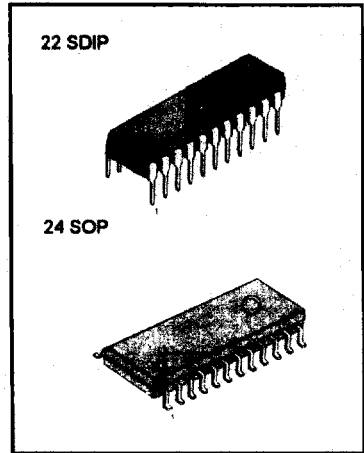


**BALLAST CONTROL IC**

The KA7531X is a ballast control IC improving power-factor. The following is the features incorporated in it. It includes PFC control block so that the power-factor can be over 0.99 % and the high voltage at lamp driving block can be maintained constantly. Besides, it prevents the inrush current of lamp discharge and the sputtering. The 3-step soft start function allows lengthen lamp use. The dimming control function is also incorporated to regulate lamp's luminance depending on the intensity of surrounding illumination. The over-current protection, over-heating protection of power switch in driving systems and non-load protection functions are also available.

**FEATURES**

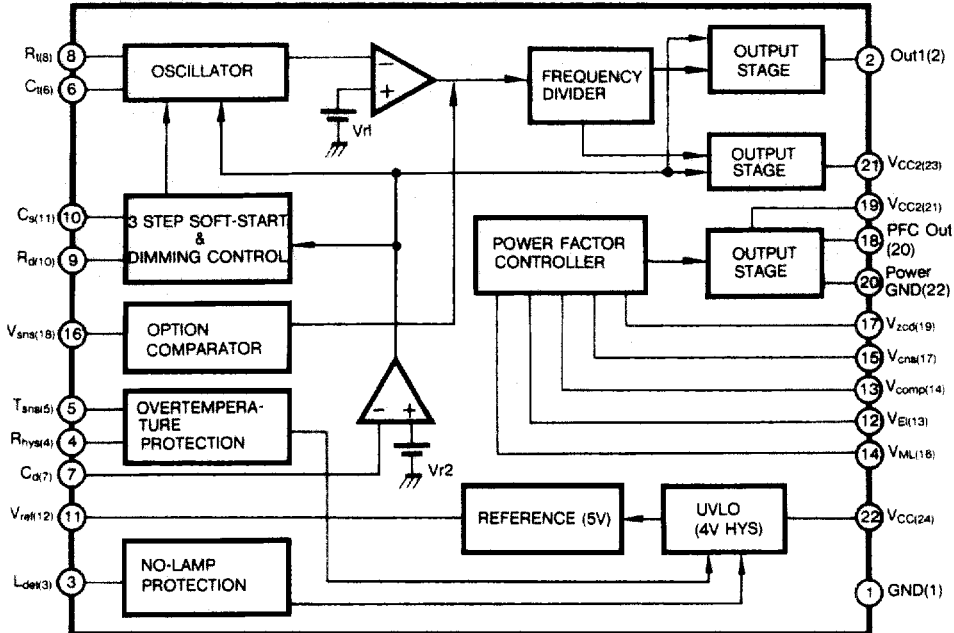
- Power Factor Correction
- Dimming control
- 3 Step Soft start
- ZVS Driving
- Non Lamp Protection
- Protection (OCP, OTP)



**ORDERING INFORMATION**

Device	Package	Operating Temperature
KA7531	22 SDIP	-25 ~ + 100 °C
KA7531D	24 SOP	

**BLOCK DIAGRAM**



( ) IS 24SOP PIN NO

ABSOLUTE MAXIMUM RATINGS ( $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	17	V
Peak driver output current	$I_{O(P)}$	500	mA
Operating ambient temperature	$T_{OPR}$	-25 ~ +100	$^\circ\text{C}$
Storage temperature	$T_{STG}$	-65 ~ +150	$^\circ\text{C}$

## ELECTRICAL CHARACTERISTICS

( $V_{CC} = 12\text{V}$ ,  $T_A = 25\text{ }^\circ\text{C}$ , unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Under Voltage Lock Out Section</b>						
Start Threshold Voltage	$V_{ST}$		10	10.8	11.6	V
UVLO Hysteresis	$V_{THS}$		2.8	3.2	3.6	V
Start-Up Supply Current	$I_{ST}$	$V_{CC} = 9\text{V}$	0.6		1.4	mA
Operating Supply Current	$I_{CC}$	$V_{CC} = 14\text{V}$ , No Load	8		14	mA
<b>Reference section</b>						
Reference Voltage	$V_{REF}$		5.0	5.1	5.2	V
Load Regulation	$\Delta V_{REF}$	$0 < I_{REF} < 5\text{mA}$		5	20	mV
<b>Preheating Section</b>						
Preheating Frequency	$F_P$	$V_{CS} = 0\text{V}$ , $R_t = 33\text{K}$ , $C_t = 330\text{pF}$	120		160	KHz
Preheating Time Current	$I_P$	$V_{CS} = 0\text{V}$	7		27	$\mu\text{A}$
Preheating Dead Time	$T_{PD}$		2		4	$\mu\text{s}$
<b>Oscillator Section</b>						
Amplitude	$V_{(OSC)}$		3.0		3.8	V
Normal Frequency	$F_N$		80		120	KHz
Normal Dead Time	$T_{ND}$	$V_{CS} = 2\text{V}$	1.7		3.7	$\mu\text{s}$

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 12V, T<sub>A</sub> = 25 °C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>3-step Frequency Section</b>						
Preheating Voltage Range	V <sub>PR</sub>	R <sub>DC</sub> = 120K, V <sub>DS</sub> = 1.75V	0.7		1.3	V
Soft start Voltage Range	V <sub>ST</sub>	R <sub>DC</sub> = 120K, V <sub>DS</sub> = 1.75V	1.3		1.9	V
Fullpower Voltage Range	V <sub>FR</sub>	R <sub>DC</sub> = 120K, V <sub>DS</sub> = 1.75V	2.8		3.4	V
Dimming Voltage Range	V <sub>DR</sub>	R <sub>DC</sub> = 120K, V <sub>DS</sub> = 1.75V	3.5		4.1	V
<b>Oscillator Section</b>						
Dimming 50 % Frequency	F <sub>DIM</sub>	R <sub>DC</sub> = 120K, V <sub>DS</sub> = 1.75V	100		140	KHz
Dimming Current	I <sub>DIM</sub>	R <sub>O</sub> = 120k Ω				μ A
<b>Output Section for Ballast Control Part</b>						
Rising Time (NOTE 2)	T <sub>R</sub>	No Load		80	120	ns
Falling Time (NOTE 2)	T <sub>F</sub>	No Load		20	60	ns
High Voltage	V <sub>OH</sub>	I <sub>O</sub> = 30mA	7	8		V
Low Voltage	V <sub>OL</sub>	I <sub>O</sub> = 30mA		0.1	0.4	V
<b>Over Temperature Protection</b>						
High Temperature Voltage	V <sub>HT</sub>		0.7		1.3	V
Reset Temperature Voltage	V <sub>RT</sub>		2.1		2.9	V
Hysteresis Max Current	I <sub>HYS</sub>	R <sub>HYS</sub> = 50K	80		120	μ A
<b>Option Comparator</b>						
Option Comparator Voltage	V <sub>OPT</sub>		2.4		3.2	V
<b>No Lamp Protection</b>						
No Lamp Protection Voltage	V <sub>NL</sub>		1.2		1.7	V
<b>Error Amplifier Section</b>						
Input Offset Voltage (NOTE 2)	V <sub>IOF</sub>		-1.5		15	mV
Input Bias Current	I <sub>BIAS</sub>		-1	-0.1	1	μ A

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 12V, T<sub>A</sub> = 25 °C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Error Amplifier Section</b>						
Large Signal Openloop Voltage Gain (NOTE2)	GV1		60	100		dB
Output Current	Source	I <sub>SOURCE</sub>	2			mA
	Sink	I <sub>SAK</sub>			-2	mA
Output Voltage Range	Low	V <sub>LO</sub>			1.2	V
	High	V <sub>HI</sub>	4			V
Unity-gain Bandwidth (NOTE2)	UBW			1.0		MHz
Phase Margin (NOTE2)	MPH			57		
<b>Multiplier Section</b>						
M1 Input Voltage Range (NOTE2)	V <sub>IN1</sub>		0		2	V
M2 Input Voltage Range (NOTE2)	V <sub>IN2</sub>		$\frac{V_{REF}}{2}$		$\frac{V_{REF} + 1}{2}$	V
Input Bias Current	I <sub>BIAS2</sub>		-2		2	μA
Multiplier Gain (NOTE2)	GV2	VM1 = 0.5V, VM2 = 3.0V		0.8		V
<b>Current-Sense Section</b>						
Input Offset Voltage (NOTE2)	V <sub>IO3</sub>		-10		10	mV
Input bias Current	I <sub>BIAS3</sub>	0V ≤ V <sub>CS</sub> ≤ 1.7V	-5	2	5	μA
Delay to Output (NOTE2)	td(s)			200	500	ns
<b>Zero-Current-Detect Section</b>						
Input Voltage threshold	V <sub>TH2</sub>		1.2		1.8	V
Hysteresis	V <sub>HYS2</sub>			200		mV
Input Low Clamp Voltage	V <sub>IC(L)</sub>	I <sub>DET</sub> = -100 μA			0.95	V
Input High Clamp Voltage	V <sub>IC(H)</sub>	I <sub>DET</sub> = 3mA	6.1	7.12		V

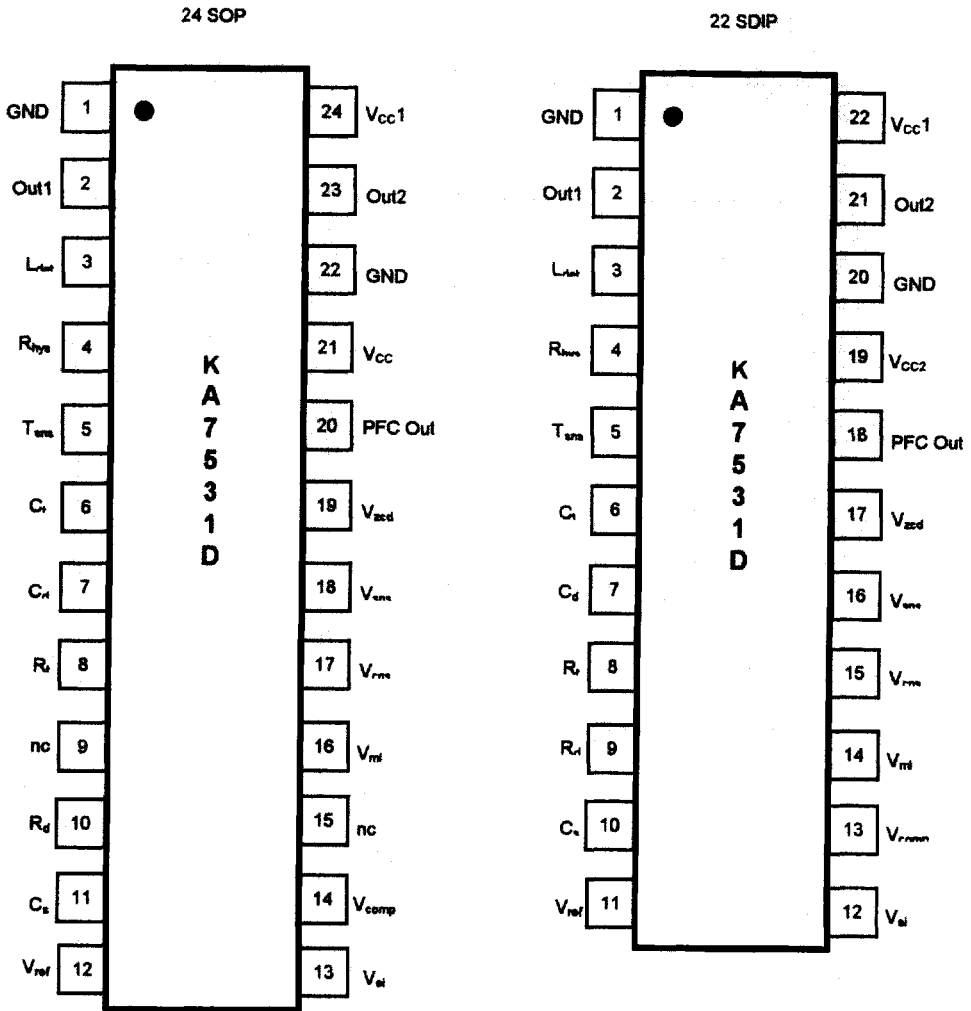
## ELECTRICAL CHARACTERISTICS

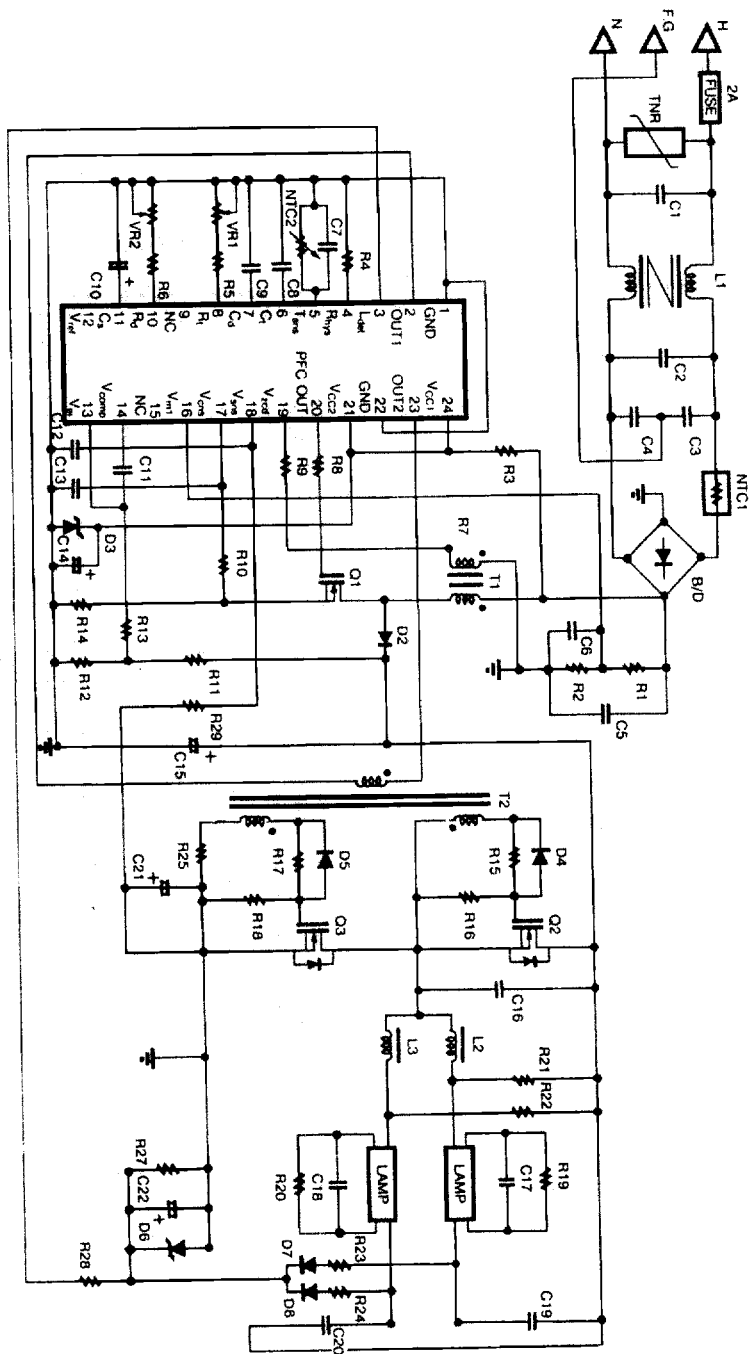
(V<sub>CC</sub> = 12V, T<sub>A</sub> = 25 °C, unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
<b>Zero-Current-Detect Section</b>						
Input Current	I <sub>I</sub>	0.9 ≤ V <sub>DET</sub> ≤ 6V		± 5		μ A
Input High/Low	I <sub>CD</sub>	V <sub>DET</sub> < 0.9V			-3	mA
Clamp Diode Current		V <sub>DET</sub> > 6V	+3			
<b>Output Section for PFC part</b>						
Rising time (NOTE1)	T <sub>R2</sub>	No Load		100	120	ns
Falling time (NOTE2)	T <sub>F2</sub>	No Load		90	110	ns
High Voltage	V <sub>OH2</sub>		7	9		V
Phase Margin	V <sub>OL2</sub>			0.2	1.5	V
<b>Self - Starting Section</b>						
Self - Starting Time (NOTE2)	T <sub>SS</sub>		12			μ s
<b>Delay Timer Section</b>						
Delay Timer Current	I <sub>CD</sub>		6		14	μ A
Delay Timer Voltage	V <sub>CD</sub>		2.5		3.5	V

NOTE1. V<sub>CC</sub> ought to set up 10V after threshold voltage approve.NOTE2. GV2 = V<sub>O(M)</sub> / ( VM1 × (VM2 - V<sub>ref</sub>/2) )

PIN CONNECTION (top view)





KA7531 APPLICATION CIRCUIT

(VER 3.1)

## PARTS LIST (KA7531/D)

Part	Value	Part	Value	Part	Value
R1	1.8K $\Omega$ 1/2W	R30	1K $\Omega$	NTC2	KTD-350
R2	10K $\Omega$ 1/2W	VR1	500K $\Omega$		
R3	100K $\Omega$ 1/2W				
R4	51K $\Omega$	C1	0.1 $\mu$ F 250V		
R5	33K $\Omega$	C2	0.1 $\mu$ F 250V	D1	1N4937
R6	240K $\Omega$ 1/2W	C3	4700pF 250V	D2	1N4937
R7	10 $\Omega$ 1/2W	C4	4700pF 250V	D3	15V 1W
R8	27 $\Omega$	C5	563 600V	D4	1N4937
R9	22K $\Omega$	C6	103 40V	D5	1N4937
R10	330 $\Omega$	C7	104 18V	D6	6.2V 0.5W
R11	1K $\Omega$ 1/2W	C8	331 10V	D7	1N4937
R12	6.2K $\Omega$ 1/2W	C9	103 10V	D8	1N4937
R13	150K $\Omega$	C10	10 $\mu$ F 16V	D9	1N4937
R14	0.5 $\Omega$ 1W	C11	104 16V	D10	1N4937
R15	51 $\Omega$				
R16	680 $\Omega$	C13	332 10V	Q1	IRF830
R17	51 $\Omega$	C14	100 $\mu$ F 25V	Q2	IRF830
R18	680 $\Omega$	C15	47 $\mu$ F 450V	Q3	IRF830
R19	1M $\Omega$	C16	152 630V		
R20	1M $\Omega$	C17	562 1000V		
R21	1M $\Omega$	C18	562 1000V	L1	BSF-2125
R22	1M $\Omega$	C19	103 630V	T1	EE1619
R23	2M $\Omega$	C20	103 630V	T2,T3,T4	EI25
R24	2M $\Omega$	C21	1 $\mu$ F 10V		
R25	0.5 $\Omega$ 1W	C22	22 $\mu$ F 16V		
R26	620K $\Omega$	C23	103 630V		B/D
R27	20K $\Omega$	C24	103 630V	IC	KA7531D
R28	430 $\Omega$	TNR	12G471K		
R29	100 $\Omega$ 1W	NTC1	10D-11	FUSE	250V/2A



## Pin Functions

Symbol	Number		Functions
	SOP	SDIP	
OUT 1	2	2	Output Pin. It drives power switching elements. Its output frequency( $f_o$ ) varies from 50 [Khz] $\pm$ 30 [Khz].
OUT 2	23	21	The output voltage level is $V_{CC}$ .
GND	1	1	IC Ground
GND	22	20	
Ldet	3	3	Non Lamp Detect
R <sub>HYS</sub>	22	20	Over Temperature Hysteresis Resistor
GND	1	1	It determines the frequency of internal triangular wave generation circuit, and then fixed frequency determines output frequency at Out1 and Out2
GND	22	20	
L <sub>DET</sub>	3	3	It performs Dimming Control which regulates lamp intensity.
R <sub>HYS</sub>	4	4	Delay Timer Capacitor
C <sub>s</sub>	11	10	It determines soft-start period during first lamp fire starting. $C = i \frac{dt}{dv}$ ( $i = 20 \mu A$ , $dv = 0.7V$ , $dt = 2.4sec$ )
V <sub>EI</sub>	13	12	Error AMP. Input
V <sub>M1</sub>	16	14	V <sub>DD</sub> Voltage Multiplier Input
V <sub>COMP</sub>	14	13	Error AMP. Output
V <sub>REF</sub>	12	11	5V Reference
V <sub>CNS</sub>	17	15	Current Sense for PFC
V <sub>SNS</sub>	18	16	Voltage Sense
V <sub>ZCD</sub>	19	17	Zero Current Detect
L <sub>DET</sub>	20	18	Power Factor MOSFET Drive output
T <sub>SNS</sub>	5	5	Temperature Sense It will be protected with 0.9V below
V <sub>CC1</sub>	24	22	V <sub>CC</sub>
V <sub>CC2</sub>	21	19	

KA7531 SYSTEM APPLICATION

**1. SYSTEM SUMMARY**

This application note is about functions and designs of electronic ballast, which can drive fluorescent lamp (32w\*2) by using a KA7531 (ballast control IC)

**1) Excellent power saving capability**

- ▶ Power Factor Correction
- ▶ Dimming Control

**2) Stable strike and life extension of fluorescent lamp**

- ▶ 3 - Step Soft-start
- ▶ Double Hot Spot generation

**3) EMI / RFI and minimize radiation noise**

- ▶ Zero voltage switching (ZVS)

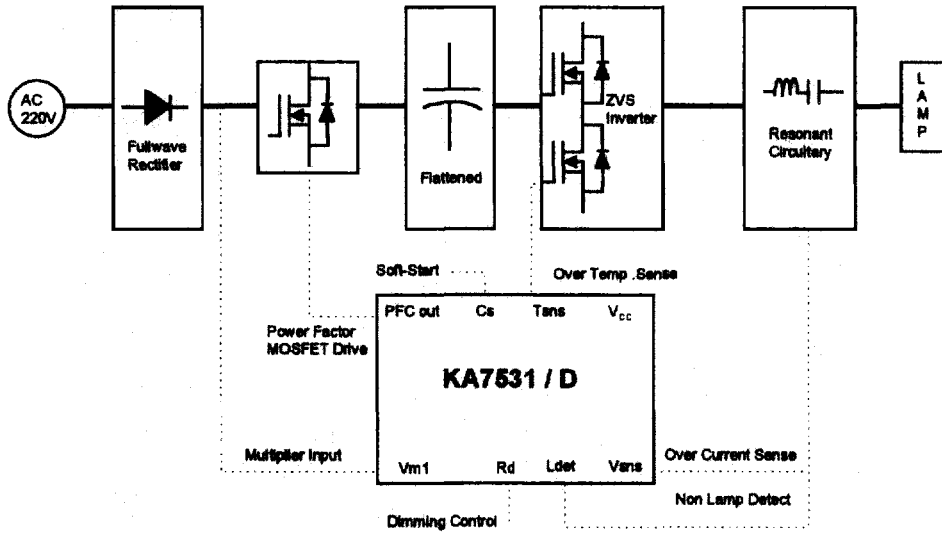
**4) Minimize eye-strain**

- ▶ Soft Ignition
- ▶ Stable Lighting Output

**5) Improvement of system reliability**

- ▶ No load protection
- ▶ Over heating protection
- ▶ Emergency Shut-Down

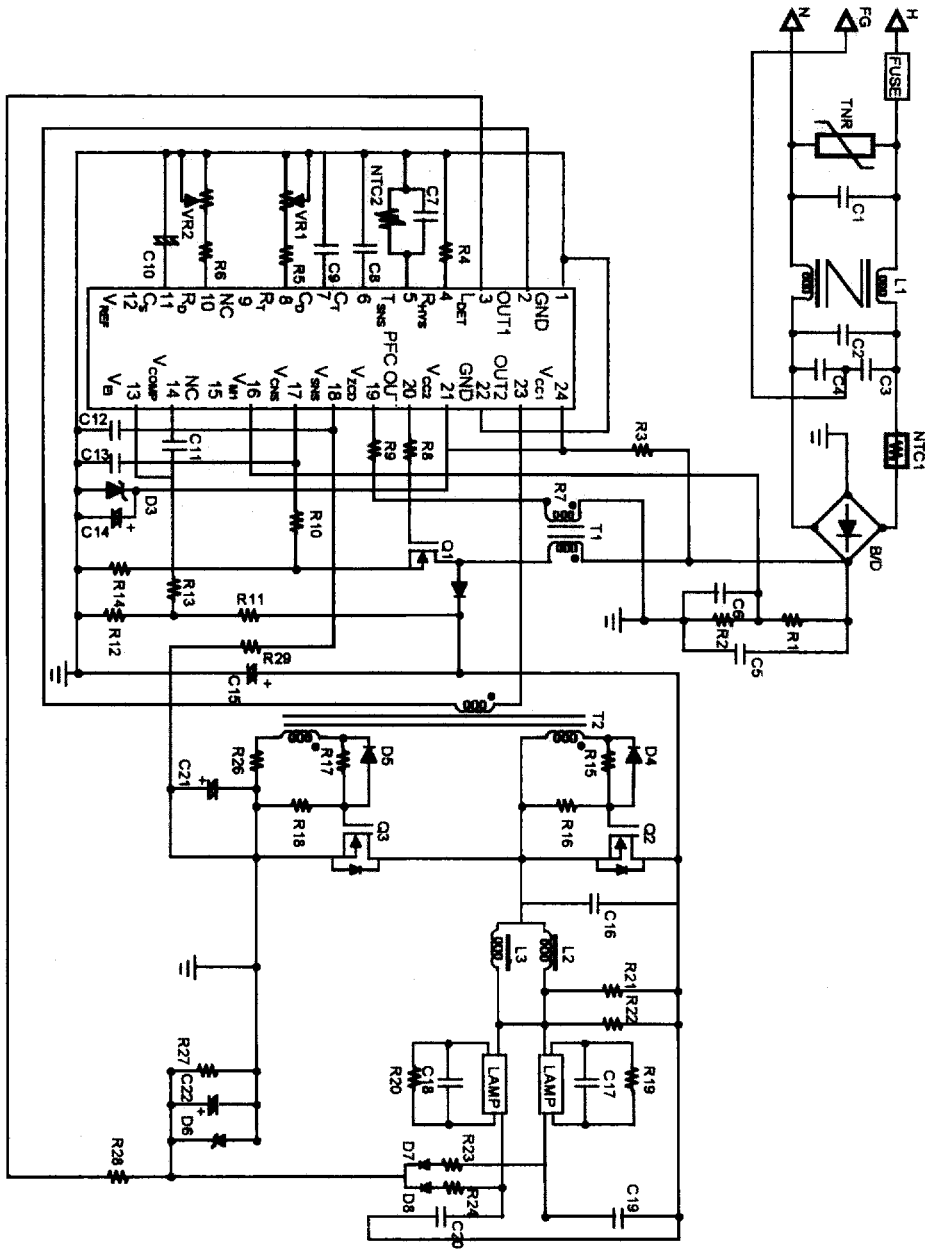
2. SYSTEM BLOCK DIAGRAM (KA7531/D)



7

3. APPLICATION CIRCUIT

3-1 Application Circuit



KA7531 APPLICATION CIRCUIT

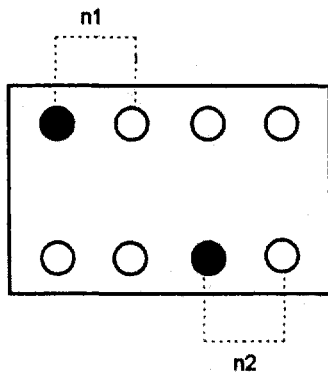
(VER 3.1)

## 3-2 Parts List (APP-243)

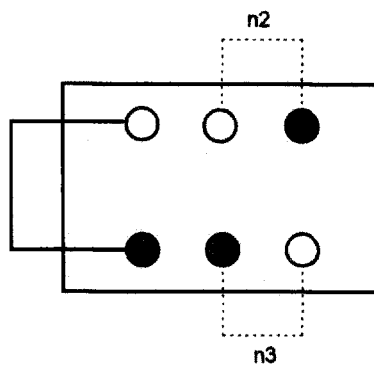
ITEM	VALUE	ITEM	VALUE	ITEM	VALUE
R1	1.8 M $\Omega$ 1/2W	C1	0.1 $\mu$ F 250V	TNR	12G471K
R2	10 k $\Omega$ 1/2W	C2	0.1 $\mu$ F 250V	NTC1	10D - 11
R3	100 k $\Omega$ 1/2W	C3	4700 pF 250V	NTC2	KTD5 - 350 (50k $\Omega$ )
R4	51 k $\Omega$	C4	4700 pF 250V		
R5	33 k $\Omega$	C5	563 600V	D1	1N4937
R6	120 k $\Omega$	C6	103 40V	D2 - D4	1N4148
R7	27 $\Omega$	C7	104 16V	D5 - D8	1N4937
R8	22 k $\Omega$	C8	331 10V		
R9	330 $\Omega$	C9	103 10V	ZD1	18V 1W
R10	150 k $\Omega$	C10	10 $\mu$ F 16V		
R11	1 $\Omega$ 1W	C11	104 16V	Q1 - Q3	IRF830
R12	1 M $\Omega$ 1/2W	C12	10 $\mu$ F 16V		
R13	6.2 k $\Omega$ 1/2W	C13	332 10V	L1	BSF-2125
R14	60 k $\Omega$	C14	47 $\mu$ F 25V	L2, L3	EI25
R15	51 $\Omega$	C15	47 $\mu$ F 450V	T1	EI25
R16	51 $\Omega$	C16	222 630V	T2	EE1619
R17	3.4 $\Omega$	C17	562 1000V		
R18	300 k $\Omega$	C18	562 1000V	B/D	KBL205
R19	390 k $\Omega$	C19	103 630V	IC	KA7531
R20	390 k $\Omega$	C20	103 630V		
R21	1 M $\Omega$	C21	103 630V	FUSE	250V/2A
R22	1 M $\Omega$	C22	103 630V		
R23	20 M $\Omega$	C23	103 10V		
R26	2.2 M $\Omega$				
R27	2.2 k $\Omega$				
VR1	10 k $\Omega$				
VR2	500 k $\Omega$				

3-3 Trans SPEC. (P.C.B TOP VIEW)

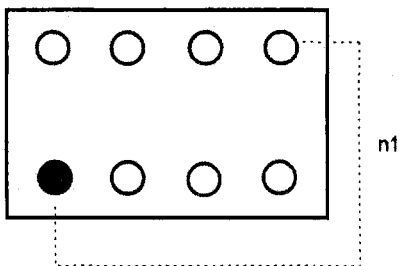
T1 : E125



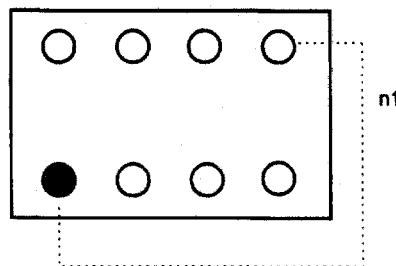
T2 : EE125



L2 : E125



L3 : E125



ITEM	$\Phi$	n1	n2	n3	n1 Value	Remark
T1	0.35	120 Turn	11 Turn	-	1.9 mH	
T2	0.25	32 Turn	24 Turn	24 Turn		
L2, L3	0.35	150 Turn	-	-	3.0 mH	

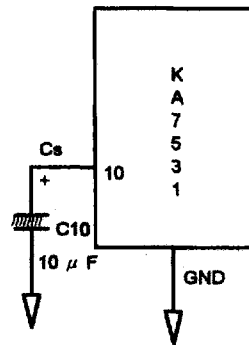
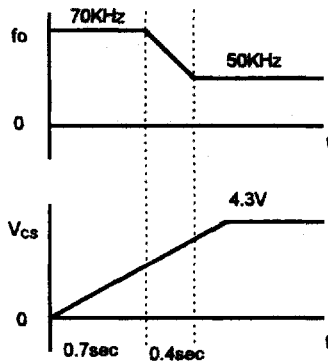
4. FUNCTION BLOCK DESCRIPTION

4-1 Start-up Operation

The KA7531 starts to operate when  $V_{CC}$  is more than start threshold voltage [ 10V ], and operating current is 10mA. If the  $V_{CC}$  decreases less than UVLO (under voltage lock out) hysteresis width, IC's operation will stop. And then all the internal circuit begin to RESET, hold the stand-by state, At this time of this function operate, stand-by state current is about 0.9mA.

4-2 Soft - Start

The 3 - step - soft - start function is pre-heat filament for 0.7 [sec] with a frequency that has a 20KHZ higher than normal control frequency of IC. And having high frequency (more than 20 KHZ) decreased to normal frequency linearly for about 0.4 [sec].



$$C = i \frac{dt}{dV} \dots(1)$$

$i = 17 \mu A$  is charged through the capacitor

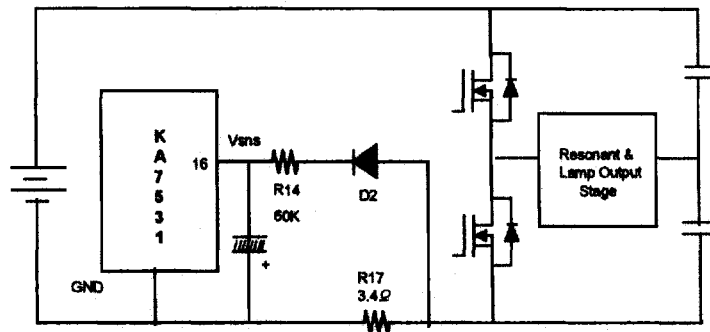
$dV = Cs$  is charged to 4.3V which is standard voltage.

$dt =$  the charging time to 4.3V is 1.1 [sec]

using by,  $C = I dt/dv$   
 $C = 10 \mu F$

4-3 Over Current Protection

In this function, sensing a input and when input becomes over current state, the output of IC will be shut-down. So this system is designed to have a function like that.

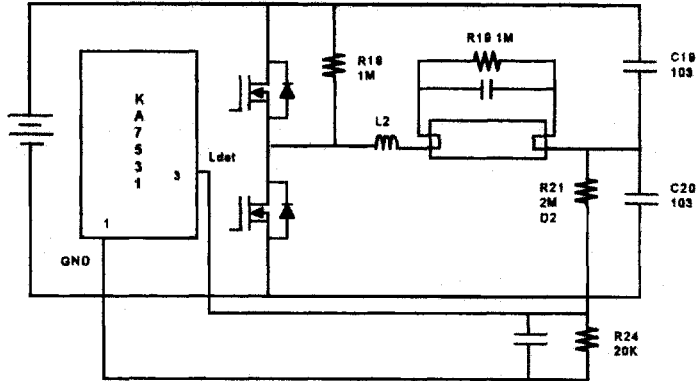


If the voltage level of pin #16 becomes more than 3V, the output will be shut-down . In the normal state, After removal of overcurrent state, IC's output is on-state. To make output on-state, IC's internal latch must be removed. To get above function, UVLO must be changed from off-state to on-state.



**4-4 No Load Protection**

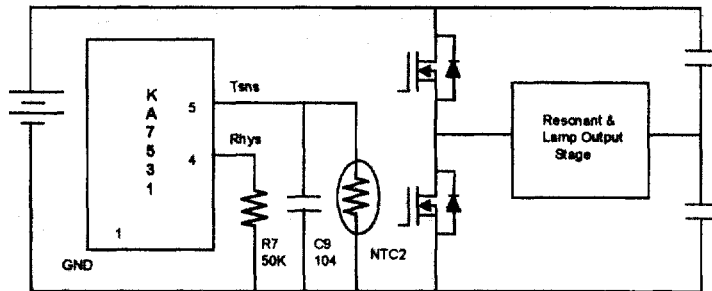
The KA7531 have a function sensing a 1 lamp insertion and a 2 lamp insertion or not. In case of no load, this system have protection circuit operated and IC's output shut down. When the insertion state change from 1 lamp to 2 lamp, lamp reset function restarting from 3-step soft start is operated. And also new inserted lamps strikes after filament pre-heating.



When the pin#3, of IC becomes lower than 1.4V, The output will be shut-down. In the state of lamp insertion, DC voltage is divided by R18, R19, R21, R23. DC link voltage in R23 is supplied to pin#3(Ldet) more than 1.4V

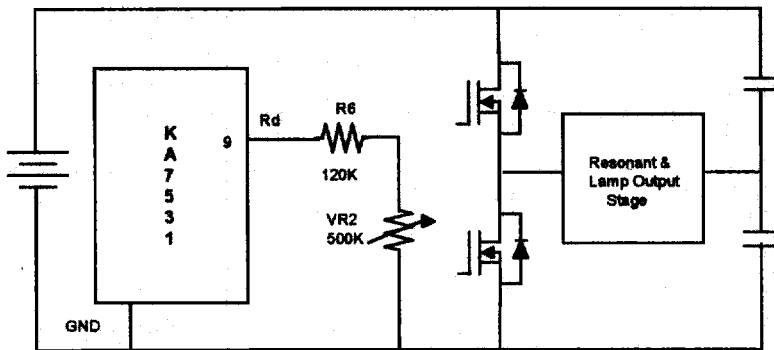
**4-5 Over Temperature Protection**

This function is designed to protect system by shut-down of IC's output. Using a NTC (negative temperature coefficient) this system sense a emitting heat state of power switching component when sensed temperature is more than specified temperature.



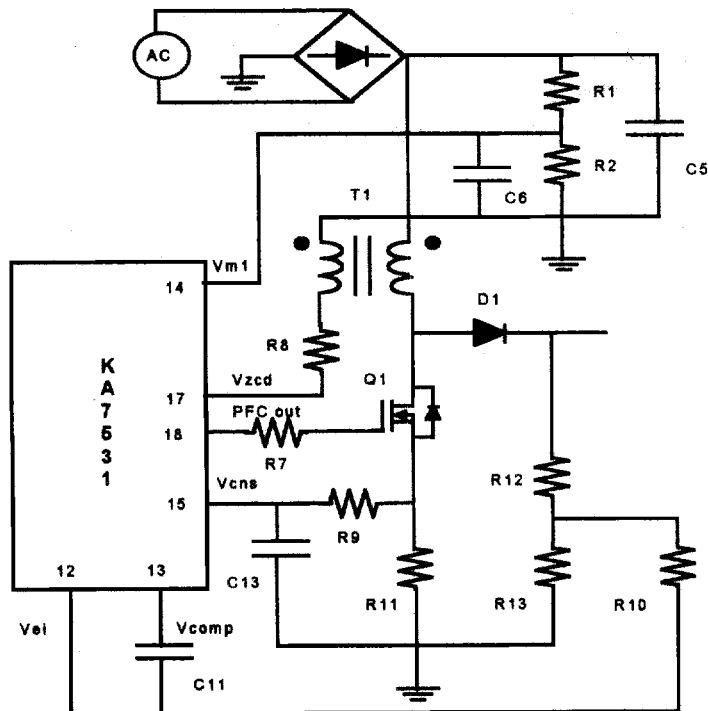
In this circuit, if the voltage level of pin#5 Tsns is less than 0.9V, IC's output is shut-down. Once the system is shut-down, This system is restarted with temperature hysteresis characteristics by voltage level of pin#4. This circuit is designed so that shut-down at the temperature of 90 °C and restart at 50 °C. The NTC have a value of 50k Ω at the temperature of 25 °C.

**4-6 Dimming Control**



Current flowing into Rd is controlled by adjusting VR2(500K). And this makes output frequency variable. In the end, dimming control is possible.

**4-7 P.F.C**



Refer to Power Device (95, 3rd Edition) of SANSUNG Data Book. (Page 73 - 86)

## 5. FUNCTION COMPARISON TABLE ( KA7521 / 7522 / 7531 )

Parameter	KA7521	KA7522	KA7531	Remark
1. P. F. C	about 0.67	about 0.67	over 0.99	
2. Soft-Start Function	○	○	○	
3. Input Voltage Variation Protection	AC 220V -20% +50%	AC 220V ± 50%	AC 220V ± 20%	
4. Over-Voltage Protection	○	○	○	
5. Emergency System Protection	○	○	○	
6. Over-Heating Protection	○	○	○	
7. Non-lamp Detection	○	○	○	
8. Dimming Control	100% ~ 10%	100% ~ 10%	100% ~ 10%	
9. AVS-Driving	○	○	○	
10. ZVS Guard Control	-	○	-	
11. Current Feedback Control	-	○	-	
12. Lamp reset	-	○	-	Preheating function while lamp setting on Power-on stage
13. Input limit & Brown out	-	○	-	
14. Low Temperature sense for preheating time control	-	○	-	
* KA7521 and KA7524 are constructed in a single construction for KA7531				