C1 – PS_ON#
C2 – Not Populated
C3 – PSKILL
C4 – Reserved
D1 – VS(-)
D2 – Not Populated
D3 – VS(+)
D4 – Reserved

Power / Signal Mating Connectors and Pin Types

Table 8. Mating Connectors for PS1650 series

Reference	On Power Supply	Mating Connector or Equivalent
AC Input Connector	FCI PwrBlade 10106262-2600001LF Or TE CONNECTIVITY 1-6450833-7	FCI PwrBlade 10106268-2600001LF
Output Power Connector	FCI PwrBlade 10106262-8004005LF Or TE CONNECTIVITY 6-6450832-0	FCI PwrBlade 10106268-8004004LF

LED indicator Definition

The PSU have one dual color LED mounted on the PSU top panel. The status LED conditions are shown on the below table.

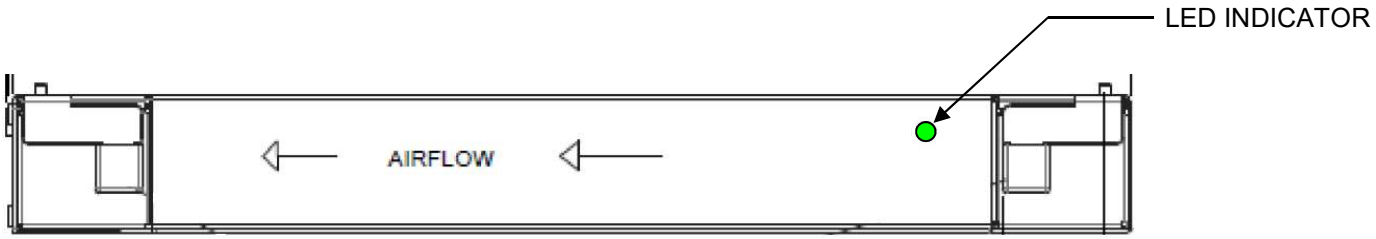


Table 9. Power Supply LED States	
Condition	LED Status
PSU operating normally	Solid Green
Secondary/Fan/bootloading Failure and/or loss of 12V	Solid Yellow
Boot loading	Blinking Yellow at 4 Hz
Primary side fault / bad AC input	Blinking Yellow-Green-Yellow (Yellow1Hz,Green1Hz rate)
Complete loss of AC power	Off

Note 1 - Toggling PS_ON#/AC input will reset the solid/blinking yellow fault light but will come up again if faults re-occur.
Note 2 - Only one of the 5 conditions will be applied at all time.

Weight

The PS1650 weight is 2065g typical.

Environmental Specifications

EMC Immunity

PS1650 series power supply is designed to meet the following EMC immunity specifications:

Table 10. Environmental Specifications:

Document	Description
FCC/ICES-003	Emissions (USA/Canada) Verification
CISPR 32	Emissions (International) and CISPR 24 (Immunity)
EN61000-3-2	Harmonics
EN61000-3-3	Voltage Fluctuations
IEC/EN61000-4-2	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Electrostatic discharge immunity test. +/-15KV air, +/-8KV contact discharge, performance Criteria C.
IEC/EN61000-4-3	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Radiated RFI immunity, performance Criteria A.
IEC/EN61000-4-4	Electromagnetic Compatibility (EMC) - Testing and measurement techniques, Electrical Fast Transient/Burst Immunity Test. 2KV for AC power port, 1.0KV for DC ports, I/O and signal ports performance Criteria B.
IEC/EN61000-4-5	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - 2KV common mode and 1KV differential mode for AC ports and 0.5kV differential mode for DC power, I/O and signal ports, performance criteria B.
IEC/EN61000-4-6	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - RF conducted.
IEC/EN61000-4-8	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Power Frequency Magnetic Fields.
IEC/EN61000-4-11	Electromagnetic Compatibility (EMC) - Testing and measurement techniques - Voltage Dips and Interruptions.
EN55024	Immunity (Europe)
EN55032	Emissions (Europe)
VCCI	Electromagnetic Compatibility (EMC) - Japan
KN 32 and KN35	Electromagnetic Compatibility (EMC) - South Korea

Safety Certifications

The PS1650 series power supplies 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 stand alone product.

Table 11. Safety Certifications for PS1650 series power supply system

Document	Description
UL/CSA 60950-1 and UL/CSA 62368-1	US and Canada Requirements
EN60950-1 and EN 62368-1	European Requirements
IEC60950-1 and IEC 62368-1	International Requirements
CB Certificate and Report	(All CENELEC Countries)
GB4943.1- CNCA Certification	China Requirements

EMI Emissions

The PS1650 series has been designed to comply with the Class A limits of EMI requirements of EN55032 (FCC Part 15) and CISPR 22 (EN55032) for emissions and relevant sections of EN61000 (IEC 61000) for immunity. The unit is enclosed inside a metal box, tested at 1000W using resistive load with cooling fan.

Conducted Emissions

The applicable standard for conducted emissions is EN55032 (FCC/ICES-003) 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 PS1650 series power supplies have internal EMI filters to ensure the convertors' conducted EMI levels comply with EN55032 (FCC/ICES-003) Class A and EN55032 (CISPR 32) Class A limits. The EMI measurements are performed with resistive loads at maximum rated loading.

Sample of EN55032 Conducted EMI Measurement at 230/400Vac input

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

Table 12. Conducted EMI emission specifications of the PS1650 series

Parameter	Model	Symbol	Min	Typ	Max	Unit
FCC/ICES-003, class A	All	Margin	6	-	-	dB
CISPR 32 (EN55032) class B	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 (FCC Part 15). Testing AC-DC converters 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 any auxiliary output cables 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 converters 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.

Operating Temperature

The PS1650 series power supplies will start and operate within stated specifications at an ambient temperature from 10 ^{O}C to 45 ^{O}C under all load conditions. Allowable derating guideline of 1 ^{O}C / 550 ft (0.55 ^{O}C / 168 m) above 3000 feet .

Forced Air Cooling

The power supplies have two internal fans with fan speed control. The fans will operate at the minimum speed needed to keep all components within the thermal derating levels for all loading and ambient conditions. Under fan fail condition the remaining fan(s) can be set to maximum speed. Upon loss of all fans the PSU should operate until overtemp is reached and then will latch off.

Storage and Shipping Temperature / Humidity

The PS1650 series power supplies can be stored or shipped at temperatures between -40 ^{O}C to +60 ^{O}C and relative humidity from 5% to 95% non-condensing.

Altitude

The PS1650 series will operate within specifications at altitudes up to 10,000 feet (3050m) above sea level. The power supply will not be damaged when stored at altitudes of up to 30,000 feet (9144m) above sea level. Rate of change less than 1500 ft/min (457 m/min)

Humidity

The PS1650 series will operate within specifications when subjected to a relative humidity from 10% to 90% non-condensing. The PS1650 series can be stored in a relative humidity from 5% to 95% non-condensing.

Vibration

The PS1650 power supply will pass the following vibration specifications:

Non-Operating Random Vibration

Acceleration	2.0		gRMS
Frequency Range	10-500		Hz
Duration	60		mins / axis
Direction	3 mutually perpendicular axis		
PSD Profile	**FREQ** 10-500 Hz	**SLOPE** **dB/oct** ---	**PSD** **g^2/Hz** 0.008 g^2/Hz

Operating Random Vibration

Acceleration	1		gRMS
Frequency Range	10-500		Hz
Duration	60		mins / axis
Direction	3 mutually perpendicular axis		
PSD Profile	**FREQ** 10-500 Hz	**SLOPE** **dB/oct** ---	**PSD** **g^2/Hz** 0.002 g^2/Hz

Shock

The PS1650 series power supply will pass the following vibration specifications:

Non-Operating Half-Sine Shock

Acceleration	140	G
Duration	2	msec
Pulse	Half-Sine	
No. of Shock	3 shock on each of 6 faces	

Operating Half-Sine Shock

Acceleration	5	G
Duration	11	msec
Pulse	Half-Sine	
No. of Shock	3 shock on each of 6 faces	

Power and Control Signal Descriptions

AC Input Connector

AC inlet connector is an FCI Power Blade part number 10106262-2600001LF or similar competitor's connector.

Pin Number	Description	
	WYE	Delta
P1	Safety Ground	Safety Ground
P2	Not Used	Not Used
P3	Neutral	Phase A
P4	Phase C	Phase C
P5	Neutral	Phase C
P6	Phase B	Phase B
P7	Neutral	Phase B
P8	Phase A	Phase A

Output Connector

The output connector is FCI PwrBlade 10106262-8004005LF or equivalent.

Pin Number	Description
P1	12.2Vdc
P2	12.2Vdc
P3	12.2Vdc
P4	12.2Vdc
P5	12_RTN
P6	12_RTN
P7	12_RTN
P8	12_RTN
A1	I^2C_SCL Reserved
A2	Analog Return
A3	I^2C_SDA Reserved
A4	PSU_ALERT# Reserved
B1	I^2C Address
B2	Analog Return
B3	Reserved
B4	PSU_PRESENT#
C1	PS_ON#
C2	Not Populated
C3	PSKILL (Short Pin)
C4	Reserved
D1	VS(-)
D2	Not Populated
D3	VS(+)
D4	Reserved

Output Connector - Control Signals

PSKILL - (pin C3)

The power supply 12V will be disabled within 5ms of PSKill going high. It will be pulled low with 100 ohm in the system board.

Signal name	Input /output to PSU	Open collector	3V3 logic	Signal pull up resistor value	Logic low max (V)	Logic high min (V)	Sink/source current max (mA)	Rise time max (usec)	Fall time max (usec)	Cmax external to PSU (pF)	Peak noise (mVpk-pk)
PSKILL	In	No	Yes	10KΩ	0.4	2.0	0.5	250	2.5	0	NA

PS_ON# - (pin C1)

The PSU will be ON when PS_ON# is pulled low below 0.8Vdc at 1mA or less source current. The PSU will be powered off when driven to 2.06Vdc or higher. Toggling of PS_ON# will reset latched faults that held 12V low. However, PS_ON# will not reset the latched bits in the PMBUS register after 12V returns. PS_ON# is 5V tolerant.

Signal name	Input /output to PSU	Open collector	3V3 logic	Signal pull up resistor value	Logic low max (V)	Logic high min (V)	Sink/source current max (mA)	Rise time max (usec)	Fall time max (usec)	Cmax external to PSU (pF)	Peak noise (mVpk-pk)
PS_ON#	In	No	Yes	49.9KΩ	0.8	2.06	N/A	50	100	No	NA

PSU_ALERT# - (pin A4)

The signal will be high until status change of the PSU.

Signal name	Input /output to PSU	Open collector	3V3 logic	Signal pull up resistor value	Logic low max (V)	Logic high min (V)	Sink/source current max (mA)	Rise time max (usec)	Fall time max (usec)	Cmax external to PSU (pF)	Peak noise (mVpk-pk)
Alert	Out	Yes	Yes	100KΩ +/- 20%	0.8	2.0	Note 1	50	250	NA	250mV

Note 1 - Pull up to 3.3V through 100Kohm

I²C_SCL, I²C_SDA, Address - (pins A1, A3, B1)

The I²C address of the PSU is 0xB0 when address is LOW (at default/open Address pin) and 0xB2 when Address is pulled High (pull up to a 3.3V with a 1K resistor at the system board side).

Signal name	Input /output to PSU	Open collector	3V3 logic	Signal pull up resistor value (Ω)	Logic low max (V)	Logic high min (V)	Sink/source current max (mA)	Rise time max (usec)	Fall time max (usec)	Cmax external to PSU (pF)	Peak noise (mVpk-pk)
SDA	I/O	No	Yes	1K +/-20%	0.8	2.0	6	1	250	120	250mV
SCL	I/O	No	Yes	1K +/-20%	0.8	2.0	6	1	250	120	250mV
Address	In	No	Yes	20K +/-20% (pull-down)	0.8	2.0	6	50	250	NA	NA

PSU_PRESENT# - (pin B4)

It is pulled low/grounded with 100 ohm internal of PSU. The system board will be pulled up to a 10Kohm resistor.

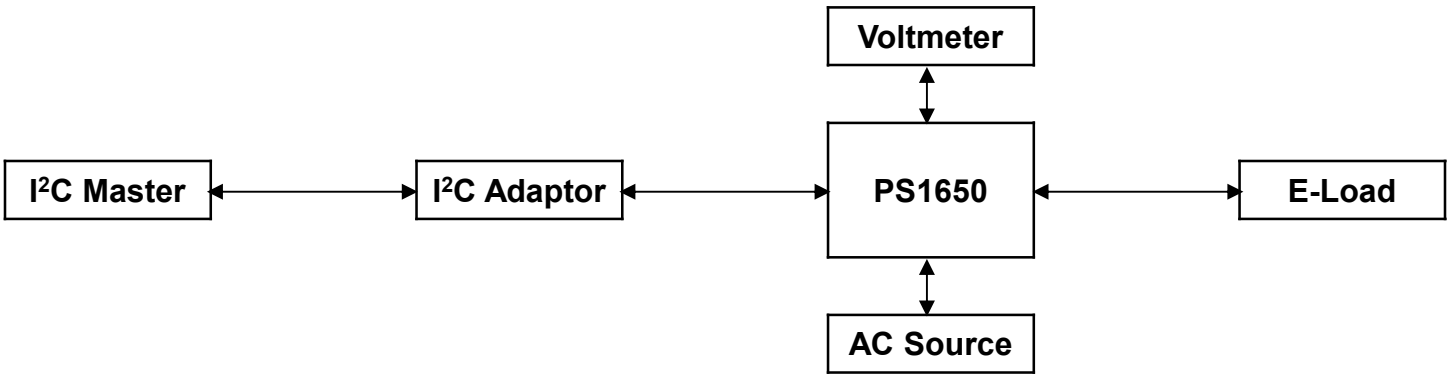
PMBus™ Interface Support

The PS1650 series are compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port.

PS1650 Series PMBus™ General Instructions

Equipment Setup

The following is typical I²C communication setup:



The I²C address of the PSU will be 0xB0 (which is also the default address) when address is LOW and will be 0xB2 when address is pulled High. I²C interface speed is 400Khz.

PS1650 Series Support PMBus™ Command List

The PS1650 is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port.

PS1650 Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
01h	OPERATION	80	R/W	1		Used to turn the unit ON/OFF.
	b7:6	10b				00 – Immediate Turn OFF (No Sequencing) 10 – PSU ON
	b5:4	00b				
	b3:2	00b				
	b1:0	00b				Reserved
03h	CLEAR_FAULTS	0	S			
04h	PHASE(overloaded)		R	1	Linear	
19h	CAPABILITY (Overloaded)		R	1	Linear	
	b7	1b				Packet Error Checking is supported
	B6:5	01b				Maximum supported bus speed is 400 Khz
	b4	1b				ALERT# signal with expected response supported
	b3	0b				if Battery present (supported), 0 if Battery NOT present (not supported)
	b2	0b				Supports all updates based on spec version V 0.94 and above
	b1	0b				Supports Blackbox Registers
	b0	0b				Reserved
1Ah	QUERY		W/BR/BW	1		Used to determine if the PSU supports a specific command; It should return the proper information about any commands listed
1Bh	SMBALERT_MASK (Overloaded)		W/BR/BW	2		This command provides the ability to configure events that may trigger SMBALERT signal.
3Bh	FAN_COMMAND_1	-	R/W	2	Linear	Adjusts the operation of the Fans. To set the fans to 100% duty cycle, set the data bytes to 0x64 0x00 (Data Byte Low, Data Byte High). To set the fans to 30% duty cycle, set the data bytes to 0x1E 0x00 (Data Byte Low, Data Byte High).
3Ch	FAN_COMMAND_2	-	R/W	2	Linear	Adjusts the operation of the Fans. To set the fans to 100% duty cycle, set the data bytes to 0x64 0x00 (Data Byte Low, Data Byte High). To set the fans to 30% duty cycle, set the data bytes to 0x1E 0x00 (Data Byte Low, Data Byte High).
46h	IOUT_OC_FAULT_LIMIT	A7E3	R	2	Linear	Sets the Over current threshold in Amps.
4Ah	IOUT_OC_WARN_LIMIT	A7E3	R/W	2	Linear	Sets the Over Current Warning threshold in Amps.
55h	VIN_OV_FAULT_LIMIT		R	2	Linear	Sets input over-voltage threshold.
57h	VIN_OV_WARN_LIMIT		R	2	Linear	Sets the threshold of input voltage that triggers high voltage warning.
5Bh	IIN_OC_FAULT_LIMIT	89CA	R	2	Linear	Sets the threshold for input current that causes over-current fault.
5Dh	IIN_OC_WARN_LIMIT	73CA	R/W	2	Linear	Sets the threshold of input current that triggers input over- current warning.
6Bh	PIN_OP_WARN_LIMIT	B509	R/W	2	Linear	Sets the threshold of input power that triggers input over- power warning.

PS1650 Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
79h	STATUS_WORD	-	R	2		Summary of units Fault and warning status.
	b15 – VOUT					An output voltage fault or warning has occurred
	b14 – IOUT/POUT					An Output current or power fault or warning has occurred.
	b13 – INPUT					An input voltage, current or power fault or warning as occurred.
	b12 – MFR					A manufacturer specific fault or warning has occurred.
	b11 – POWER_GOOD#					The POWER_GOOD signal is de-asserted
	b10 - FANS					A fan or airflow fault or warning has occurred.
	b9 – OTHER					A bit in STATUS_OTHER is set.
	b8 – UKNOWN					A fault type not given in bits [15:1] of the STATUS_WORD has been detected.
	b7 – BUSY					A fault was declared because the device was busy and unable to respond.
	b6 – OFF					Unit is OFF
	b5 – VOUT_OV					Output over-voltage fault has occurred
	b4 – IOUT_OC					Output over-current fault has occurred
	b3 - VIN_UV					An input under-voltage fault has occurred
	b2 – TEMPERATURE					A temperature fault or warning has occurred
	b1 – CML					A communication, memory or logic fault has occurred.
	b0 – NONE_OF_THE_ABOVE					A fault or warning not listed in bits[7:1] of this byte has occurred.
7Ah	STATUS_VOUT	-	R	1		Output voltage related faults and warnings
	b7					VOUT Over--voltage Fault
	b6					VOUT Over-voltage warning
	b5					VOUT Under-voltage Warning
	b4					VOUT Under-voltage Fault
	b3					VOUT_MAX Warning, an attempt has been made to set output to a value higher that the highest permissible voltage.
	b2					TON_MAX_FAULT
	b1					TOFF_MAX Warning
	b0					Reserved
7Bh	STATUS_IOUT	-	R	1		Output Current related faults and warnings
	b7					IOUT Over current Fault
	b6					IOUT Over current And Low Voltage shutdown Fault
	b5					IOUT Overcurrent Warning
	b4					IOUT Undercurrent Fault
	b3					Current Share Fault Set if Ishare level is much greater or lower than the actual output current. Refer to Output Specifications (Table 3) for Current sharing limits.
	b2					Power Limiting
	b1					POUT Overpower Fault
	b0					POUT Overpower Warning

PS1650 Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
7Ch	STATUS_INPUT	-	R	1		Input related faults and warnings
	b7					VIN Overvoltage Fault
	b6					VIN Overvoltge Warning
	b5					VIN Undervoltage Warning
	b4					VIN Undervoltage Fault
	b3					Unit is OFF for insufficient Input Voltage
	b2					IIN Overcurrent Fault
	b1					IIN Overcurrent Warning
	b0					PIN overpower Warning
7Dh	STATUS_TEMPERATURE	-	R	1		Temperature related faults and warnings
	b7					Overtemperature Fault
	b6					Overtemperature Warning
	b5					Undertemperature Warning
	b4					Undertemperature Fault
	b3:0					reserved
7Eh	STATUS_CML	-	R	1		Communications, Logic and Memory
	b7					Invalid or unsupported Command Received
	b6					
	b5					Packet Error Check Failed
	b4					Memory Fault Detect, CRC Error
	b3					
	b2					
	b1					
	b0					
88h	READ_VIN	-	R	2	Linear	Returns input Voltage in Volts ac.
89h	READ_IIN	-	R	2	Linear	Returns input Current in Amperes
8Ch	READ_IOUT	-	R	2	Linear	Returns the output current in amperes.
8Dh	READ_TEMPERATURE_1	-	R	2	Linear	PSU infernal hotspot (inside PSU)
8Eh	READ_TEMPERATURE_2	-	R	2	Linear	PSU Air inlet temp (inside PSU)
8Fh	READ_TEMPERATURE_3[1]	-	R	2	Linear	PSU Air Outlet temp (inside PSU)
96h	READ_POUT	-	R	2	Linear	Returns the output power, in Watts.
97h	READ_PIN	-	R	2	Linear	Returns the input power, in Watts.
99h	MFR_ID		BR,	15	ASCII	Abbrev or symbol of manufacturers name.
9Ah	MFR_MODEL		BR/BW	15	ASCII	Manufacturers Model number, ASCII format
9Eh	MFR_SERIAL		BR/BW	15	ASCII	Unit serial number, ASCII format.
ADh	IC_DEVICE_ID[2]	-	BR	20	ASCII	

Note 1 - 0x8F only applies if a thermistor is present in the current hardware, else report 0x0000.
Note 2 - MFR_MODEL, MFR_SERIAL, IC_DEVICE_ID and MFR_ID will have the length of the ASCII string as the first byte in the data payload.

Application Notes

Input Power Sharing

The three input modules shall share the load so that input current sharing between modules meets the requirements in the table below:

Total Input Power	Input current share accuracy
0 - 330W	< 100mA
330W - 660W	+/- 5%
>660W	+/- 3%

Load Sharing

The PS1650 series power supply will current share using voltage droop share. The failure of a module inside the PSU will not affect the load sharing or output voltages of the other supplies still operating. The supplies are able to load share in parallel and operate in a hot-swap / redundant 1+1 configurations. The output will fall within the regulation spec 11.7-12.8V shown in Table 3. Droop Slope per module is 350mV/44.9A.

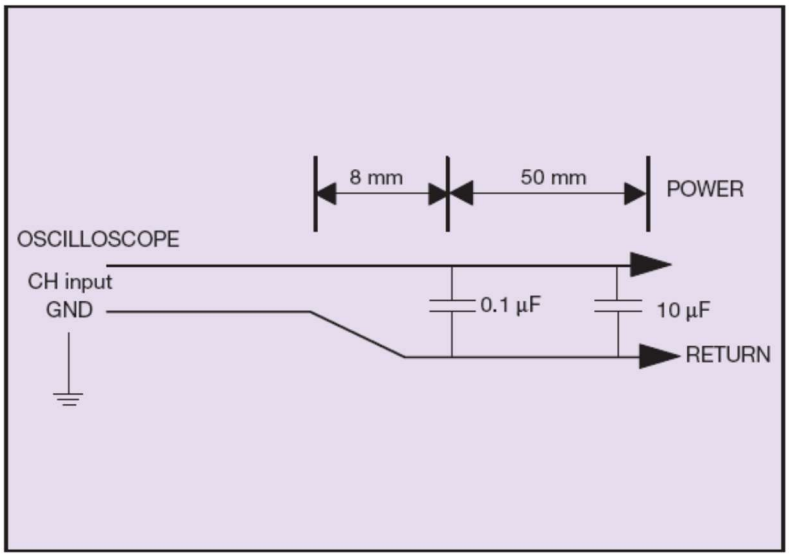
Current Sharing Accuracy

Total output load	**Max current difference between 2 PSUs**
< 54A/660W	+/- 8.1A
660W-1320W	+/- 15%
>1320W	+/- 10%

Application Notes

Output Ripple and Noise Measurement

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the PS1650 Series. When measuring output ripple and noise, a scope jack in parallel with a 0.1uF ceramic chip capacitor, and a 10 uF aluminum electrolytic capacitor should be used. Oscilloscope should be set to 20 MHz bandwidth for this measurement.



Record of Revision and Changes

Issue	Date	Description	Originators
1.0	07.07.2020	First Issue	E. Wang

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