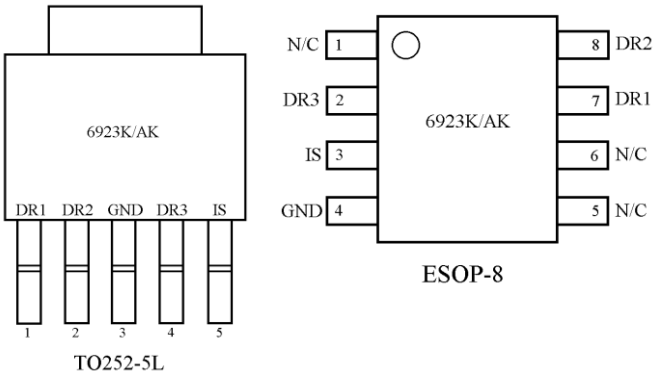
GENERAL DESCRIPTION

6923K/AK is a special current regulator to drive HV LED. Few external components design is very flexible in many compact size applications.

6923K/AK supports maximum 400V input voltage that ensures the high reliability for HV LED lighting. LED open/short is protected by 6923K/AK. The high voltage will be absorbed by 6923K/AK itself. LEDs will never face high voltage problem.

6923K/AK has integrated temperature compensation function. When internal junction temperature is higher than 130°C, 6923K/AK will decrease the output current linearly. The output current will be zero when internal junction temperature reaches 150°C. This protection method effectively avoids the flicker problem during abnormal environment temperature.

PIN CONFIGURATION



FEATURES

- 5V to 400V Operating Voltage
- Maximum 60mA Output Current
- ±5% Current Accuracy
- Proprietary 3-Segment Driving Technology
- Low THDI
- High Power Factor up to 98%
- High Efficiency
- Few External Components
- Electrical Capacitor Needless
- TRIAC Dimming Compatible (for 6923K only)
- LED Open/Short Protection
- Temperature Compensation
  When T_J > 130°C, output current will be decreased.
  Output current will be zero when T_J = 150°C
- TO-252-5L Package
- ESOP-8 Package

APPLICATIONS

- LED Bulb
- LED Tube Lamp
- Compact Size LED Lighting

TYPICAL APPLICATION

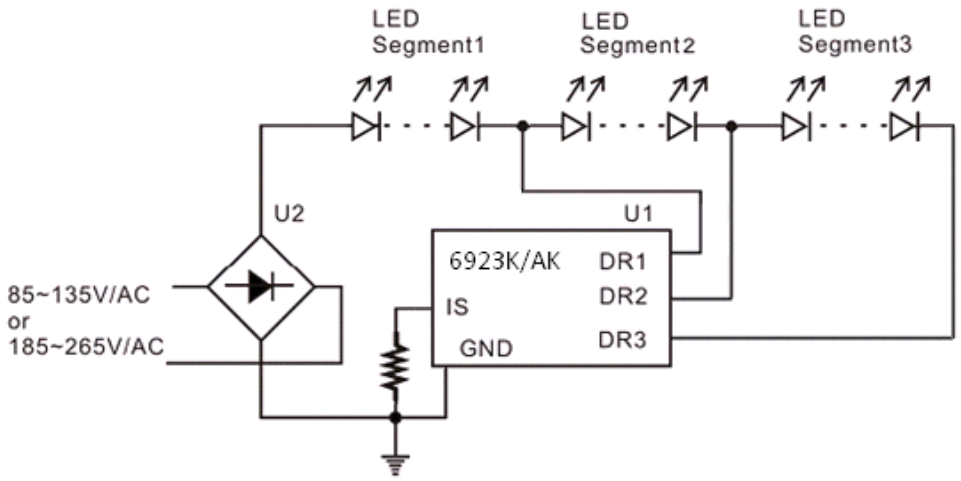


Fig. 1

PIN DESCRIPTION

TO-252-5L

Pin Number	Pin Name	Pin Function
1	DR1	IC Power Supply and Drain of the First Switch, use in Combination with V_{IN}
2	DR2	Drain of the Second Switch
3	GND	Ground
4	DR3	Drain of the Third Switch
5	IS	Output Current Setting. The Output Current is programmable with a resistor across IS pin and IC GND pin

ESOP-8

Pin Number	Pin Name	Pin Function
1	N/C	
2	DR3	Drain of the Third Switch
3	IS	Output Current Setting. The Output Current is programmable with a resistor across IS pin and IC GND pin
4	GND	IC Ground
5	N/C	
6	N/C	
7	DR1	IC Power Supply and Drain of the Switch, use in Combination with V_{IN}
8	DR2	Drain of the Second Switch

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Ratings	Unit
Pin DR1, DR2, DR3 to GND	V_{DR}	-0.3 to +600	V
Pin IS to GND	V_{IS}	-0.3 to +5.0	
Maximum Output Current	I_{OUT}	100	mA
Junction Temperature	T_J	125	°C
Operating Ambient Temperature Range	T_A	-40 to +105	
Storage Temperature Range	T_{STG}	-40 to +150	
Continuous Power Dissipation, T_A=25°C	P_{TOT}	2.0	W
Electrostatic Discharge (ESD), HBM	$V_{(ESD)}$	2.0	kV

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Ratings	Unit
Input Supply Voltage Range	V_{DR}	5 to +370	V
Operating Ambient Temperature Range	T_A	0 to +85	°C

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, T_A = 25 °C)

Parameter		Symbol	Conditions	Min	Typ	Max	Unit
Input Supply Voltage Range		V_{DR}		5.0		400	V
Input Active Current		I_{AC}	V_{DR1}=30V, DR2, DR3 Floating, IS Floating		300		µA
IS Threshold Voltage	6923K	V_{IS1}	V_{DR1}=30V, DR2, DR3 Floating, R_{IS} = 1KΩ	95	100	105	mV
		V_{IS2}	V_{DR1}=V_{DR2}=30V, DR3 Floating, R_{IS} = 1KΩ	190	200	210	
		V_{IS3}	V_{DR1}=V_{DR2}=V_{DR3}=30V, R_{IS} = 1KΩ	285	300	315	
	6923AK	V_{IS1}	V_{DR1}=30V, DR2, DR3 Floating, R_{IS} = 1KΩ	247	260	273	
		V_{IS2}	V_{DR1}=V_{DR2}=30V, DR3 Floating, R_{IS} = 1KΩ	266	280	294	
		V_{IS3}	V_{DR1}=V_{DR2}=V_{DR3}=30V, R_{IS} = 1KΩ	285	300	315	
IS Threshold Voltage Line Regulation		ΔV_{IS}	V_{DR1}=V_{DR2}=V_{DR3}=5 to 30V, R_{IS} = 1KΩ			1.0	%
Voltage Drop of Internal Switch		V_{DRD}	I_{DRX} = 60mA	12			V
Output Current Range		I_{OUTR}		1		60	mA
Temperature Compensation Threshold		T_{TRIG}		120	130	140	°C
Temperature Coefficient of IS Voltage after T_{TRIG}	6923K	K_T			-20		mV/°C
	6923AK				-15		

FUNCTIONAL DESCRIPTION/OPERATION

OPERATION

The 6923K/AK is conveniently used for HV LED or LED string application. Referring to the typical application, the LED string constitutes three separated segments which are controlled apart by DR1, DR2, DR3. The three LED segments work subsequently with increasing AC input voltage. While the AC input voltage dropping, DR3 will be off firstly. Then, DR2, DR1 will be off following the continuously dropping AC input voltage. The input current will change with input voltage. That is to say, the LED loading will be more like a resistive loading. Higher power factor and low THDI will be got easily by this topology.

OUTPUT CURRENT 6923K

The output current is set by the resistor across IS and GND. For 3-segments application, the output current flowing through DR1 can be calculated as following equation.

$$I_{DR1} = \frac{100mV}{R_{IS}}$$

The output current flowing through DR2 and DR3 is controlled by internal circuit. It will keep the fixed ratio with DR1. While the I_{DR2} is twice of I_{DR1}, and I_{DR3} is three times of I_{DR1}.

OUTPUT CURRENT 6923AK

The output current is set by the resistor across IS and GND. For 3-segments application, the internal reference of 1st segment is 260mV and the output current flowing through DR1 can be calculated as following equation.

$$I_{DR1} = \frac{260mV}{R_{IS}}$$

The output current flowing through DR2 and DR3 is controlled by internal circuit. The references are 280mV and 300mV, and the I_{DR2}, I_{DR3} are shown as following equations.

$$I_{DR2} = \frac{280mV}{R_{IS}} \quad I_{DR3} = \frac{300mV}{R_{IS}}$$

TEMPERATURE COMPENSATION

The 6923K/AK integrates temperature compensation function. When the internal junction temperature is higher than 130°C typically, the IS threshold voltage will decrease by 20 mV/°C for 6923K and 15 mV/°C for 6923AK. Normally, the output current will be zero if the junction temperature rises up to 150°C.
This function is useful when environment temperature is abnormal high. 6923K/AK will try to reduce the environment temperature by reducing the LED current. The temperature will be balanced at some level if the abnormal condition is not removed. The device will be protected and flicker doesn't happen.

LED SHORT PROTECTION

The worst case is one of the LED segments shorted with two terminals. 6923K/AK will still try to regulate constant current. But the voltage across DR3 will be very high. The internal junction temperature will be increased because of higher power dissipation. 6923K/AK will work in temperature compensation mode. It means that LED short protection is realized by temperature compensation.

LED OPEN PROTECTION

The 6923K/AK provides LED open protection function. If the LED segment 1 is open, IC will be shut-down without power supply. If the LED segment 2 is open, there isn't current flowing through LED segment 3. The voltage across DR1 will be very high; this will cause 6923K/AK working into temperature compensation mode. If the LED segment 3 is open, the voltage across DR2 will be very high. Similarly, 6923K/AK will work into temperature compensation mode.

BLOCK DIAGRAM

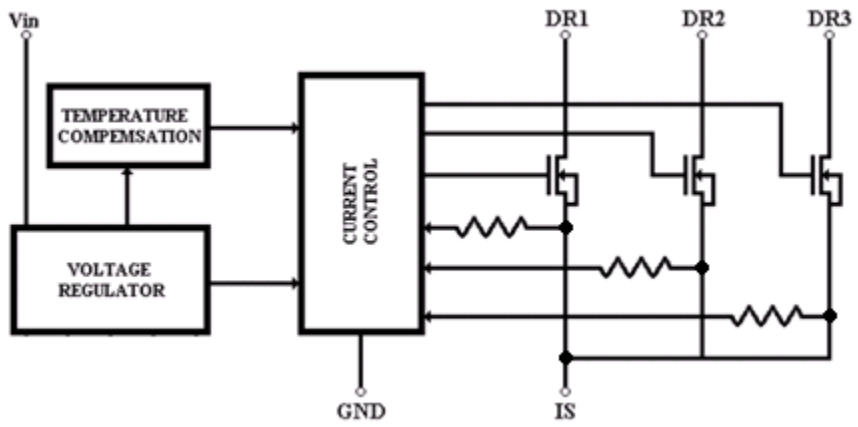


Fig. 2. Block diagram

APPLICATION NOTES

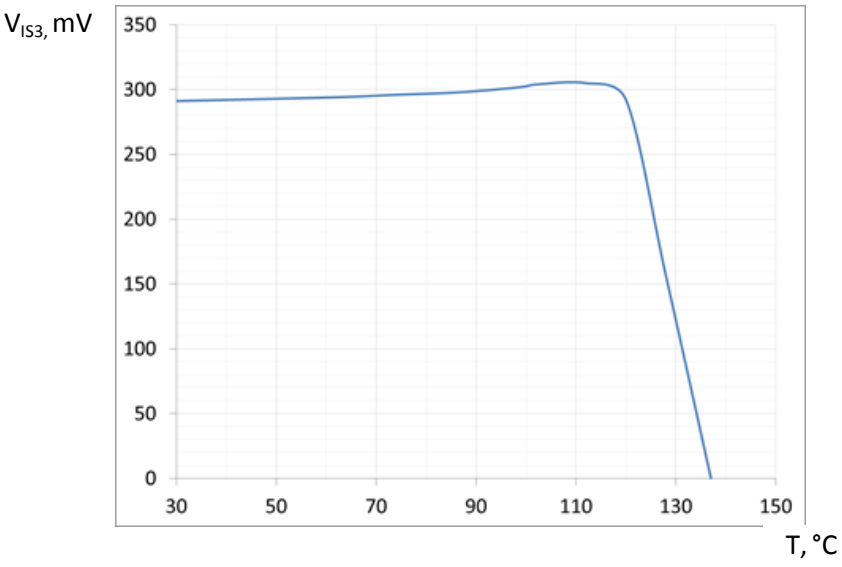


Fig. 3. Over Thermal Protection (OTP), V_{IS3} vs Temperature

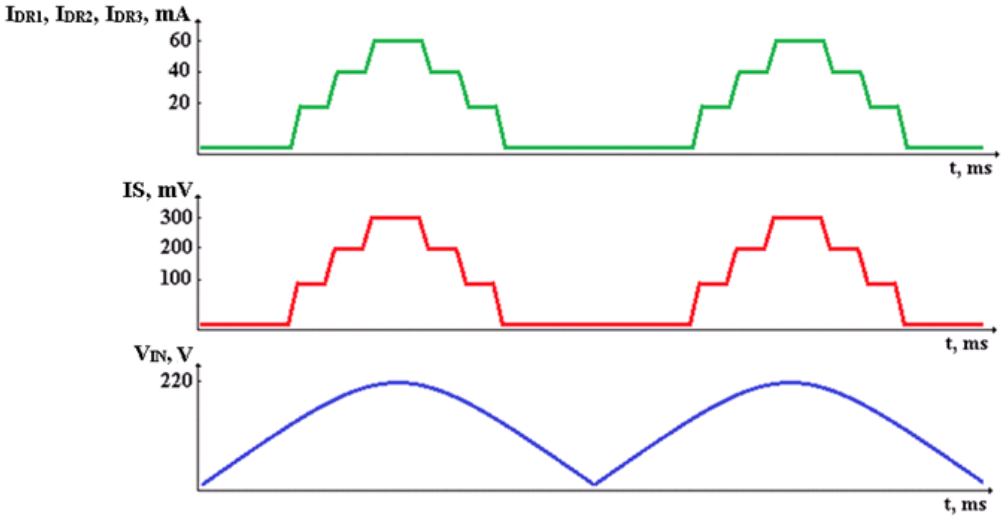


Fig. 4. LED current waveform for 6923K

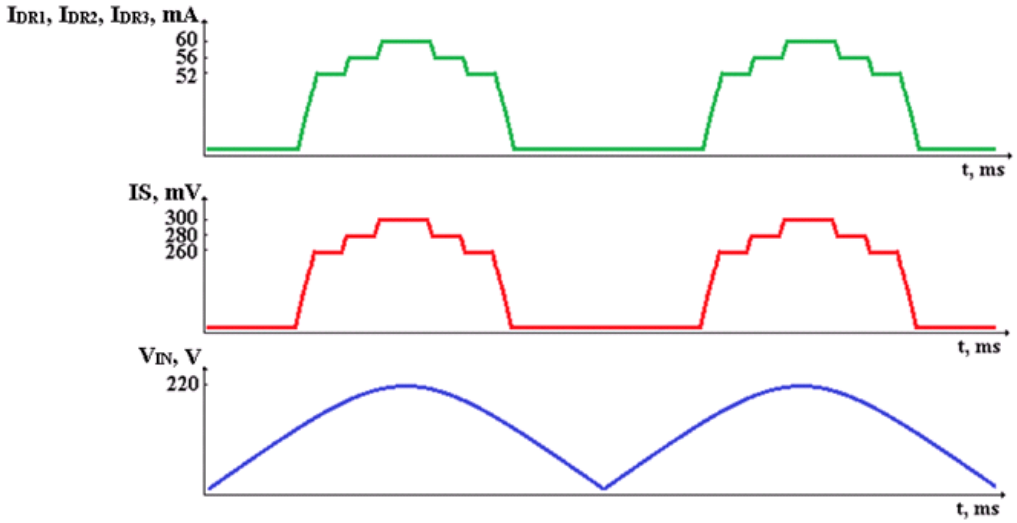


Fig. 5. LED current waveform for 6923AK

APPLICATION 220Vac (6923AK), R_{IS}=5 Ω.

	P_{LOAD} (W)							P_{IN} (W)						
S1,V	**44**	**66**	**88**	**132**	**154**	**176**	**220**	**44**	**66**	**88**	**132**	**154**	**176**	**220**
S2, V	**88**	**88**	**88**	**88**	**66**	**44**	**22**	**88**	**88**	**88**	**88**	**66**	**44**	**22**
S3, V	**132**	**110**	**88**	**44**	**44**	**44**	**22**	**132**	**110**	**88**	**44**	**44**	**44**	**22**
190Vac	6,48	6,92	7,19	7,16	6,99	6,64	5,32	9,50	9,31	9,05	8,27	7,81	7,24	5,53
200Vac	7,55	7,89	8,07	7,92	7,75	7,43	6,21	10,15	9,97	9,72	8,99	8,57	8,04	6,52
210Vac	8,23	8,51	8,65	8,47	8,31	8,00	6,88	10,75	10,58	10,35	9,66	9,26	8,78	7,39
220Vac	8,76	9,00	9,12	8,92	8,77	8,48	7,44	11,34	11,18	10,96	10,31	9,93	9,48	8,20
230Vac	9,19	9,41	9,51	9,31	9,16	8,88	7,92	11,91	11,76	11,55	10,94	10,58	10,15	8,97
240Vac	9,56	9,76	9,84	9,64	9,50	9,24	8,33	12,48	12,34	12,14	11,56	11,22	10,81	9,71
250Vac	9,88	10,06	10,14	9,94	9,81	9,56	8,70	13,05	12,91	12,72	12,17	11,84	11,46	10,42
260Vac	10,16	10,33	10,40	10,21	10,08	9,84	9,03	13,62	13,48	13,30	12,77	12,46	12,09	11,11

	Power dissipation (W)							η						
S1, V	44	66	88	132	154	176	220	44	66	88	132	154	176	220
S2, V	88	88	88	88	66	44	22	88	88	88	88	66	44	22
S3, V	132	110	88	44	44	44	22	132	110	88	44	44	44	22
190Vac	3,02	2,40	1,86	1,11	0,82	0,61	0,21	0,68	0,74	0,79	0,87	0,89	0,92	0,96
200Vac	2,59	2,08	1,65	1,08	0,81	0,62	0,31	0,74	0,79	0,83	0,88	0,91	0,92	0,95
210Vac	2,52	2,07	1,69	1,19	0,95	0,77	0,51	0,77	0,80	0,84	0,88	0,90	0,91	0,93
220Vac	2,58	2,17	1,84	1,39	1,16	1,00	0,76	0,77	0,81	0,83	0,87	0,88	0,89	0,91
230Vac	2,73	2,35	2,04	1,63	1,42	1,27	1,05	0,77	0,80	0,82	0,85	0,87	0,88	0,88
240Vac	2,93	2,58	2,29	1,91	1,72	1,57	1,37	0,77	0,79	0,81	0,83	0,85	0,85	0,86
250Vac	3,18	2,85	2,58	2,22	2,04	1,90	1,72	0,76	0,78	0,80	0,82	0,83	0,83	0,84
260Vac	3,45	3,15	2,89	2,56	2,38	2,25	2,08	0,75	0,77	0,78	0,80	0,81	0,81	0,81

Note: Modes highlighted by gray are the modes when IC can be damaged due to exceeding maximum power dissipation

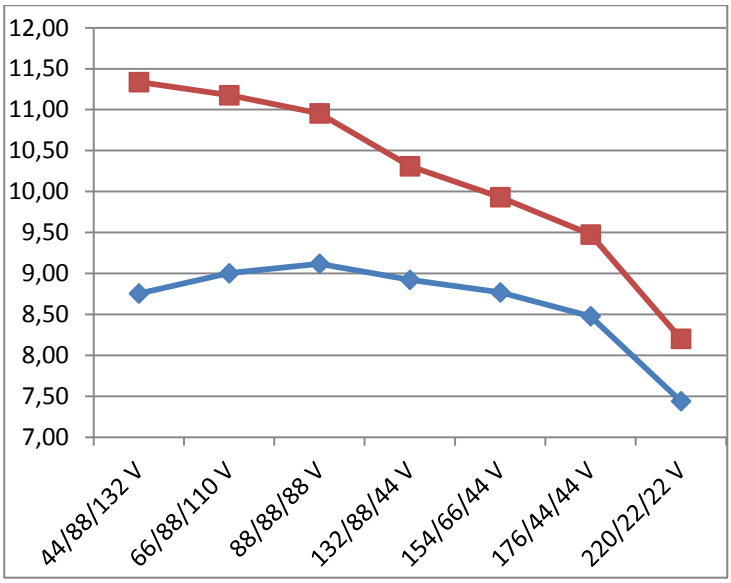


Fig. 6. P_{IN}, P_{LOAD} vs Segment Voltage V_{S1}, V_{S2}, V_{S3}

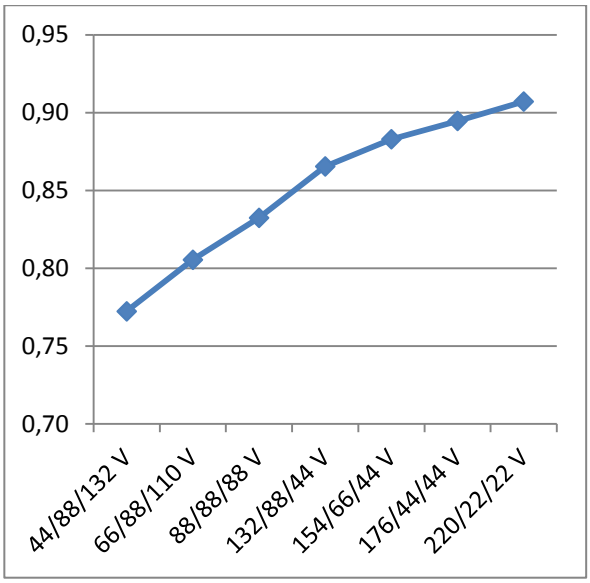
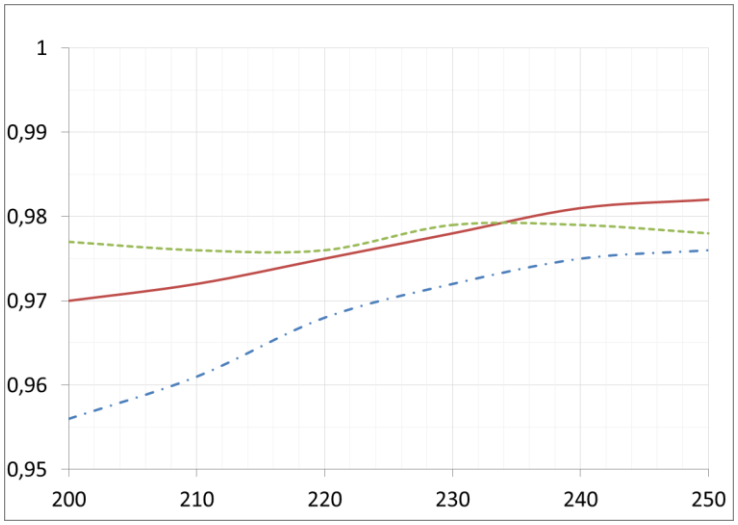


Fig. 7. Efficiency (η) vs Segment Voltage V_{S1}, V_{S2}, V_{S3}



Segment Voltage V_{S1}, V_{S2}, V_{S3}
177/45/46V
155/67/46V
91/88/88V

Fig. 8. Power Factor (PF) vs Vac

APPLICATION 110Vac (6923AK), R_{IS}=5 Ω.

	P_{LOAD} (W)							P_{IN} (W)						
S1, V	22	22	44	66	77	88	99	22	22	44	66	77	88	99
S2, V	33	44	44	33	22	22	11	33	44	44	33	22	22	11
S3, V	66	55	33	22	22	11	11	66	55	33	22	22	11	11
95Vac	3,63	3,76	3,91	3,80	3,66	3,42	3,14	4,85	4,84	4,61	4,26	4,03	3,71	3,35
100Vac	3,92	4,03	4,14	4,03	3,91	3,68	3,42	5,14	5,13	4,92	4,59	4,37	4,08	3,76
105Vac	4,15	4,24	4,34	4,23	4,11	3,90	3,66	5,43	5,42	5,22	4,91	4,71	4,43	4,14
110Vac	4,34	4,42	4,51	4,40	4,29	4,09	3,87	5,72	5,71	5,52	5,22	5,03	4,78	4,50
115Vac	4,50	4,58	4,65	4,55	4,44	4,26	4,05	6,00	5,99	5,81	5,53	5,35	5,11	4,85
120Vac	4,64	4,71	4,78	4,68	4,58	4,40	4,21	6,28	6,27	6,10	5,83	5,66	5,44	5,20
125Vac	4,77	4,84	4,90	4,80	4,70	4,53	4,35	6,56	6,55	6,39	6,13	5,97	5,76	5,53
130Vac	4,88	4,94	5,00	4,91	4,81	4,65	4,48	6,84	6,83	6,68	6,43	6,28	6,07	5,86

	Power dissipation (W)							η						
S1, V	22	22	44	66	77	88	99	22	22	44	66	77	88	99
S2, V	33	44	44	33	22	22	11	33	44	44	33	22	22	11
S3, V	66	55	33	22	22	11	11	66	55	33	22	22	11	11
95Vac	1,22	1,08	0,70	0,46	0,36	0,28	0,21	0,75	0,78	0,85	0,89	0,91	0,92	0,94
100Vac	1,23	1,11	0,78	0,55	0,46	0,40	0,33	0,76	0,78	0,84	0,88	0,89	0,90	0,91
105Vac	1,29	1,18	0,88	0,68	0,59	0,53	0,48	0,76	0,78	0,83	0,86	0,87	0,88	0,88
110Vac	1,38	1,29	1,01	0,82	0,74	0,69	0,64	0,76	0,77	0,82	0,84	0,85	0,86	0,86
115Vac	1,50	1,41	1,16	0,98	0,91	0,86	0,81	0,75	0,76	0,80	0,82	0,83	0,83	0,83
120Vac	1,64	1,56	1,32	1,15	1,08	1,03	0,99	0,74	0,75	0,78	0,80	0,81	0,81	0,81
125Vac	1,79	1,72	1,49	1,33	1,27	1,22	1,18	0,73	0,74	0,77	0,78	0,79	0,79	0,79
130Vac	1,96	1,89	1,67	1,52	1,46	1,42	1,38	0,71	0,72	0,75	0,76	0,77	0,77	0,76

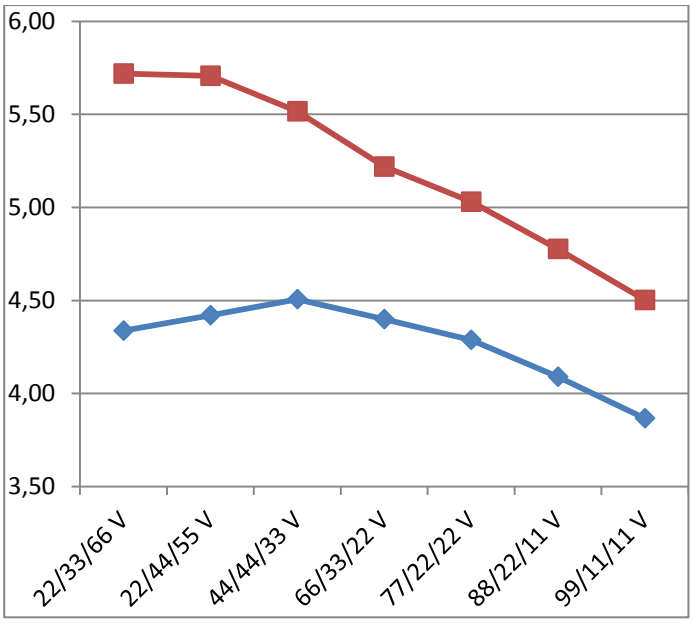


Fig. 9. P_{IN}, P_{LOAD} vs Segment Voltage V_{S1}, V_{S2}, V_{S3}

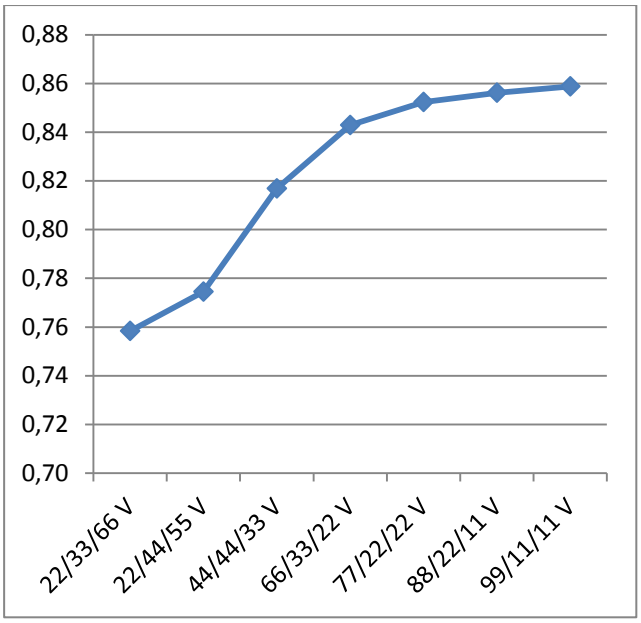


Fig. 10. Efficiency (η) vs Segment Voltage V_{S1}, V_{S2}, V_{S3}

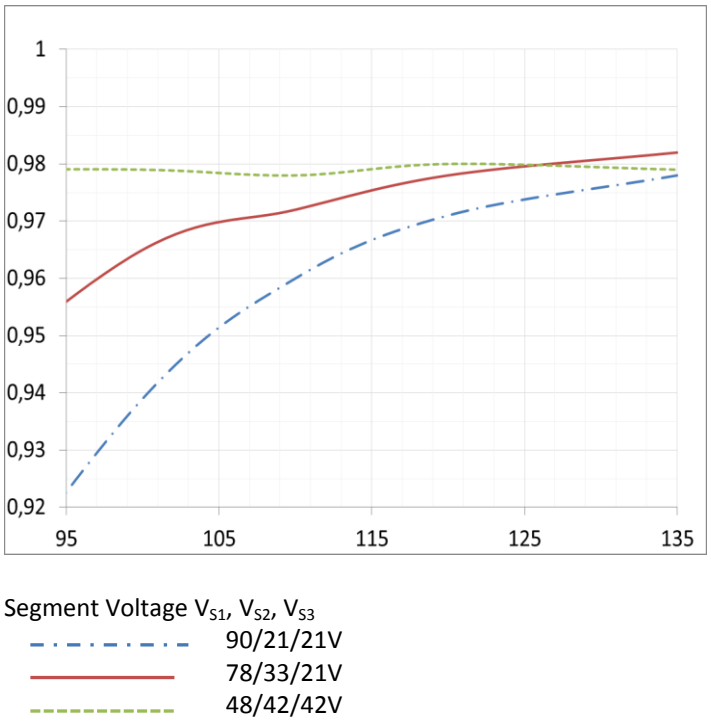
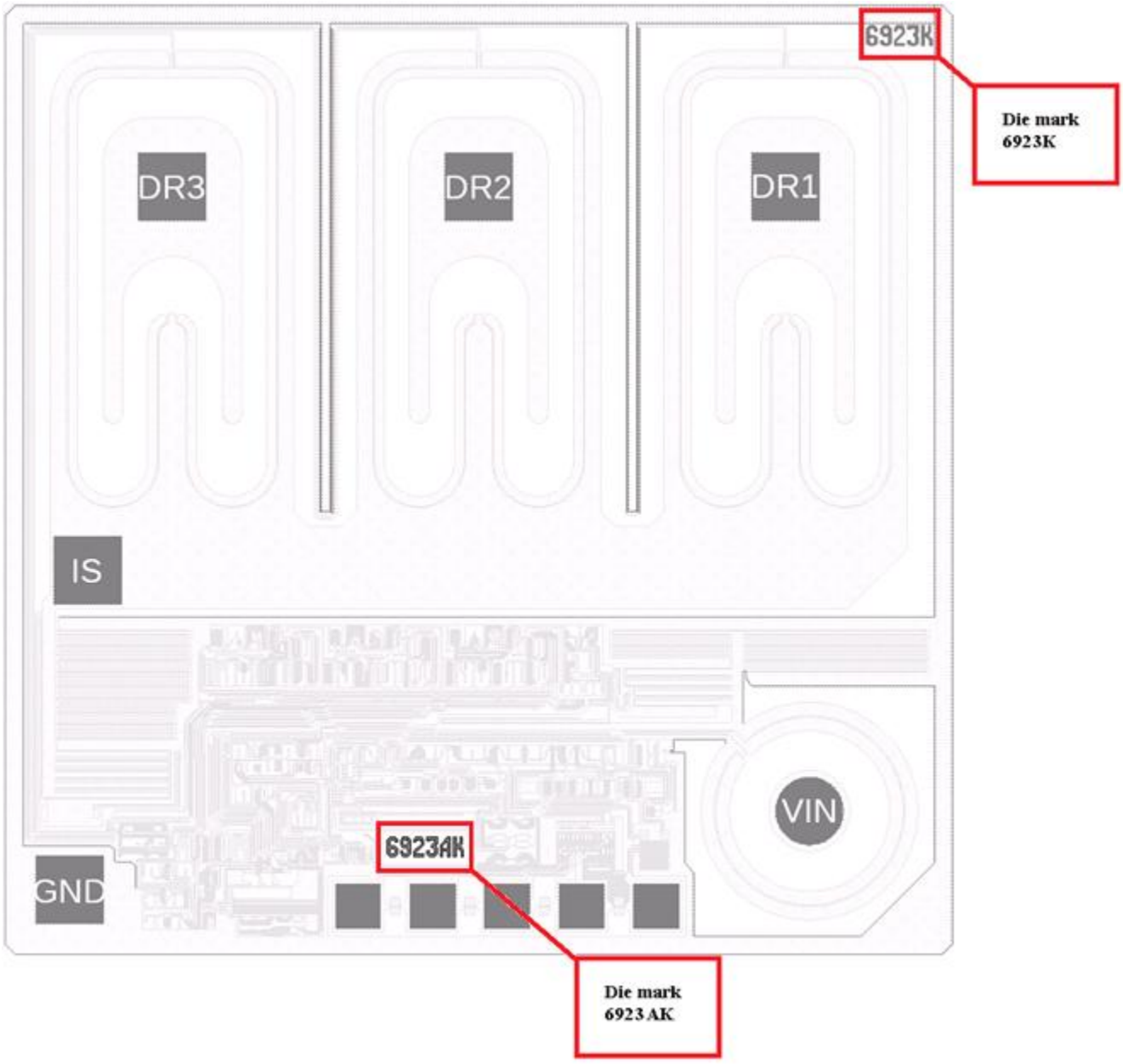


Fig. 11. Power Factor (PF) vs Vac

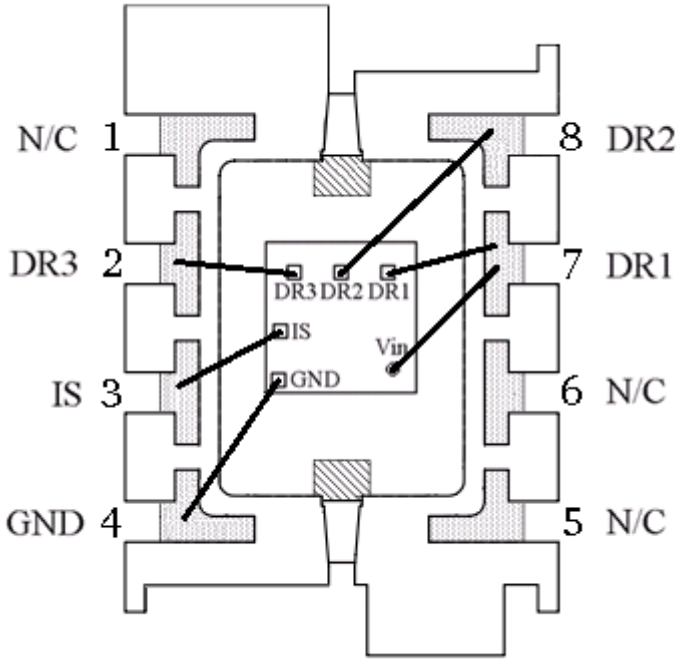
PAD LOCATION AND COORDINATES



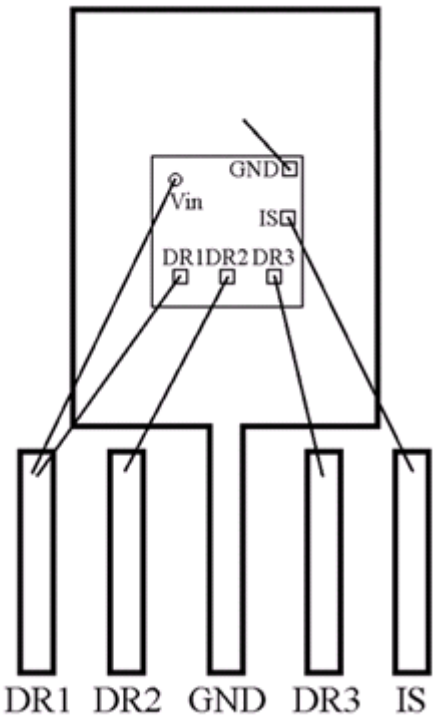
Die size (including scribe line): 1.37mm× 1.37mm

Pad #	Name (Package)	Pad opening size (µm x µm)	Pad centers coordinates (µm)	
			X	Y
1	GND	90 x 90	-549	-549
2	IS	90 x 90	-525	-121
3	VIN	Ø 90	444	-444
4	DR1	90 x 90	411	392
5	DR2	90 x 90	0	392
6	DR3	90 x 90	-411	392

BONDING DIAGRAM



ESOP-8



TO-252-5L

ASSEMBLY CHARACTERISTICS

No.	Assembly Characteristics	Value
1	Wafer Size	6 Inch
2	Wafer Thickness before Grinding	675±25 µm
3	Scribe Street Width	100 µm
4	Chip Size (including Scribe Line)	1.37x1.37 mm^2
5	Die Attach Material	Substrate is connected to GND
6	Quantity of Bond Pad Metal Layers	1
7	Pad Thickness	2.6 µm
8	Composition of Metal Layers	Al+Si(1.0%)+Ti(0.5%)
9	Min. Bond Pad Opening Size	90×90 µm
10	Min. Bond Pad Pitch	321 µm
11	Min. Wire Diameters	1 mil (25 µm)
12	Circuit Under Pad Design (CUP)	No

ADDITIONAL INFORMATION

Pb-free products:

- RoHS compliant and compatible with the current requirements of IPC/JEDEC J-STD-020.

Green products:

- Lead-free (RoHS compliant).
- Halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

The appearance complies with the requirements of the company standards.