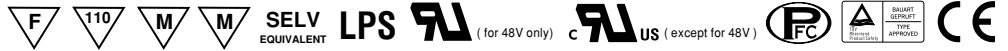




■ Features :

- Universal AC input / Full range
- High efficiency 90%
- Protections: Short circuit / Overload / Over voltage / Over temperature
- Built-in active PFC function
- UL1310 Class 2 power unit
- Pass LPS
- Cooling by free air convection
- 100% full load burn-in test
- High reliability
- Suitable for LED lighting and moving sign applications
- Compliance to worldwide safety regulations for lighting
- 2 years warranty



SPECIFICATION

MODEL	PLC-100-12	PLC-100-15	PLC-100-20	PLC-100-24	PLC-100-27	PLC-100-36	PLC-100-48				
OUTPUT	DC VOLTAGE	12V	15V	20V	24V	27V	36V	48V			
	CONSTANT CURRENT REGION Note.4	9 ~ 12V	11.25 ~ 15V	15 ~ 20V	18 ~ 24V	20.25 ~ 27V	27 ~ 36V	36 ~ 48V			
	RATED CURRENT Note.6	5A	5A	4.8A	4A	3.55A	2.65A	2A			
	CURRENT RANGE Note.6	0 ~ 5A	0 ~ 5A	0 ~ 4.8A	0 ~ 4A	0 ~ 3.55A	0 ~ 2.65A	0 ~ 2A			
	RATED POWER Note.6	60W	75W	96W	96W	95.85W	95.4W	96W			
	RIPPLE & NOISE (max.) Note.2	150mVp-p	150mVp-p	150mVp-p	150mVp-p	150mVp-p	150mVp-p	200mVp-p			
	VOLTAGE ADJ. RANGE(Vo ADJ)	10.2 ~ 12V	12.8 ~ 15V	17 ~ 20V	20.4 ~ 24V	23 ~ 27V	30.6 ~ 36V	40.8 ~ 48V			
	CURRENT ADJ. RANGE(Io ADJ)	3.75 ~ 5A	3.75 ~ 5A	3.6 ~ 4.8A	3 ~ 4A	2.6 ~ 3.55A	2 ~ 2.65A	1.5 ~ 2A			
	VOLTAGE TOLERANCE Note.3	±3.0%	±3.0%	±3.0%	±3.0%	±3.0%	±2.0%	±2.0%			
	LINE REGULATION	±1.0%									
LOAD REGULATION	±2.0%										
SETUP, RISE TIME	1200ms, 80ms/230VAC 1200ms, 80ms/115VAC at full load										
HOLD UP TIME (Typ.)	60ms/230VAC 30ms/115VAC at full load										
INPUT	VOLTAGE RANGE Note.5	90 ~ 264VAC		127 ~ 370VDC							
	FREQUENCY RANGE	47 ~ 63Hz									
	POWER FACTOR (Typ.)	PF>0.95/230VAC		PF>0.95/115VAC at full load		PF≥0.9 at 75 ~ 100% load					
	EFFICIENCY (Typ.)	84.5%	86.5%	90%	90%	90%	89%				
	AC CURRENT (Typ.)	12V:0.8A/115VAC	0.4A/230VAC	15V:0.9A/115VAC	0.45A/230VAC	20V ~ 48V:1.1A/115VAC	0.55A/230VAC				
	INRUSH CURRENT (Typ.)	COLD START 40A/230VAC									
LEAKAGE CURRENT	<0.75mA / 240VAC										
PROTECTION	OVER CURRENT (Typ.) Note.4	95 ~ 102%									
	OVER VOLTAGE	Protection type : Constant current limiting, recovers automatically after fault condition is removed		13 ~ 16V		16.5 ~ 20V	22 ~ 27V	27 ~ 34V	30 ~ 36V	39 ~ 48V	52 ~ 64V
	OVER TEMPERATURE	90°C ±10°C (RTH2)		Protection type : Shut down o/p voltage, re-power on to recover							
ENVIRONMENT	WORKING TEMP.	-30 ~ +50°C (Refer to output load derating curve)									
	WORKING HUMIDITY	20 ~ 95% RH non-condensing									
	STORAGE TEMP., HUMIDITY	-40 ~ +80°C, 10 ~ 95% RH									
	TEMP. COEFFICIENT	±0.03%/°C (0 ~ 50°C)									
	VIBRATION	10 ~ 500Hz, 2G 12min./1cycle, period for 72min. each along X, Y, Z axes									
SAFETY & EMC	SAFETY STANDARDS Note.7	UL1310 Class 2, TUV EN60950-1, EN61347-1, EN61347-2-13, CAN/CSA C22.2 No. 223-M91(except for 48V) approved									
	WITHSTAND VOLTAGE	I/P-O/P:3.75KVAC I/P-FG:1.88KVAC O/P-FG:0.5KVAC									
	ISOLATION RESISTANCE	I/P-O/P, I/P-FG, O/P-FG:100M Ohms / 500VDC / 25°C / 70% RH									
	EMI CONDUCTION & RADIATION	Compliance to EN55015, EN55022 (CISPR22) Class B									
	HARMONIC CURRENT	Compliance to EN61000-3-2,-3, Class C (≥70% load) ; EN61000-3-3									
	EMS IMMUNITY	Compliance to EN61000-4-2,3,4,5,6,8,11; ENV50204, EN61547, EN55024, light industry level, (surge 4KV), criteria A									
OTHERS	MTBF	297.9Khrs min. MIL-HDBK-217F (25°C)									
	DIMENSION	200.5*69.5*35mm (L*W*H)									
	PACKING	0.52Kg; 25pcs/14Kg/0.65CUFT									

NOTE

1. All parameters NOT specially mentioned are measured at 230VAC input, rated load and 25°C of ambient temperature.
2. Ripple & noise are measured at 20MHz of bandwidth by using a 12" twisted pair-wire terminated with a 0.1uf & 47uf parallel capacitor.
3. Tolerance : includes set up tolerance, line regulation and load regulation.
4. Constant current operation region is within 75% ~ 100% rated output voltage. This is the suitable operation region for LED related applications, but please reconfirm special electrical requirements for some specific design.
5. Derating may be needed under low input voltage. Please check the static characteristics for more details.
6. This is the maximum possible output current and power. Over load protection may be activated slightly below this level to comply with the requirement of UL1310 class 2.
7. Safety and EMC design refer to EN60598-1, subject 8750(UL), CNS15233, GB7000.1, FCC part18.
8. The power supply is considered as a component that will be operated in combination with final equipment. Since EMC performance will be affected by the complete installation, the final equipment manufacturers must re-qualify EMC Directive on the complete installation again.

MODEL : PLC-100-20

### OUTPUT FUNCTION TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	RIPPLE & NOISE	V1 : 150 mVp-p (Max)	I/P : 230VAC O/P : FULL LOAD Ta : 25°C	V1 : 24 mVp-p (Max)	P
2	OUTPUT VOLTAGE ADJUST RANGE	CH1 : 17 V~ 20 V	I/P : 230 VAC I/P : 115 VAC O/P : MIN LOAD Ta : 25°C	16.21 V~ 20.42 V/ 230 VAC 16.21 V~ 20.42 V/ 115 VAC	P
3	OUTPUT CURRENT ADJUST RANGE	CH1 : 3.6 A~ 4.8 A	I/P : 230 VAC I/P : 115 VAC Ta : 25°C	3.06 A~ 5.596 A/230V 3.09 A~ 5.578 A/115V	P
4	CONSTANT CURRENT REGION	CH1 : 14 ~ 20V	I/P : 230VAC I/P : 115VAC O/P : FULL LOAD Ta : 25°C	9.56 V~ 20 V/230V 9.56 V~ 20 V/115V	P
5	OUTPUT VOLTAGE TOLERANCE	V1 : 3% ~ -3% (Max)	I/P : 100 VAC / 264 VAC O/P : FULL/ MIN LOAD Ta : 25°C	V1 : 2% ~ -2%	P
6	LINE REGULATION	V1 : 1% ~ -1% (Max)	I/P : 100 VAC ~ 264 VAC O/P : FULL LOAD Ta : 25°C	V1 : 0.06% ~ -0.06%	P
7	LOAD REGULATION	V1 : 2% ~ -2% (Max)	I/P : 230 VAC O/P : FULL ~MIN LOAD Ta : 25°C	V1 : 0.6% ~ -0.6%	P
8	SET UP TIME	230VAC : 1200 ms (Max) 115 VAC : 1200 ms (Max)	I/P : 230 VAC I/P : 115 VAC O/P : FULL LOAD Ta : 25°C	230VAC/ 786 ms 115VAC/ 779 ms	P
9	RISE TIME	230VAC : 80 ms (Max) 115VAC : 80 ms (Max)	I/P : 230 VAC I/P : 115 VAC O/P : FULL LOAD Ta : 25°C	230VAC/ 7 ms 115VAC/ 7 ms	P
10	HOLD UP TIME	230VAC : 60 ms 115VAC : 30 ms	I/P : 230 VAC I/P : 115 VAC O/P : FULL LOAD Ta : 25°C	230VAC/ 109 ms 115VAC/ 35 ms	P
11	OVER/UNDERSHOOT TEST	< ±5%	I/P : 230 VAC O/P : FULL LOAD Ta : 25°C	TEST : < 5%	P
12	DYNAMIC LOAD	V1 : 2000 mVp-p	I/P : 230 VAC O/P : FULL /Min LOAD 90%DUTY/1KHZ Ta : 25°C	782 mVp-p	P

## INPUT FUNCTION TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	INPUT VOLTAGE RANGE	90VAC~264 VAC	I/P : TESTING O/P : FULL LOAD Ta : 25°C	52V~264V	P
			I/P : LOW-LINE-3V= 97 V HIGH-LINE+15%=300 V O/P : FULL/MIN LOAD ON : 30 Sec . OFF : 30 Sec 10MIN ( AC POWER ON/OFF NO DAMAGE )	TEST : OK	
2	INPUT FREQUENCY RANGE	47HZ ~63 HZ NO DAMAGE OSC	I/P : 100VAC ~ 264 VAC O/P : FULL-MIN LOAD Ta : 25°C	TEST : OK	P
3	POWER FACTOR	0.95 / 230 VAC 0.95 / 115 VAC PF ≥ 0.9 at 75 ~ 100% load	I/P : 230 VAC I/P : 115 VAC O/P : FULL LOAD Ta : 25°C	PF= 0.979 / 230 VAC PF= 0.983 / 115 VAC PF ≥ 0.9 at 75 ~ 100% load	P
4	EFFICIENCY	89% (TYP)	I/P : 230 VAC O/P : FULL LOAD Ta : 25°C	91%	P
5	INPUT CURRENT	230V/ 0.55 A (TYP) 115V/ 1.1 A (TYP)	I/P : 230 VAC I/P : 115 VAC O/P : FULL LOAD Ta : 25°C	I = 0.47 A/ 230 VAC I = 0.94 A/ 115 VAC	P
6	INRUSH CURRENT	230V/ 40 A (TYP)  COLD START	I/P : 230 VAC O/P : FULL LOAD Ta : 25°C	I = 32 A/ 230 VAC	P
7	LEAKAGE CURRENT	< 0.75 mA/ 240 VAC	I/P : 264 VAC O/P : Min LOAD Ta : 25°C	L-FG : 0.42 mA N-FG : 0.40 mA	P

## PROTECTION FUNCTION TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	OVER LOAD PROTECTION	95 %~ 102 %	I/P : 230 VAC I/P : 115 VAC O/P : TESTING Ta : 25°C	100.2%/ 230 VAC 100.2%/ 115 VAC Constant Current Limiting	P
2	OVER VOLTAGE PROTECTION	CH1 : 22 V~ 27 V	I/P : 230 VAC I/P : 115 VAC O/P : MIN LOAD Ta : 25°C	25.36V/ 230 VAC 25.39V/ 115 VAC Constant current limiting, recovers automatically after fault condition is removed	P
3	OVER TEMPERATURE PROTECTION	SPEC : RTH2 : 90 ± 10°C O.T.P. NO DAMAGE	I/P : 230 VAC O/P : FULL LOAD	O.T.P. Active Shut down Re-power ON	P
4	SHORT PROTECTION	SHORT EVERY OUTPUT 1 HOUR NO DAMAGE	I/P : 264 VAC O/P : FULL LOAD Ta : 25°C	NO DAMAGE Constant Current Limiting	P

## ENVIRONMENT TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT																																																																																																									
1	TEMPERATURE RISE TEST	MODEL : PLC-100-24 1. ROOM AMBIENT BURN-IN : 1.5 HRS I/P : 230VAC O/P : FULL LOAD Ta= 31 °C 2. HIGH AMBIENT BURN-IN : 13.5 HRS I/P : 230VAC O/P : FULL LOAD Ta= 56.6 °C			P																																																																																																									
		<table border="1"> <thead> <tr> <th>NO</th> <th>Position</th> <th>P/N</th> <th>ROOM AMBIENT Ta= 31 °C</th> <th>HIGH AMBIENT Ta= 56.6 °C</th> </tr> </thead> <tbody> <tr><td>1</td><td>LF3</td><td>TR689</td><td>68.4°C</td><td>89.4°C</td></tr> <tr><td>2</td><td>BD1</td><td>4A/800V US4KB80R-7000</td><td>73.3°C</td><td>93.7°C</td></tr> <tr><td>3</td><td>L1</td><td>TR623</td><td>74.4°C</td><td>94.5°C</td></tr> <tr><td>4</td><td>L2</td><td>TF1356-R1 155°C</td><td>60.6°C</td><td>70.8°C</td></tr> <tr><td>5</td><td>C5</td><td>150u/400V 105°C 18*35.5 KMG</td><td>77.7°C</td><td>97.8°C</td></tr> <tr><td>6</td><td>D2</td><td>RD 1A/1KV 1N4007GP</td><td>96.7°C</td><td>117.3°C</td></tr> <tr><td>7</td><td>T1</td><td>MT TF1492-R9</td><td>85.7°C</td><td>106.2°C</td></tr> <tr><td>8</td><td>Q1</td><td>SPA11N65C3 11A/650V TO220F</td><td>65.3°C</td><td>105.0°C</td></tr> <tr><td>9</td><td>U1</td><td>TDA4863G PG</td><td>79.3°C</td><td>98.9°C</td></tr> <tr><td>10</td><td>C42</td><td>47u/63V L7Kh 8*11.5 YXF</td><td>76.8°C</td><td>96.5°C</td></tr> <tr><td>11</td><td>Q2</td><td>2SK3683-01MR 19A/500V</td><td>78.8°C</td><td>99.0°C</td></tr> <tr><td>12</td><td>U2</td><td>TEA1552 SOT108-1</td><td>75.1°C</td><td>94.3°C</td></tr> <tr><td>13</td><td>RTH2</td><td>NTC 220KΩ 3Φ 1%</td><td>70.2°C</td><td>90.0°C</td></tr> <tr><td>14</td><td>C55</td><td>22u/50V L5Kh 5*11 KY</td><td>76.8°C</td><td>96.6°C</td></tr> <tr><td>15</td><td>C120</td><td>22u/50V L5Kh 5*11 KY</td><td>80.1°C</td><td>101.1°C</td></tr> <tr><td>16</td><td>L100</td><td>TR624</td><td>87.4°C</td><td>110.0°C</td></tr> <tr><td>17</td><td>Q101</td><td>IRF3415 43A/150V TO220</td><td>84.8°C</td><td>109.6°C</td></tr> <tr><td>18</td><td>C105</td><td>680u/35V UL10Kh 12.5*20 KY</td><td>78.5°C</td><td>100.2°C</td></tr> <tr><td>19</td><td>C106</td><td>470u/35V UL7Kh 10*20 KY</td><td>79.2°C</td><td>101.3°C</td></tr> <tr><td>22</td><td>CASE</td><td>UP CASE</td><td>58.7°C</td><td>80.1°C</td></tr> </tbody> </table>	NO	Position		P/N	ROOM AMBIENT Ta= 31 °C	HIGH AMBIENT Ta= 56.6 °C	1	LF3	TR689	68.4°C	89.4°C	2	BD1	4A/800V US4KB80R-7000	73.3°C	93.7°C	3	L1	TR623	74.4°C	94.5°C	4	L2	TF1356-R1 155°C	60.6°C	70.8°C	5	C5	150u/400V 105°C 18*35.5 KMG	77.7°C	97.8°C	6	D2	RD 1A/1KV 1N4007GP	96.7°C	117.3°C	7	T1	MT TF1492-R9	85.7°C	106.2°C	8	Q1	SPA11N65C3 11A/650V TO220F	65.3°C	105.0°C	9	U1	TDA4863G PG	79.3°C	98.9°C	10	C42	47u/63V L7Kh 8*11.5 YXF	76.8°C	96.5°C	11	Q2	2SK3683-01MR 19A/500V	78.8°C	99.0°C	12	U2	TEA1552 SOT108-1	75.1°C	94.3°C	13	RTH2	NTC 220KΩ 3Φ 1%	70.2°C	90.0°C	14	C55	22u/50V L5Kh 5*11 KY	76.8°C	96.6°C	15	C120	22u/50V L5Kh 5*11 KY	80.1°C	101.1°C	16	L100	TR624	87.4°C	110.0°C	17	Q101	IRF3415 43A/150V TO220	84.8°C	109.6°C	18	C105	680u/35V UL10Kh 12.5*20 KY	78.5°C	100.2°C	19	C106	470u/35V UL7Kh 10*20 KY	79.2°C	101.3°C	22	CASE	UP CASE	58.7°C	80.1°C		
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2	LOW TEMPERATURE TURN ON TEST	TURN ON AFTER 2 HOUR	I/P : 230 VAC O/P : CV=23 V LOAD Ta= -30 °C	TEST : OK	P																																																																																																									
3	HIGH HUMIDITY HIGH TEMPERATURE HIGH VOLTAGE TURN ON TEST	AFTER 12 HOURS IN CHAMBER ON CONTROL 40 °C NO DAMAGE	I/P : 272 VAC O/P : FULL LOAD Ta= 40 °C HUMIDITY= 95 %R.H	TEST : OK	P																																																																																																									
4	TEMPERATURE COEFFICIENT	± 0.03 %(0~50°C)	I/P : 230 VAC O/P : FULL LOAD	± 0.004 %(0~50°C)	P																																																																																																									
5	VIBRATION TEST	1 Carton & 1 Set (1) Waveform : Sine Wave (2) Frequency : 10~500Hz (3) Sweep Time : 12min/sweep cycle (4) Acceleration : 2G (5) Test Time : 1 hour in each axis (X.Y.Z) (6) Ta : 25°C		TEST : OK	P																																																																																																									

### SAFETY TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	WITHSTAND VOLTAGE	I/P-O/P : 3.75 KVAC/min I/P-FG : 1.88 KVAC/min O/P-FG : 0.5 KVAC/min	I/P-O/P : 4.5 KVAC/min I/P-FG : 2.256 KVAC/min O/P-FG : 0.6 KVAC/min Ta : 25°C	I/P-O/P : 5.95 mA I/P-FG : 4.85 mA O/P-FG : 2.630 mA NO DAMAGE	P
2	ISOLATION RESISTANCE	I/P-O/P : 500VDC>100MΩ I/P-FG : 500VDC>100MΩ O/P-FG : 500VDC>100MΩ	I/P-O/P : 500 VDC I/P-FG : 500 VDC O/P-FG : 500 VDC Ta : 25°C / 70%RH	I/P-O/P : 30 GΩ I/P-FG : 30 GΩ O/P-FG : 30 GΩ NO DAMAGE	P
3	GROUNDING CONTINUITY	FG(PE) TO CHASSIS OR TRACE < 100 mΩ	40 A / 2min Ta : 25°C / 70%RH	36 mΩ	P
4	APPROVAL	TUV : Certificate NO : UL : File NO :			N/A

### E.M.C TEST

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	HARMONIC	EN61000-3-2 CLASS C	I/P : 230 /240/220VAC/50HZ O/P : 100%75% 50%LOAD Ta : 25°C	PASS	P
2	CONDUCTION	EN55022 EN55015 CLASS B	I/P : 230 VAC (50HZ) O/P : FULL/50% LOAD Ta : 25°C	PASS Test by certified Lab	P
3	RADIATION	EN55022 EN55015 CLASS B	I/P : 230 VAC (50HZ) O/P : FULL LOAD Ta : 25°C	PASS Test by certified Lab	P
4	Test by certified Lab & Test Report Prepare				

### M.T.B.F & LIFE CYCLE CALCULATION

NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	CAPACITOR LIFE CYCLE	PLC-100-24 : SUPPOSE C105 IS THE MOST CRITICAL COMPONENT I/P : 230VAC O/P : FULL LOAD Ta= 25 °C LIFE TIME= 104610 HRS I/P : 230VAC O/P : FULL LOAD Ta= 40 °C LIFE TIME=48510 HRS			P
2	MTBF	MIL-HDBK-217F NOTICES2 PARTS COUNT TOTAL FAILURE RATE : 297.9K HRS			P
3	ORT (Ongoing Reliability test)	PLC-100-12:I/P : 230VAC O/P : 60% LOAD TA=50°C Sample=5pcs TEST TIME=2208HRS			P



## COMPONENT STRESS TEST

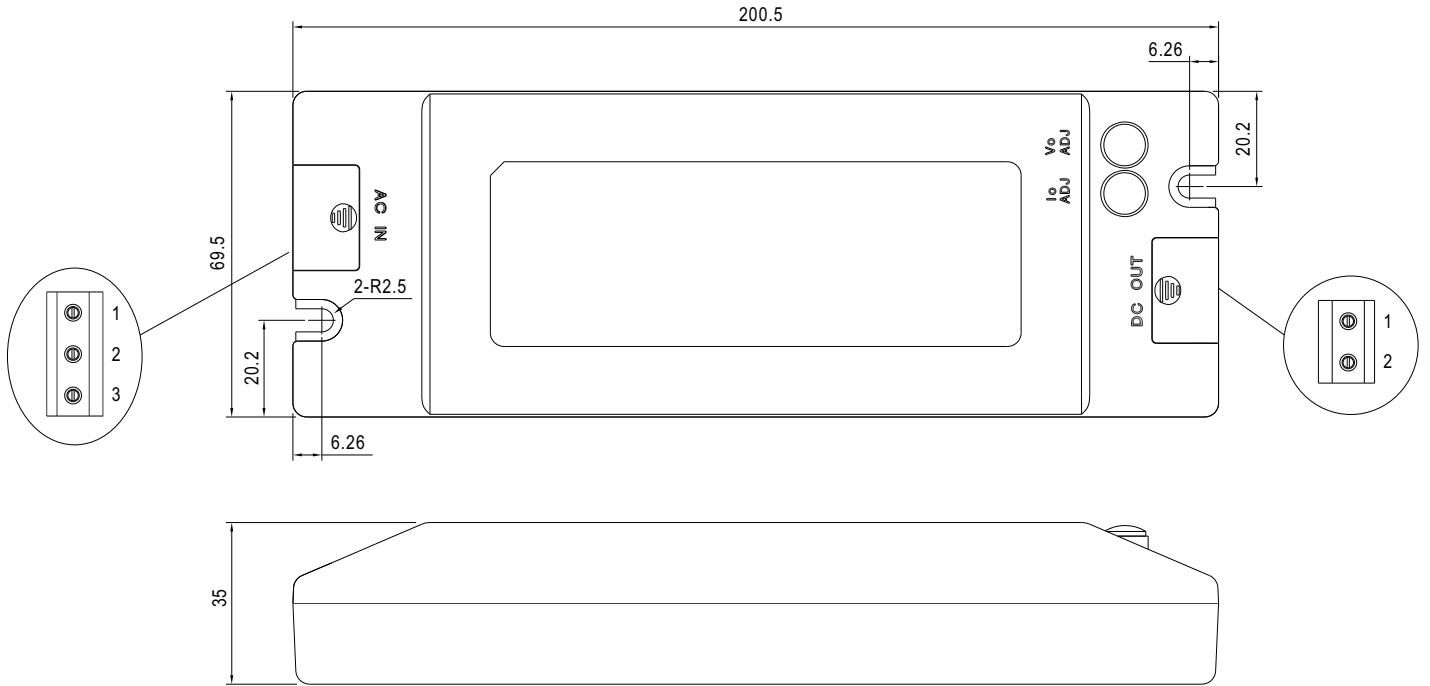
NO	TEST ITEM	SPECIFICATION	TEST CONDITION	RESULT	VERDICT
1	Power Transistor ( D to S) or (C to E) Peak Voltage	Q 1 Rated SPA11N65C3 11A/650V	I/P : High-Line +3V = 267 V O/P : (1)Full Load Turn on (2) Output Short Ta : 25°C	(1) 576 V (2) 526 V	P
2	Diode Peak Voltage	Q100 Rated STP80NF12 80A/120V	I/P : High-Line +3V = 267 V O/P : (1)Full Load Turn on (2)Output Short Ta : 25°C	(1) 107 V (2) 80.4 V	P
3	Clamp Diode Peak Voltage	D2 Rated 1A/1KV 1N4007GP	I/P : High-Line +3V = 267 V O/P : (1) Dynamic Load 90%Duty/1KHz Ta : 25°C	(1) 492 V	P
4	Input Capacitor Voltage	C5 Rated 150u/400V 105°C 1 KMG	I/P : High-Line +3V = 267 V O/P : (1)Full Load Turn on /Off (2) Min load Turn on /Off (3)Full Load /Min load Change Ta : 25°C	(1) 384.3 V (2) 384.7 V (3) 384.7 V	P
5	Control IC Voltage Test	U2 Rated TEA1552: 9.3V ~20V	I/P : High-Line +3V = 267 V O/P : (1)Full Load Turn on /Off (2) Min load Turn on /Off (3)Full Load /Min load Change Ta : 25°C	(1) 17.125 V (2) 12.72 V (3) 12.72 V	P

DATE	SAMPLE	TEST RESULT	TESTER	APPROVAL
2008/11/27	RD SAMPLE	PASS	SANFORD SU	VINCENT TSENG
2009/3/31	PRODUCT SAMPLE W0901D33	PASS	SANFORD SU	VINCENT TSENG

2003/12/12 A50-F023

### Mechanical Specification

Case No.981A Unit:mm



Terminal Pin No. Assignment (TB1):  
SWITCLAB MB310-75003

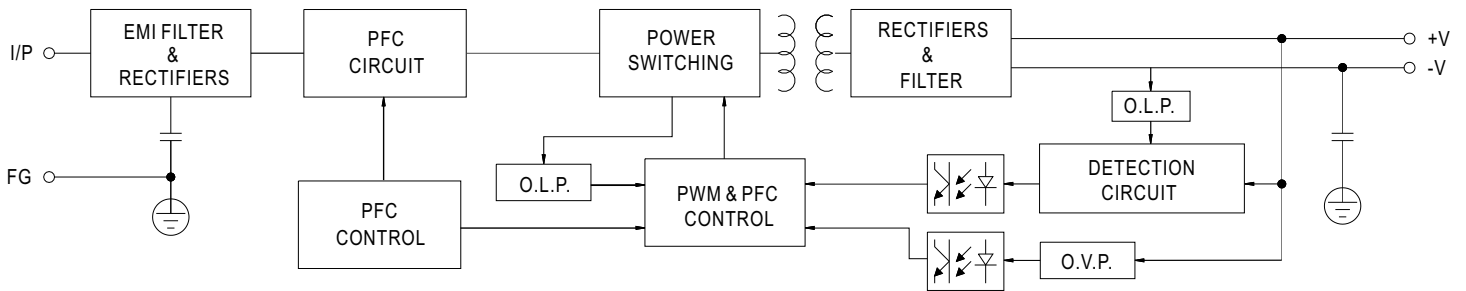
Pin No.	Assignment
1	FG ⊕
2	AC/N
3	AC/L

Terminal Pin No. Assignment (TB2):  
SWITCLAB MB310-75002

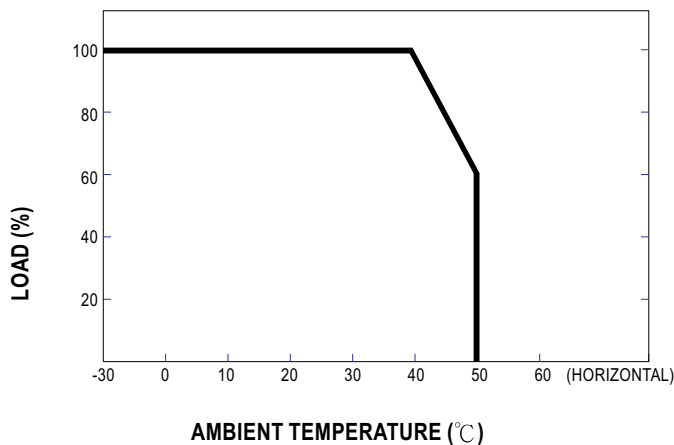
Pin No.	Assignment
1	+V
2	-V

### Block Diagram

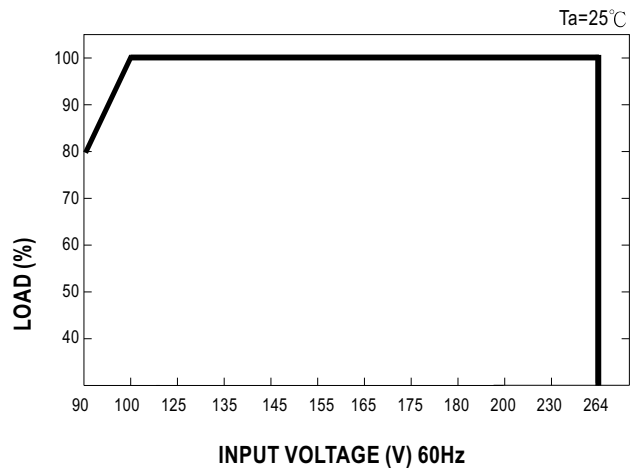
Fosc : 100KHz



### Derating Curve



### Static Characteristics

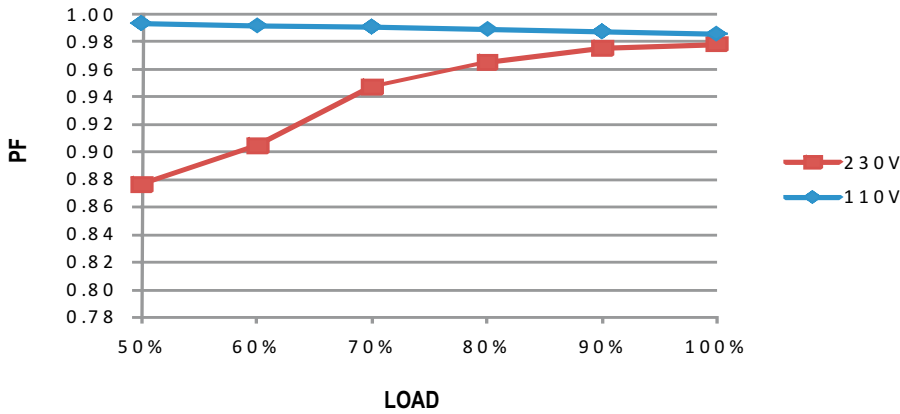




**Power Factor Characteristic**

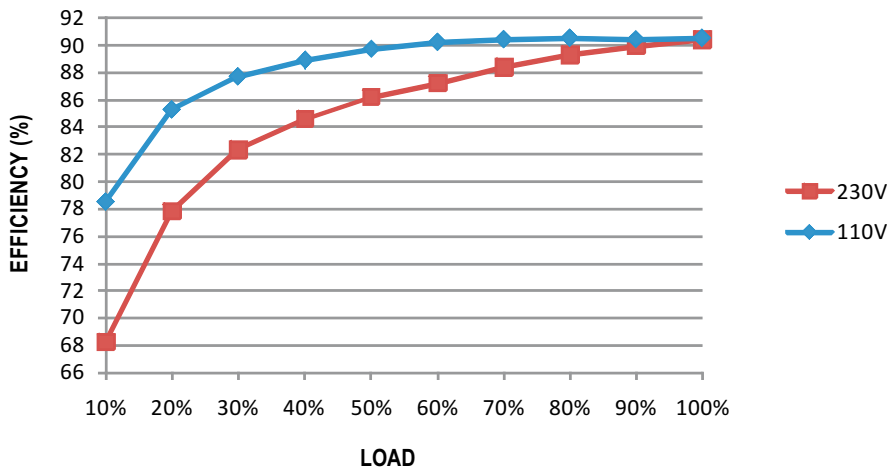
Power factor will be higher than 0.9 when output loading is 75% or higher.

**Constant Current Mode**



**EFFICIENCY vs LOAD (48V Model)**

PLC-100 series possess superior working efficiency that up to 91% can be reached in field applications.

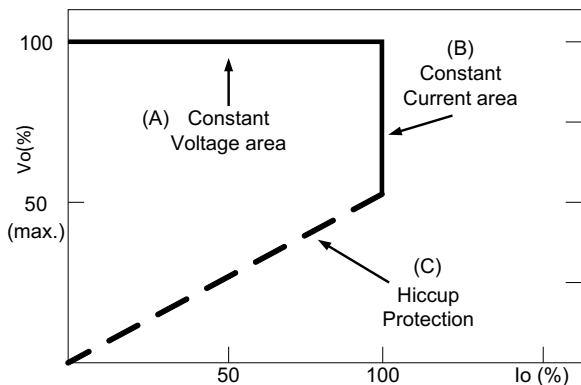


**DRIVING METHODS OF LED MODULE**

There are two major kinds of LED drive method "direct drive" and "with LED driver".

A typical LED power supply may either work in "constant voltage mode (CV) or constant current mode (CC)" to drive the LEDs.

Mean Well's LED power supply with CV+ CC characteristic can be operated at both CV mode [with LED driver, at area (A)] and CC mode [direct drive, at area (B)].



Typical LED power supply I-V curve