ARTESYN CSU1600AT SERIES

1600 Watts Distributed Power System

PRODUCT DESCRIPTION

Advanced Energy's CSU1600AT power supply is housed in a 1U high rack-mount enclosure measuring just 2.89 x 7.28 inches (73.5 x 185.0 mm). This form factor is significantly narrower and shorter than that of similarly rated earlier generation power supplies — freeing up valuable system space — and is achieved by use of the latest power switching technology and high-density component packaging techniques. This form factor conforms to the standard market's Common Redundant Power Supplies.

AT A GLANCE

Total Power

1600 Watts

Input Voltage

90 to 127 Vac

180 to 264 Vac

180 to 336 Vdc

# of Outputs

Main and Standby

SPECIAL FEATURES

- 1600 Watts output power
- 1U power supply
- Ultra high-density design
- Active power factor correction
- EN61000-3-2 harmonic compliance
- Inrush current control
- 80 PLUS® Titanium efficiency
- N+N, N+1 redundant
- Hot-pluggable
- Active current sharing
- Closed loop throttle
- Cold redundancy
- Two-year warranty
- RoHS compliant
- PMBus™ compliant

SAFETY

- UL/cUL/CSA
- CB Test Certification
- CE Mark
- CQC
- BSMI
- KC
- EAC
- BIS
- UKCA Mark

TYPICAL APPLICATIONS

- Server, Storage, Networking

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Section 1 MODEL NUMBERS

Standard	Output Voltage	Minimum Load[1]	Maximum Load	Standby Supply	Air Flow Direction
CSU1600AT-3-100	12.2 Vdc	0 A	131.1 A	12.0 Vdc @ 3.5 A	Normal (DC Connector to Handle)

Note 1 - 1A minimum current for transient load response testing only. Unit is designed to operate and be within output regulation range at zero load.

Options

None

Family Comparison

Model Number	Input Type	Output Voltages	Output Power	Standby Output	Dimension
CSU550AP Series	AC Input	12.0V	550W	12V @ 2.5A	1U x 2.89" x 7.28"
CSU800AP Series	AC Input	12.0V	800W	12V @ 3A	1U x 2.89" x 7.28"
CSU1300AP Series	AC Input	12.2V	1300W	12V @ 3A	1U x 2.89" x 7.28"
CSU1300ADC Series	DC Input	12.2V	1300W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU1800AP Series	AC Input	12.2V	1800W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU1800AT Series	AC Input	12.2V	1800W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU1600AT Series	AC Input	12.2V	1600W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU2000AP Series	AC Input	12.2V	2000W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU2000AT Series	AC Input	12.2V	2000W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU2000ADC Series	DC Input	12.2V	2000W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU2400AP Series	AC Input	12.2V	2400W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU2400AT Series	AC Input	12.2V	2400W	12V @ 3.5A	1U x 2.89" x 7.28"
CSU3200ET Series	AC Input	12.2V	3200W	12V @ 3.5A	1U x 2.89" x 10.43"

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	Models	Symbol	Min	Typ	Max	Unit
Input Voltage AC continuous operation	All models	$V_{IN,AC}$	90 180	- -	127 264	Vac Vac
DC continuous operation	All models	$V_{IN,DC}$	180	-	336	Vdc
Maximum Output Power[1]	All models	$P_{O,max}$	-	-	1600	W
Operating Temperature	CSU1600AT-3-100[2]	T_A	-5	-	65	^{O}C
Storage Temperature	All models	T_{STG}	-40	-	70	^{O}C
Humidity (non-condensing) Operating Non-operating	 All models All models		 5 5	 - -	 95 95	 % %
Altitude Operating Non-operating	 All models All models		 - -	 - -	 5000 12,100	 Meters Meters
MTBF[3]	All models		700	-	-	KHours
Operating Life[4]	All models		5	-	-	Years
Fan L10 Life @ 50^{O}C	All models		45	-	-	KHours

Note 1 - Total output power is limited to 1000 W at 90 to 127 Vac input and 1600 W at 180 to 264 Vac input.
Note 2 - -5^{O}C to 55^{O}C full rated power and derated power from 55^{O}C to 65^{O}C.
Note 3 - Telcordia SR-332 at 55^{O}C ambient (40^{O}C for reverse air), nominal input, full load.
Note 4 - It is calculated under 55^{O}C (40^{O}C for reverse air) ambient temperature and 85% $I_{O,max,}$ nominal input, sea level.

Section 2 ELECTRICAL SPECIFICATIONS

2.2 Input Specifications

Table 2. Input Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, AC	All	$V_{IN,AC}$	90 180	115 230	127 264	Vac Vac
Operating Input Voltage, DC	All	$V_{IN,DC}$	180	240	336	Vdc
Input AC Frequency	All	$f_{IN,AC}$	47	50/60	63	Hz
Maximum Input Current ($I_O = I_{O,max}$, $I_{SB} = I_{SB,max}$)	$V_{IN,AC}$ = 180 Vac $V_{IN,AC}$ = 200 Vac $V_{IN,AC}$ = 230 Vac $VI_{N,DC}$ = 240 Vdc $V_{IN,DC}$ = 336 Vdc	$I_{IN,max}$	- - - - -	- - - - -	11 9.1 7.3 7.3 5.5	A A A A A
No Load Input Current (V_O = On, I_O = 0 A, I_{SB} = 0 A)	$V_{IN,AC}$ = 90 Vac $V_{IN,AC}$ = 180 Vac	$I_{IN,no-load}$	- -	104 169	- -	mA mA
No Load Input Power (V_O = On, I_O = 0 A, I_{SB} = 0 A)	$V_{IN,AC}$ = 90 Vac $V_{IN,AC}$ = 180 Vac	$P_{IN,no-load}$	- -	5.1 4.5	- -	W W
Standby Input Current (V_O = Off, I_{SB} = 0 A)	$V_{IN,AC}$ = 90 Vac $V_{IN,AC}$ = 180 Vac	$I_{IN,Standby}$	- -	98.4 169.3	- -	mA mA
Standby Input Power (V_O = Off, I_{SB} = 0 A)	$V_{IN,AC}$ = 90 Vac $V_{IN,AC}$ = 180 Vac	$P_{IN,Standby}$	- -	4.5 4.1	- -	W W
Harmonic Line Currents	All	THD	EN/IEC 61000-3-2			
Input vTHD		vTHD	-	-	15	%
Input iTHD	$V_{IN,AC}$ = 200 to 240 Vac $f_{IN,AC}$ = 50 Hz / 60 Hz I_O = 5 to 10% $I_{O,max}$ I_O = 11 to 20% $I_{O,max}$ I_O = 21 to 50% $I_{O,max}$ I_O > 50% $I_{O,max}$	iTHD	- - - -	- - - -	20 10 5 3.5	%
Power Factor	I_O = 10% $I_{O,max}$ I_O = 20% $I_{O,max}$ I_O = 50% $I_{O,max}$ I_O = 100% $I_{O,max}$	PF	0.90 0.96 0.98 0.99	- - - -	- - - -	
Startup Surge Current (Inrush)[1] @ 25°C	$V_{IN,AC}$ = 264 Vac	$I_{IN,surge}$	-	-	35	Apk
Input Fuse	Internal, L 5x20 mm, Fast Acting 20 A, 420 Vdc		-	-	20	A
Leakage Current to Earth Ground	$V_{IN,AC}$ = 264 Vac $f_{IN,AC}$ = 60 Hz		-	-	0.583	mA
Turn-on Voltage	AC Low Line AC High Line	$V_{IN,AC}$	81 165	- -	90 180	Vac Vac
Typical Hysteresis is 5 to 11V	DC Input	$V_{IN,DC}$	165	-	180	Vdc
Turn-off Voltage	AC Low Line AC High Line	$V_{IN,AC}$	79 165	- -	85 175	Vac Vac
Typical Hysteresis is 5 to 11V	DC Input	$V_{IN,DC}$	165	-	174	Vdc

Note 1 - The input peak current will not exceed 35 A peak when the power supply input is cycled between on and off states at 240 Vac, where the off state is not more than one full AC cycle at half load or ½ cycle at full load. The AC input can return at any phase. Peak currents greater than 35 A, during the input recovery period, should not exceed 65 A and not have a duration of more than 200 us above 35 A.

Section 2 ELECTRICAL SPECIFICATIONS

2.2 Input Specifications

Table 2. Input Specifications con't

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Input Under Voltage Warning	AC Low Line AC High Line	$V_{IN,AC}$	87 175	- -	89 177	Vac Vac
	DC Input	$V_{IN,DC}$	175	-	177	Vdc
Efficiency	$V_{IN,AC}$ = 230 Vac I_O = 10% $I_{O,max}$ I_O = 20% $I_{O,max}$ I_O = 50% $I_{O,max}$ I_O = 100% $I_{O,max}$	η	 90 94 96 91	 - - - -	 - - - -	 % % % %
Hold-up Time	I_O = 50% $I_{O,max}$ I_O = 60% $I_{O,max}$ I_O = 70% $I_{O,max}$ I_O = 100% $I_{O,max}$	$t_{Hold-up}$	11 16 14 11	- - - -	- - - -	mS mS mS mS
System Stability Phase Margin Gain Margin			 45 -6	 - -	 - -	 Ø dB

Note - When the input is >275 Vrms, the power supply will issue a warning alert via PMBus status. The main and standby outputs will not shutdown. Warning bit will be cleared when the input is <270 Vrms.

Section 2 ELECTRICAL SPECIFICATIONS

2.3 Output Specifications

Table 3. Output Specifications

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Factory Set Voltage	$V_{IN,AC}$ = 230 Vac I_O = 50% $I_{O,max}$ I_{SB} = 50% $I_{SB,max}$ T_A = 25°C	$\%V_O$	-0.2	-	0.2	V
		$\%V_{SB}$	-2.5	-	2.5	
Output Regulation	Inclusive of set-point, temperature change, warm-up drift and dynamic load	$\%V_O$	-5	-	5	%
		$\%V_{SB}$	-5	-	5	
Output Ripple, Pk-Pk	Measure with a 0.1 µF ceramic capacitor in parallel with a 10 µF tantalum capacitor, 10 to 20 MHz bandwidth	V_O	-	-	120	mV_{PK-PK}
		V_{SB}	-	-	120	
Output Current[1, 2]	$V_{IN,AC}$ = 90 to 127 Vac $V_{IN,AC}$ = 180 to 264 Vac	I_O	1 1	- -	81.9 131.1	A
	All	I_{SB}	0	-	3.5	
Main Output Current Share Accuracy[3]	25% to 100% $I_{O,max}$	$\%I_O$	-	-	3	%
Number of Parallel Units	Main output current share connected		-	-	4	Units
Load Capacitance	Start up and stability	C_O	-	-	70,000	uF
	Cold redundancy and dynamic load		2000	-	-	
	Support peak current[4]		18,000	-	-	
	Standby output start up	C_{SB}	47	-	3100	
V_O Dynamic Response[5] Peak Deviation	60% load change slew rate = 1 A/us	V_O	11.6	-	12.8	V
	1A load change, slew rate = 0.5A/us	V_{SB}	11.4	-	12.6	V

Note 1 - Permissible overload of up to 217 A under short-term conditions. See over-current protection section.
Note 2 - 1 A minimum current for transient load response testing only. Unit is designed to operate and be within output regulation range at zero load.
Note 3 - The current sharing function starts when the total system load has reached 7% of the power supply rating.
Note 4 - For fast OCP/OCW, slow OCP/OCW.
Note 5 - Load changes from minimum to maximum or maximum to minimum may cause output voltage to go out of regulation but will not cause the power supply to shut down. Minimum output capacitance is 2000uF.

Section 2 ELECTRICAL SPECIFICATIONS

2.4 System Timing Specifications

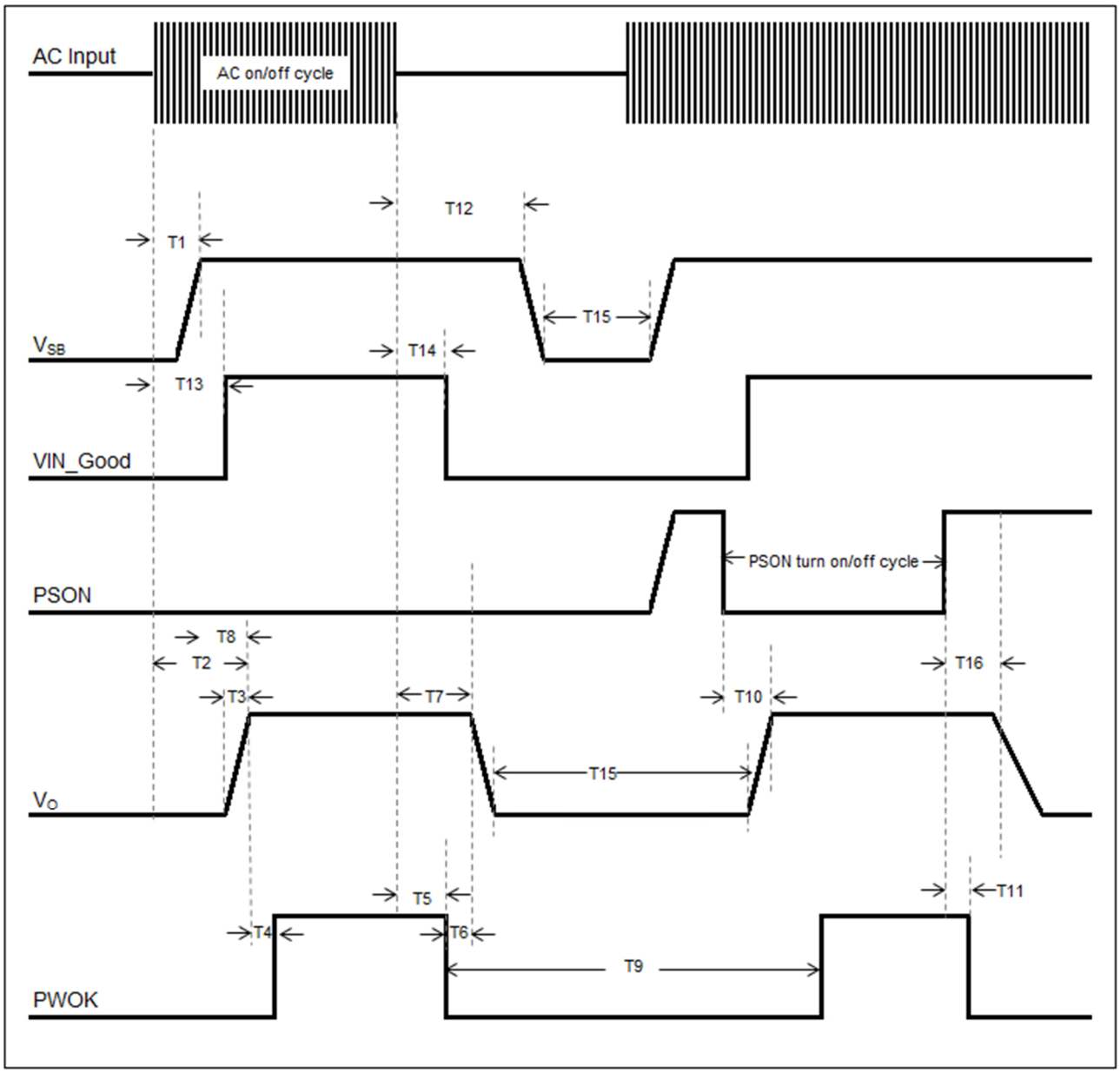
Table 4. System Timing Specifications

Label	Parameter	Min	Typ	Max	Unit
T1	Delay from AC being applied to V_{SB} being within regulation.	-	-	1500	ms
T2	Delay from AC being applied to all output voltages being within regulation.	-	-	3000	ms
T3	Output voltage rise time for 12 V from 10% to within regulation limits. The default is 25 ms. The default rise time setting corresponds to a maximum dV/dt of 0.5 V/ms	10	-	70	ms
T4	Delay from output voltages within regulation limits to PWOK asserted high at turn on.	100	-	500	ms
T5	Delay from loss of AC to de-assertion of PWOK.	10	-	-	ms
T6	Delay from PWOK de-asserted to output voltages dropping out of regulation limits.	1	-	-	ms
T7	Hold up time - time output voltages stay within regulation after the loss of AC.	11	-	-	ms
T8	Delay from standby voltage in regulation to output voltage in regulation at AC turn on.	50	-	1500	ms
T9	Duration of PWOK being in the de-asserted state during an off/on cycle using AC or the PSON signal.	100	-	-	ms
T10	Delay from PSON active to output voltages within regulation limits.	5	-	400	ms
T11	Delay from PSON de-active to PWOK de-asserted low.	–	-	5	ms
T12	Hold up time - time standby voltages stay within regulation after the loss of AC.	70	-	-	ms
T13	Delay from input being applied to VIN_GOOD assertion.	-	-	1800	ms
T14	Delay from loss of AC to de-assertion of VIN_GOOD.	-	-	3	ms
T15	This is the time the PSU must stay off when being powered off with loss of AC input. Both outputs must meet this off time: 1) whenever PWOK is de-asserted for the 12V main output; 2) whenever the 12V V_{SB} output drops below regulation limits.	500	-	-	ms
T16	Delay from PSON de-asserted to power supply turning off.	-	-	5	ms

Note 1 - T12 is supported when the total output power does not exceed max. total combined (12V + 12Vsb) power output., and the 12Vsb load is at 1.75 A.
Note 2 - To recycle the power supply, the input power must be kept off for > 1 s to ensure restart.
Note 3 - T6 is configurable by the system from 1 ms to 4 ms. The PSU may be configured to meet T6 of 2.5 ms at 107 A before the output drops below 10.8 V, with T7 still at a minimum of 11 ms.
Note 4 - T16 is to be tested with 3 A minimum load on the 12 V main output.

Section 2 ELECTRICAL SPECIFICATIONS

2.4 System Timing Diagram



Section 2 ELECTRICAL SPECIFICATIONS

2.5 CSU1600AT-3-100 Performance Curves

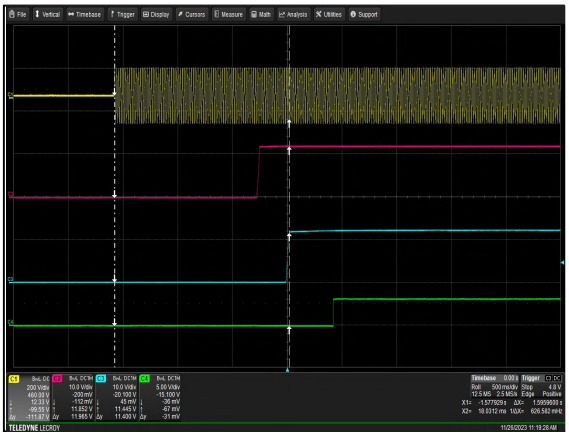


Figure 1: CSU1600AT-3-100 Turn-On Delay via AC Mains
Vin = 90Vac Load: I_O = 81.9A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: V_{SB} Ch 3: V_O Ch 4: PWOK

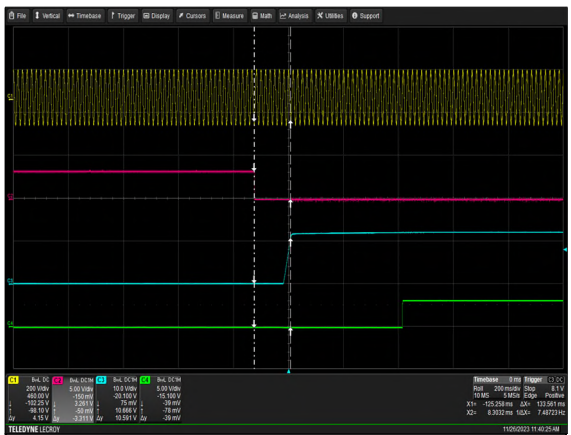


Figure 2: CSU1600AT-3-100 Turn-On Delay via PSON
Vin = 90Vac Load: I_O = 81.9A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: PSON Ch 3: V_O Ch 4: PWOK

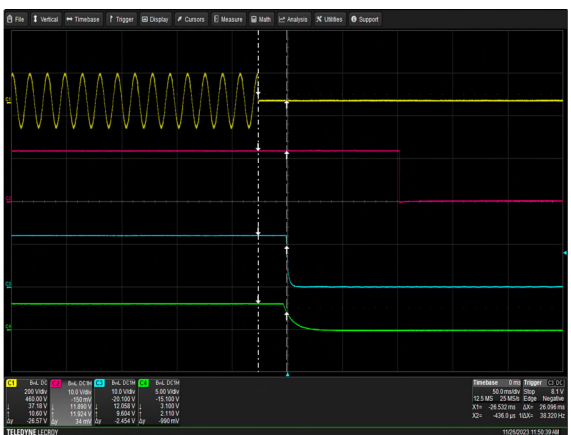


Figure 3: CSU1600AT-3-100 Hold-Up Time
Vin = 90Vac Load: Io = 81.9A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: V_{SB} Ch 3: V_O Ch 4: PWOK

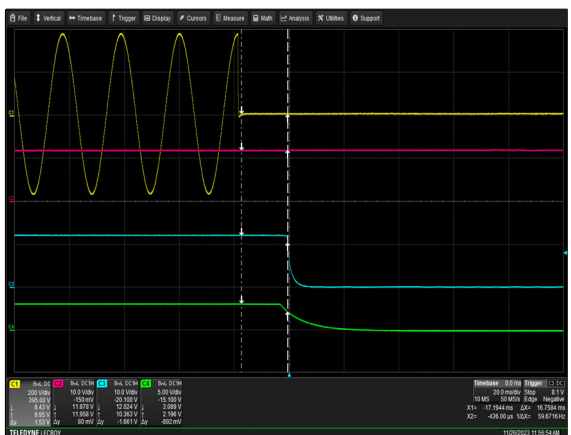


Figure 4: CSU1600AT-3-100 Hold-Up Time
Vin = 264Vac Load: Io = 131.1A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: V_{SB} Ch 3: V_O Ch 4: PWOK

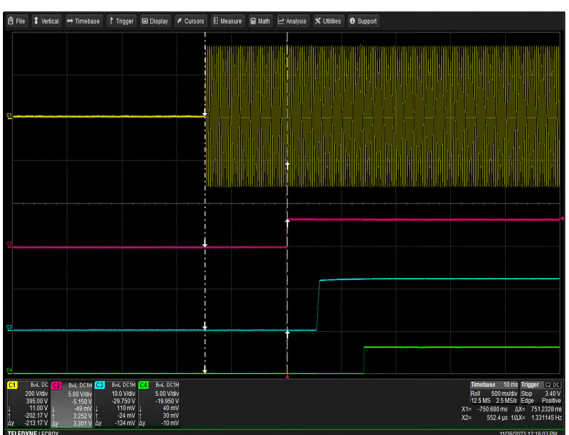


Figure 5: CSU1600AT-3-100 VIN_GOOD Assert Characteristic
Vin = 230Vac Load: Io = 131.1A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: VIN_GOOD Ch 3: V_O Ch 4: PWOK

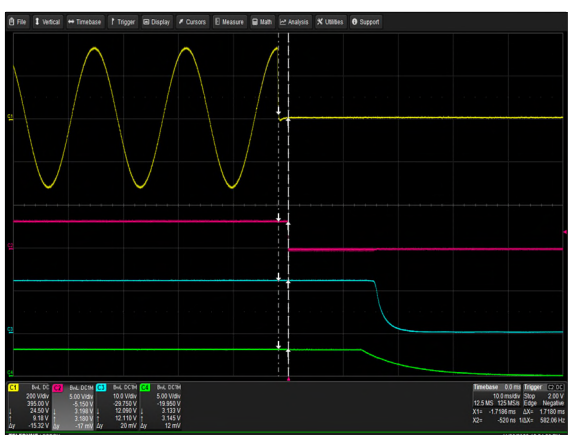


Figure 6: CSU1600AT-3-100 VIN_GOOD De-assert Characteristic
Vin = 230Vac Load: Io = 131.1A I_{SB} = 3.5A
Ch 1: AC Mains Ch 2: VIN_GOOD Ch 3: V_O Ch 4: PWOK

Section 2 ELECTRICAL SPECIFICATIONS

CSU1600AT-3-100 Performance Curves

Figure 7: CSU1600AT-3-100 Inrush Current
Vin = 240Vac Load: Io = 0A, Turn on at 90 deg
Ch 1: V_{IN} Ch 2: I_{IN}

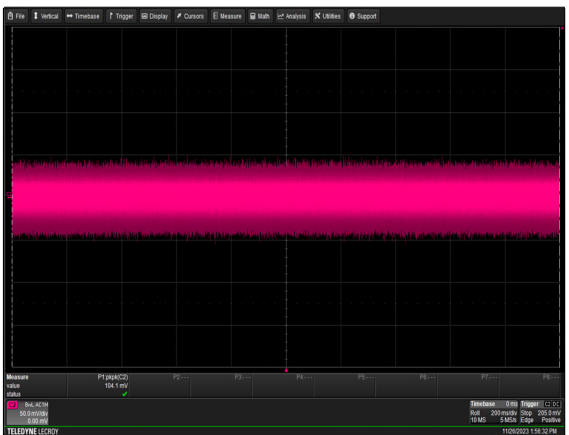


Figure 8: CSU1600AT-3-100 Ripple and Noise Measurement
Vin = 180Vac Load: Io = 131.1A I_{SB} = 3.5A
Ch 2: V_O

Figure 9: CSU1600AT-3-100 Output Voltage Startup Characteristic
Vin = 90Vac Load: Io = 81.9A I_{SB} = 3.5A
Ch 1: V_O

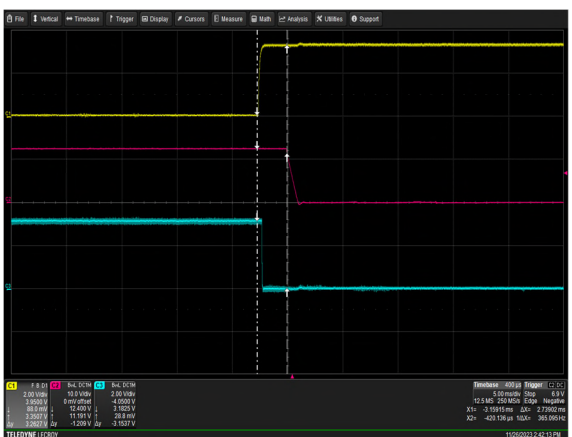


Figure 10: CSU1600AT-3-100 Turn Off Characteristic via PSON
Load: Io = 131.1A I_{SB} = 3.5A
Ch 1: PSON Ch 2: V_O Ch 3: PWOK

Figure 11: CSU1600AT-3-100 Transient Response - V_O Deviation
40% to 100% load change 1A/µS slew rate Vin = 230Vac
Ch 1: V_O Ch 2: I_O Output Cap: 2200uF

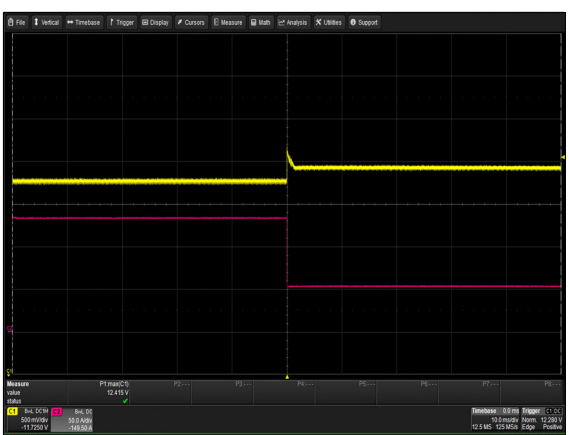


Figure 12: CSU1600AT-3-100 Transient Response - V_O Deviation
100% to 40% load change 1A/µS slew rate Vin = 230Vac
Ch 1: V_O Ch 2: I_O Output Cap: 2200uF

Section 2 ELECTRICAL SPECIFICATIONS

CSU1600AT-3-100 Performance Curves

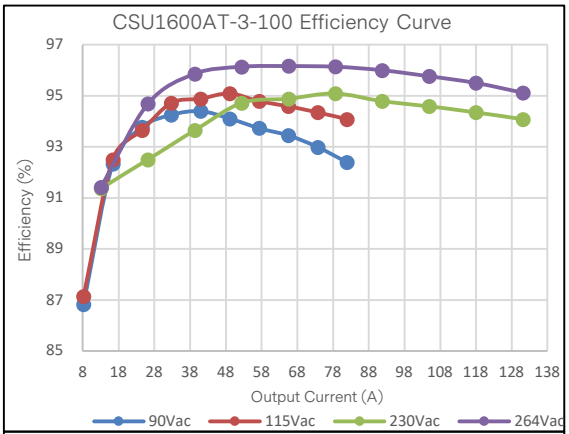


Figure 13: CSU1600AT-3-100 Efficiency Curve @ 25°C

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

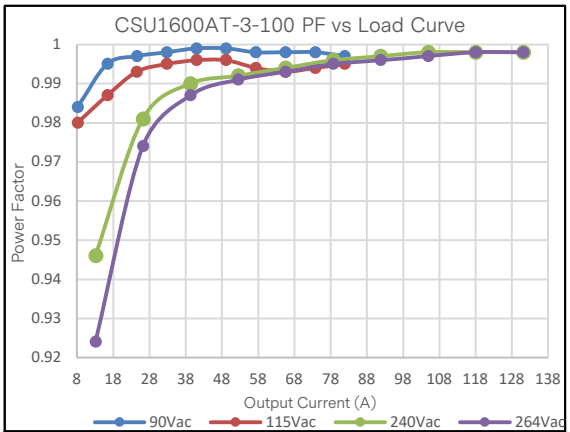


Figure 15: CSU1600AT-3-100 PF vs Load Curve

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

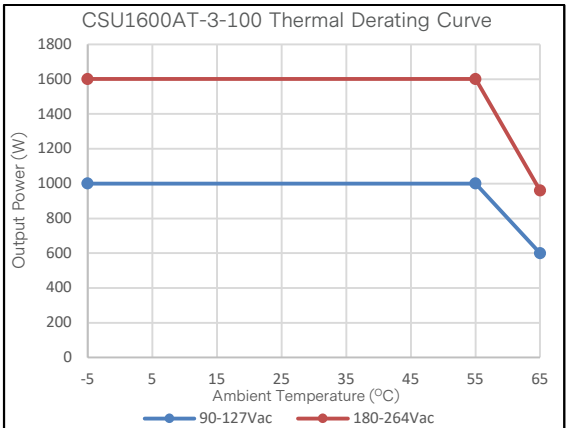


Figure 16: CSU1600AT-3-100 Thermal Derating Curve

Section 2 ELECTRICAL SPECIFICATIONS

2.6 Protection Function Specifications

Input Fuse

CSU1600AT series power supply is equipped with an internal non user serviceable 20 A Fast Acting 420 Vdc fuse to IEC127 for fault protection on L line input.

Over Voltage Protection (OVP)

When the OVP circuit is activated on the main output, only the main output is shut down and latches off. Reset will require PSON or the input power to be recycled manually by turning off the input for at least 1 sec. An OVP on the standby output would shutdown the main output and the standby output. The power supply will reset and auto-recover when the OVP on the standby is removed.

Parameter	Min	Nom	Max	Unit
Main Output Overvoltage	-	-	14.5	V
Standby Output Overvoltage	-	-	14.5	V

Short Circuit Protection (SCP)

The power supply withstands a continuous short circuit with no permanent damage, applied to its main output during start-up or while running. A short is defined as impedance less than 0.02 ohms or less.

When the standby output V_{SB} is shorted, the output will go into “hiccup mode”. When the V_{SB} attempts to restart, the maximum peak current from the V_{SB} output will be less than 10 A.

Over Temperature Protection (OTP)

The power supply is internally protected against over temperature conditions. When the OTP limit is reached, all outputs, except standby, will shutdown and remain off until the over temperature condition no longer exists.

Model Number	Parameter (Inlet Air Temperature)	Min	Max	Unit
CSU1600AT-3-100	Over Temperature Warning (OTW) Over Temperature Protection (OTP)	61 65	64 /	°C °C

Section 2 ELECTRICAL SPECIFICATIONS

Over Current Protection (OCP)

CSU1600AT series includes internal current limit circuitry to prevent damage in the event of overload or short circuit. It has over current protection (OCP), over current warning (OCW), and over power protection (OPP) limits as defined in table below. They are defined to protect the PSU and to allow peak current to power the system without the PSU shutting down. Fast OCW and slow OCW levels are defined to assert SMBAlert to allow the system to throttle power to protect the PSU and also to allow peak current draws by the system. When OCP trips, it will shutdown and latch off the PSU. The latched PSU is cleared by an AC power cycle or PSON recycle. The power supply can not be damaged from repeated power cycling in this condition. $12V_{SB}$ is auto-recovered after removing OCP limit.

Parameter	Thresholds		Timing		Protection Mode[1]
	Min	Max	Min	Max	
V_O Output Slow Overcurrent Warning	159.1 A	169.1 A	10 mS	15 mS	SMBAlert
V_O Output Slow Overcurrent Protection	170.1 A	204.1 A	20 mS	0.1 S	Shut down and latch only after min - max timing
V_O Output Fast Overcurrent Warning	205.1 A	214.1 A	5 uS	20 uS	SMBAlert
V_O Output Fast Overcurrent Protection	214.1 A	224.1 A	0.1 mS	-	Foldback then latch after min timing
V_{SB} Output Overcurrent Protection	4.7 A	6.6 A	10 mS	-	Shut down and hiccup mode

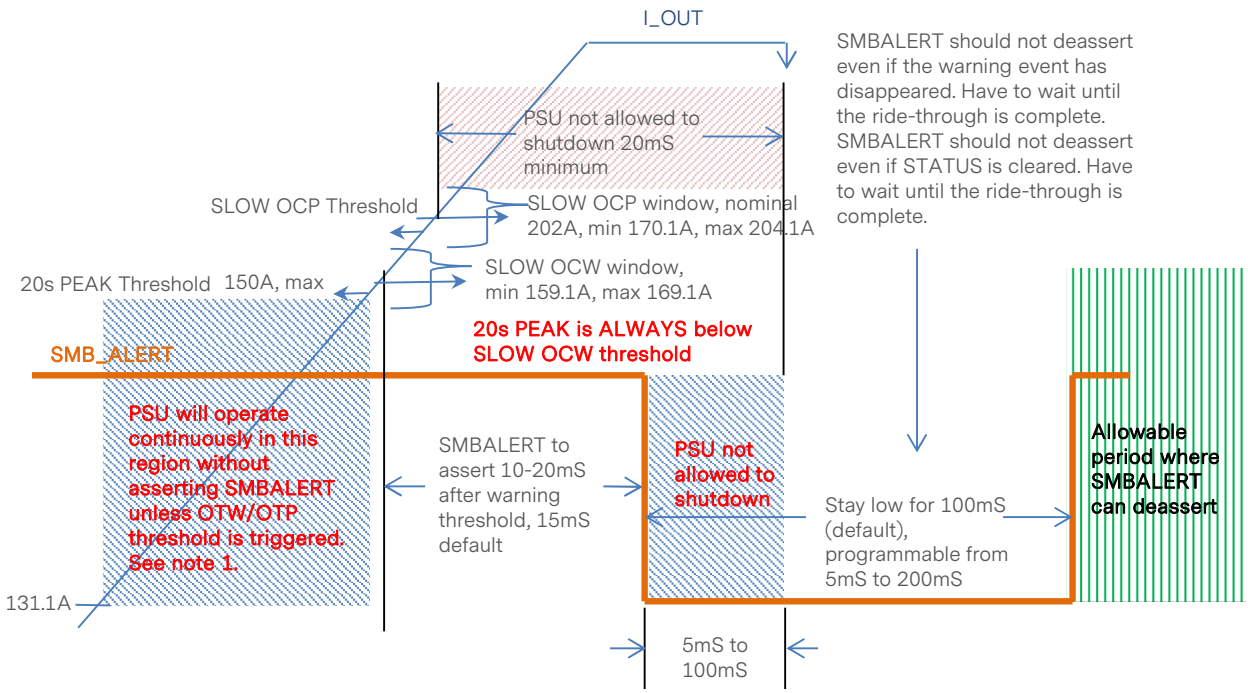
Note 1 - Slow OCW threshold is set below the slow OCP threshold.
Note 2 - Fast OCW threshold is below the OPP / fast OCP threshold. Fast OCW will hold the SMBAlert# signal asserted for 50 to 150 ms; then de-assert.
Note 3 - Over power protection mode will be held for at least 100 µs before OCP shuts down the PSU.

Fan Fault

The power supply protects itself from a locked rotor fan. During a locked rotor, the PSU issues a fan fault warning in the first 5 seconds. If the locked rotor persists for another 5 seconds, the PSU will set the fan fault bit. The main output will shutdown after waiting for another 5 seconds after the fan fault bit has been set and the fault condition persists. The standby output will shutdown after another 5 seconds. This is done to prevent hotspots from damaging the power supply.

Section 2 ELECTRICAL SPECIFICATIONS

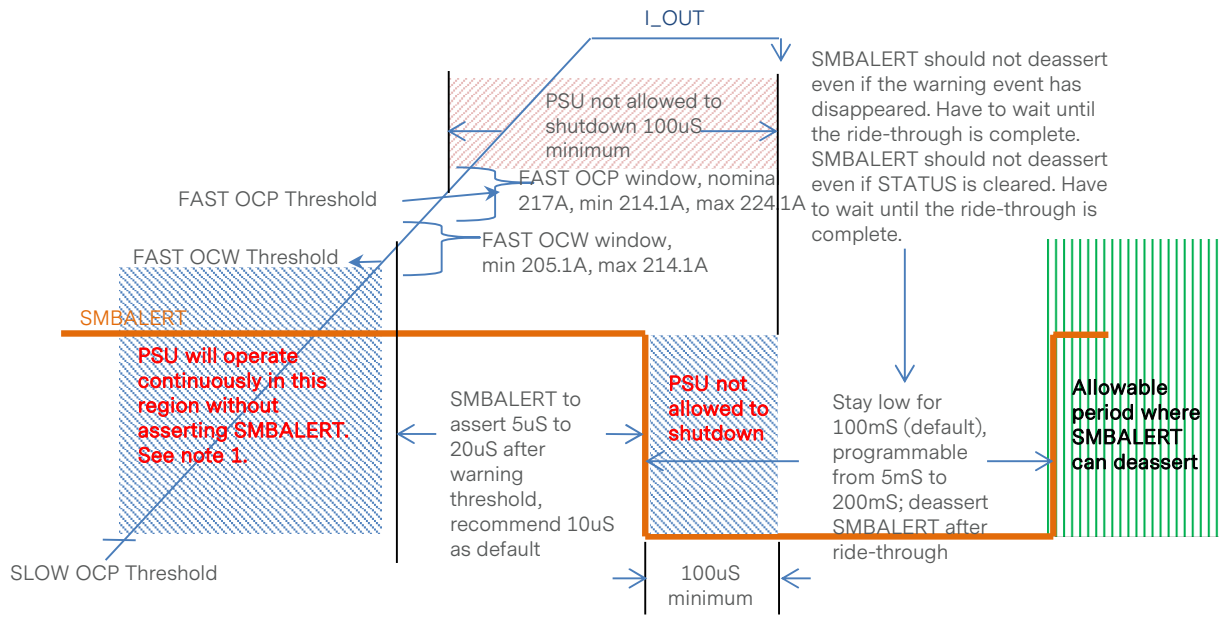
Thermal Warning, CLST, SLOW OCW, SLOW OCP



Note 1 - OTW threshold should be set, at the minimum, 4°C below the OTP threshold. OTW asserts SMBALERT, sets STATUS, but does not shutdown the PSU. PSU will shutdown when OTP threshold is triggered.
Note 2 - The system must ensure that the average of the pulsed currents do not exceed the DC-max rating of the power supply.

Section 2 ELECTRICAL SPECIFICATIONS

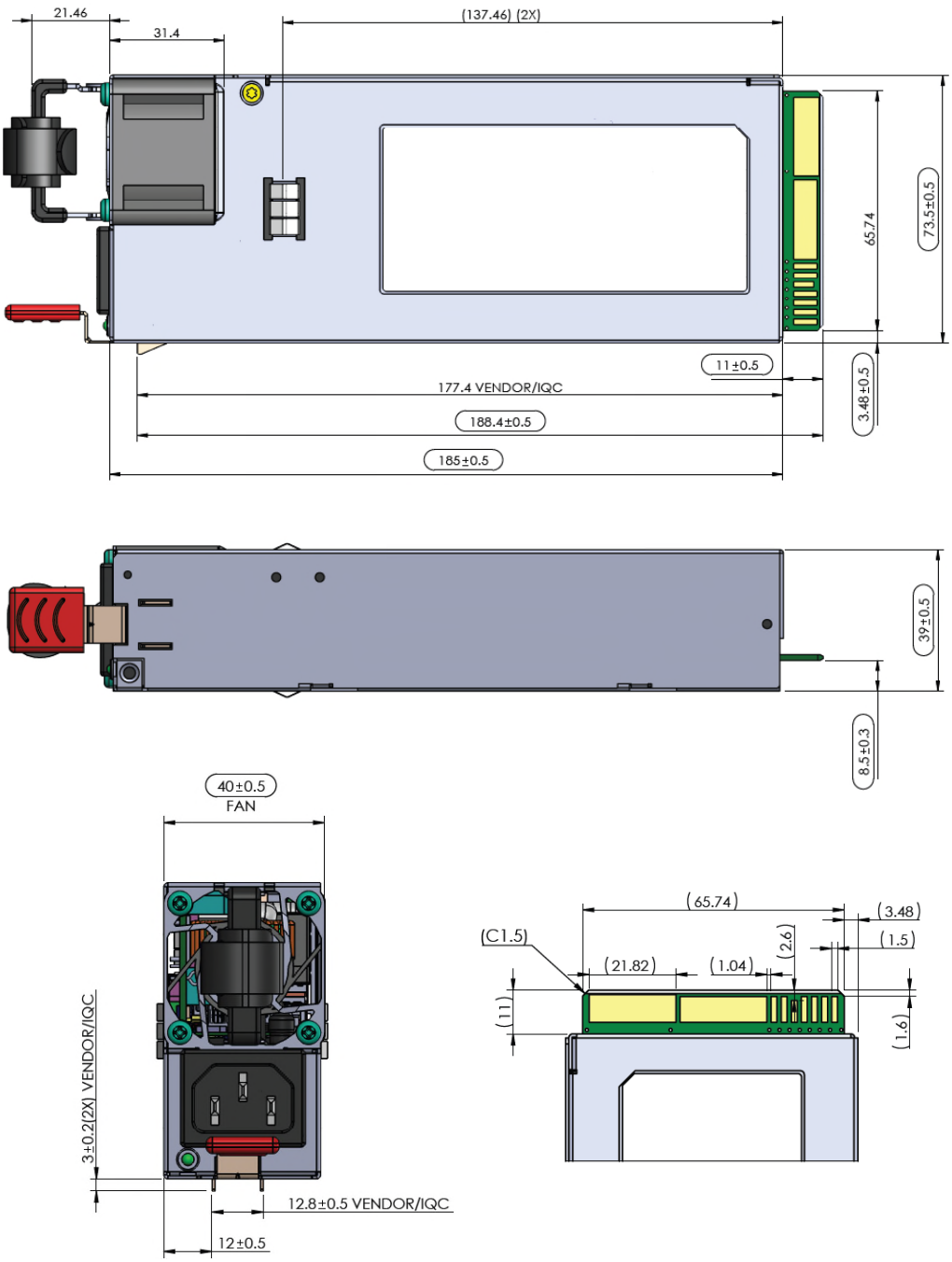
Fast OCW, Fast OCP



Note 1 - Fast OCW must be set below the fast OCP threshold.
Note 2 - The system must ensure that the average of the pulsed currents do not exceed the DC-max rating of the power supply.

Section 3 MECHANICAL SPECIFICATIONS

3.1 Mechanical Outlines (unit: mm)



Section 3 MECHANICAL SPECIFICATIONS

3.2 Mechanical Data

Table 5. Mechanical Data	
Dimensions (D x W x L)	1U x 2.89" x 7.28"
Weight	1052 g / 2.319 lbs
Cooling	Built in fan
Audible Noise	25 dbA @ 35^{O}C, 34 dbA @ 45^{O}C, 61dbA @ 50^{O}C

3.3 Unit Packaging Requirement

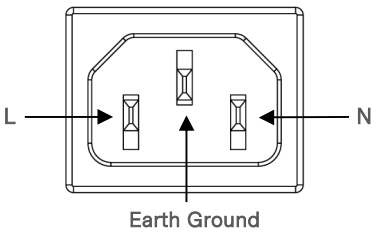
Table 6. Unit Packaging Requirement	
Inserted Instructions	Instruction sheet to be provided with all units packaged in individual unit box if used.
Individual Unit Packing	Units can be packed in egg crate type cartons for production quantities. Individual product shipments include an individual unit box.
Master Carton Shipping Box	Only anti-static packing material may be used inside the box. Exterior box sealing tape is anti-static type.
Individual Carton Packing Box (When Used)	Individual carton is labelled with RoHS sticker and individual label showing unit serial number, manufacturing date, manufacturing part number, bar codes, country of origin.

Section 3 MECHANICAL SPECIFICATIONS

3.4 Connector Definitions

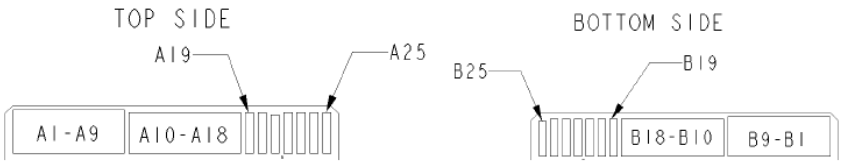
AC Input Connector

Pin 1	–	Line
Pin 2	–	Neutral
Pin 3	–	Earth Ground



Output Connector - Power Blades

A1-A9	–	Main Output Return
A10-A18	–	Main Main Output (V_O)
B1-B9	–	Main Output Return
B10-B18	–	Main Output (V_O)



View from power supply output connector end

Output Connector - Control Signals

A19	–	SDA
A20	–	SCL
A21	–	PSON
A22	–	SMBAlert
A23	–	$-V_{SENSE}$
A24	–	$+V_{SENSE}$
A25	–	PWOK
B19	–	A0 (SMBus Address)
B20	–	A1 (SMBus Address)
B21	–	$12V_{SB}$
B22	–	CR_BUS
B23	–	12V Load Share
B24	–	GND
B25[1]	–	VIN_GOOD/PS_KILL

Note 1 - B25 should be assignable to function either as PS_KILL or the compatibility check pin. DSP or MCU pin assignment for this signal should support high-speed interrupt and ADC. The default assignment is VIN_GOOD.

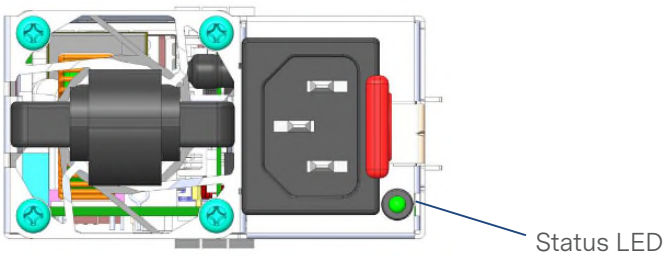
Section 3 MECHANICAL SPECIFICATIONS

Power / Signal Mating Connectors and Pin Types

Table 6. Mating Connectors for CSU1600AT Series		
Reference	On Power Supply	Mating Connector or Equivalent
AC Input Connector	IEC320-C14	IEC320-C13
Output Connector	Card-edge	2x25 pin configuration of the FCI Amphenol power card connector 10147875-001LF and GPCEFX4361411HHR

Section 3 MECHANICAL SPECIFICATIONS

LED Indicator Definitions



One bi-color (green/amber) LED at the power supply front provides the status signal. The status LED conditions are shown on the following table.

Conditions	SMBAlert# State	LED Status
Output ON and OK	High	Green
No AC power to all power supplies	Off	Off
PSU standby state AC present / Only $12V_{SB}$ / Cold standby state or always standby state as defined in the Cold Redundancy section	High	1Hz Blink Green
AC cord unplugged / AC power lost with a second power supply in parallel still with AC input power	Low	Amber
Power supply critical event causing a shutdown (Failure, over current, short circuit, over voltage, fan failure, over temperature)	Low	Amber
Power supply warning events where the power supply continues to operate (High temp, high power, high current, slow fan)	Low	1Hz Blink Amber
Power supply firmware updating	High	2Hz Blink Green

Section 4 ENVIRONMENTAL SPECIFICATIONS

4.1 EMC Immunity

CSU1600AT series power supply is designed to meet the following EMC immunity specifications.

Table 7. Environmental Specifications

Test Items	Standard	Test Level	Criteria[1]
Conducted Emissions	EN 55032, FCC CFR 47 Part 15 Subpart B	Class A. 150k to 30MHz	6dB Margin, average
Radiated Emissions	EN 55032, FCC CFR 47 Part 15 Subpart B	Class A. 30M to 1GHz, 10m setup	6dB Margin, average
Harmonic Current Emissions	EN 61000-3-2	-	-
Voltage Fluctuations	IEC 61000-3-3	-	-
Electro Static Discharge (ESD) Immunity	EN/IEC 61000-4-2	8kV contact, 15kV air	A
Radiated RF EM Fields Susceptibility	EN/IEC 61000-4-3	10V/m	A
Electrical Fast Transients (EFT) / Bursts	EN/IEC 61000-4-4	+/- 2kV	A
Surges - Line to Line (DM) and Line to GND (CM)	EN/IEC 61000-4-5	2kV DM, 2kV CM	A
Conducted Immunity	EN/IEC 61000-4-6	10Vrms	A
Voltage Dips & Sags	EN 61000-4-11	>95% for 10ms ≤30% for 500ms >95% for 500ms	A A C
Ring Wave	IEC 61000-4-12	1kV DM, 2kV CM	A

Note 1: Performance Criteria as defined by EN300386.

Performance Criteria A: The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below specified performance level during intended use of operation.

Performance Criteria B: The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below specified performance level during intended use of operation. Degradation of performance is allowed during the exposure to an electromagnetic phenomenon but no change of actual operating state is allowed.

Performance Criteria C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Section 4 ENVIRONMENTAL SPECIFICATIONS

4.2 Safety Certifications

The CSU1600AT series power supply is 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 8. Safety Certifications for CSU1600AT Series Power Supply

Standard	Agency	Description
IEC/EN 62368	CE	European Requirements, CE Mark
UL62368-1:2014, CAN/CSA C22.2 No.62368-1:2014	UL + CUL	US and Canada Requirements
CB Certificate and Report		All CENELEC Countries
CHINA CCC or CQC Approval		China Requirements
KC		Korea Certification
EAC		Russia Requirements
BIS		India Requirements
BSMI		Taiwan Requirements
CE		LVD, ROHS, EMC
UKCA		UKCA Mark

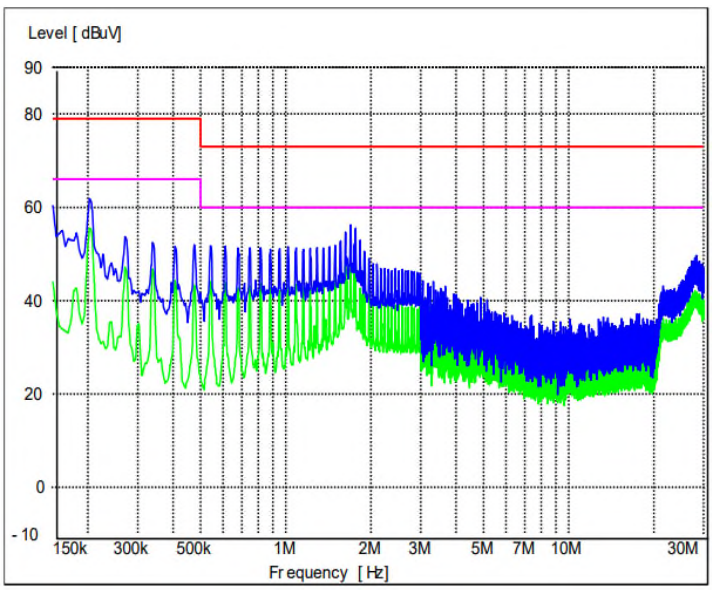
Section 4 ENVIRONMENTAL SPECIFICATIONS

4.3 EMI Emissions

The CSU1600AT series power supply has been designed to comply with the Class A limits of EMI requirements of FCC CFR 47 Part 15 Subpart B and EN55032 for emissions and relevant sections of EN55032: 2011 for immunity. The unit is tested at 1600 W 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 CSU1600AT series power supply has internal EMI filters to ensure the convertor's conducted EMI levels comply with EN55032 (FCC Part 15) Class A limits. The EMI measurements are performed with resistive loads at maximum rated loading.

Sample of EN55032 conducted EMI measurement at 230 Vac input.

Note: Red Line refers to Advanced Energy's Artesyn Quasi Peak margin, which is 6dB below the CISPR international limit. Pink Line refers to the Advanced Energy's Artesyn Average margin, which is 6 dB below the CISPR international limit.

Conducted EMI emissions specifications of the CSU1600AT series power supply:

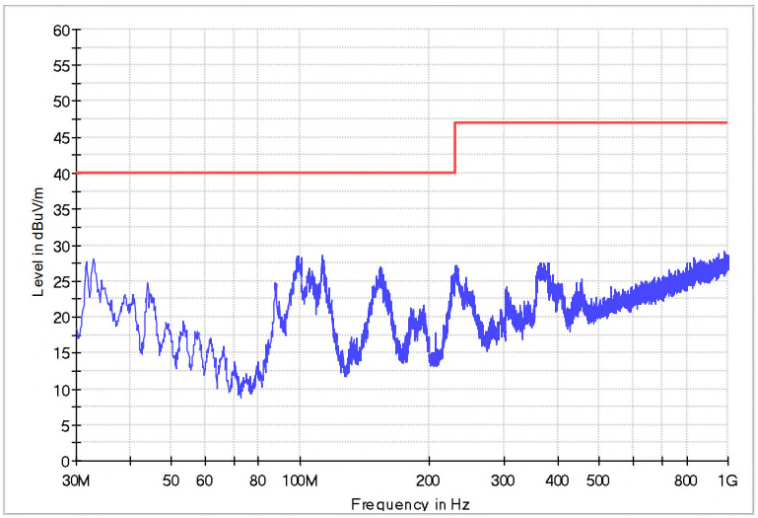
Parameter	Model	Symbol	Min	Typ	Max	Unit
FCC Part 15, class A	All	Margin	-	6	-	dB
CISPR 32 (EN55032), class A	All	Margin	-	6	-	dB

Section 4 ENVIRONMENTAL SPECIFICATIONS

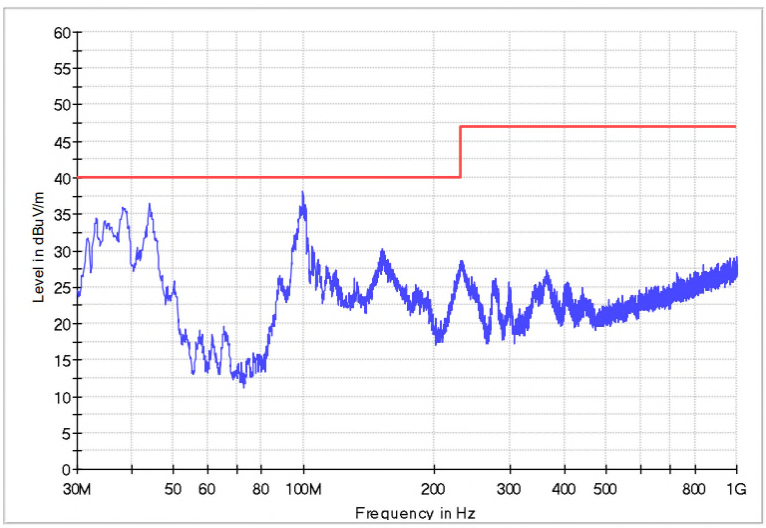
Radiated Emissions

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 converters as a stand-alone component to the exact requirements of EN55032 can be difficult because the standard calls for 1m lead 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 converters could pass. However, the standard also states that an attempt will be made to maximize the disturbance consistent with the typical application by varying the configuration of the test sample.

Horizontal (230 Vac / 50 Hz, full load)



Vertical (230 Vac / 50 Hz, full load)



Section 4 ENVIRONMENTAL SPECIFICATIONS

4.4. Operating Temperature

The CSU1600AT series ambient operating limits are shown in the table below.

Table 9. Operating Temperature Requirements (Air Inlet Temperature)

Model	Output Power	Altitude	Operating Temperature	
			Min	Max
CSU1600AT-3-100	1600 W	3000 m	-5°C	55°C
	960 W	See level	-5°C	65°C
	1600 W	5000 m	-5°C	35°C

Output Power vs Operating Temperature

Forward Airflow: Output power derated linearly from 100% to 60% when operating from 55°C to 65°C.

4.5 Forced Air Cooling

The CSU1600AT series includes internal cooling fans as part of the power supply assembly to provide forced air-cooling to maintain and control temperature of devices and ambient temperature in the power supply to appropriate levels. The standard direction of airflow is from the DC connector end to the AC connector end of the power supply.

Section 4 ENVIRONMENTAL SPECIFICATIONS

4.6 Storage and Shipping Temperature

The CSU1600AT series power supply can be stored or shipped at temperatures between -40°C to +70°C and relative humidity from 5% to 95% non-condensing.

4.7 Altitude

The CSU1600AT series power supply is certified for safety spacing's requires for 5000 meters altitude. The power supply will not be damaged when stored at altitudes of up to 12,100 meters above sea level.

4.8 Humidity

The CSU1600AT series power supply can operate within specifications when subjected to a relative humidity from 5% to 95% non-condensing. The power supply can be stored in a relative humidity from 5% to 95% non-condensing.

4.9 Vibration

The CSU1600AT series power supply will pass the following vibration specifications:

Non-Operating Random Vibration

Acceleration	0.5	gRMS
Frequency Range	5 - 500	Hz
Duration	0.5	Octave/min
Direction	15 mins at each of 3 resonant point	

Non-Operating Random Vibration

Acceleration	3.13		gRMS
Frequency Range	5 - 500		Hz
Duration	15		Mins
Direction	3 mutually perpendicular axis		
PSD Profile	FREQ (Hz)	SLOPE (db/oct)	PSD (g^2/Hz)
	5	/	0.01
	20	/	0.02
	20 - 500	/	0.02

Section 4 ENVIRONMENTAL SPECIFICATIONS

Operating Random Vibration

Acceleration	0.15		gRMS
Frequency Range	5 - 100		Hz
Duration	30		Mins
Direction	3 mutually perpendicular axis		
PSD Profile	FREQ (Hz)	SLOPE (db/oct)	PSD (g^2/Hz)
	5 - 50	/	0.002
	50 - 100	/	0.04

4.10 Shock

The CSU1600AT series power supply will pass the following shock specifications:

Non-Operating Trapezoidal Shock

Acceleration	50	G
Duration	4.3	m / Sec
Pulse	Trapezoidal wave	
Number of Shock	3 shocks in each of 6 faces	

Operating Half-Sine Shock

Acceleration	20	G
Duration	10	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 CSU1600AT series power supply.

Pin 1 – L
Pin 2 – N
Pin 3 – Earth Ground

5.2 Output Connector – Power Blades

These pins provide the main output for the CSU1600AT series power supply. The Main Output (V_O) and the Main Output Return pins are the positive and negative rails, respectively, of the V_O main output of the CSU1600AT series power supply.

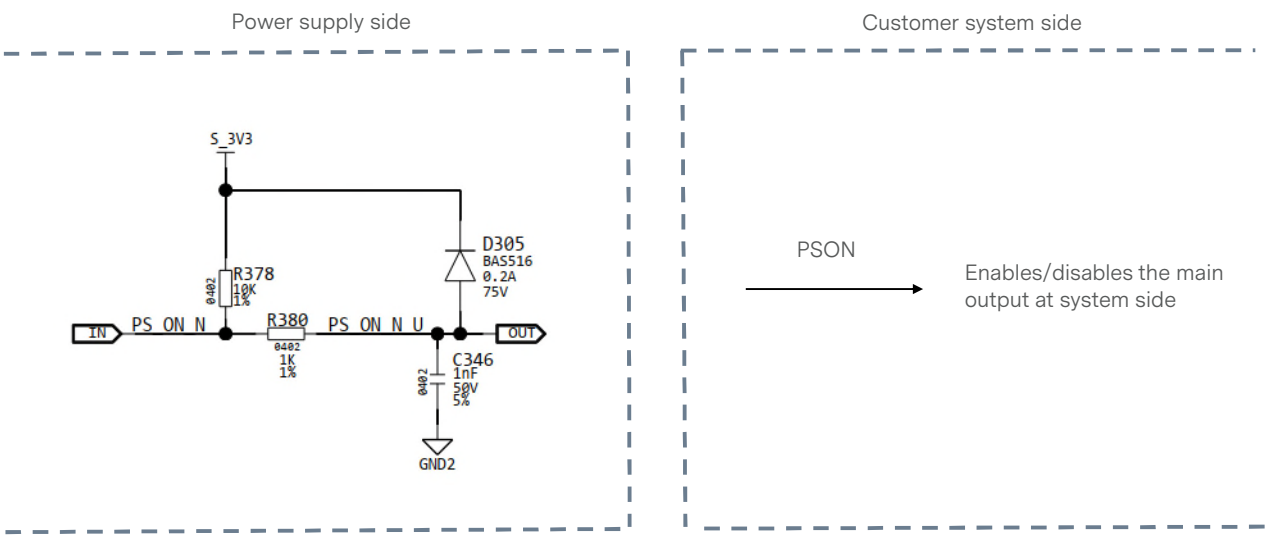
A1-A9 – Main Output Return
A10-A18 – Main Output (V_O)
B1-B9 – Main Output Return
B10-B18 – Main Output (V_O)

5.3 Output Connector – Control Signals

The CSU1600AT series power supply contains a 14 pins control signal header providing an analogue control interface, standby power and I^2C interface signal connections.

PSON - (Pin A21)

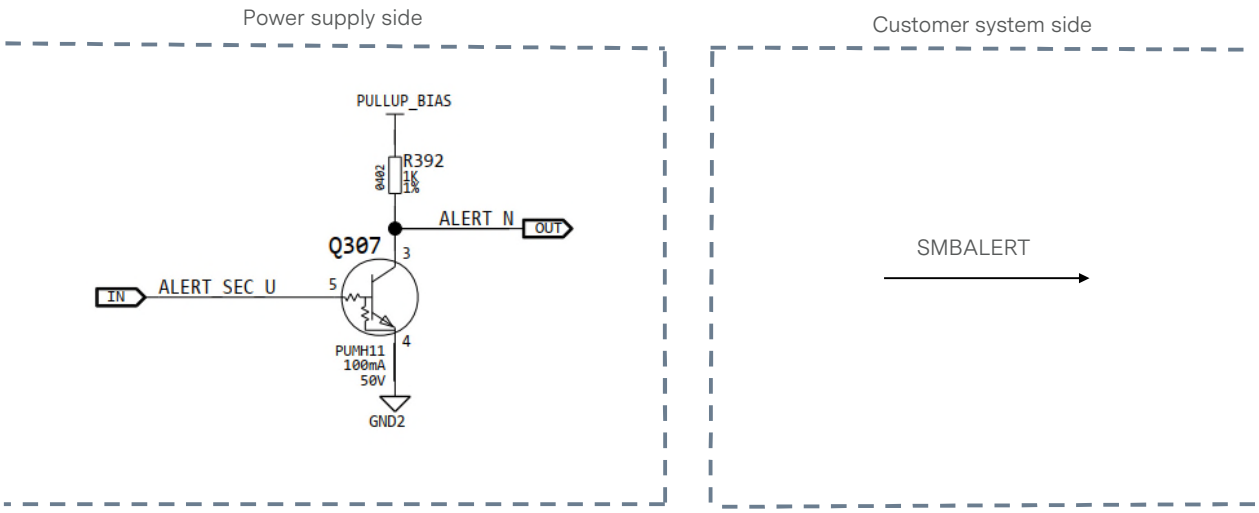
This signal input pin controls the normal turn on and off of the main output of the CSU1600AT series power supply. The power supply main output (V_O) will be enabled when this signal is pulled low below 0.8 V. The power supply output (except V_{SB} output) will be disabled when this input is driven higher than 2.0 V. This signal can be pulled high to 5 V maximum. The PSU has a 10k ohm internal pull-up resistor, hence no additional pull-up resistor required by system. The source current is 4 mA maximum when Vpson is low.



Section 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

SMBALERT - (Pin A22)

SMBALERT is an active low signal used to send an interrupt to the system that a warning or critical event in the PSU occurred. The pin is normally high. It is asserted (goes low) when a warning or fault occurred. The conditions where in the signal is de-asserted (goes back to high) are AC recycle, PSON recycle and issuance of a CLEAR_FAULTS PMBus™ command.

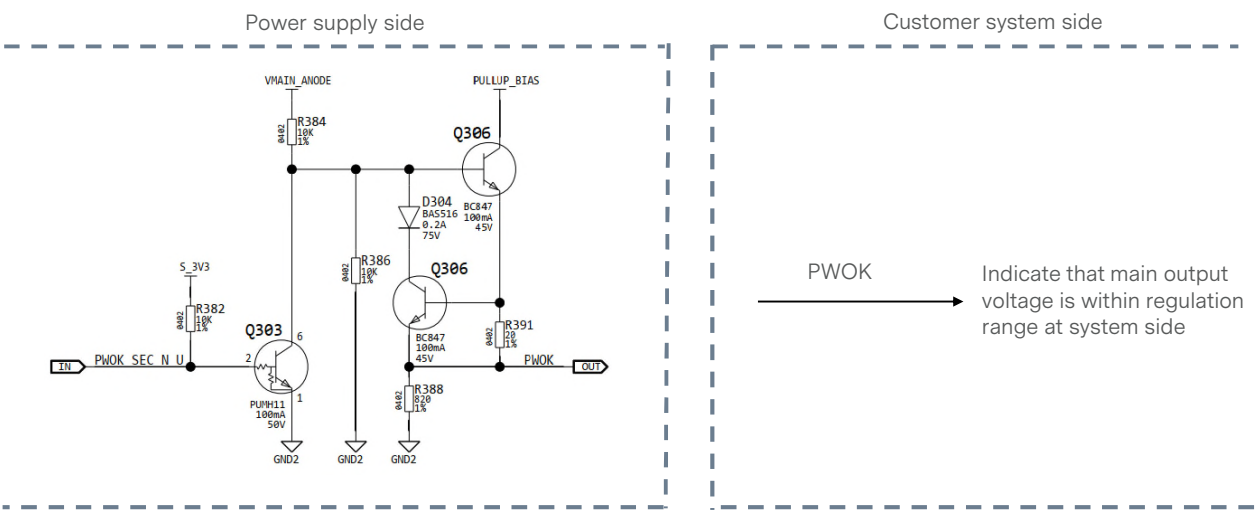


+VSENSE & -VSENSE - (Pins A23, A24)

+ VSENSE and -VSENSE are the remote sense signals for 12 V main output voltage. This remote sense circuit is designed to compensate for a power path drop of 100 mV on each sense line.

PWOK - (Pin A25)

The PWOK is an output signal driven high above 2.0 V by the power supply to indicate that all outputs are valid. If any of the power supply outputs fails below its regulation limits, this signal will be driven low below 0.4 V. The sink current is 4 mA maximum when the signal is high. The rise time and fall time of the signal is 100 uS maximum. If the AC power is lost, this signal must be driven low at least 20 mS before the standby output goes below regulation range. This signal has 1K ohm pull-up resistor connected to standby bus before oring device inside PSU.



Section 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

CR_BUS - (Pin B22)

There is an additional signal defined supporting cold redundancy. This is connected to a bus shared between the power supplies and CR_BUS. This is a tri-state output signal of the power supply used to communicate a fault or Vout under-voltage level has occurred in one of the power supplies. This is used to power on all the power supplies in the system via the CR_BUS. When the signal is pulled high, it allows all power supplies in cold standby mode to go into cold standby state when the load share voltage is below the VCR_ON level. When the signal is left open on all power supplies, it forces all cold standby power supplies into the ON. The cold redundancy section showing the logic state of the CR_BUS signal depending upon the programmed configuration of the power supply in D0h, the operating state of the power supply, and the power supply fault status.

12V Load Share - (Pin B23)

12V load share is a single wire bus signal used to help equalize the output current from two or more power supplies connected to a common load. The current share signal is a DC signal that represents the load current that a power supply is providing. This voltage increases proportionately with the output load. The expected voltage levels are stated as below table.

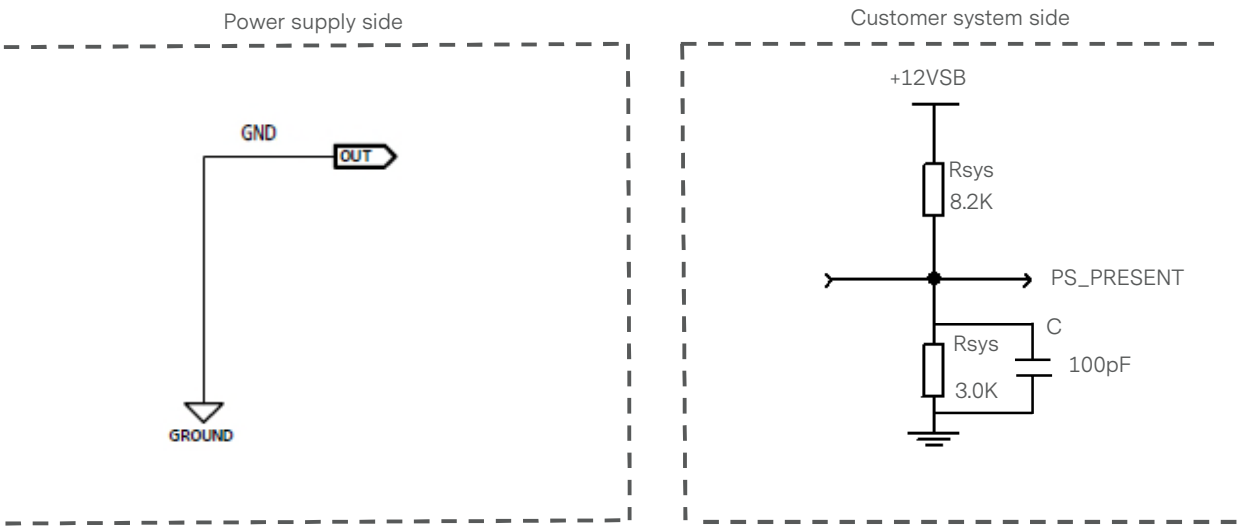
ISHARE signal voltage of the CSU1600AT series power supply:

Load (per power supply unit)	Model	Min	Nom	Max	Unit
100%$I_{O,max}$	All	7.6	8.0	8.4	Vdc
50%$I_{O,max}$	All	3.8	4.0	4.2	Vdc

GND (Used by system for presence detect) - (Pin B24)

This signal used to indicate to the system that a power supply is inserted in the power bay. This pin is grounded inside the power supply. Recommended pull-up resistor to 12Vsb is 8.2k ohm with a 3.0k ohm pull-down to ground. A 100 pF decoupling capacitor is also recommended.

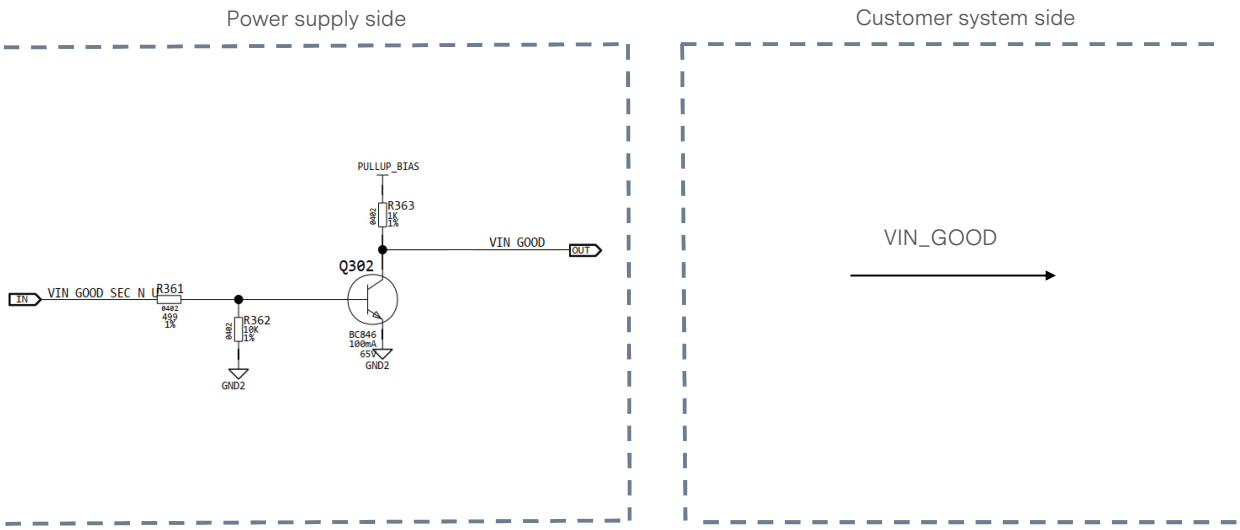
- Low - PS is present.
- High - PS is removed from system.



Section 5 POWER AND CONTROL SIGNAL DESCRIPTIONS

VIN_GOOD - (Pin B25)

When B25 is used as VIN_GOOD, this signal will be asserted, driven HIGH (> 2.0 V) by the power supply to indicate that the input applied is within the valid range. If the input power is lost to 0 V, this signal must be driven low. The sink current is 4 mA maximum when the signal is low and is 2 mA maximum when the signal is high. The rise time and fall time of the signal is 100 µS maximum.



Section 6 COMMUNICATION BUS DESCRIPTIONS

6.1 I²C Bus Signals

CSU1600AT series power supply contains enhanced monitor and control functions implemented via the I²C bus. The CSU1600AT series I²C functionality (PMBus™ and FRU data) can be accessed via the output connector control signals. The communication bus is powered either by the internal 3.3V supply or from an external power source connected to the standby output (i.e. accessing an unpowered power supply as long as the standby output of another power supply connected in parallel is on).

If units are connected in parallel or in redundant mode, the standby outputs must be connected together in the system. Otherwise, the I²C bus will not work properly when a unit is inserted into the system without the DC source connected.

Note: PMBus™ functionality can be accessed only when the PSU is powered-up. Guaranteed communication I²C speed is 100 kHz.

A0, A1 (I²C Address Signals) - (Pins B19, B20)

These input pins are the address lines A0 and A1 to indicate the slot position the power supply occupies in the power bay and define the power supply addresses for FRU data and PMBus™ data communication. This allows the system to assign different addresses for each power supply. During I²C communication between the system and power supplies, the system will be the master and the power supplies will be the slave. They are internally pulled up to internal 3.3 V supply.

SDA, SCL (I²C Data and Clock Signals) - (Pins A19, A20)

I²C serial data and clock bus - these pins must be pulled-up by a 2.2k ohm resistor to 3.3 V at the system side.

I²C Bus Communication Interval

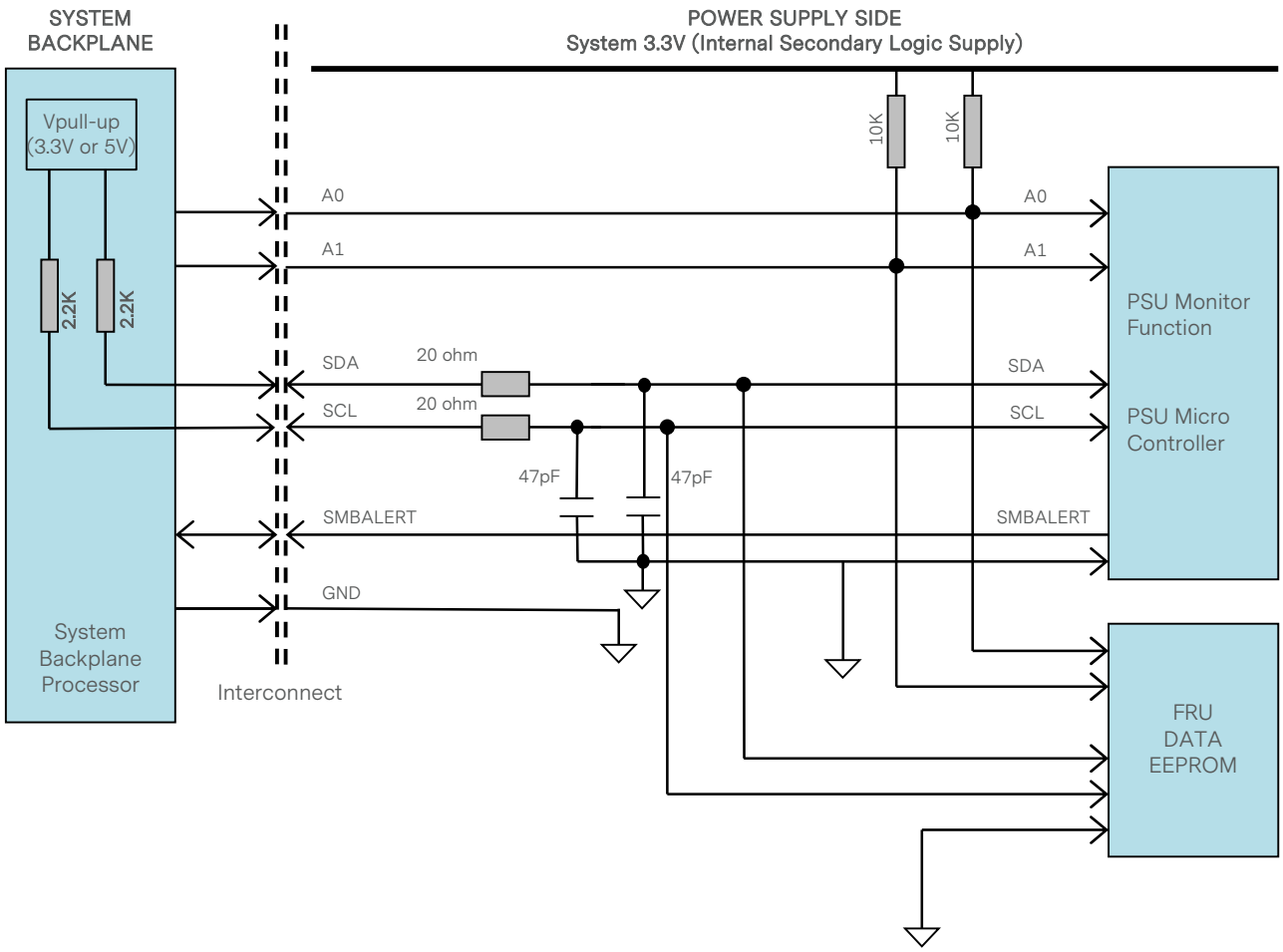
The interval between two consecutive I²C communications to the power supply must be at least 15 mS to ensure proper monitoring functionality.

I²C Bus Signal Integrity

The noise on the I²C bus (SDA, SCL lines) due to the power supply will be less than 300 mV peak-to-peak. This noise measurement should be made with an oscilloscope bandwidth limited to 100 MHz. Measurements must be made at the power supply output connector with 2.2k ohm resistors pulled up to 3.3 V source and a decoupling 47 pF ceramic capacitors to standby output return.

Section 6 COMMUNICATION BUS DESCRIPTIONS

I²C Bus Internal Implementation, Pull-ups and Bus Capacitances



I²C Bus - Recommended external pull-ups

Electrical and interface specifications of I²C 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}	-	47	-	pF
Recommended External Pull-up Resistor	1 to 4 PSU	R_{ext}	1	2.2	3	Kohm
Recommended External Pull-up Voltage		Vpull-up	3.3	-	5	V

Section 6 COMMUNICATION BUS DESCRIPTIONS

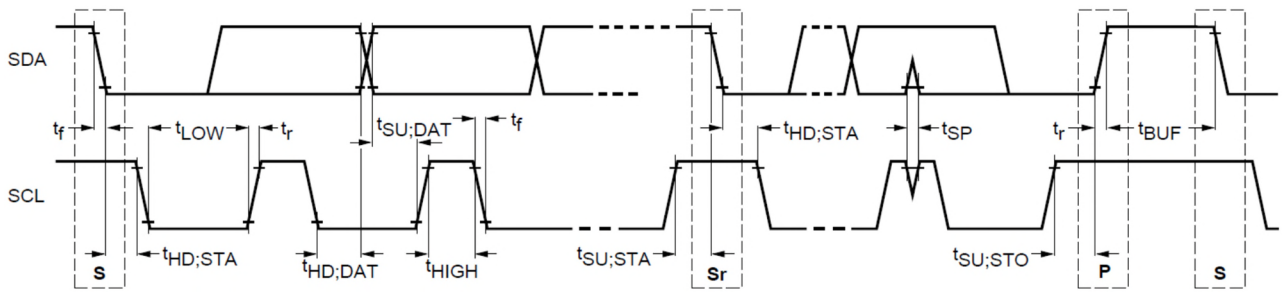
6.2 Logic Levels

CSU1600AT series power supply I²C communication bus will respond to logic levels as per below:

Logic High: 3.3 V nominal (Spec is 2.1 V to 5.5 V)**
Logic Low: 500 mV nominal (Spec is 800 mV max)**

**Note: Advanced Energy's Artesyn 73-769-001 I²C adapter was used.

Timings



Parameter	Symbol	Standard-Mode Specs		Actual Measured		Unit
		Min	Max			
SCL clock frequency	f_{SCL}	10	100	98		KHz
Hold time (repeated) START condition	$t_{HD;STA}$	4.0	-	5		µS
LOW period of SCL clock	t_{LOW}	4.7	-	5.2		µS
HIGH period of SCL clock	t_{HIGH}	4.0	-	4.8		µS
Setup time for repeated START condition	$t_{SU;STA}$	4.7	-	5.4		µS
Data hold time	$t_{HD;DAT}$	0	3.65	0.6		µS
Data setup time	$t_{SU;DAT}$	250	-	4200		nS
Rise time	t_r	-	1000	SCL = 669.6	SDA = 710.4	nS
Fall time	t_f	-	300	SCL = 156.8	SDA = 146	nS
Setup time for STOP condition	$t_{SU;STO}$	4.0	-	5.02		µS
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	95***		µS

***Note: Advanced Energy's Artesyn 73-769-001 I²C adapter (USB-to-I²C) and Universal PMBus™ GUI software was used.

Section 6 COMMUNICATION BUS DESCRIPTIONS

6.3 Device Addressing

The CSU1600AT series power supply will respond to supported commands on the I²C bus that are addressed according to A1 and A0 pins of output connector.

Address pins are held HIGH by default via pulled up to internal 3.3 V supply. To set the address as “0”, the corresponding address line needs be pulled down to logic ground level. Below tables show the address of the power supply with A0 and A1 pins set to either “0” or “1”.

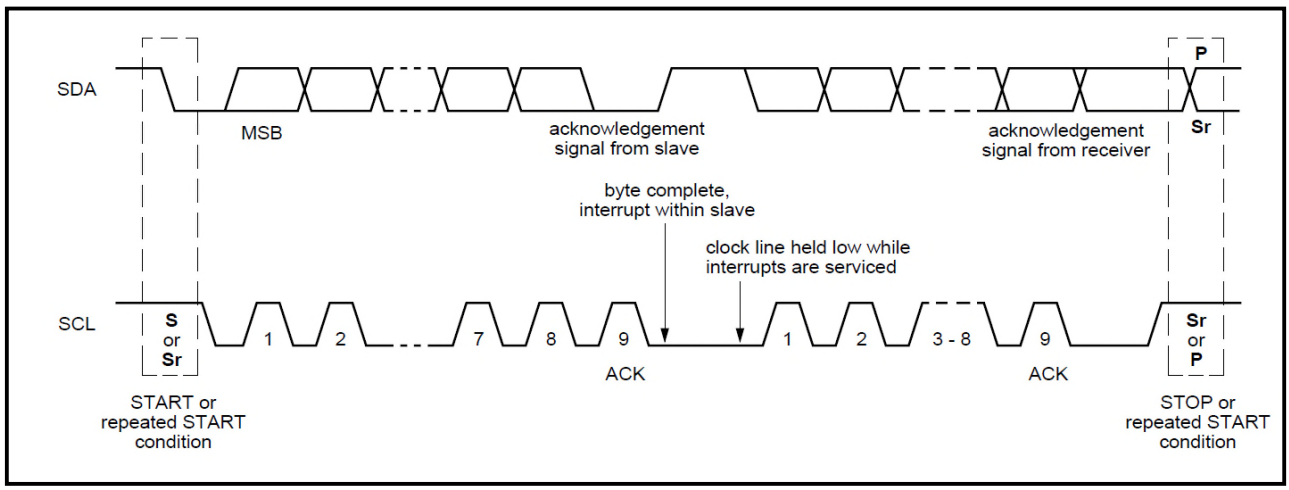
PSU Slot	Slot ID Bits		PMBus™ Address	EEPROM (FRU) Read Address
	A1	A0		
1	0	0	0xB0	0xA0
2	0	1	0xB2	0xA2
3	1	0	0xB4	0xA4
4	1	1	0xB6	0xA6

Section 6 COMMUNICATION BUS DESCRIPTIONS

6.4 I²C Clock Synchronization

The CSU1600AT series power supply applies clock stretching. An addressed slave power supply holds the clock line (SCL) low after receiving (or sending) a byte, indicating that it is not yet ready to process more data. The system master that is communicating with the power supply will attempt to raise the clock to transfer the next bit but must verify that the clock line was actually raised. If the power supply is clock stretching, the clock line will still be low (because the connections are open-drain).

The maximum time-out condition for clock stretching for CSU1600AT series is 30 milliseconds.



Section 6 COMMUNICATION BUS DESCRIPTIONS

6.5 Cold Redundancy

The CSU1600AT series power supply supports capabilities for cold redundancy. This capability helps improve the efficiency and iTHD of the power subsystem when more than one power supply is used in a system. Cold redundancy uses the PMBus™ manufacturer specific command area to define commands for the system to configure the power supplies for cold redundancy.

Overview

A system in 1+1, 2+1, 3+1 or 2+2 redundant mode configuration may not be operated at the optimum efficiency especially when the load is <50% of each power supply's capacity. The cold redundancy mode addresses this condition, where certain power supplies in a system can go into "cold standby" mode, thereby consuming the least amount of power and still be redundant.

Each power supply in this system will have a preprogrammed threshold for output current by which that power supply may determine whether to be actively providing power to the system, or be in cold standby state. A CR_BUS signal that connects all power supplies in the system, also indicates whether it is safe for power supplies in cold redundant mode to enter into cold standby state. The CR_BUS signal prevents power supplies from going into cold standby mode whenever there isn't any active power supply.

The following table shows the state of the power supplies programmed for cold standby mode based on the condition of the CR_BUS signal and the load share bus voltage.

Logic Matrix for Cold Standby Power Supplies:

CR_BUS	Load Share	Cold Standby Power Supply State
High	< VCR_ON	Cold Standby
Low	< VCR_ON	Active
High	> VCR_ON	Active
Low	> VCR_ON	Active

Note: VCR_ON is the voltage threshold set inside the power supplies configured for cold standby which tells them to power down into cold standby state when the load share voltage is less than VCR_ON.

When CR_BUS is asserted (or goes low), all power supplies in the system should go active and immediately provide power to the system.

SMBus Commands for Cold Redundancy

Configuring Cold Redundancy with Cold_Redundancy_Config (D0h)

The PMBus™ manufacturer specific command MFR_SPECIFIC_00 is used to configure the operating state of the power supply related to cold redundancy. This command for Cold_Redundancy_Config is D0h. The table below shows the configuration of the power supply based on the value in the Cold_Redundancy_Config register. PEC is used for read/write of this register.

Section 6 COMMUNICATION BUS DESCRIPTIONS

Cold Redundancy Configuration Table

Cold_Redundancy_Config (D0h)		
Value	State	Description
00h	Standard Redundancy (Default Power on State)	Turns the power supply into standard redundant load sharing mode. The power supply's CR_BUS# signal shall be OPEN but still pull the bus low if a fault occurs to activate any power supplies still in Cold Standby state.
01h	Cold Redundant Active	Defines this power supply to be the one that is always ON in a cold redundancy configuration.
02h	Cold Standby 1	Defines the power supply that is the first to turn on in a cold redundant configuration as the load increases.
03h	Cold Standby 2	Defines the power supply that is the second to turn on in a cold redundant configuration as the load increases.
04h	Cold Standby 3	Defines the power supply that is the third to turn on in a cold redundant configuration as the load increases.
05h	Always Cold Standby	Defines this power supply to be always in cold redundant configuration no matter what the load condition.
06h-FFh	Reserved	

When the CR_BUS transitions from a high to a low state; each PSU programmed to be in cold standby state shall be put into standard redundancy mode (Cold_Redundancy_Config = 00h). For the power supplies to enter cold redundancy mode the system must re-program the power supplies using the Cold_Redundancy_Config command.

Note: Cold Redundancy mode 05h can be supported only up to 80% of the max rated loading.

Cold Redundant Signal (CR_BUS)

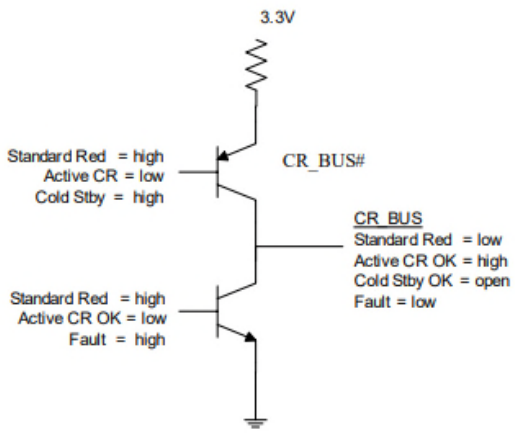
There is an additional signal defined supporting Cold Redundancy. This is connected to a bus shared between the power supplies: CR_BUS. This is a tri-state output signal of the power supply used to communicate a fault or Vout under voltage level has occurred in one of the power supplies. This is used to power on all the power supplies in the system via the CR_BUS. When the signal is pulled high, it allows all power supplies in cold standby mode to go into cold standby state when the load share voltage is below the VCR_ON level. When the signal is left open on all power supplies, it forces all cold standby power supplies into the ON. Below is a table showing the logic state of the CR_BUS signal depending upon the programmed configuration of the power supply in D0h, the operating state of the power supply, and the power supply fault status.

Section 6 COMMUNICATION BUS DESCRIPTIONS

Cold Redundancy State Table

Cold Redundant Config	Operating State	Power Supply Fault Status	CR_Bus#
Active	On	OK	High
Cold Standby 1,2,3	On	OK	Open
Cold Standby 1,2,3	Cold Standby	OK	Open
Active	Off	Fault	Low
Cold Standby 1,2,3	On	Fault	Low
Cold Standby 1,2,3	Cold Standby	Fault	Low

The CR_Status input is based on both the Cold_Redundancy_Config register as well as the fault state of the power supply. The resulting output is a tri-state output. The output is low when there is a fault in any power supply or when cold redundancy is disabled. The output is high only when a power supply is programmed for the cold redundancy active mode and it is functioning OK. The output is open only when the power supply is programmed for cold redundant standby mode and is functioning OK. This means that there needs to be one good power supply programmed for active cold redundant mode to allow power supply to function in cold standby mode; otherwise, all power supplies will power ON and come out of cold redundant mode.



CR_BUS Signal Characteristic

Signal Type	Active: Tri-State Output Cold Standby: Input Signal	
	Min	Max
Logic Level Low (Power Supply ON)	0 V	0.4 V
Logic Level High (Power Supply OFF)	2.4 V	3.46 V
Cold_Red Fault Delay	-	10 µS
Cold_Red Turn on Delay	-	100 µS

BMC Requirements

The BMC uses the Cold_Redundancy_Config command to configure the power supply's roll in cold redundancy and to enabled/disable cold redundancy. It is recommended that the BMC schedules a rolling change for which PSU is the Active, Cold Stby 1, Cold Stby 2, and Cold Stby 3 power supply. This allows for equal loading across power supply over their life.

Section 6 COMMUNICATION BUS DESCRIPTIONS

6.6 Black Box

The power supply can store PMBus and other data into non-volatile memory upon a critical failure that caused the power supply to shut down. The data can be accessed via the PMBus interface by applying power to the $12V_{SB}$ pins. No AC power needs to be applied to the power supply.

Data is saved to the black box for the following fault events:

- General fault
- Over voltage on output
- Over current on output
- Loss of AC input
- Input voltage fault
- Fan failure
- Over temperature

Black Box Process:

1) System writes system tracking data to the power supply RAM at power ON.
2) System writes the real time clock data to the PSU RAM once every ~5 minutes.
3) Power supply tracks the number of PSON and AC power cycles in FLASH.
4) Power supply tracks ON time in FLASH.
5) Power supply loads warning and fault event counter data from FLASH into RAM.
6) Upon a warning event, the PSU will increment the associated counter in RAM.
7) Upon and fault event, the PSU will increment the associated counter in RAM.
8) Upon a fault event that causes the PSU to shut down, all event data in the PSU's RAM is saved to event data location N in the power supply's FLASH. This data includes the real time clock, the number of AC & PSON power cycles, PSU ON time, warning event counters and fault event counters.

Section 6 COMMUNICATION BUS DESCRIPTIONS

Commands:

Name: MFR_BLACKBOX
Format: Read Block with PEC (238 bytes)
Code:

	Item	Number of Bytes	Description
System tracking data	System top assembly number	10	The system will write its Intel part number for the system top assembly to the power supply when it is powered ON. This is 9 ASCII characters.
	System serial number	10	The system will write the system serial number to the power supply when it is powered ON. This includes the serial number and date code.
	Motherboard assembly number	10	The system will write the motherboard Intel part number for the assembly to the power supply when it is powered ON. This is 9 ASCII characters.
	Motherboard serial number	10	The system will write the motherboard's serial number to the power supply when it is powered ON. This includes the serial number and date code.
	Present total PSU ON time	3	Total on time of the power supply with PSON asserted in minutes. LSB = 1 minute.
	Present number of AC power cycles	2	Total number of times the power supply powered OFF then back ON due to loss of AC power. This is only counted when the power supply's PSON signal is asserted. This counter will stay at FFFFh once the max is reached.
	Present number of PSON power cycles	2	Total number of times the power supply is powered OFF then back ON due to the PSON signal de-asserting. This is only counted when AC power is present to the power supply. This counter will stay at FFFFh once the max is reached.
Power supply event data (N)		38	Most recent occurrence of saved black box data.
Time stamp			The power supply will track these time and power cycle counters in RAM. When the a black box event occurs the data is saved into the black box.
	Power supply total power on time	3	Total on time of the power supply in minutes. LSB = 1 minute.
	Real time clock data from system (Reserved for future use)	4	This time stamp does not need to generated by the power supply. The system rights a real time clock value periodically to the power supply using the MFR_REAL_TIME command. Format is based on IPMI 2.0. Time is an unsigned 32-bit value representing the local time as the number of seconds from 00:00:00, January 1, 1970. This format is sufficient to maintain time stamping with 1 second resolution past the year 2100. This is based on a long standing UNIX-based standard for time keeping, which represents time as the number of seconds from 00:00:00, January 1, 1970 GMT. Similar time formats are used in ANSI C.
	Number of AC power cycles	2	Number of times the power supply powered OFF then back ON due to loss of AC power at the time of the event. This is only counted when the power supply's PSON signal is asserted.
	Number of PSON power cycles	2	Number of times the power supply is powered OFF then back ON due to the PSON signal deasserting at the time of the event. This is only counted when AC power is present to the power supply.

Section 6 COMMUNICATION BUS DESCRIPTIONS

	Item	Number of Bytes	Description
PMBus			The power supply will save these PMBus values into the black box when a black box event occurs. Fast events may be missed due to the filtering effects of the PMBus sensors.
	STATUS_WORD	2	
	STATUS_IOUT	1	
	STATUS_INPUT	1	
	STATUS_TEMPERTATURE	1	
	STATUS_FAN_1_2	1	
	READ_VIN	2	
	READ_IIN	2	
	READ_IOUT	2	
	READ_TEMPERATURE_1	2	
	READ_TEMPERATURE_2	2	
	READ_FAN_SPEED_1	2	
	READ_PIN	2	
	READ_VOUT	2	
Event counters			The power supply will track the total number for each of the following events. These value will be saved to the black box when a black box event occurs. Once a value has reached 15, it will stay at 15 and not reset.
	AC shutdown due to under voltage on input	Lower ½	The power supply will save a count of these critical events to non-volatile memory each time they occur. The counters will increment each time the associated STATUS bit is asserted.
	Thermal shutdown	Upper ½	
	Over current or over power shutdown on output	Lower ½	
	General failure shutdown	Upper ½	
	Fan failure shutdown	Lower ½	
	Shutdown due to over voltage on output	Upper ½	
	Input voltage warning; no shutdown	Lower ½	The power supply will save into RAM a count of these warning events. Events are count only at the initial assertion of the event/bit. If the event persists without clearing the bit the counter will not be incremented. When the power supply shuts down it will save these warning event counters to non-volatile memory. The counters will increment each time the associated STATUS bit is asserted.
	Thermal warning; no shutdown	Upper ½	
	Output current power warning; no shutdown	Lower ½	
	Fan slow warning; no shutdown	Upper ½	
Power supply event data (N-1)		38	
Power supply event data (N-2)		38	
Power supply event data (N-3)		38	
Power supply event data (N-4)		38	

Section 6 COMMUNICATION BUS DESCRIPTIONS

Name: MFR_REAL_TIME_BLACK_BOX
Format: Write/Read Block with PEC (4 bytes)
Code: DDh

The system will use this command to periodically write the real time clock data to the power supply.

Format is based on IPMI 2.0. Time is an unsigned 32-bit value representing the local time as the number of seconds from 00:00:00, January 1, 1970. This format is sufficient to maintain time stamping with 1 second resolution past the year 2100.

This is based on a long standing UNIX-based standard for time keeping, which represents time as the number of seconds from 00:00:00, January 1, 1970 GMT. Similar time formats are used in ANSI C.

Name: MFR_SYSTEM_BLACK_BOX
Format: Write/Read Block with PEC (40 bytes). Low byte first.
Code: DEh

The system uses this command to write the following data to the PSU.

Item	Bytes	
System top assembly number	1–10	Low bytes
System serial number	11–20	
Motherboard assembly number	21–30	
Motherboard serial number	31–40	High bytes

Name: MFR_BLACKBOX_CONFIG
Format: Read/Write Byte with PEC
Code: DFh

Bit	Value	Description
0	0 = disable black box function 1 = enable black box function	Writing a '1' enables the power supply with black box function. Writing a '0' disables the power supply black box function. The state of MFR_BLACKBOX_CONFIG will be saved in non-volatile memory so that it is not lost during power cycling. Intel will receive the power supply with the black box function enabled; bit 0 = '1'.

Name: MFR_CLEAR_BLACKBOX
Format: Send Byte with PEC
Code: E0h

The MFR_CLEAR_BLACKBOX command is used to clear all black box records simultaneously. This command is write only. There is no data byte for this command.

Section 6 COMMUNICATION BUS DESCRIPTIONS

FRU (EEPROM) Data

The FRU (Field Replaceable Unit) data format is compliant with the Intel IPMI v1.0 specification.

The CSU1600AT series uses 1 page of EEPROM for FRU purpose. A page of EEPROM contains up to 256 byte-sized data locations.

Where: OFFSET -The OFFSET denotes the address in decimal format of a particular data byte within CSU1600AT series EEPROM.

VALUE -The VALUE details data written to a particular memory location of the EEPROM.

DEFINITION -The contents DEFINITION refers to the definition of a particular data byte.

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
		COMMON HEADER, 8 BYTES		
0	00	**FORMAT VERSION NUMBER** (Common header) 7:4 - Reserved, write as 0000b 3:0 - Format version number = 1h for this specification	1	01
1	01	**INTERNAL USE AREA OFFSET** (Not required, do not reserve)	0	00
2	02	**CHASSIS INFO AREA OFFSET** (Not required, do not reserve)	0	00
3	03	**BOARD INFO AREA OFFSET** (Not required, do not reserve)	0	00
4	04	**PRODUCT INFO AREA OFFSET**	7	07
5	05	**MULTI RECORD AREA OFFSET**	23	17
6	06	**PAD** (Not required, do not reserve)	0	00
7	07	**ZERO CHECK SUM** (256 - (Sum of bytes 0 to 6))	225	E1
8	08	(08h-37Fh is Reserved, default value is 0.)	0	0
9	09		0	0
10	0A		0	0
11	0B		0	0
12	0C		0	0
13	0D		0	0
14	0E		0	0
15	0F		0	0
16	10		0	0
17	11		0	0
18	12		0	0
19	13		0	0
20	14		0	0
21	15		0	0
22	16		0	0
23	17		0	0
24	18		0	0
25	19		0	0
26	1A		0	0
27	1B		0	0
28	1C		0	0
29	1D		0	0
30	1E		0	0
31	1F		0	0
32	20		0	0
33	21		0	0
34	22		0	0
35	23		0	0
36	24		0	0
37	25		0	0

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
38	26		0	0
39	27		0	0
40	28		0	0
41	29		0	0
42	2A		0	0
43	2B		0	0
44	2C		0	0
45	2D		0	0
46	2E		0	0
47	2F		0	0
48	30		0	0
49	31		0	0
50	32		0	0
51	33		0	0
52	34		0	0
53	35		0	0
54	36		0	0
55	37		0	0
PRODUCT INFORMATION AREA, 128 BYTES				
56	38	**FORMAT VERSION NUMBER** (Product Info Area) 7:4 - Reserved, write as 0000b 3:0 - Format Version Number = 1h for this specification	1	01
57	39	**PRODUCT INFO AREA LENGTH** (In multiples of 8 bytes)	14	E
58	3A	**Language (English)**	25	19
59	3B	**MANUFACTURER NAME TYPE / LENGTH (0CH)** 7:6 - (11)b, ASCII code 5:0 - (001100)b, 12 bytes allocation	204	CC
		MANUFACTURER'S NAME 12 bytes sequence		
60	3C	"A"= 41h	65	41
61	3D	"r"= 72h	114	72
62	3E	"t"= 74h	116	74
63	3F	"e"= 65h	101	65
64	40	"s"= 73h	115	73
65	41	"y"= 79h	121	79
66	42	"n"= 6Eh	110	6E
67	43		32	20
68	44		32	20
69	45		32	20
70	46		32	20
71	47		32	20
72	48	**PRODUCT NAME** Type/Length (24H) 7:6 - (11)b, ASCII code 5:0 - (100100)b, 36 bytes allocation	228	E4
73	49	**Product Name,** 36 bytes sequence	67	43
74	4A	**"CRPS: Common Redundant Power Supply "**	82	52
75	4B	In Decimal = 067d, 082d, 080d, 083d, 058d, 032d, 067d, 111d, 109d,	80	50
76	4C	109d, 111d, 110d, 32d, 82d, 101d, 100d, 117d, 110d, 100d, 97d, 110d,	83	53
77	4D	116d, 32d, 80d, 111d, 119d, 101d, 114d, 32d, 83d, 117d, 112d, 112d,	58	3A
78	4E	108d, 121d, 00d	32	20
79	4F	In Hex = 43H, 52H, 50H, 53H, 3AH, 20H, 43H, 6FH, 6DH, 6DH, 6FH, 6EH,	67	43
80	50	20H, 52H, 65H, 64H, 75H, 6EH, 64H, 61H, 6EH, 74H, 20H, 50H, 6FH,	111	6F
81	51	77H, 65H, 72H, 20H, 53H, 75H, 70H, 70H, 6CH, 79H, 00H	109	6D
82	52		109	6D
83	53		111	6F
84	54		110	6E
85	55		32	20

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
86	56		82	52
87	57		101	65
88	58		100	64
89	59		117	75
90	5A		110	6E
91	5B		100	64
92	5C		97	61
93	5D		110	6E
94	5E		116	74
95	5F		32	20
96	60		80	50
97	61		111	6F
98	62		119	77
99	63		101	65
100	64		114	72
101	65		32	20
102	66		83	53
103	67		117	75
104	68		112	70
105	69		112	70
106	6A		108	6C
107	6B		121	79
108	6C		20	20
109	6D	**PRODUCT PART/MODEL NUMBER** Type/Length (10H) 7:6 - (11)b, ASCII code 5:0 - (010000)b, 16-byte allocation	208	D0
110	6E	**Part / Model Number**	67	43
111	6F	"CSU1600AT-3-100"	83	53
112	70	In Decimal = 067d, 083d, 085d, 0490d, 0540d, 048d, 048d, 065d, 084d,	85	55
113	71	045d, 051d, 045d, 049d, 048d, 048d	50	32
114	72	In Hex = 43H, 53H, 55H, 31H, 36H, 30H, 41H, 54H, 2DH, 33H, 2DH, 31H,	48	30
115	73	30H, 30H	48	30
116	74		48	30
117	75		65	41
118	76		84	54
119	77		45	2D
120	78		51	33
121	79		45	2D
122	7A		49	31
123	7B		48	30
124	7C		48	30
125	7D		32	20
126	7E	**PRODUCT VERSION NUMBER** Type/Length (10h) 7:6 - (11)b, ASCII code 5:0 - (010000)b, 16-byte allocation	208	D0
127	7F	**Version,** 16 bytes sequence	XX	XX
128	80	"XXXXXXXXXXXXXXXX"	XX	XX
129	81		XX	XX
130	82		XX	XX
131	83		XX	XX
132	84		XX	XX
133	85		XX	XX
134	86		XX	XX
136	87		XX	XX
136	88		XX	XX
137	89		XX	XX
138	8A		XX	XX
139	8B		XX	XX

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
140	8C		XX	XX
141	8D		XX	XX
142	8E		XX	XX
143	8F	**PRODUCT SERIAL NUMBER** Type/Length 7:6 - (11)b, ASCII code 5:0 - (001110)b, 14-byte allocation	206	CE
144	90	**Serial number,** 14 bytes sequence	XX	XX
145	91	"XXXXXXXXXXXXXX"	XX	XX
146	92		XX	XX
147	93		XX	XX
148	94		XX	XX
149	95		XX	XX
150	96		XX	XX
151	97		XX	XX
152	98		XX	XX
153	99		XX	XX
154	9A		XX	XX
155	9B		XX	XX
156	9C		XX	XX
157	9D		XX	XX
		PAD (reserved)		
158	9E	Default value is 0.	0	00
159	9F	Default value is 0.	0	00
160	A0	**ZERO CHECK SUM** (256-(sum of bytes 32 to 135)) Per Unit Zero Check Sum: should follow check sum calculation as per IPMI v1.3 specs	NA	NA
161	A1	(A1h-A6h, A8h-B7h is Reserved, the default value is 0.)	0	0
162	A2	A7 - 2's complement checksum from 0x30 to 0xA6	0	0
163	A3		0	0
164	A4		0	0
165	A5		0	0
166	A6		0	0
167	A7		NA	NA
168	A8		0	0
169	A9		0	0
170	AA		0	0
171	AB		0	0
172	AC		0	0
173	AD		0	0
174	AE		0	0
175	AF		0	0
176	B0		0	0
177	B1		0	0
178	B2		0	0
179	B3		0	0
180	B4		0	0
181	B5		0	0
182	B6		0	0
183	B7		0	0
MULTI RECORD AREA, 96 BYTES				
		Power Supply Record Header		
184	B8	Record type = 00 for power supply info	0	00
185	B9	End of list / Record format version number for 12V output record	2	02
186	BA	Record length of 12V output record	24	18
187	BB	Record checksum	NA	NA
188	BC	Header checksum	NA	NA

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
POWER SUPPLY RECORD				
189 190	BD BE	**Combined Wattage,** 1600W = 0640H 2 bytes sequence Byte 1 (LSB) = 08h = 40d Byte 2 (MSB) = 07h = 06d	64 07	40 06
191 192	BF C0	**Peak VA,** 1808W = 0710H 2 bytes sequence Byte 1 (LSB) = 10h Byte 2 (MSB) = 07h	16 07	10 07
193	C1	**Inrush Current**, 35A In Decimal = 35d In Hex = 23H	35	23
194	C2	**Inrush Interval**, 255mS In Decimal = 255d In Hex = FFH	255	FF
195 196	C3 C4	**Low End Input Voltage Range 1(10mV),** (200V/10mV) 20000=4E20H 2 bytes sequence Byte 1 (LSB) = 20h Byte 2 (MSB) = 4Eh	32 78	20 4E
197 198	C5 C6	**High End Input Voltage Range 1(10mV),** (240V/10mV) 24000=5DC0H 2 bytes sequence Byte 1 (LSB) = C0h Byte 2 (MSB) = 5Dh	192 93	C0 5D
199 200	C7 C8	**Low End Input Voltage Range 2(10mV),** (100V/10mV) 10000=2710H 2 bytes sequence Byte 1 (LSB) = 10h Byte 2 (MSB) = 27h	16 39	10 27
201 202	C9 CA	**High End Input Voltage Range 2(10mV),** (115V/10mV) 11500=2CECH 2 bytes sequence Byte 1 (LSB) = ECh Byte 2 (MSB) = 2Ch	236 44	EC 2C
203	CB	**Low End Input Frequency Range**	00	00
204	CC	**High End Input Frequency Range**	60	3C
205	CD	**AC Dropout Tolerance in ms,** 1mS = 01H	01	01
206	CE	**Binary Flags: For each of the following binary flags No = 0, Yes = 1.** Bits 7-5: RESERVED, Write as 000b Bit4: Tachometer Pulses Per Rotation / Predictive Fail Polarity BIT = 0 Bit3: Hot Swap / Redundancy Support BIT = 1 Bit2: Auto switch Support BIT = 0 Bit1: Power Factor Correction Support BIT = 1 Bit0: Predictive Fail Support BIT = 1	11	0B
207 208	CF D0	**Peak Wattage Capacity and Holdup Time, (Set for** 1830Watts/**15mS)** In Decimal = 38 In Hex = 26H (LSB First) In Decimal = 247 In Hex = F7H	38 247	26 F7
209 210 211	D1 D2 D3	**Combined Wattage,** 0x00 0x00 0x00 No combined voltages for the power supply	0 0 0	0 0 0

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
212	D4	**Predictive Fail Tachometer Lower Threshold,** Not Applicable. Predictive failure is not supported.	00	00
		12V OUTPUT RECORD HEADER		
213	D5	Record Type = 01 for power supply info	01	01
214	D6	End of List / Record Format Version Number for 12V Output Record	02	02
215	D7	Record Length of 12V Output Record	13	0D
216	D8	Record checksum (256-(sum of bytes 194 to 206))	NA	NA
217	D9	Header checksum (256-(sum of bytes 189 to 192))	NA	NA
		12V OUTPUT RECORD		
218	DA	**Output Information,** 000 = 00H Bit 7: Standby information = 0b Bits 6-5: Reserved, write as 000b Bits 4: Current units, 0b = 10mA Bits 3-0: Output number 0 = 000b	00	00
		Nominal Voltage (10mV), (12.2V / 10mV) 1220 = 04C4H 2 bytes sequence		
219	DB	In Decimal: 196d, 004d	196	C4
220	DC	In Hex: C4H, 04H	04	04
		Maximum Negative Voltage Deviation (11.6V / 10mV), 1160 = 0488H 2 bytes sequence		
221	DD	In Decimal: 156d, 004d	156	88
222	DE	In Hex: 9CH, 04H	04	04
		Maximum Positive Voltage Deviation (12.8V / 10mV), 1280 = 0500H **2 bytes sequence**		
223	DF	In Decimal: 000d, 005d	00	00
224	E0	In Hex: 00H, 05H	05	05
		Ripple and Noise pk-pk (mV), 120 = 78H 2 bytes sequence		
225	E1	In Decimal: 120d, 000d	120	78
226	E2	In Hex: 78H, 00H	0	00
		Minimum Current Draw (mA), 1000 = 03E8H 2 bytes sequence		
227	E3	In Decimal: 232d, 003d	232	E8
228	E4	In Hex: E8H, 03H	03	03
		Maximum Current Draw (mA), 65535 = FFFFH 2 bytes sequence		
229	E5	In Decimal: 255d, 255d	255	FF
230	E6	In Hex: FFH, FFH	255	FF
		12VSB OUTPUT RECORD HEADER		
231	E7	Record type = 01 for DC Output Record	01	01
232	E8	End of List / Record Format Version Number for $12V_{SB}$ Output Record	130	82
233	E9	Record Length of 12V DC Output Record	13	0D
234	EA	Record CHECKSUM of $12V_{SB}$ Output Record	NA	NA
235	EB	Header CHECKSUM of $12V_{SB}$ Output Record Header	NA	NA
		12VSB OUTPUT RECORD		
236	EC	**Output Information,** 129 = 81H Bit 7: Standby Information = 1b Bits 6-4: Reserved, write as 000b Bits 3-0: Output number 1 = 0001b	129	81

Section 6 COMMUNICATION BUS DESCRIPTIONS

CSU1600AT series FRU (EEPROM) Data:

OFFSET		DEFINITION	SPEC VALUE	
(DEC)	(HEX)	(REMARKS)	(DEC)	(HEX)
237 238	ED EE	**Nominal Voltage (10mV), (12V / 10mV)** 1200 = 04B0H 2 bytes sequence In Decimal: 176d, 004d In Hex: B0H, 04H	176 4	B0 04
239 240	EF F0	**Maximum Negative Voltage Deviation (10mV),** 1140 = 0474H 2 bytes sequence In Decimal: 116d, 004d In Hex: 74H, 04H	116 04	74 04
241 242	F1 F2	**Maximum Positive Voltage Deviation (10mV),** 1260 = 04ECH 2 bytes sequence In Decimal: 236d, 004d In Hex: ECH, 04H	236 4	EC 04
243 244	F3 F4	**Ripple and Noise pk-pk (mV),** 120 = 78H 2 bytes sequence In Decimal: 120d, 000d In Hex: 78H, 00H	120 0	78 00
245 246	F5 F6	**Minimum Current Draw (10mA),** 0000 = 0000H 2 bytes sequence In Decimal: 000d, 000d In Hex: 00H, 00H	0 0	00 00
247 248	F7 F8	**Maximum Current Draw (10mA), 3500 = 0DACH** 2 Bytes Sequence In Decimal: 172d, 13d In Hex: ACH, 0DH	172 13	AC 0D
249 250 251 252 253 254 255	F9 FA FB FC FD FE FF	(F9h-FFh is reserved. Default value is 0.)	0 0 0 0 0 0 0	00 00 00 00 00 00 00

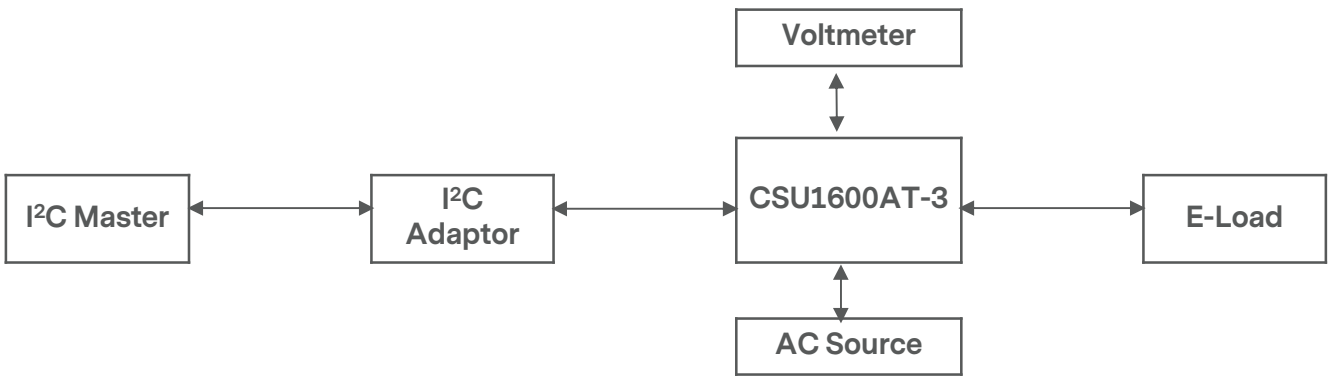
Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT series is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port.

7.1 CSU1600AT Series PMBus™ General Instructions

Equipment Setup

The following is typical I²C communication setup:



I²C Accuracy

Output Load	Input Voltage	Input Current	Input Power	Output Voltage	Output Current	Output Power	Temperature	Fan speed
40W to 200W	±3%	±0.1A	±5W	±3%	±1A	±10W	±3°C	±250RPM
200W to 300W	±3%	±3%	±2%	±3%	±4%	±4%	±3°C	±250RPM
300W to 1600W	±2%	±2%	±2%	±2%	±2%	±2%	±3°C	±250RPM

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
00h	PAGE	00	R	1	Hex	Valid input: 00h
03h	CLEAR_FAULTS	00	S		N/A	Page Support If the page is set to FFh, both BMC and ME STATUS bits are cleared.
05h	PAGE_PLUS_WRITE		BW		N/A	
06h	PAGE_PLUS_READ		BR		N/A	
19h	CAPABILITY	90	R	1	Bitmapped	Provides a way for the hosts system to determine some key capabilities of a PMBus™ device.
	b7 - Packet Error Checking	1				0 - PEC not supported 1 - PEC supported
	b6:5 - Maximum Bus Speed	01				00 - Maximum supported bus speed, 100KHz 01 - Maximum supported bus speed, 400KHz 10 - Maximum supported bus speed, 1MHz 11 - Reserved
	b4 - SMBALERT#	1				0 - SMBus Alert Pin not supported 1 - SMBus Alert Pin supported
	b3 - Numeric Format	0				0 - Linear11, Ulinear16, Slinear16, or Direct 1 - IEEE half precision floating point format
	b2 - AVSBus	0				0 - AVSBus not supported 1 - AVSBus supported
	b1:0	00				Reserved
1Ah	QUERY	-	BR/BW		N/A	Supported in ISP mode
1Bh	SMBALERT_MASK	-	BR/BW	2	N/A	Default masks per Intel spec: Page 00: STATUS_VOUT = FFh STATUS_IOUT = FFh STATUS_INPUT = FFh STATUS_TEMP = FFh STATUS_CML = FFh Page 01: STATUS_VOUT = FFh STATUS_IOUT = DFh STATUS_INPUT = EFh STATUS_TEMP = BFh STATUS_CML = FFh Non-paged: STATUS_FANS_1_2 = FFh
20h	VOUT_MODE	17	R	1	Bitmapped	Specifies the mode and parameters of output voltage related data formats

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
30h	COEFFICIENTS		BW/BR	5	Hex	Use to retrieve the m, b and R coefficients, needed for DIRECT data format.
	byte 5	00				R byte
	byte 4:3	0000				b low byte, b high byte
	byte 2:1	0000				m low byte, m high byte
3Ah	FAN_CONFIG_1_2	90	R/W	1	Bitmapped	Default Duty Mode.
3Bh	FAN_COMMAND_1	0000	R/W	2	Linear	Adjusts the operation of the Fans in RPM. The device may override the command, if it requires higher value to maintain proper device temperature.
4Ah	IOUT_OC_WARNING_LIMIT	F290	R/W	2	Linear	Sets the over current warning threshold in Amps.
51h	OT_WARN_LIMIT (Hot Spot)	EBD8	R/W	2	Hex	Secondary ambient temperature warning threshold, in degree C. Operating limit
78h	STATUS_BYTE	-	R	1	Bitmapped	Returns the summary of critical faults.
	b7 - BUSY					Not supported.
	b6 - OFF					Unit is OFF.
	b5 - VOUT_OV_Fault					Not supported.
	b4 - IOUT_OC_Fault					Output over-current fault has occurred.
	b3 - VIN_UV_Fault					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.

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
79h	STATUS_WORD	-	R	2	Bitmapped	Summary of units fault and warning status.
	b15 - VOUT					An output voltage fault or warning has occurred.
	b14 - IOUT					An output current or power fault or warning has occurred.
	b13 - INPUT					An input voltage, current or power fault or warning as occurred.
	b11 - POWER_GOOD#					The POWER_GOOD signal is de-asserted.
	b10 - FANS					Not supported.
	b6 - OFF					Unit is OFF.
	b5 - VOUT_OV_FAULT					Output over-voltage fault has occurred
	b4 - IOUT_OC_FAULT					Output over-current fault has occurred.
	b3 - VIN_UV_FAULT					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					
7Ah	STATUS_VOUT	-	R	1	Bitmapped	
	b7 - VOUT Over-Voltage Fault	-				VOUT over-voltage fault
	b4 - VOUT Under-Voltage Fault	-				VOUT under-voltage fault
7Bh	STATUS_IOUT		R	1	Bitmapped	
	b7 - IOUT Overcurrent Fault					IOUT overcurrent fault
	b5 - IOUT Overcurrent Warning					IOUT overcurrent warning
	b1 - POUT_OP_FAULT					POUT overpower fault
	b0 - POUT_OP_WARNING					POUT overpower warning
7Ch	STATUS_INPUT		R	1	Bitmapped	Input related faults and warnings
	b7 - VIN_OV_FAULT					Not supported
	b6 - VIN_OV_WARNING					VIN over-voltage warning
	b5 - VIN_UV_WARNING					VIN under-voltage warning
	b4 - VIN_UV_FAULT					VIN under-voltage fault
	b3 - Unit Off For Low Input Voltage					Unit is Off for insufficient input voltage.
	b2 - IIN_OC_FAULT					IIN overcurrent fault
	b1 - IIN_OC_WARNING					IIN overcurrent warning
	b0 - PIN_OP_WARNING					PIN overpower warning

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
7Dh	STATUS_TEMPERATURE		R	1	Bitmapped	Temperature related faults and warnings
	b7 - Over Temperature Fault					Over temperature fault
	b6 - Over Temperature Warning					Over temperature warning
7Eh	STATUS_CML		R	1	Bitmapped	Communications, logic and memory
	b7 -Invalid/Unsupported command					Invalid or unsupported command received
	b6 - Invalid/Unsupported Data					Invalid data
	b5 - Packet Error Check Failed					Packet error check failed
81h	STATUS_FANS_1_2		R	1	Bitmapped	
	b7 - Fan1 Fault					Fan1 Fault
	b5 - Fan1 Warning					Fan1 Warning
	b3 - Fan1 Speed Overridden					Fan1 Speed Overridden
86h	Ein		BR	6	Direct	Returns the accumulated input power over time.
87h	Eout		BR	6	Direct	Returns the accumulated output power over time.
88h	READ_VIN		R	2	Linear	Returns input voltage in Volts ac.
89h	READ_IIN		R	2	Linear	Returns input current in Amperes.
8Bh	READ_VOUT		R	2	Linear	Returns the actual, measured voltage in Volts.
8Ch	READ_IOUT		R	2	Linear	Returns the output current in amperes.
8Dh	READ_TEMPERATURE_1		R	2	Linear	Returns the inlet temperature in degree Celsius.
8Eh	READ_TEMPERATURE_2		R	2	Linear	Returns the primary hot pot temperature in degree Celsius.
8Fh	READ_TEMPERATURE_3		R	2	Linear	Returns the secondary hot pot temperature in degree Celsius.
90h	READ_FAN_SPEED_1		R	2	Linear	Speed of fan 1. Minimum speed: 8,000 RPM when in standby mode; 10,000 RPM when main output is on. Maximum speed: 33,000 RPM.
96h	READ_POUT		R	2	Linear	Returns the output power, in Watts.
97h	READ_PIN		R	2	Linear	Returns the input power, in Watts.

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
98h	PMBUS_REVISION	22	R	1	Bitmapped	Reads the PMBus revision number.
	b7:5	0010				Part 1 Revision 0000 - Revision 1.0 0001 - Revision 1.1 0010 - Revision 1.2
	b4:0	0010				Part 2 Revision 0000 - Revision 1.0 0001 - Revision 1.1 0010 - Revision 1.2
99h	MFR_ID	Artesyn (0x41 52 54 45 53 59 4E 20 20 20 20)	BR	12	ASCII	Supported in ISP mode linked to FRU. MFR_ID FRU Offset: 3Ch~47h. Default: "Artesyn"
9Ah	MFR_MODEL	CSU1600AT-3-100(0x43 53 55 31 36 30,30 41 54 2D 33 2D 31 30 30)	BR	16	ASCII	Supported in ISP mode Model number matching label.
9Bh	MFR_REVISION		BR	6	ASCII	Linked to FRU Format "Release - 00xx"
9Ch	MFR_LOCATION		BR	Varies	ASCII	Supported in ISP Mode Linked to FRU Model number matching label.
9Dh	MFR_DATE		BR	Varies	ASCII	Linked to FRU
9Eh	MFR_SERIAL		BR	Varies	ASCII	Linked to FRU
9Fh	APP_PROFILE_SUPPORT	05	R	1	Hex	Returns byte 05h
A0h	MFR_VIN_MIN	00C8	R	2	Linear	Minimum high line input voltage (200Vac)
A1h	MFR_VIN_MAX	00F0	R	2	Linear	Maximum input voltage (240Vac)
A2h	MFR_IIN_MAX	D246	R	2	Linear	Maximum input current (9.1A)
A3h	MFR_PIN_MAX	0B8E	R	2	Linear	Maximum input power (1820W)
A4h	MFR_VOUT_MIN	1614	R	2	Linear	Minimum output voltage Regulation window (11.6V)
A5h	MFR_VOUT_MAX	410C	R	2	Linear	Maximum output voltage. Regulation window (12.8V)
A6h	MFR_IOUT_MAX	F20C	R	2	Linear	Maximum output current (131.1A)
A7h	MFR_POUT_MAX	0B20	R	2	Linear	Maximum output power (1600W)
A8h	MFR_TAMBIENT_MAX	EA30	R	2	Linear	70degC
A9h	MFR_TAMBIENT_MIN	CD80	R	2	Linear	-5degC
C0h	MFR_MAX_TEMP_1 (Ambient)	EA30	R	2	Linear	Maximum continuous ambient operating temperature (Normal air flow: 70degC)
C1h	MFR_MAX_TEMP_2 (hot Spot)[1]	F200	R	2	Linear	Maximum secondary hot spot temperature (128degC)
C2h	MFR_MAX_TEMP_3 (hot Spot)[2]	F200	R	2	Linear	Maximum primary hot spot temperature (128degC)

Note 1 - MFR_MAX_TEMP_2 (hot spot) is the maximum hot spot temperature where the power supply can continue to operate without shutting down the main output. This corresponds to the over temperature warning value.

Note 2 - MFR_MAX_TEMP_3 (Hot spot) is the maximum hot spot (RT500 and RT501) temperature where the power supply can continue to operate without shutting down the main output. This corresponds to the over temperature warning value.

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
D0h	Cold_Redundancy_Config	00	R/W	1	Bitmapped	00 - Normal 01 - Active 02 - Cold standby 1 03 - Cold standby 2 04 - Cold standby 3 05 - Always cold standby
DBh	MFR_FRU_PROTECTION	01	R/W	1	Bitmapped	0 - 00h means the FRU can be written 1 - 01h means the device can't be written
DCh	MFR_BLACKBOX	Varies	BR/BW	230	Varies	See page 43
DDh	MFR_REAL_TIME_BLACK_BOX	-	BR/BW	4		Write the real time clock data to the power supply.
DEh	MFR_SYSTEM_BLACK_BOX	-	BR/BW	40		Write the system information.
DEh	MFR_SYSTEM_BLACK_BOX	-	BR/BW	40		Write the system information.
DFh	MFR_BLACKBOX_CONFIG	00	R/W	1	Bitmapped	Enable/disable the black box function.
	B7:1	-				Reserved
	B0	0				0 - Disable Blackbox Function 1 - Enable Blackbox Function
E0h	MFR_CLEAR_BLACKBOX	NA	W	0	NA	Clear the black box data, making all history data set registers zero
F0h	MFR_PWOK_WARNING_TIME	C200	R/W	2	Linear 11	Config the Tpwok_off. It is recommended to use 1ms steps
F1h	MFR_MAX_IOUT_CAPABILITY	20 0B 58 F2 C0 D2 28 F3 8F 82 64 F3 20 F3 =>HL E8 03 E8 EA C0 D2 50 F2 8F 82 94 F2 20 F3 => LL	BR	14	Linear 11	b1:2 - I rating b3:4 - Inom1 b5:6 - Inom1 delay b7:8 - Inom2 b9:10 - Inom2 delay b11:12 - Inom3 b13:14 - Inom3 delay

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Firmware Update Command List:
The power supply uses the following commands during the bootload process.

Command Code	Command Name	Default Value	Access Type	Data Bytes	Description
D4h	MFR_HW_COMPATIBILITY	-	R	2	This is a COMPATIBILITY value used to tell if there are any changes in the FW that create an incompatibility with the FW. This value only changes when the PSU HW is changed creating an incompatibility with older versions of FW.
D5h	MFR_FWUPLOAD_CAPABILITY	01	R	1	The system can read the power supply's FW upload mode capability using this command. For any given power supply, more than one FW upload mode may be supported. The supported FW upload mode(s) must support updating all available FW in the power supply. This power supply supports FW uploading in standby mode only. Bit 0: "1" FW uploading in standby mode only All other bits configurations are not supported.
D6h	MFR_FWUPLOAD_MODE	00	R/W	1	Writing a "1" puts the power supply into firmware upload mode and gets it ready to receive the first image block via the MFR_FW_UPLOAD command. The system can use this command at any time to restart sending the FW image. Writing a "0" puts the power supply back into normal operating mode. Writing a "1" restart. This command will put the PSU into standby mode if the PSU supports FW update in standby mode only. If the power supply image passed to the PSU is corrupt the power supply will stay in firmware upload mode even if the system requested the PSU to exit the FW upload mode. Value: 0 = Exit firmware upload mode 1 = Firmware upload mode
D7h	MFR_FWUPLOAD	-	BW	16	Command used to send each block of the FW image.

Section 7 PMBUS™ SPECIFICATIONS

The CSU1600AT Series Firmware Update Command List:
The power supply uses the following commands during the bootload process.

Command Code	Command Name	Default Value	Access Type	Data Bytes	Description
D8h	MFR_FWUPLOAD_STATUS	-	R	2	At any time during or after the firmware image upload the system can read this command to determine status of the firmware upload process. All bits get reset to “0” when the power supply enters FW upload mode. Bit 0: “1” full image received Bit 1: “1” full image not received. This remains asserted until the full image is received Bit 2: “1” bad or corrupt image received Bit 3: For future use Bit 4: “1” FW image is not supported and not received Bit 5-15: Reserved
D9h	MFR_FW_REVISION	-	BR	3	Supported in ISP mode Label vAA.BB.CC returns 0xCCBBAA.

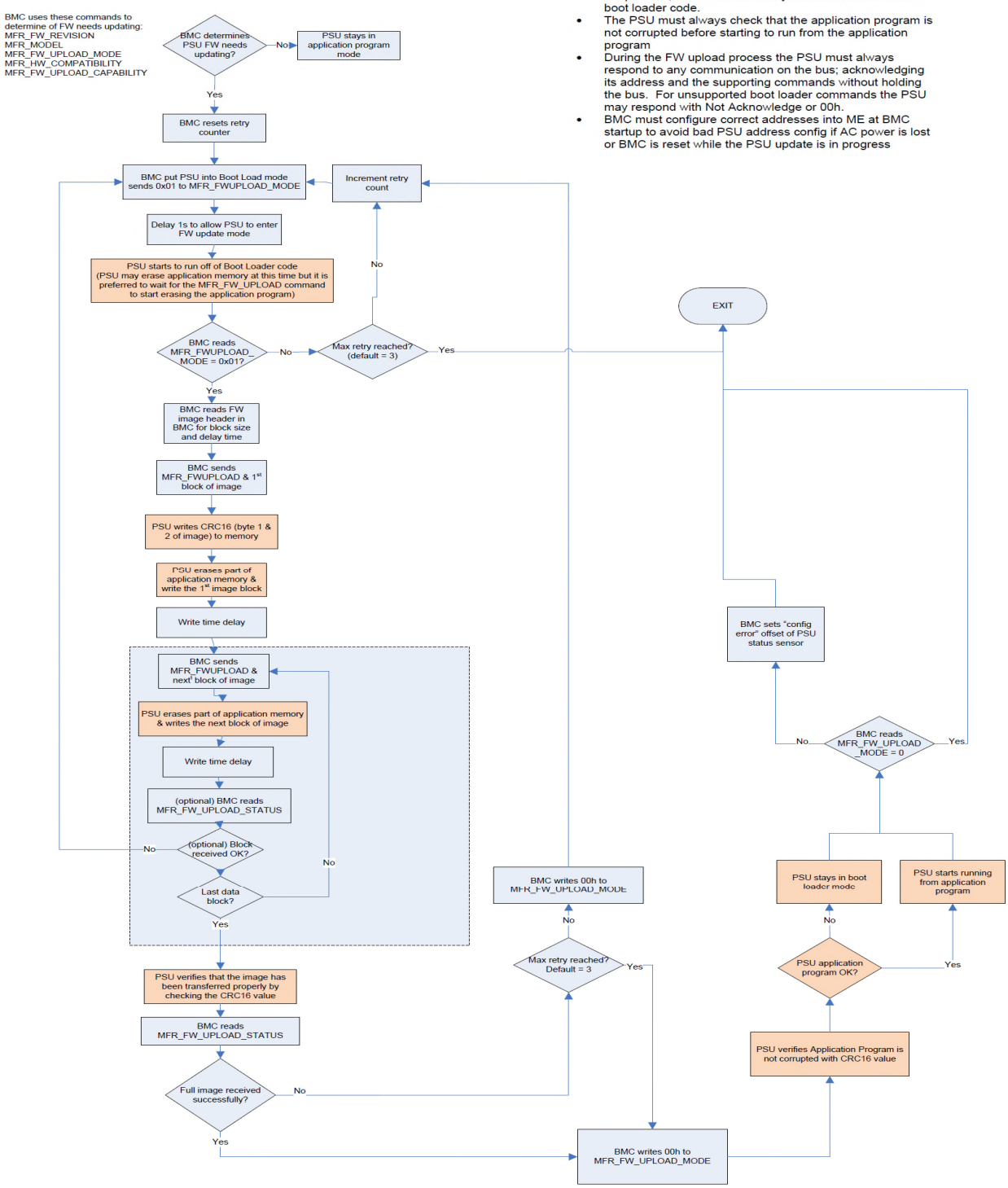
Noted: While the PSU FW image is being updated the PSU will blink the green LED at a 2Hz rate.

Section 7 PMBUS™ SPECIFICATIONS

7.2 Firmware Update Process

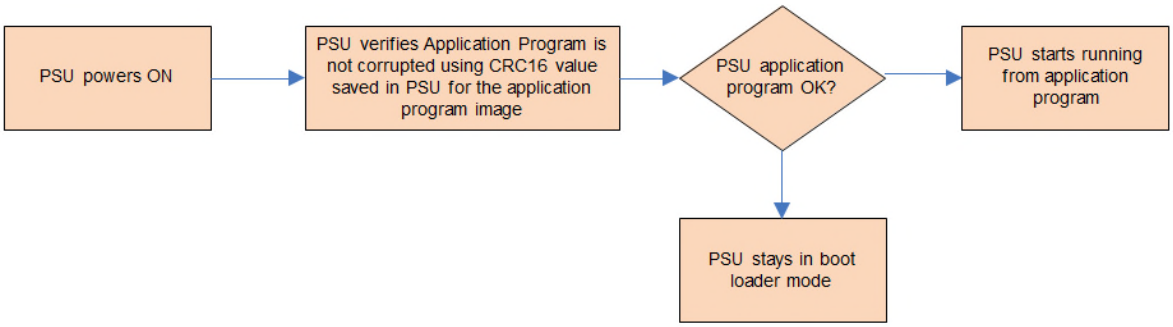
IMPORTANT!

- PSU may be in standby mode or ON mode during FW update process
- If the FW update process is interrupted at any point during the process; the PSU must always be able to return to the boot loader code.
- The PSU must always check that the application program is not corrupted before starting to run from the application program
- During the FW upload process the PSU must always respond to any communication on the bus; acknowledging its address and the supporting commands without holding the bus. For unsupported boot loader commands the PSU may respond with Not Acknowledge or 00h.
- BMC must configure correct addresses into ME at BMC startup to avoid bad PSU address config if AC power is lost or BMC is reset while the PSU update is in progress



Section 7 PMBUS™ SPECIFICATIONS

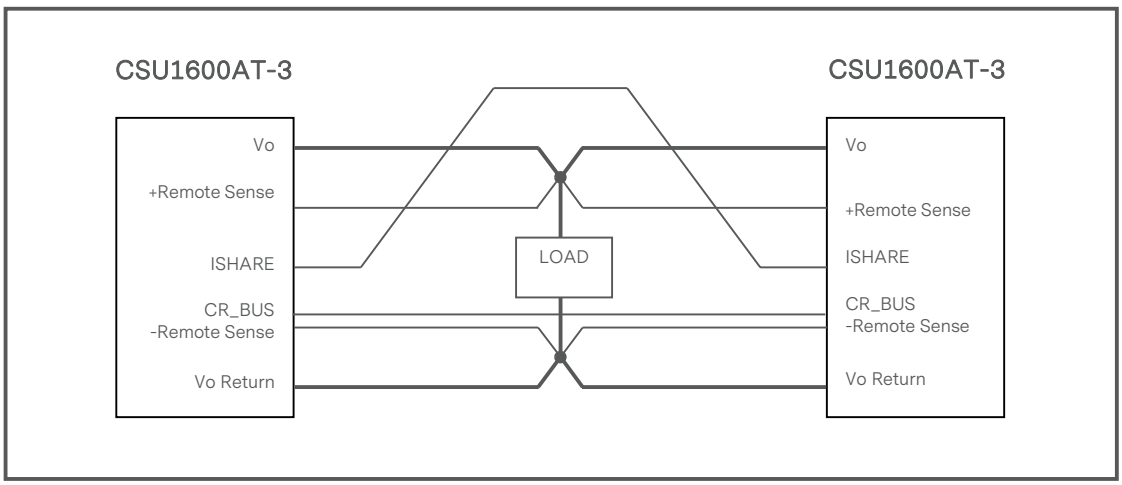
7.3 PSU Flow During Powering ON



Section 8 APPLICATION NOTES

8.1 Current Sharing

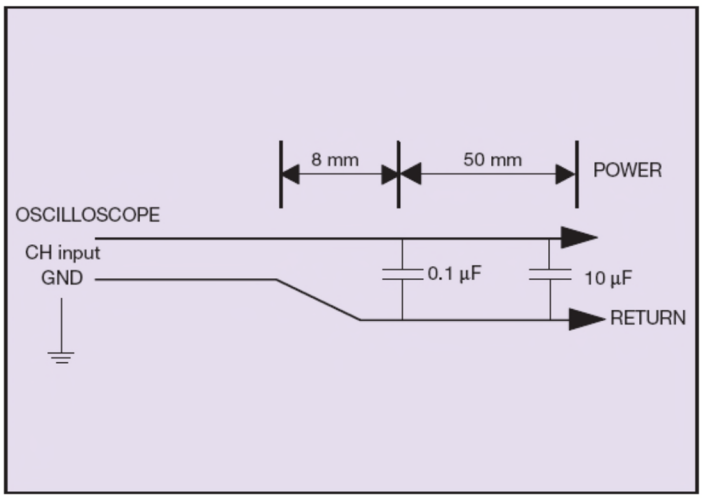
The CSU1600AT series main output V_O is equipped with current sharing capability. This will allow up to 3+1 power supplies to be connected in parallel for higher power application. Current share accuracy is typically 3% when the load is larger than 25%. Below 7% total loading, there is no guarantee of output current sharing.



Section 8 APPLICATION NOTES

8.2 Output Ripple and Noise Measurement

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the CSU1600AT 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 will be used. Oscilloscope can be set to 20 MHz bandwidth for this measurement.



Section 9 RECORD OF REVISION AND CHANGES

Issue	Date	Description	Originators
1.0	02.21.2024	First issue	V. Guo

ABOUT ADVANCED ENERGY

Advanced Energy (AE) has devoted more than four decades to perfecting power for its global customers. AE designs and manufactures highly engineered, precision power conversion, measurement and control solutions for mission-critical applications and processes.

Our products enable customer innovation in complex applications for a wide range of industries including semiconductor equipment, industrial, manufacturing, telecommunications, data center computing, and medical. With deep applications know-how and responsive service and support across the globe, we build collaborative partnerships to meet rapid technological developments, propel growth for our customers, and innovate the future of power.

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CSU1600AT-3 Rev.11.16.24_#1.0