LCM1000Q-T

1000Watts
Bulk Front End

RoHS

Total Power:	1000 Watts
Input Voltage:	90-264 Vac
# of Outputs:	Single

Special Features

- 1000 W output power
- Low Cost
- 2.5" x 5.2" x 10.0"
- 7.7 Watts Per Cubic Inch
- Industrial/Medical Safety
- -40 ^{O}C to 70 ^{O}C with derating
- Optional 5 V @ 2 A Housekeeping
- High Efficiency: 91% Typical
- Variable speed "Smart Fans"
- DSP controlled
- Conformal coat option
- ± 10% adjustment range
- Margin programming
- OR-ing FET
- Low Acoustic Noise
- EMI Class A; Class B with internal modification option
- EN61000 Immunity
- RoHS 2

Safety

ULcUL Recognized
ITE(UL60950-1)
ULcUL Recognized Medical(ANSI/ AAMI ES60601-1)
TUV-SuD ITE + Medical (EN60950-1 and EN60601-1)
CE LVD (EN60950-1 + ROHS)
BSMI
CB Report
- through Demko for IEC60950-1
- through TUV-SuD for IEC60601-1

Product Descriptions

The LCM1000Q-T is industry's low cost 1000W ac-dc power supplies, they maintain Artesyn Embedded Technologies's high standards of quality and reliability, demonstrated by a MTBF of greater than 300,000 hours at 25 ^{O}C ambient temperature with full load. A wide array of safety approvals make the LCM1000Q-T ideal for use in a variety of applications in industrial, medical, process and digital signage/display markets.

The LCM1000Q-T output power density is 7.7W per cubic inch. Like other power supplies, the power supply comes equipped with variable speed "smart" fans supported by integrated controls to enhance reliability and achieve even higher levels of energy efficiency.

The LCM1000Q-T is equipped with active Power Factor Correction (PFC) rated at 0.99 typical to minimize input harmonic current distortion. It features active ac inrush controls-limiting inrush current at power-on to 25 A and is protected against overvoltage conditions up to 145 percent. The power supply can be equipped with an optional 5V auxiliary output for powering standby circuitry when minimizing unplanned downtime and enhancing serviceability are critical. An OR-ing FET is also available.

The LCM1000Q-T supports a wide operating temperature range of minus 40 ^{O}C to plus 70 ^{O}C, providing design flexibility for applications in a variety of demanding environments.

ARTESYN™
EMBEDDED TECHNOLOGIES

Model Numbers

Standard[1]	Output Voltage	Minimum Load	Maximum Load Current ($I_{O,max}$)	Standby	Maximum Load Power ($P_{O,max}$)
LCM1000Q-T	24V	0A	41.7A	5V/2A	1000W

Note 1 - Add "-T" for terminal block

Options

1. LCM1000Q-T-1: Conformal Coating adder
2. LCM1000Q-T-4: 5V Standby adder
3. LCM1000Q-T-5: Conformal Coating and 5V Standby adder

Absolute Maximum Ratings

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

Table 1. Absolute Maximum Ratings:

Parameter	Model	Symbol	Min	Typ	Max	Unit
Input Voltage AC continuous operation	LCM1000Q-T	V_{IN}	90	-	264	Vac
Maximum Output Power, continuous	LCM1000Q-T	$P_{O,max}$	-	-	1000	W
Isolation Voltage Input to outputs Input to safety ground Outputs to safety ground	 LCM1000Q-T LCM1000Q-T LCM1000Q-T		 - - -	 - - -	 4000 2500 500	 Vac Vdc Vdc
Ambient Operating Temperature	LCM1000Q-T	T_A	-40	-	+70[1]	^{O}C
Storage Temperature	LCM1000Q-T	T_{STG}	-40	-	+85	^{O}C
Humidity (non-condensing) Operating Non-operating	 LCM1000Q-T LCM1000Q-T		 20 10	 - -	 90 95	 % %
Altitude Operating Non-operating	 LCM1000Q-T LCM1000Q-T		 - -	 - -	 16,405 30,000	 feet feet

Note 1 - With linear 50% derating from 50 ^{O}C to 70 ^{O}C

Input Specifications

Table 2. Input Specifications:

Parameter	Conditions	Symbol	Min	Typ	Max	Unit
Operating Input Voltage, AC	All	$V_{IN,AC}$	90	115/230	264	Vac
Input AC Frequency	All	f_{IN}	47	50/60	440	Hz
Maximum steady state Input Current	$V_{IN,AC}$ = 100V_{AC}	$I_{IN,max}$	-	-	12	A
No Load Input Current	$V_{IN,AC}$ = 90V_{AC} $V_{IN,AC}$ = 264V_{AC}	$I_{IN,no-load}$	- -	- -	480 350	mA
No Load Input Power (I_O = 0)	$V_{IN,AC}$ = 90V_{AC}	$P_{IN,no-load}$	-	-	30	W
Harmonic Line Currents	All	THD	IEC61000-3-2			
Power Factor	I_O = $I_{O,max}$ $V_{IN,AC}$ = 90 to 264Vac	PF	-	0.99	-	
Startup Surge Current (Inrush) @ 25 ^{O}C	$V_{IN,AC}$ = 264V_{AC}	$I_{IN,surge}$	-	-	25	A_{PK}
Input Fuse	Internal, L and N 250VAC rated		-	-	20	A
Input AC Low Line Start-up Voltage	I_O = $I_{O,max}$	$V_{IN,AC-start}$	85	-	90	Vac
Input AC Undervoltage Lockout Voltage	I_O = $I_{O,max}$	$V_{IN,AC-stop}$	80	-	90	Vac
PFC Switching Frequency	All	$f_{SW,PFC}$	40	-	60	kHz
Ripple Switching Frequency	All	$f_{SW,DC-DC}$	120	-	150	kHz
Efficiency (T_A = 25 ^{O}C , forced air cooling)	$V_{IN,AC}$ = 230Vac I_O = $I_{O,max}$	η	-	91	-	%
Hold Up Time	See note 1	$t_{Hold-Up}$	20	-	-	mSec
Turn On Delay Resistive Load	$V_{IN,AC}$ = 90Vac I_O = $I_{O,max}$	$t_{Turn-On}$	-	-	3	Sec
Leakage Current to safety ground	(V_{IN} = 264Vac, f_{IN} = 60 Hz)	$I_{IN,leakage}$	-	-	0.4	mA

Note 1 - Adjusting the output to higher tolerance (i.e. 26.4V which is the +10% adjustment range of 24V nominal) will give a typical Hold-up of 10msec.

Output Specifications

Table 3. Output Specifications:

Parameter	Condition	Symbol	Min	Typ	Max	Unit
Factory Set Voltage	I_O = 0A	$V_{O,Factory}$	22.88	24.0	25.2	V
Output Adjust Range	I_O = 0A See note 1	V_O	21.6	-	26.4	V
Total Regulation	Inclusive of line, load temperature change, warm-up drift	V_O	-2.0	-	+2.0	% V_O
Output Ripple, pk-pk	See note 2	V_O	-	-	240	mV
Output Current, continuous	All	$I_{O,max}$	0	-	41.7	A
Maximum Output Power, continuous	All	$P_{O,max}$	-	-	1000	W
Overload Protection	Main Standby	$I_{O,SC}$	105 120	- -	125 170	% $I_{O,max}$
Dynamic Response - Peak Deviation	50% to 100% of $I_{O,max}$ load change Slew rate = 1A/us	±%V_O	-	-	2	%
Dynamic Response - Setting Time		T_s	-	-	300	uSec
Turn On Overshoot	I_O = 0A	%V_O	-	-	10	%
Over Voltage Protection	Main Standby	V_O	125 110	-	145 125	% Vo
Load Capacitance	Main Standby	C_O	0 0	- -	10,000 270	uF
Over Temperature Protection	All	Auto Recovery				

Note 1 - See page 13 for voltage adjustment pot location
Note 2 - Measure with a 0.1uF ceramic capacitor in parallel with a 10uF tantalum capacitor using a 20MHz bandwidth limited oscilloscope

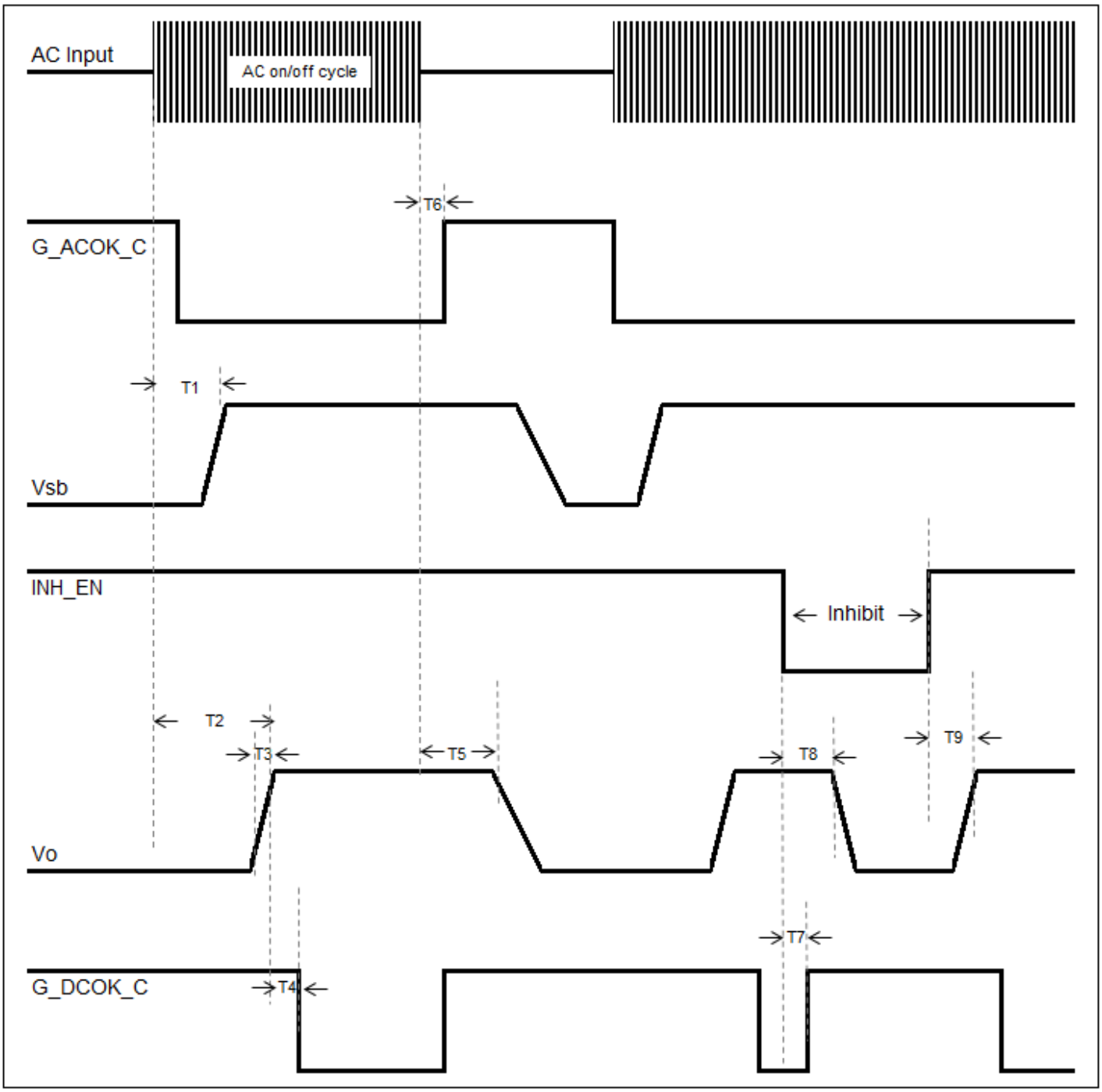
System Timing Specifications

Table 4. System Timing Specifications:

Label	Parameter	Min	Typ	Max	Unit
T1	Delay from AC being applied to Vsb being within regulation.	-	-	2000	mSec
T2	Delay from AC being applied to main output voltages being within regulation.	-	-	3000	mSec
T3	Vo rise time, 10% to 90% Vo of the nominal voltage.	5	-	50	mSec
T4	Delay from output voltages within regulation limits to G_DCOK_C asserted low.	-	-	500	mSec
T5	Hold up time - Delay from AC loss to main output within regulation (90% Vo of the nominal voltage).	20	-	-	mSec
T6	Delay from loss of AC input to G_ACOK_C going to low.	5	-	12	mSec
T7	Delay from INH_EN going to low to G_DCOK_C going to high.	-	-	10	mSec
T8	Delay from INH_EN going to low to main output within regulation (90% Vo of the nominal voltage).	-	-	50	mSec
T9	Delay from INH_EN going to high to main output within regulation (90% Vo of the nominal voltage).	-	-	500	mSec

System Timing Specifications

Figure 1. System Timing Diagram:



LCM1000Q-T-4 Performance Curves

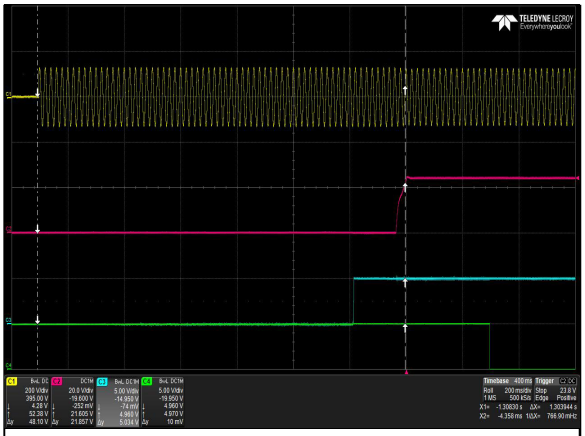


Figure 2: LCM1000Q-T-4 Turn-on delay via AC mains – Vin = 90Vac
Full Load: Io = 41.7A (24V), Isb= 2A (5V)
Ch 1: AC Mains Ch 2: Vo Ch3:Vsb Ch 4: G_DCOK_C

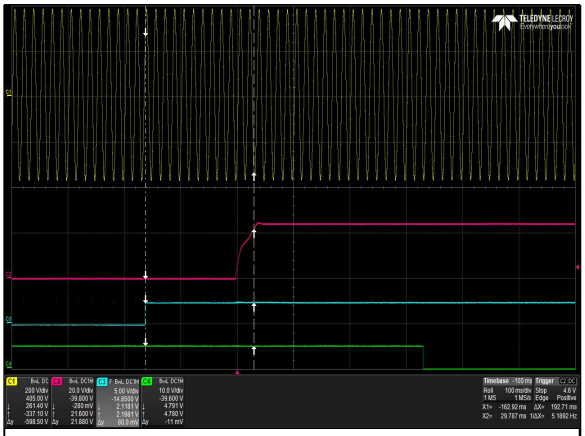


Figure 3: LCM1000Q-T-4 Turn-on delay via INH_EN – Vin = 264Vac
Full Load: Io = 41.7A (24V), Isb = 2A (5V)
Ch 1: AC Mains Ch 2: Vo Ch 3: INH_EN Ch 4: G_DCOK_C

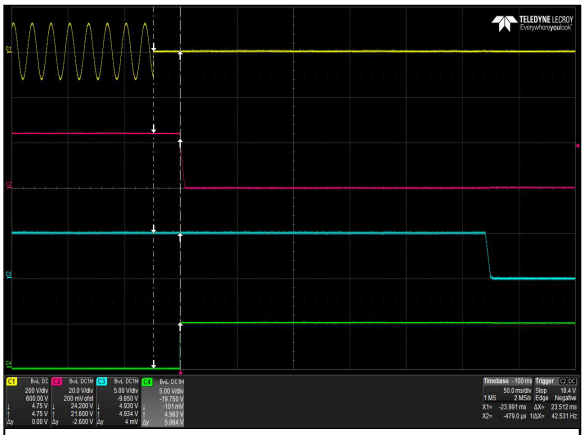


Figure 4: LCM1000Q-T-4 Hold-up Time – Vin = 90Vac / 60Hz / 0°
Full Load: Io = 41.7A (24V), Isb= 2A (5V)
Ch 1: AC Mains Ch 2: Vo Ch3:Vsb Ch 4: G_DCOK_C

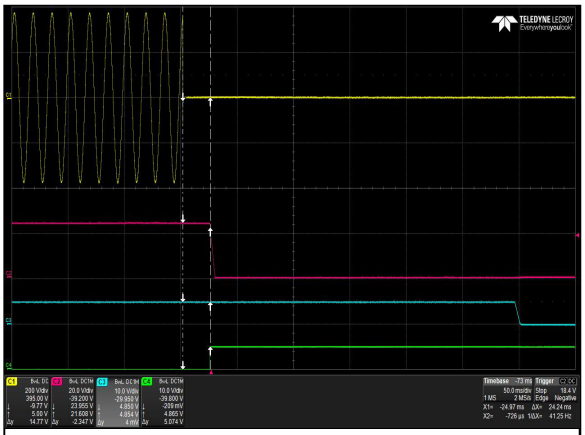


Figure 5: LCM1000Q-T-4 Hold-up time – Vin = 264Vac / 60Hz / 0°
Full Load: Io = 41.7A (24V), Isb = 2A (5V)
Ch 1: AC Mains Ch 2: Vsb Ch 3: Vo Ch 4: G_DCOK_C

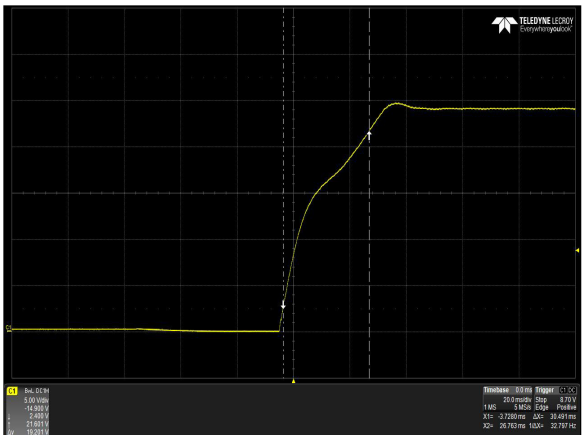


Figure 6: LCM1000Q-T-4 Output Voltage Startup Characteristic - Vin=90Vac
Full Load: Io = 41.7A (24V)
Ch 1: Vo

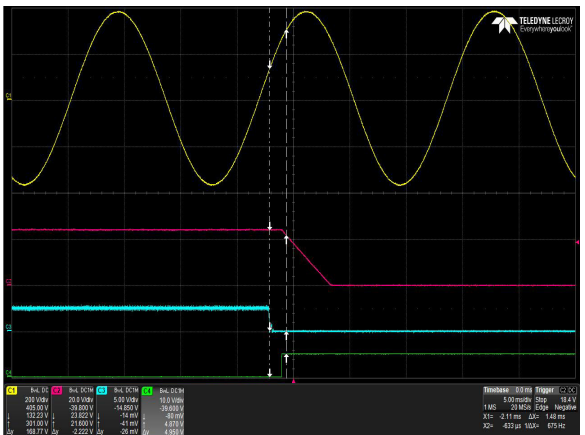


Figure 7: LCM1000Q-T-4 Turn Off Characteristic via INH_EN
Full Load: Io = 41.7A (24V), Isb = 2A (5V)
Ch 1: AC Mains Ch 2: Vo Ch3:INH_EN Ch 4: G_DCOK_C

LCM1000Q-T Performance Curves

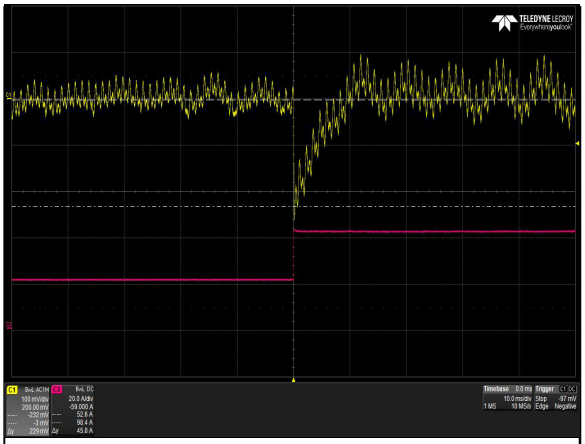


Figure 8: LCM1000Q-T-4 Transient Response – Vo Deviation (low to high) 50% to 100% load change, 1A/uS slew rate, Vin = 90Vac
Ch 1: Vo Ch 2: Io

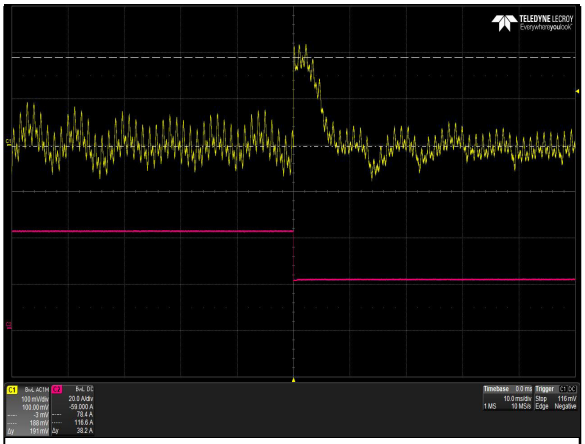


Figure 9: LCM1000Q-T-4 Transient Response – Vo Deviation (high to low) 100% to 50% load change, 1A/uS slew rate, Vin = 90Vac
Ch 1: Vo Ch 2: Io

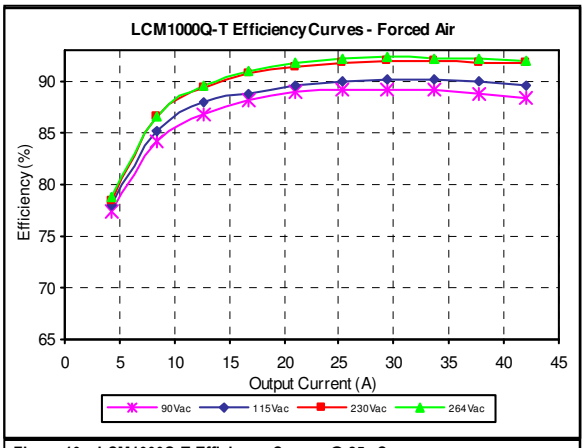


Figure 10: LCM1000Q-T Efficiency Curves @ 25 °C,
Loading: Io = 0A increment to 41.7A

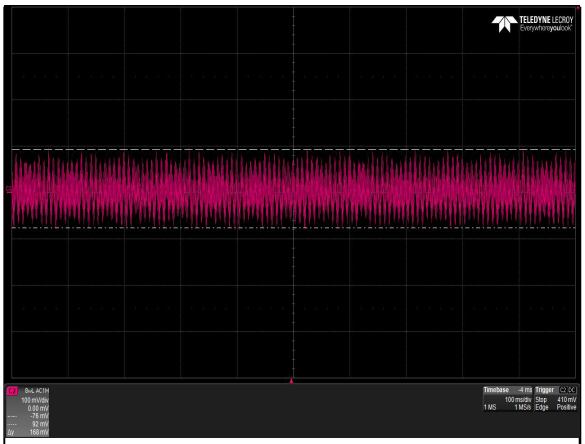


Figure 11: LCM1000Q-T-4 Ripple and Noise Measurement – Vin = 115Vac Full Load: Io = 41.7A (24V),
Ch 2: Vo

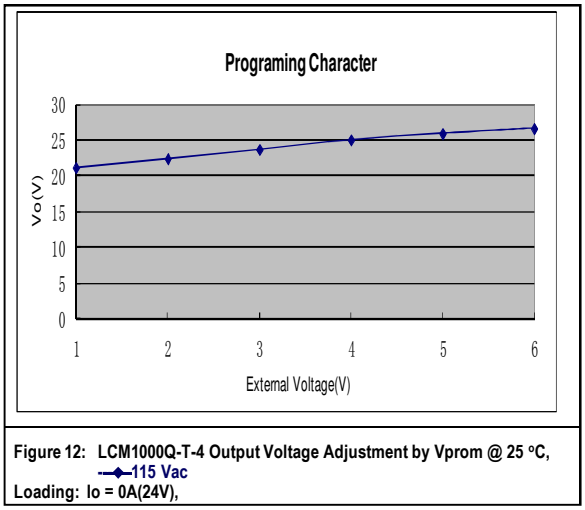


Figure 12: LCM1000Q-T-4 Output Voltage Adjustment by Vprom @ 25 °C,
--◆--115 Vac
Loading: Io = 0A(24V),

Protection Function Specification

Input Fusing

LCM1000Q-T is equipped with an internal non user serviceable 20A High Rupturing Capacity (HRC) 250Vac fuse to IEC 127 for fault protection in both the L1 and L2 lines input.

Over Voltage / Under Voltage Protection (OVP)

The power supply latches off during output overvoltage with the AC line recycled to reset the latch.

Parameter	Min	Nom	Max	Unit
V_O Output Overvoltage	125	/	145	% Vo
Standby Voltage Overvoltage	110	/	125	% Vo

Over Current Protection (OCP)

LCM1000Q-T output will be in automatic mode with a recovery time delay of 20 sec when the output current hits the OCP limit provided.

Parameter	Min	Nom	Max	Unit
V_O Output Overcurrent	105	/	125	% Io max
Standby Voltage Overcurrent	120	/	170	% Io max

Short Circuit Protection (SCP)

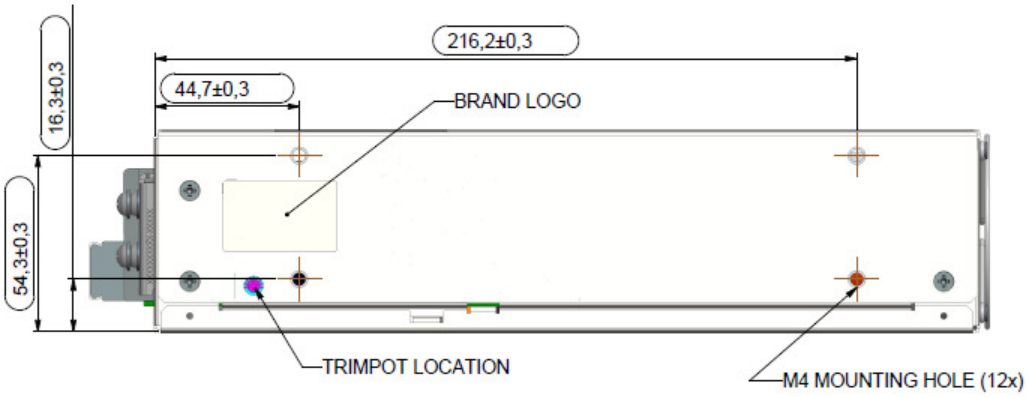
A short circuit is defined as less than 0.03 ohm resistance between the output terminals. All outputs will be protected against short circuit to ground or other outputs. No damage will result. In the event of short circuit, LCM1000Q-T will be in bouncing mode with a recovery delay of 20 sec.
Optional 5V standby, independent of the main output, will also be in bouncing mode once the fault occurred.

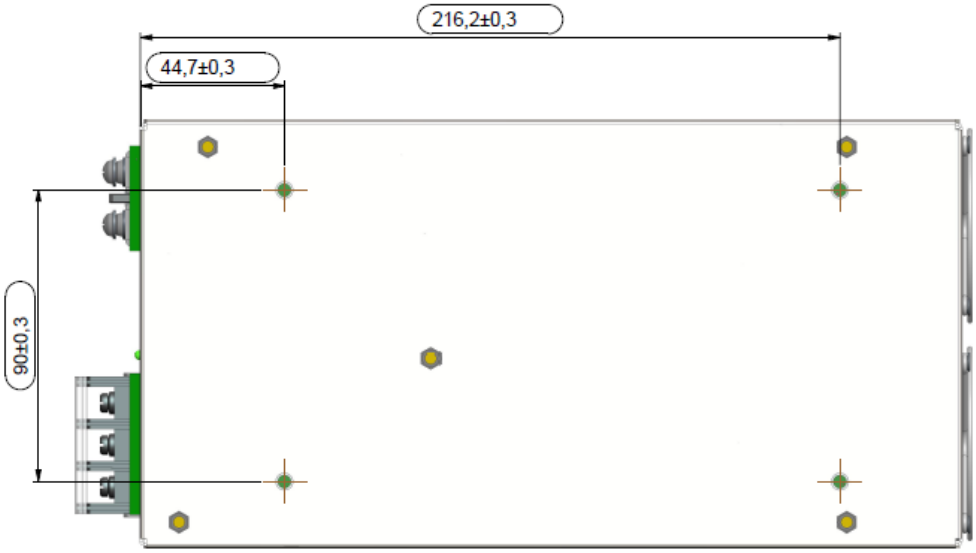
Over Temperature Protection (OTP)

The power supply will be internally protected against over temperature conditions. When the OTP circuit is activated, the power supply will shut off and will auto-recover once the OTP condition is gone. OTP trip-point at full Load is set at a nominal of 55 ^{O}C to 65 ^{O}C ambient temperature

Mechanical Specifications

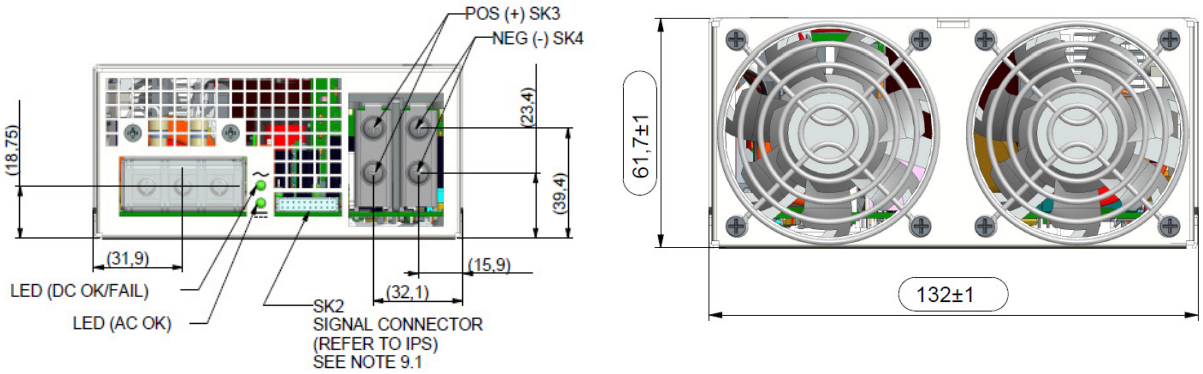
Mechanical Outlines



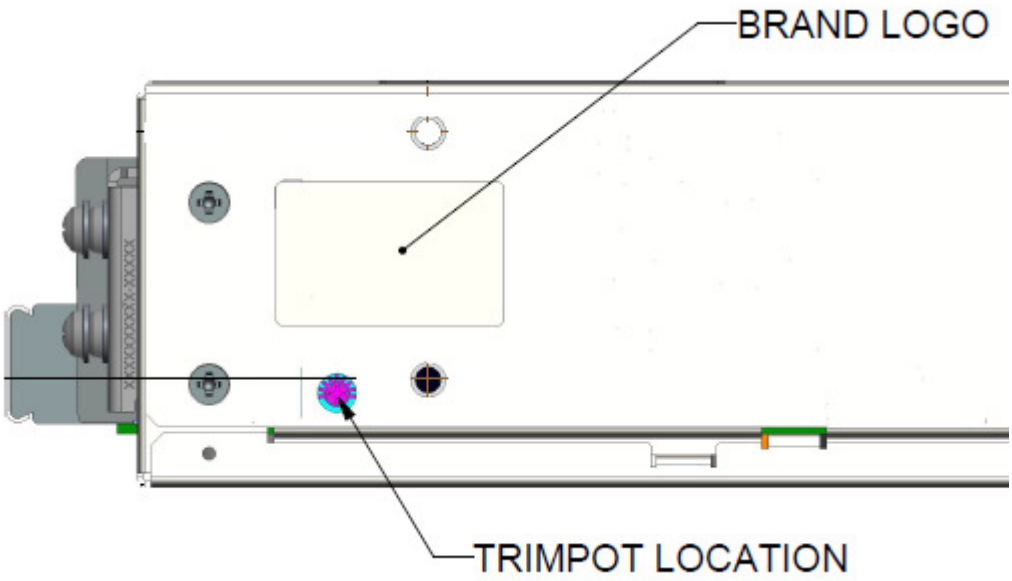


Mechanical Specifications

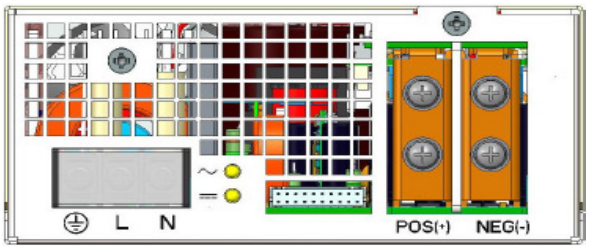
Mechanical Outlines



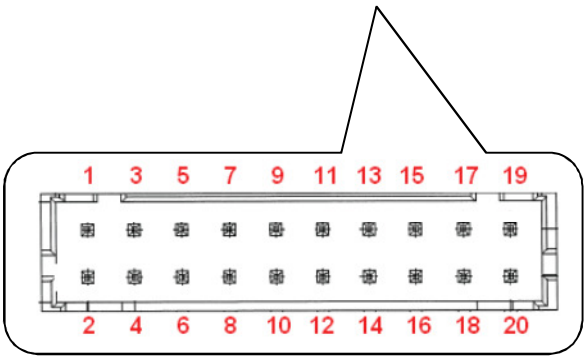
Mechanical Outlines - Voltage Adjustment Pot Location



Connector Definitions



SK1 SK2 SK3 SK4



AC Input Connector – SK1

SK1 – Earth Ground
SK1 – Line
SK1 – Neutral

Output Connector – SK3&SK4

SK3 – +Vout
SK4 – GND

Control Signals – SK2

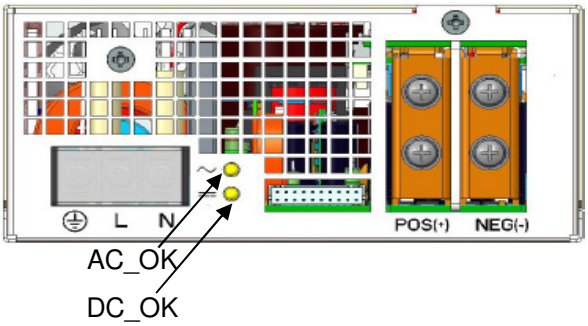
Pin 1 – A2
Pin 2 – -VPROG
Pin 3 – A1
Pin 4 – -VSense
Pin 5 – ISHARE
Pin 6 – A0
Pin 7 – SDA1
Pin 8 – +VPROG
Pin 9 – SCL1
Pin 10 – +Vsense
Pin 11 – 5VSB
Pin 12 – GND
Pin 13 – 5VSB
Pin 14 – G_DCOK_C
Pin 15 – N/A
Pin 16 – G_DCOK_E
Pin 17 – GND
Pin 18 – G_ACOK_C
Pin 19 – INH_EN
Pin 20 – G_ACOK_E

Power / Signal Mating Connectors and Pin Types

Table 5. Mating Connectors for LCM1000Q-T

Reference	Mating Connector or Equivalent
SK2	LANDWIN (LWE PN: 2050S2000) Housing (LWE PN: 2053T021V) Terminal CIVILUX (CX PN: CI0120SD000) Housing (CX PN: CI01TD21PE0) Terminal
SK3, SK4	Molex: 19141-0058

LED Indicator Definitions



Two user-friendly LEDs for status and diagnostics shows status of input power, output power and alarm condition valuable troubleshooting aid to reduce system downtime.

Condition	LED Conditions	
	ACOK LED	**DCOK/FAIL LED**
AC present / Output On	Green	Green
No AC power to PSU	OFF	OFF
Standby mode/main output off	Green	OFF
Power supply failure	Green	OFF

Weight

The LCM1000Q-T weight is 4.354lbs.(1.975kg).

Environmental Specifications

EMC Immunity

The LCM1000Q-T power supply is designed to meet the following EMC immunity specifications

Table 5. Environmental Specifications:

Document	Description
EMC Emission:	
EN55022	Conducted and radiated EMI limits specified in FCC Docket No. 20780 Part 15 Subpart J Class A and the limits specified in EN55022, Level A with a minimum of 6dB margin under the limits.
EN61000-3-2	EMC limits for harmonic current emissions
EMC Immunity:	
EN61000-4-2	ESD: +/-8KV air, +/-15kV contact discharge, Level 3
EN61000-4-3	Conducted Susceptibility: 0.15 - 80 MHz, 10V/m, AM 80% (1KHz), Level 3 – designed to meet
EN61000-4-4	Fast Transient: 2KV for AC power port, 1.0 KV for DC power, I/O and signal ports, Level 3
EN61000-4-5	Surges: 2KV common mode and 1KV differential mode for AC power ports and 0.5 KV differential mode for DC power, I/O and signal ports, Level 3
EN61000-4-8	Power Frequency Magnetic, Level 3
EN61000-4-11	Voltage Dips and Interruptions: 30% reduction for 500 mS – Criteria B, >95% reduction for 10 mS, Criteria A, >95% reduction for 5000 mS, Level 3
EN55024: 1998	Information Technology Equipment – Immunity Characteristics, Limits and Method of Measurement
General Protection Safety:	
IEC60950-1	SELV

Safety Certifications

The LCM1000Q-T are intended for inclusion in other equipment and the installer must ensure that it is in compliance with all the requirements of the end application. This product is only for inclusion by professional installers within other equipment and must not be operated as a standard alone product.

Table 6. Safety Certifications for LCM1000Q-T series power supply system

Document	File #	Description
UL 60950-1 2nd Edition/ CSA C22.2 No. 60950-1-07, 2nd Edition	E186249-A270-UL-X6	US and Canada Requirements
UL ANSI/AAMI ES60601-1 (2005 + C1:09 + A2:10 + A1:12), CAN/CSA-C22.2 No. 60601-1	E182560-V4-S5	US and Canada Medical Electrical Equipment
UL ANSI/AAMI ES60601-1 (2005 + C1:09 + A2:10, CAN/CSA-C22.2 No. 60601-1 (2008)	E182560-A37-UL-X1	US and Canada Medical Electrical Equipment
Tuv EN60950-1	Z2 15 02 13890 02176	European Requirements
IEC60950-1/EN60950	E186249-A270-CB-1	International Requirements
IEC60601	SG-MD-00487	International Medical Electrical Equipment
IEC60601-1/EN60601-1	211-400848-000	European and International Electrical Equipment
CB Certificate and Report	DK-38857-A2-UL	(All CENELEC Countries)
CE (LVD+RoHS),EN60950-1	15072	European Requirements

EMI Emissions

The LCM1000Q-T has been designed to comply with the Class A limits of EMI requirements of EN55022 (FCC Part 15) 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 EN55022 (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.

Table 7. Conducted EMI emission specifications of the LCM1000Q-T series

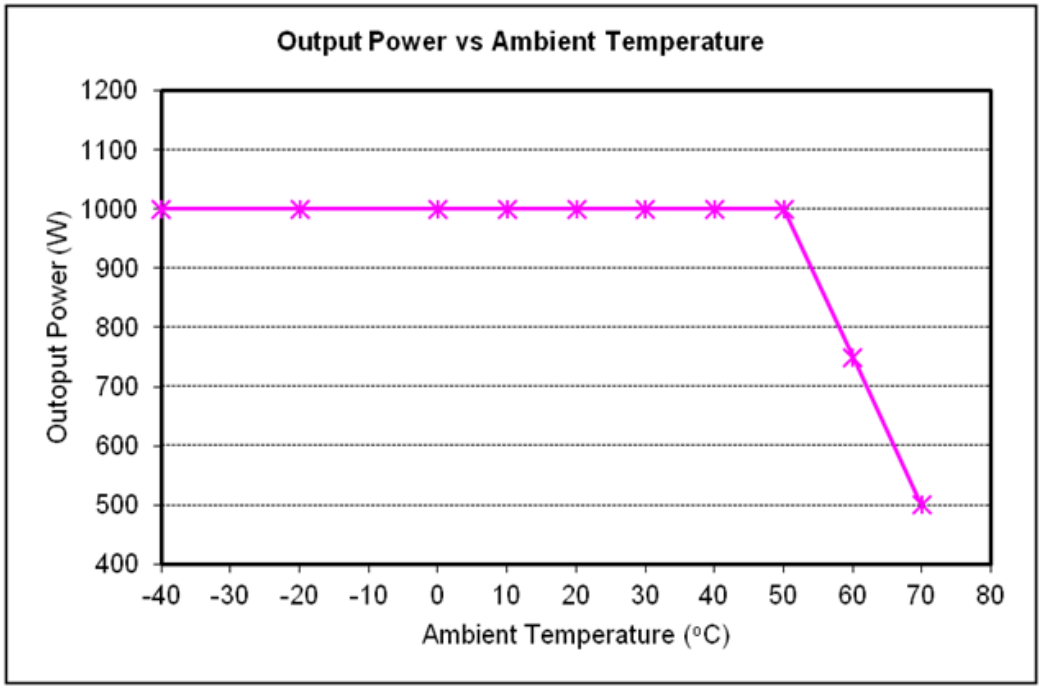
Parameter	Model	Symbol	Min	Typ	Max	Unit
FCC Part 15, class A	LCM1000Q-T	Margin	-	-	6	dB

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 EN55022 Class A (FCC Part 15). Testing ac-dc convertors as a stand-alone component to the exact requirements of EN55022 can be difficult, because the standard calls for 1m leads to be attached to the input and outputs and aligned such as to maximize the disturbance. In such a set-up, it is possible to form a perfect dipole antenna that very few ac-dc convertors could pass. However, the standard also states that 'an attempt should be made to maximize the disturbance consistent with the typical application by varying the configuration of the test sample.

Operating Temperature

The LCM1000Q-T maximum output power (1000W) can be loaded up to an ambient temperature of +50 ^{O}C .
Only 50%(500W) of the maximum output power can be loaded at ambient temp of +70 ^{O}C. Linear derating to 50% nominal output power starts from +50 ^{O}C. The elapsed time between the application of input power and the attainment steady state values requires 5 minute warm up for -20 ^{O}C to -40 ^{O}C operation.



Forced Air Cooling

The LCM1000Q-T power supply 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. The standard direction of airflow is from the end of the power supply. The cooling fan is a variable speed fan. Fan will be smart based on internal temperature. Fan noise <45 dB with 80% load @ 30 ^{O}C.

Storage and Shipping Temperature / Humidity

The LCM1000Q-T can be stored or shipped at temperatures between -40 ^{O}C to +85 ^{O}C and relative humidity from 10% to 95% non-condensing.

Altitude

The LCM1000Q-T will operate within specifications at altitudes up to 16405 feet above sea level. The power supply will not be damaged when stored at altitudes of up to 30,000 feet above sea level.

Humidity

The LCM1000Q-T will operate within specifications when subjected to a relative humidity from 20% to 90% non-condensing. The LCM1000Q-T can be stored in a relative humidity from 10% to 95% non-condensing.

Vibration

The LCM1000Q-T will pass the following vibration specifications:

Non-Operating Random Vibration

Acceleration	2.70		gRMS
Frequency Range	10-2000		Hz
Duration	20		mins
Direction	3 mutually perpendicular axis		
PSD Profile	**FREQ** 10 Hz 200 Hz 500 Hz	**SLOPE** **dB/oct** --- -2.66dB/oct ---	**PSD** **g^2/Hz** 0.009 g^2/Hz 0.009 g^2/Hz 0.004 g^2/Hz

Operating Random Vibration

Acceleration	1.0		gRMS
Frequency Range	10-500		Hz
Duration	20		mins
Direction	3 mutually perpendicular axis		
PSD Profile	**FREQ** 5 Hz 10-50 Hz 100 Hz	**SLOPE** **dB/oct** 11dB/oct --- -10dB/oct	**PSD** **g^2/Hz** 0.00003 g^2/Hz 0.00004 g^2/Hz 0.00003 g^2/Hz

Shock

The LCM1000Q-T will pass the following vibration specifications:

Non-Operating Half-Sine Shock

Acceleration	30	G
Duration	18	msec
Pulse	Half-Sine	
No. of Shock	3 shock on each of 6 faces	

Operating Half-Sine Shock

Acceleration	4	G
Duration	22	msec
Pulse	Half-Sine	
No. of Shock	3 shock on each of 6 faces	

Power and Control Signal Descriptions

AC Input Connector

This connector supplies the AC Mains to the LCM1000Q-T.

SK1 - Earth Ground

SK1 - Line

SK1 - Neutral

Output Connector – SK3&SK4

These pins provide the main output for the LCM1000Q-T. The +Vout and the GND pins are the positive and negative rails, respectively, of the V_O main output of the LCM1000Q-T. The +Vout is electrically isolated from the power supply chassis.

SK3 - +Vout

SK4 - GND

Control Signals – SK2

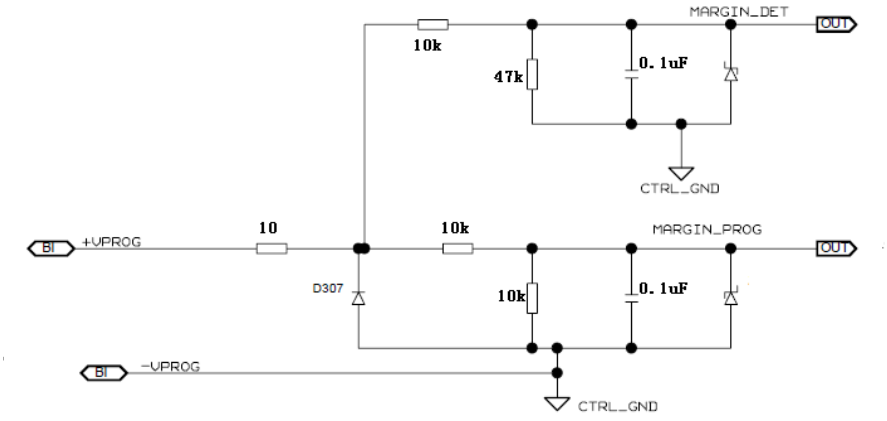
The LCM1000Q-T SK2 contains 20 pins control signal header providing analogy control interface, standby power and i^2C interface.

A0, A1, A2 – (Pin 6, Pin3, Pin1)

Please refer to “Communication Bus Descriptions” section.

-VPROG, +VPROG – (Pin2, Pin8)

Positive and return connection of external supply for Margin Programming. The LCM1000Q-T will have a “margin” pin which will accept a 1-6VDC signal referenced to a floating return that will program the output the entire adjustment range.– VPROG pin need to connect the main output/standby GND. Applying voltage greater than 6V may result to damage of PSU internal circuit.



-Vsense, +Vsense – (Pin 4, Pin10)

This remote sense circuit will be designed to compensate for a power path drop around the entire loop of 0.5 volt. These pins should be connected as close to the loading as possible, If left open, the remote sense does not work properly and the voltage level of main output will go lower than the guaranteed spec.

ISHARE – (Pin 5)

The main output will have active load sharing. The output will share within 10% at full load. All current sharing functions are implemented internal to the power supply by making use of the ISHARE signal. The system connects the ISHARE lines between the power supplies. The supplies must be able to load share with up to 10 power supplies in parallel.

SDA1, SCL1, GND– (Pin 7, Pin9, Pin17)

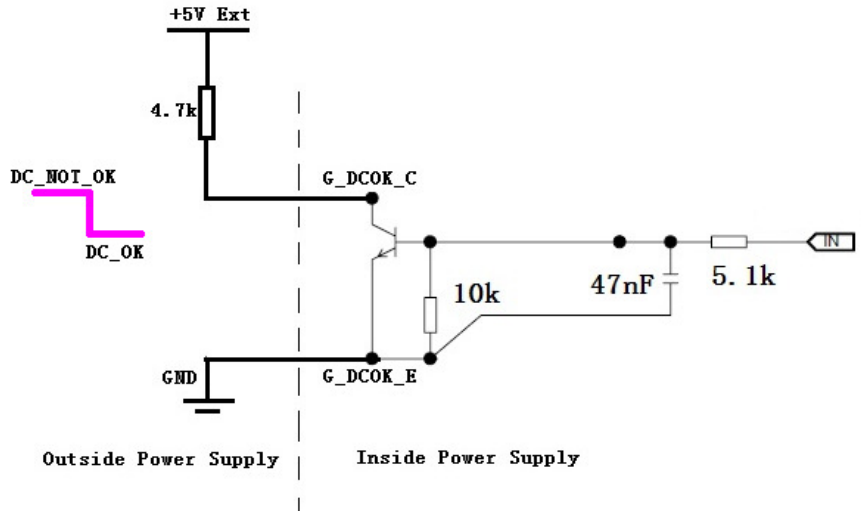
Please refer to “Communication Bus Descriptions” section on Page 27.

5VSB, GND – (Pin11, Pin12, Pin13)

The LCM1000Q-T provides a regulated 5 volt 2 amp auxiliary output voltage to power critical circuitry that must remain active regardless of the on/off status of the power supply’s main output. The 5VSB standby voltage is available whenever a valid AC input voltage is applied to the unit.

G_DCOK_C, G_DCOK_E– (Pin14, Pin16)

G_DCOK_C is a power good signal and will be pulled LOW by the power supply to indicate that both the outputs are above the regulation limits of the power supply. When any output voltage falls below regulation limits or when AC power has been removed for a time sufficiently long so that power supply operation is no longer guaranteed, G_DCOK_C will be de-asserted to a HIGH state. Connect 4.7K resistor on G_DCOK_C to PSU’s 5V stand- by.

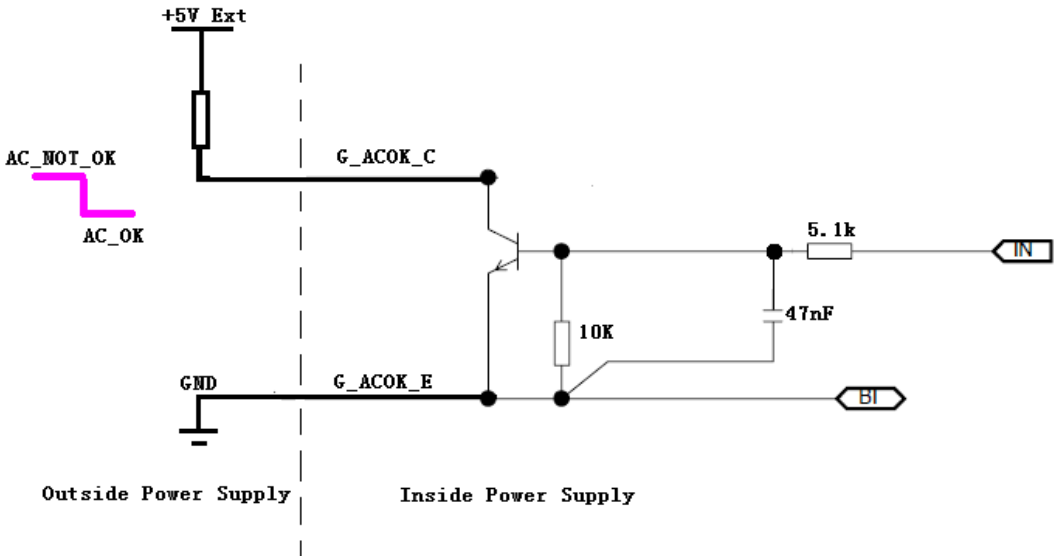


N/A – (Pin15)

Unused Pin

G_ACOK_C, G_ACOK_E– (Pin18, Pin20)

G-ACOK_C signal is used to indicate presence of AC input to the power supply. A logic “Low” level on this signal shall indicate AC input to the power supply is present. A Logic “High” on this signal shall indicate a loss of AC input to the power supply. Connect 4.7K resistor on G_ACOK_C to 5V stand-by.



INH_ENA – (Pin19)

0.0 – 0.5V on this Pin will disable the Main output. If left it open, the Main output will enable.

Communication Bus Descriptions

I²C Bus Signals

The LCM1000Q-T contains enhanced monitor and control functions implemented via the I²C bus. The LCM1000Q-T 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 (ie: 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 AC source connected.

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

SDA1, SCL1 (I²C Data and Clock Signals) – (pin7, pin 9)

I²C serial data and clock bus - these pins are internally pulled up to internal digital system controller.

A0, A1, A2 (I²C Address BIT 0, BIT1, BIT2 Signals) – (pin6, pin3, pin1)

These three input pins are the address lines A0, A1 and A2 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 system and power supplies, the system will be the master and power supplies will be slave.

They are internally pulled up to internal 3.3V supply with a 2K resistor.

I²C Bus Communication Interval

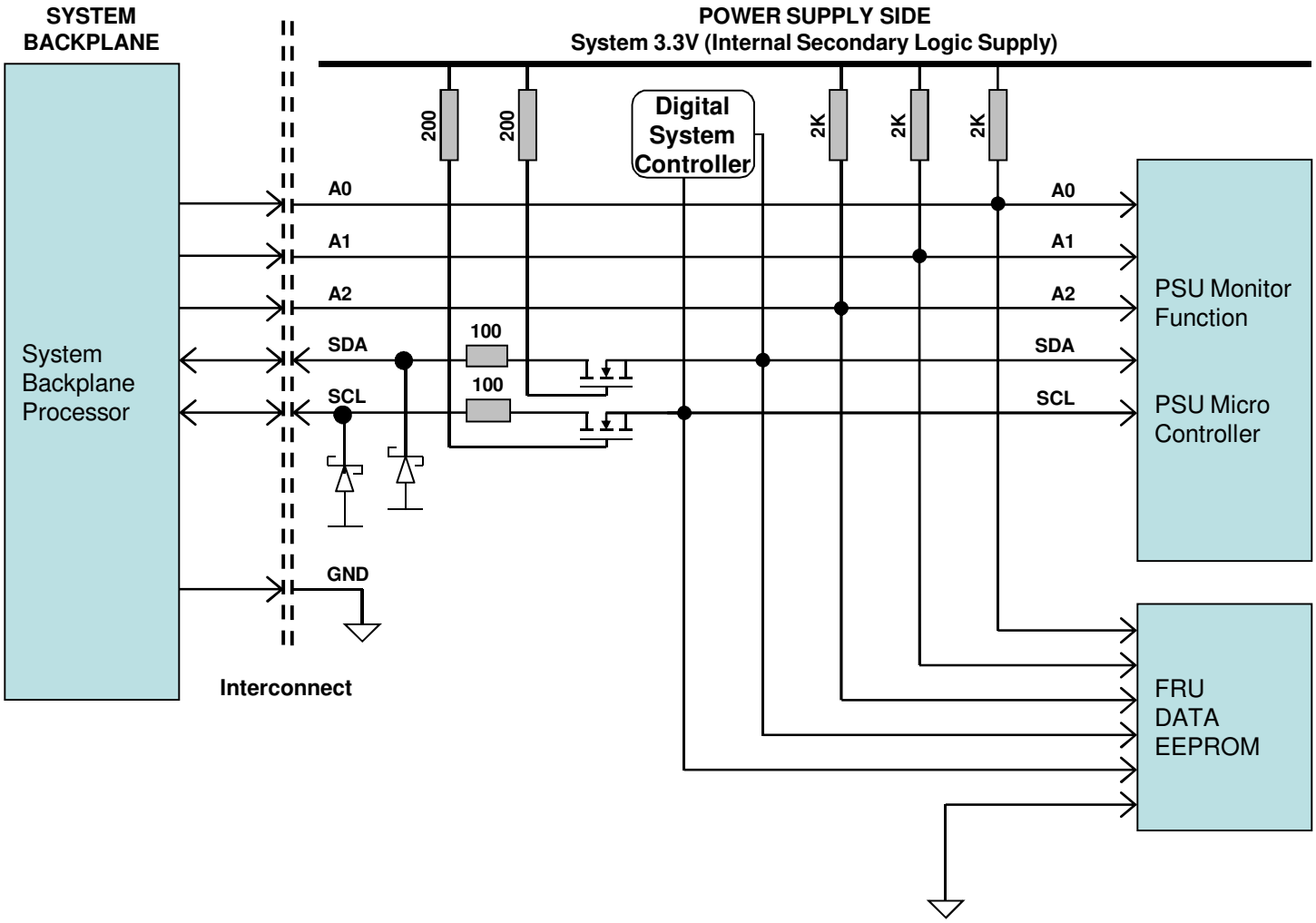
The interval between two consecutive I²C communications to the power supply should be at least 50ms to ensure proper monitoring functionality.

I²C Bus Signal Integrity

The noise on the I²C bus (SDA, SCL lines) due to the power supply will be less than 450mV peak-to-peak. This noise measurement should be made with an oscilloscope bandwidth limited to 20MHz. Measurements should be make at the power supply output connector with 2.2K ohm resistors pulled up to StandBy Output and 20pf ceramic capacitors to StandBy Output Return.

The noise on the address lines A0 and A1 will be less than 100mV peak-to-peak. This noise measurement should be made at the power supply output connector.

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	Typ	Max	Unit
Recommended external pull-up resistor 1 PSU	1 PSU	R_{ext}	-	2.2	-	Kohm
	8 PSU		-	0.275	-	Kohm

Device Addressing

The LCM1000Q-T will respond to supported commands on the I²C bus that are addressed according to pins A0, A1 and A2 of output connector.

Address pins are held HIGH by default via pull up to internal 3.3V supply with a 2K resistor. To set the address as “0”, the corresponding address line should be pulled down to logic ground level. Below tables show the address of the power supply with A0, A1 and A2 pins set to either “0” or “1”.:

PSU Slot	Slot ID Bits			PMBus™ Address
	A2	A1	A0	
1	0	0	0	B0
2	0	0	1	B2
3	0	1	0	B4
4	0	1	1	B6
5	1	0	0	B8
6	1	0	1	BA
7	1	1	0	BC
8	1	1	1	BE

* Default PMBus™ address is BE

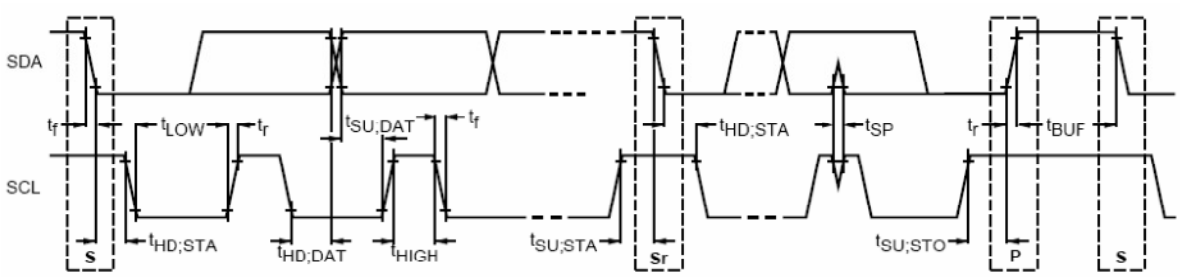
Logic Levels

LCM1000Q-T power supply I²C Communication Bus will respond to logic levels as per below:

Logic High: 5.1V Nominal (Specs is 2.1V to 5.5V)**
Logic Low: 500mV nominal (Specs is 800mV max)**

** Note: Philips™ I²C adapter was used.

Timings



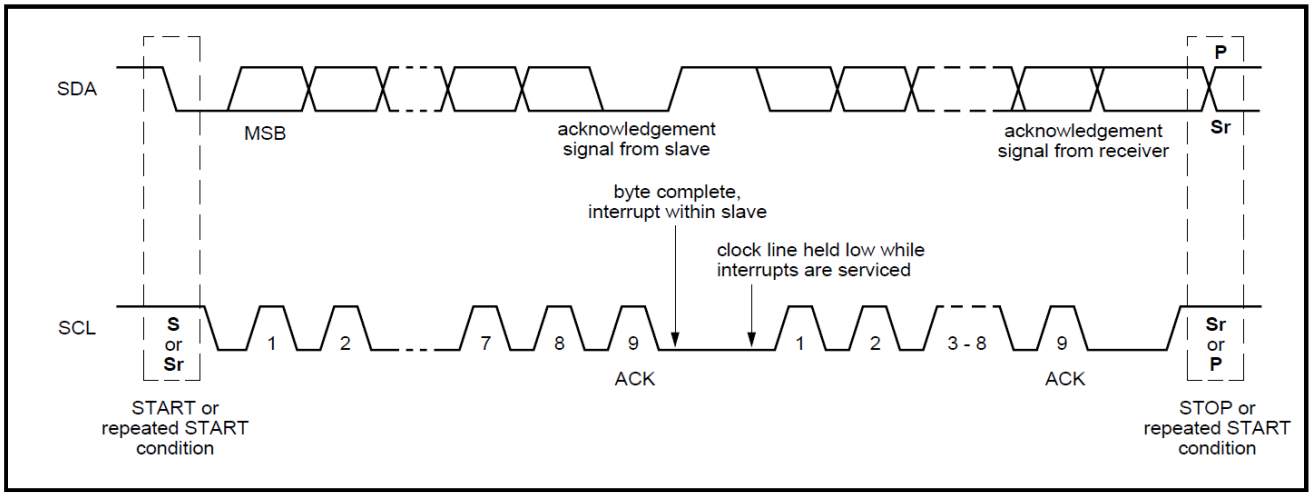
Parameter	Symbol	Standard-Mode Soecs		Actual		Unit
		Min	Max			
SCL Clock Frequency	f_{SCL}	0	100	98		KHz
Hold time (repeated) START condition	$t_{HD;STA}$	4.0	-	4.5		us
LOW period of SCL clock	t_{LOW}	4.7	-	5.9		us
HIGH period of SCL clock	t_{HIGH}	4.0	-	4.3		us
Setup time for repeated START condition	$t_{SU;STA}$	4.7	-	4.5		us
Data hold time	$t_{HD;DAT}$	0	3.45	1.2		us
Data setup time	$t_{SU;DAT}$	250	-	4500		ns
Rise time	t_r	-	1000	SCL =850	SDA =903	ns
Fall time	t_f	-	300	SCL =298	SDA =590	ns
Setup time for STOP condition	$t_{SU;STO}$	4.0	-	5.2		us
Bus free time between a STOP and START condition	t_{BUF}	4.7	-	60***		us

*** Note Philips™ I2C adapter and bundled software (USB-to-I2C) was used

I²C Clock Synchronization

The LCM1000Q-T power supply might apply clock stretching. An addressed slave power supply may hold 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 LCM1000Q-T is 100 microseconds.



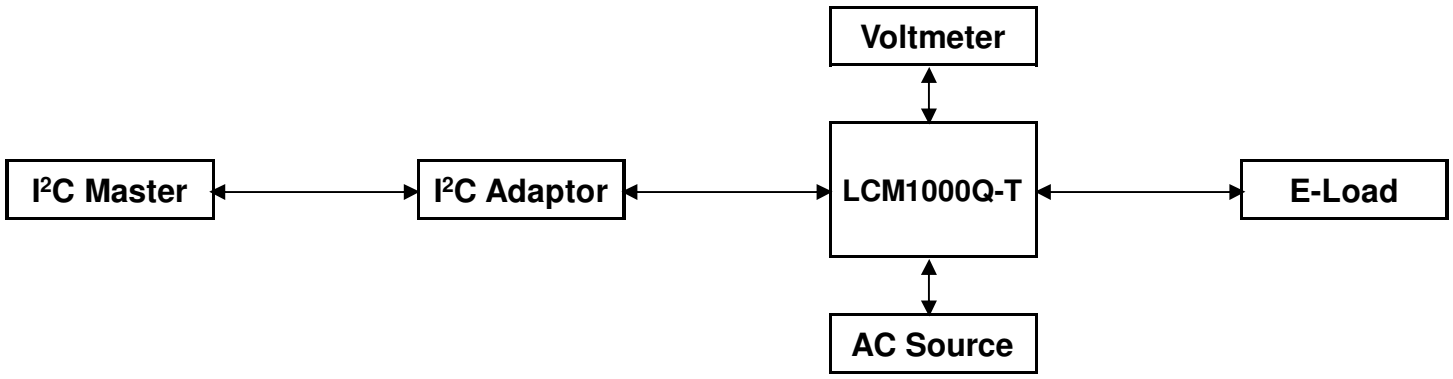
PMBus™ Interface Support

The LCM1000Q-T is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port.

LCM1000Q-T PMBus™ General Instructions

Equipment Setup

The following is typical I²C communication setup:



PMBus™ Writing Instructions

When writing to any PMBus™ R/W registers, ALWAYS do the following:

Disable Write Protect (command 10h) by writing any of the following accordingly:

Levels: 00h – Enable writing to all writeable commends

20h – Disables write except 10h, 01h, 00h, 02h and 21h commands

40h – Disables write except 10h, 01h, and 00h commends

80h – Disable write except 0x00h

To save changes on the USER PMBus™ Table:

Use send byte command: 15h STORE_USER_ALL

To save changes on the DEFAULT PMBus™ Table:

Use send byte command: 11h STORE_DEFAULT_ALL

Wait for 5 seconds, turn-off the PSU, wait for another 5 seconds before turning it on.

LCM1000Q-T Support PMBus™ Command List

The LCM1000Q-T is compliant with the industry standard PMBus™ protocol for monitoring and control of the power supply via the I²C interface port.

LCM1000Q-T Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
01h	OPERATION	80	R/W	1	B	Used to turn the unit ON/OFF in conjunction with the input INH_EN pin.
02h	ON_OFF_CONFIG	1E	R	1	B	Configures the combination of INH_EN pin and serial communication commands needed to turn the unit ON/OFF.
03h	CLEAR_FAULTS	-	S	1		
10h	WRITE_PROTECT	80	R/W	1	MSF	Used to Control Writing to the PMBus Device 80h - Disables write except 10h 40h - Disables write except 10h, 01h, 00h 20h - Disables write except 10h,01h,00h,02h and 21h commands 00 -Enables write to all writeable commands.
15h	STORE_USER_ALL	-	S	0		Copies the Operating memory table to the matching USER non-volatile memory.
20h	VOUT_MODE	17	R	1	B	Specifies the mode and parameters of Output Voltage related Data Formats
21h	VOUT_COMMAND	3000	R	2	Linear	Sets the Output Voltage Reference Vout command sends discreet value to change or trim output voltage.
24h	VOUT_MAX	34CC	R	2	Linear	Sets the max adjustable output voltage limit. 26.4V
40h	VOUT_OV_FAULT_LIMIT	40CC	R/W	2	Linear	Sets Output Over voltage threshold. (31V)
41h	VOUT_OV_FAULT_RESPONSE	80	R	1	MSF	Unit Latches OFF. Resets on INH_EN or CONTROL pin recycle or AC recycle.
42h	VOUT_OV_WARN_LIMIT	35DC	R	2	Linear	Sets Over-voltage Warning threshold. (30V)
43h	VOUT_UV_WARN_LIMIT	28CC	R	2	Linear	Sets Under-voltage Warning threshold. (18V)
44h	VOUT_UV_FAULT_LIMIT	2800	R/W	2	Linear	Sets Under-voltage Fault threshold. (15V)
45h	VOUT_UV_FAULT_RESPONSE	80	R	1	MSF	Turn PSU OFF
46h	IOUT_OC_FAULT_LIMIT	EA18	R/W	2	Linear	Sets the Over current threshold in Amps. (67A)
47h	IOUT_OC_FAULT_RESPONSE	C0	R	1	MSF	OCP ride through. If OCP persists.
4Ah	IOUT_OC_WARN_LIMIT	EA03	R	2	Linear	Sets the Over Current Warning threshold in Amps. (64.4A)
4Fh	OT_FAULT_LIMIT	EB80	R	2	Linear	Secondary ambient temperature Fault threshold, in °C. (80 °C)
50h	OT_FAULT_RESPONSE	F8	R	1	MSF	Turn PSU OFF and will retry indefinitely
51h	OT_WARN_LIMIT	EB60	R	2	Linear	Secondary ambient temperature warning threshold, in °C. Operating limit. refer to section 3.1. (108°C)
5Eh	POWER_GOOD_ON	2E00	R	2	Linear	Sets the threshold by which the Power Good signal is asserted. (19V)
5Fh	POWER_GOOD_OFF	2B33	R	2	Linear	Sets the threshold by which the Power Good signal is de-asserted.
60h	TON_DELAY	EB20	R	2	Linear	Sets the time (sec), from start condition (Power ON) until the output starts to rise.

LCM1000Q-T Supported PMBus™ Command List:

Command Code	Command Name	Default Value (HEX)	Access Type	Data Bytes	Data Format	
61h	TON_RISE	DA80	R	2	Linear	Sets the time (ms), for the output rises from 0 to regulation.
64h	TOFF_DELAY	1226	R	2	Linear	Sets the time (ms), from a stop condition (Power OFF) until the output starts to drop (converter OFF).
78h	STATUS_BYTE	00	R	1	Binary	Returns the summary of critical faults
	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 Warning not listed in bits[7:1] has occurred.
79h	STATUS_WORD	0000	R	2	Binary	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.

LCM1000Q-T Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
7Ah	STATUS_VOUT	00	R	1	Binary	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	00	R	1	Binary	Output Current related faults and warnings
	b7					IOUT Over current Fault
	b6					IOUT Over current And Low Voltage shutdown Fault
	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
7Dh	STATUS_TEMPERATURE	00	R	1	Binary	Temperature related faults and warnings
	b7					Overtemperature Fault
	b6					Overtemperature Warning
	b5					Under temperature Warning
	b4					Under temperature Fault
	b3:0					reserved
7Eh	STATUS_CML	00	R	1	Binary	Communications, Logic and Memory
80h	STATUS_MFR_SPECIFIC	0	R	1	Binary	Manufacturer Status codes
88h	READ_VIN	-	R	2	Linear	Returns input Voltage in Volts ac
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	PSU Air inlet temp (inside PSU)
8Eh	READ_TEMPERATURE_2	-	R	2	Linear	PSU Air inlet 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	07, 41, 52, 54, 45, 53, 59, 49	R/W	8	ASCII	ARTESYN
9Ah	MFR_MODEL	4C,43,4D,31, 30, 30, 30, 51	R/W	8	ASCII	LCM1000Q-T
9Bh	MFR_REVISION	06, 41	R/W	2	ASCII	
9Ch	MFR_LOCATION	06,4C,41,47,55,4E,41	R/W	8	ASCII	Laguna
9Dh	MFR_DATE	06,31,34, 30, 39, 31, 38, 41	R/W	8	ASCII	Manufacture Date, ASCII format structure : YYMMDD
9Eh	MFR_SERIAL	0D,4B , 39, 38, 36, 4E, 59, 30	R/W	13	ASCII	13 CHAR

LCM1000Q-T Supported PMBus™ Command List:

Command Code	Command Name	Default Value	Access Type	Data Bytes	Data Format	Description
A0h	MFR_VIN_MIN	EAD0	R	2	Linear	Minimum Input Voltage (90Vac)
A1h	MFR_VIN_MAX	FA10	R	2	Linear	Maximum Input Voltage (264Vac)
A2h	MFR_IIN_MAX	DA60	R	2	Linear	Maximum Input Current (19A)
A4h	MFR_VOUT_MIN	2B33	R	2	Linear	Minimum Output Voltage Regulation Window. (21.6V)
A5h	MFR_VOUT_MAX	34CC	R	2	Linear	Maximum Output Voltage. Regulation Window
A6h	MFR_IOUT_MAX	EA08	R	2	Linear	Maximum Output Current
A7h	MFR_POUT_MAX	0B0C	R	2	Linear	Maximum Output Power (600W for High Line and 1000 For Low Line)
A8h	MFR_TAMBIENT_MAX	EA30	R	2	Linear	Maximum Operating Ambient Temperature (Secondary Ambient) (70 °C)
A9h	MFR_TAMBIENT_MIN	0000	R	2	Linear	Minimum Operating Ambient Temperature (Secondary Ambient) (0 °C)
D5h	Code revision	-	R	8	ASCII	

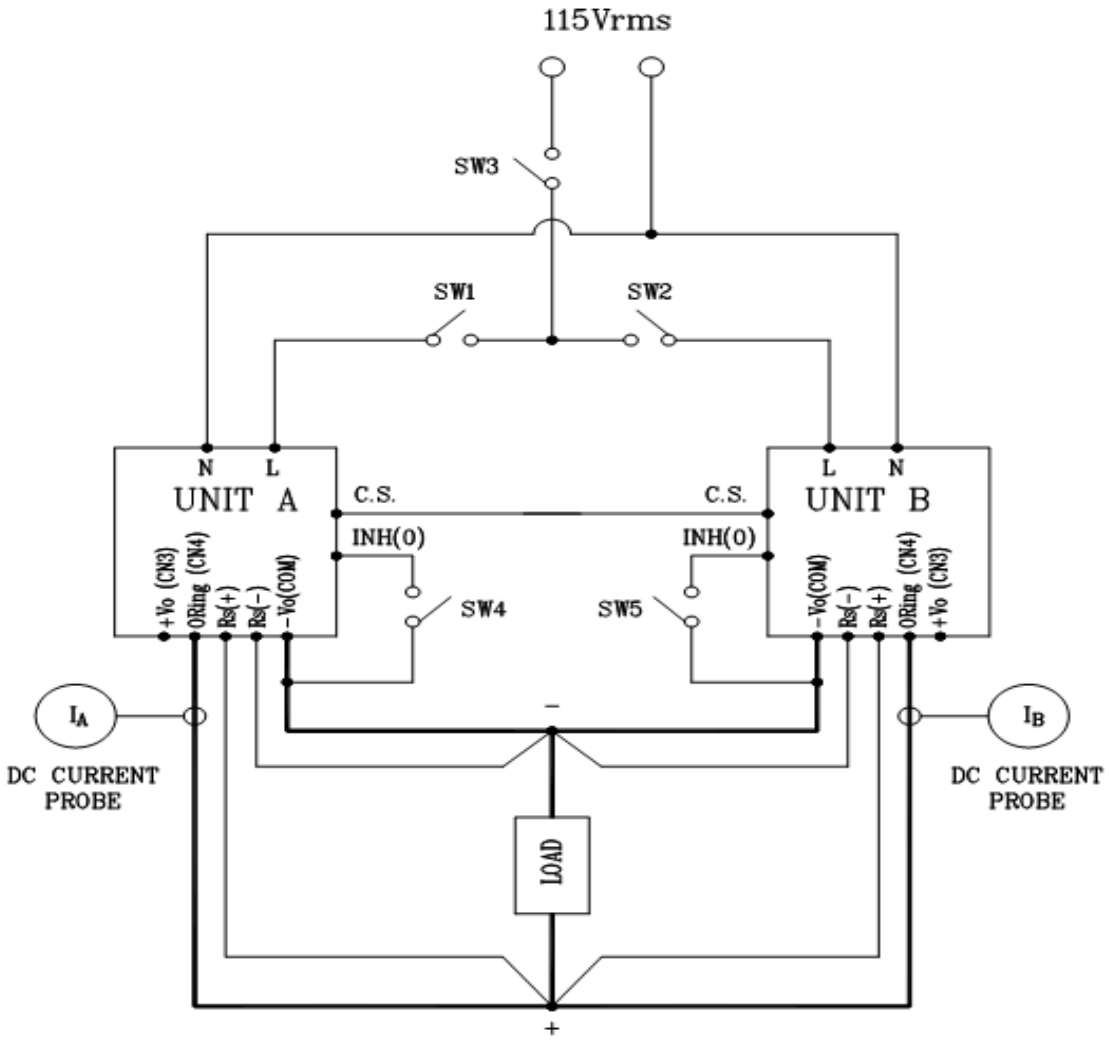
Application Notes

Current Sharing

The LCM1000Q-T main output is equipped with current sharing capability. This will allow up to 10 power supplies to be connected in parallel for higher power application. Current share accuracy is typically 10% of full load. SWP Mode voltage at full load is to be 5.5-6.5Volts and 2.5-3.5Volts at 50% of maximum current. The I^2C Line should be connected separately when the number of units in parallel is more than 8. The minimum load at parallel operation is 1% of the total Output current that the units can deliver.
The table below shows the derated maximum power capacity when units are in parallel configuration. This is to consider the 10% load sharing tolerance.

Number of Units in Parallel (N)	**Maximum Output power** Rated + [(N-1) x 0.9] x Rated, Where: Rated - 1000W, N - Number of PSU in Parallel
Stand-alone	1000W
2	1900W
3	2800W
..	..
....	….
10	9100W

Redundant Operation Connection Diagram



Note 1 Above figure shows connection for two power supply. Similar connection must below followed for higher number of power supplies connected. The maximum number of power supply is 8 power supply connection.

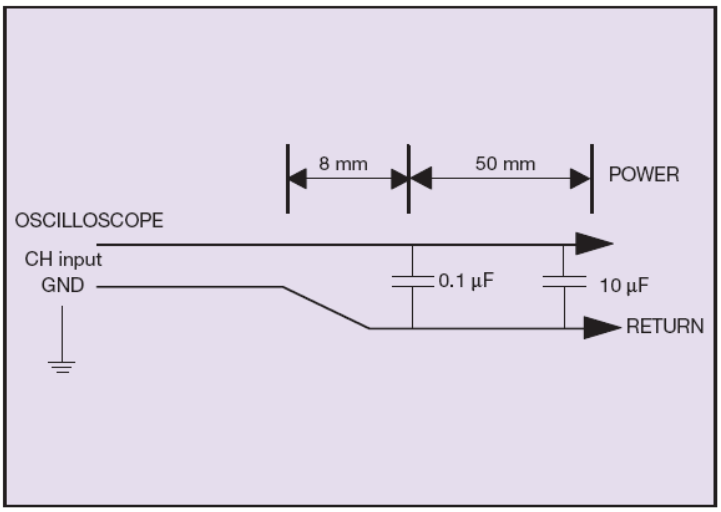
Note 2 PMbus Address should be set unique per power supply.

Note 3 The G_DCOK _C pins and G_ACOK_C pins can be connected together to the system DCOK and ACOK input pins. This can also we wired separately so the system will still continue to operate in case 1 PSU fails. The system should have a 3 separate input for ACOK and DCOK signals.

Note 4 Read I_out per power supply. The reported I-out per power supply should be the same or similar.

Output Ripple and Noise Measurement

The setup outlined in the diagram below has been used for output voltage ripple and noise measurements on the LCM1000Q-T. 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	05.14.2015	First Issue	L. Lee
1.1	10.10.2015	Updated the “EMC” Section	L. Lee
1.2	01.07.2016	Updated the I^2C detail	L. Lee

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