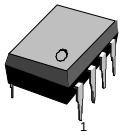
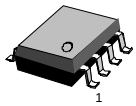
INTRODUCTION

The KA7540/41 provides simple, yet high performance electronic ballast control functions. KA7540/41 is optimized for electronic ballast requiring a minimum board area, reduced component count and low power dissipation. Internal soft start circuitry eliminates the need for an external soft start PTC resistor. The initial soft start switching frequency and soft start time can be adjusted depending on the types of lamps. Voltage controlled dimming circuit is built into the IC to control the lighting output in a wide range. Protection circuitry has also been added to prevent burning out of switches in no lamp condition. Output gate drive circuit clamps power MOSFET gate voltage irrespective of supply voltage

8-DIP



8-SOP



FEATURES

- Internal soft start
- Flexable soft start frequency (KA7540)
- No lamp protection
- Voltage controlled dimming (KA7541)
- Trimmed 1.5% internal bandgap reference
- Under voltage lock out with 1.8V of hysteresis
- Totem pole output with high state clamp
- Low start-up and operating current
- 8-pin DIP & 8-pin SOP

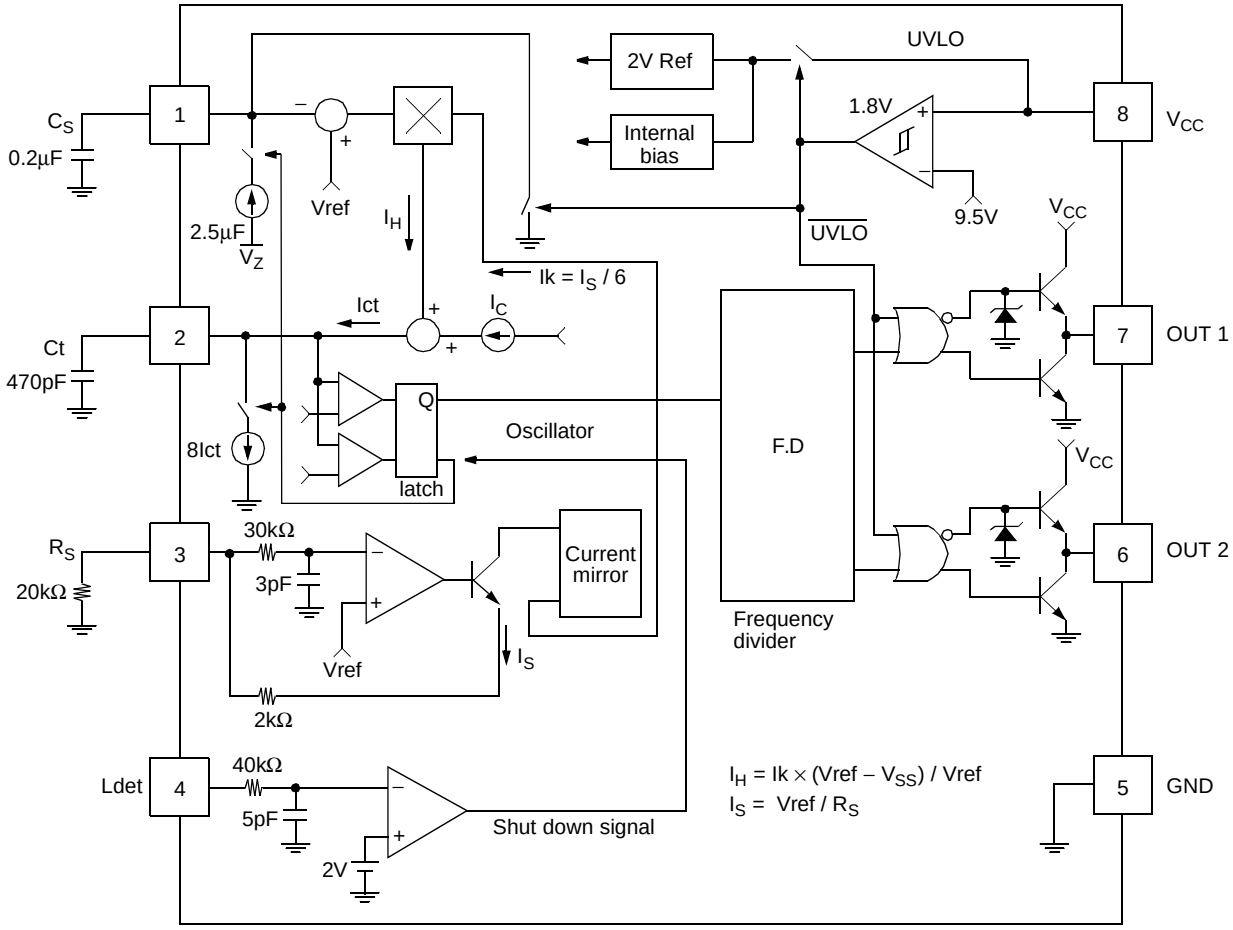
ORDERING INFORMATION

Device	Package	Operating Temperature
KA7540/41	8-DIP	0 ~ +105°C
KA7540D/41D	8-SOP	

APPLICATIONS

- Electronic Ballast

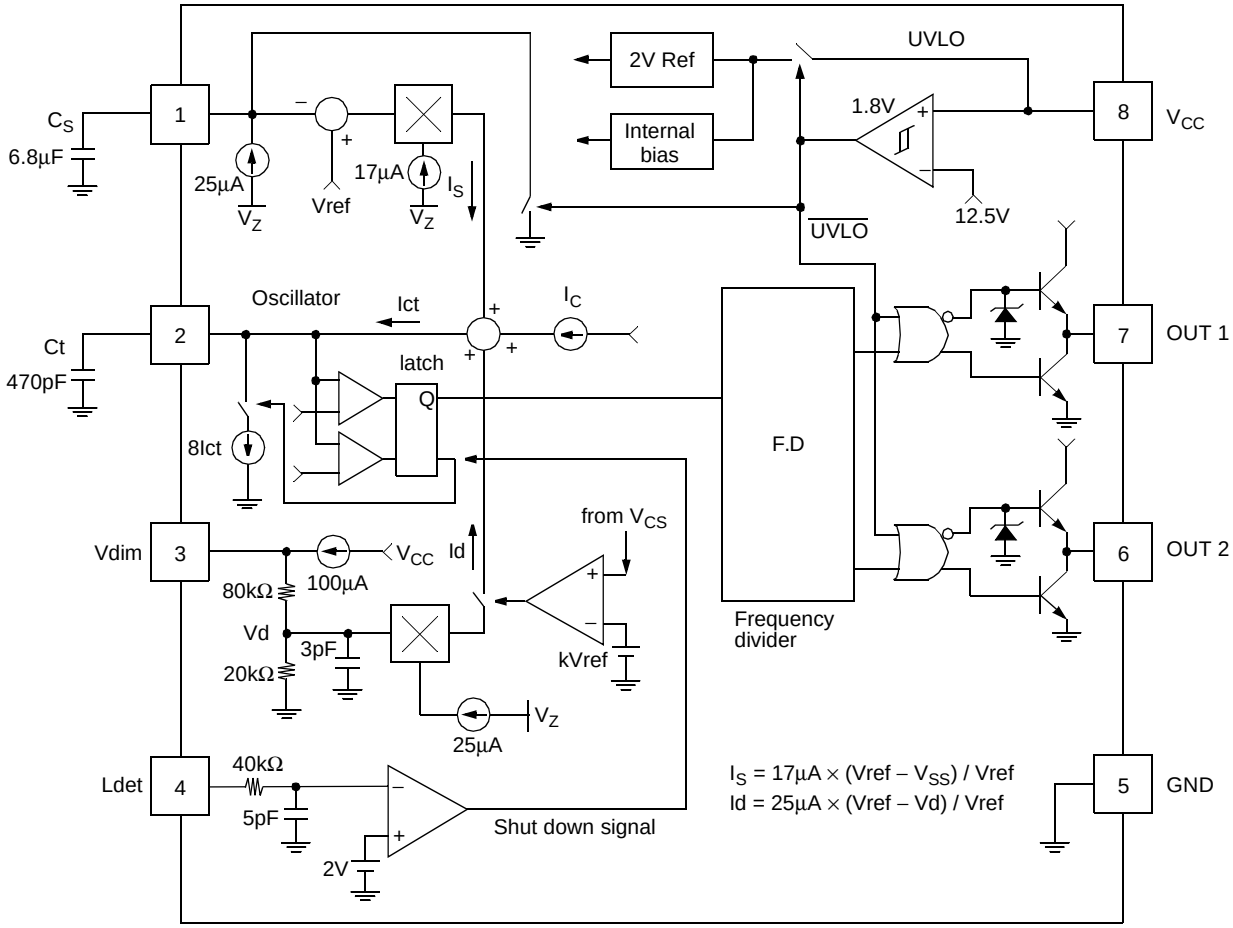
BLOCK DIAGRAM (KA7540)



IC SELECTION GUIDE

Function \ Option	KA7540
Initial soft start frequency	Flexable
Voltage controlled dimming	None

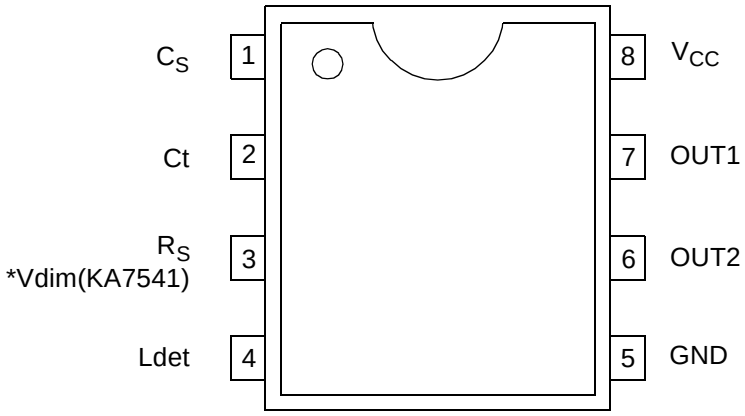
BLOCK DIAGRAM (KA7541)



IC SELECTION GUIDE

Function \ Option	KA7541
Initial soft start frequency	1.33 × normal operating frequency
Voltage controlled dimming	0 ~ 10V

PIN CONNECTION



(Top View)

PIN FUNCTIONS

Pin No.	Name	Function
1	C_S	Soft start capacitor connection pin. The pin voltage determines the phase of soft start, normal, and dimming mode.
2	C_T	Timing capacitor connection pin. The timing capacitor is charged and discharged to generate the sawtooth waveform that determines the oscillation frequency in the internal oscillator block.
3	R_S *Vdim(KA7541)	Soft start resistor connection pin. The soft start resistor value determines the initial preheating switching frequency during soft start mode. *Input to the dimming stage. The pin voltage sets the switching frequency in dimming mode. (KA7541)
4	Ldet	Input to the protection circuit. If the pin voltage is lower than 2V, the output of the gate driver is inhibited.
5	GND	The ground potential of all the pins.
6	OUT 2	The output of a high-current power driver capable of driving the gate of a power MOSFET
7	OUT 1	The output of high-current power driver capable of driving the gate of a power MOSFET.
8	V_{CC}	The logic and control power supply connection.

MAXIMUM RATINGS

Characteristics	Symbol	Value	Unit
Supply voltage	V_{CC}	30	V
Peak drive output current	I_{OH}, I_{OL}	±300	mA
Drive output clamping diodes V_O>V_{CC}, or V_O<–0.3	Iclamp	±10	mA
Dimming, soft start, and no lamp detection input voltage	V_{IN}	–0.3 to 6	V
Operating junction temperature range	Topr	–25 to 150	°C
Storage temperature range	Tstg	–65 to 150	°C
Power dissipation	Pd	0.8	W
Thermal resistance (Junction-to-air)	θja	100	W / °C

MAXIMUM RATINGS (0°C£Ta£105°C)

Characteristics	Symbol	Value	Unit
Temperature stability for reference voltage (Vref)	ΔVref (Typ)	15	mV
Temperature stability for operating frequency (fs)	ΔVref (Typ)	5	kHz

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, these specifications apply over operating ambient temperatures for the KA7540/41 with 0°C≤Ta≤105°C and V_{CC}=14V

Characteristic		Symbol	Test conditions	Min.	Typ.	Max.	Unit
UNDER VOLTAGE LOCK OUT SECTION							
Start threshold voltage	KA7540	V_{TH}(st)	V_{CC} increasing	8.5	9.5	10.5	V
	KA7541			11.5	12.5	13.5	V
UVLO hysteresis		HY(st)	–	1.4	1.8	2.2	V
SUPPLY CURRENT SECTION							
Start up supply current	KA7540	I_{ST}	V_{CC}<V_{TH}(st)	–	0.15	0.25	mA
	KA7541			–	0.2	0.3	mA
Operating supply current		I_{CC}	Output not switching	–	6	10	mA
Dynamic operating supply current		I_{DCC}	50kHz, CI=1nF	–	7	14	mA
REFERENCE SECTION							
Reference voltage		Vref	Iref=0mA	1.95	2	2.05	V
Line regulation		ΔVref 1	14V≤V_{CC}≤25V	–	0.1	10	mV
Temperature stability of Vref		ΔVref 2	0≤Ta≤75°C	–	15	–	mV
OSCILLATOR SECTION							
Operating frequency		fos	V_{SS}=3V, C_T=470pF	40	50	60	kHz
Operating dead time		tod	V_{SS}=3V	2.4	2.9	3.4	µs
Soft start frequency		fss	V_{SS}=3V, C_T=470pF	54	67	80	kHz
Soft start time current	KA7541	I_{SS}	V_{SS}=0V	17	25	33	µA
Soft start dead time		tsd	V_{SS}=0V	1.8	2.3	2.8	µs
Dimming frequency	KA7541	fd	–	58	72	86	kHz
Dimming voltage range	KA7541	ΔVdim	–	1	–	10	V
OUTPUT SECTION							
Rising time (note)		tr	CI=1nF	–	120	200	ns
Falling time (note)		tf	CI=1nF	–	50	100	ns
Maximum output voltage		Vomax(o)	V_{CC}=20V	12	14.5	17	V
Output voltage with UVLO activated		Vomin(o)	V_{CC}=5V, I_O=100µA	–	–	1	V
NO LAMP PROTECTION SECTION							
No lamp detect voltage		Vnd	–	1.9	2	2.1	V

NOTE: This parameter, although guaranteed, is not tested in production.

START-UP CIRCUIT

Start-up current is supplied to the IC through the start-up resistor (Rst). In order to reduce the power dissipation in Rst, the Rst is connected to the full-wave rectified output voltage.

The following equation can be used to calculate the size of Rst.

$$Rst = \frac{Vin(ac) \times \sqrt{2} - Vth(st),max}{Ist,max}$$

$$= \frac{90 \times 1.4 - }{0.4 \times 10^{-3}} = 283k\Omega$$

The size of start-up capacitor (Cst) is normally decided in terms of the start-up time and operating current build-up time with auxiliary operating current source.

The turn-off snubber capacitor (Cq2) and two diodes (D1, D2) constitute the auxiliary operating current source for the IC. The charging current through the Cq2 flows into the IC and also charges the start-up capacitor. If the size of Cq2 is increased, the V_{CC} voltage of the Cst is also increased.

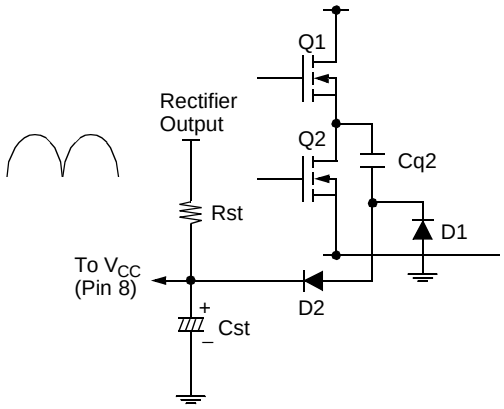


Figure 1. Start-up circuit

OSCILLATOR

The gate drive output frequency is as half as that of the triangular waveform in timing capacitor (Ct) at pin #12. In normal operating mode, the timing capacitor charging current is 50mA. The discharging current is seven times of the charging current ($7 \times 50\mu A$). The charging period of the timing capacitor is the on-duty of the gate drive. The discharging period the off-duty of the gate drive.

The rising slop and falling slop of the triangular waveform are as following.

Rising slop: dv/dt = i/C = 50μA / Ct

Falling slop: dv/dt = i/C = $7 \times 50\mu A$ / Ct

For example, when the timing capacitor is 47pF,

$\Delta Tch = 17.5\mu s$

$\Delta Tdis = 2.5\mu s$

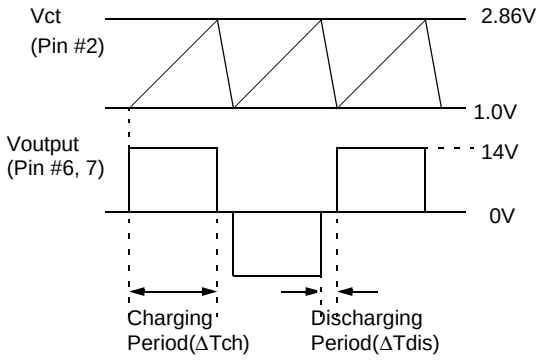


Figure 2. Oscillator sawtooth & Output gate drive waveform

As a result, the switching frequency is as following

$Ts = 2 \times (\Delta Tch + \Delta Tdis) = 40\mu s$

$fsw = 1 / T_S = 25kHz$

The explicit equation calculating the size of the timing capacitor for a certain switching frequency is written below.

$$Ct = \frac{11.76 \times 10^{-6}}{fsw}$$

SOFT START

The switching frequency is linearly decreasing from the pre-heating frequency to the normal switching frequency. In KA7541, the normal timing capacitor charging current is increased by 25μA during pre-heating mode. This addition of the charging current sets the pre-heating frequency to be 1.33 times the normal mode switching frequency.

$$fsw = 1.33 \times fsw(nor)$$

With KA7540, in comparison to the KA7541, the initial pre-heating frequency can be adjusted depending on the types of the lamps used. During the pre-heating mode, the sixth of the soft start current (I_S) which flows through the soft start resistor (R_{SS}) at pin #3 is added to the normal timing capacitor charging current (50μA). The rising and falling slop of the triangular waveform are increased due to this added current.

Soft start current (I_S) = 2V / R_{SS}

Rising slop: dv/dt = i/C = (50μA + I_S / 6) / Ct

Falling slop: dv/dt = i/C = 7 × (50μA + I_S / 6) / Ct

So, once the value of R_{SS} and Ct are known, the pre-heating frequency can be calculated straightforward by using the following equation.

$$fsw(pre) = \frac{50 \times 10^{-6} + \frac{0.33}{R_S}}{Ct \times 4.25}$$

The dead time ratio during pre-heating mode is maintained to be constant as well as in normal mode.
(7:1 = on-duty: dead time)

The voltage of the soft start capacitor (C_S) determines the soft start time (ts/s). When V_{CC} voltage exceeds the start-up voltage (Vth (st)), the soft start capacitor starts to be charged by the current source (313nA). The switching frequency decreases linearly to fsw (nor) from fsw (pre) until the soft start capacitor voltage (V_{CS}) touches 2V. Therefore the soft start duration time (ts/s) can be acquired by the following formula.

$$ts = \frac{Cs \times V}{i}$$

$$= \frac{0.2 \times 10^{-6} \times 2}{313 \times 10^{-9}} = 1.28s$$

For example, the soft start capacitor of 0.2μF makes the soft start time (ts/s) to be 1.28sec

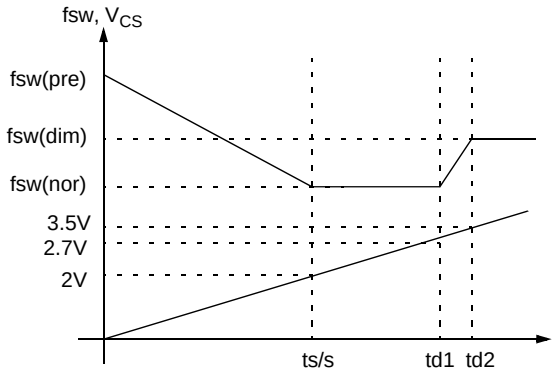


Figure 3. Frequency & Soft start capacitor voltage variation during soft start and dimming mode

NO LAMP PROTECTION

When the voltage at pin #4 is lower than 2V, the gate drive output is off-state, so the external power MOSFE stops switching. In no lamp protection circuit the dc link voltage is divided by a couple of resistors including both lamp filaments to be applied to the pin #4 before the MOSFETs start switching.

$$V_{R4} = Vdd \times \frac{R4}{R1 + \frac{R2 + R3}{2} \quad 2 \times Rf \quad R4}$$

$$\cong 400 \times \frac{8k\Omega}{180k\Omega + \frac{330k\Omega + 680k\Omega}{2} \quad 8k\Omega}$$

$$V3 = V2 \times \frac{R3}{R2 + R3} \cong 200V$$

When in normal mode the average voltage of the V3 is the half of the dc link voltage (Vdd). So, in order to make stable start condition, the resistors are designed to make the voltage of V3 to be the half of the dc link voltage.

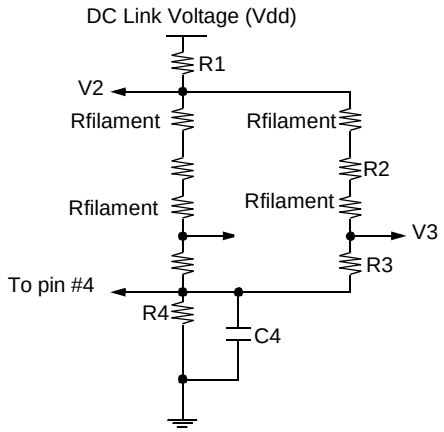


Figure 4. Lamp detection resistor network

DIMMING (KA7541)

The lighting output of the lamp can be controlled by varying the switching frequency of the ballast circuit. In voltage source series resonant type converter, the output power is inversely proportional to the switching frequency. As result, in order to make the lamp lighting output less bright (so called "dimming"), the switching frequency should be increased compared to that of the normal full lighting output.

With KA7541 the switching frequency can be controlled by the voltage level at the pin #3 (Vdim). Since the IC starts to operate, the voltage level at the dimming pin doesn' t affect the oscillator frequency unit the time of td1 in figure 3. At the time td1, the switching frequency starts to ramp up to the dimming switching frequency level that is determined by the voltage level at the dimming pin. In dimming mode, the timing capacitor charging current is increased by the following amount of the dimming current (Id).

Id = Ik $\times$ (Vref - Vd) / Vref

Ik = 2 / (6 $\times$ R_S)

Vd = Vdim / 5

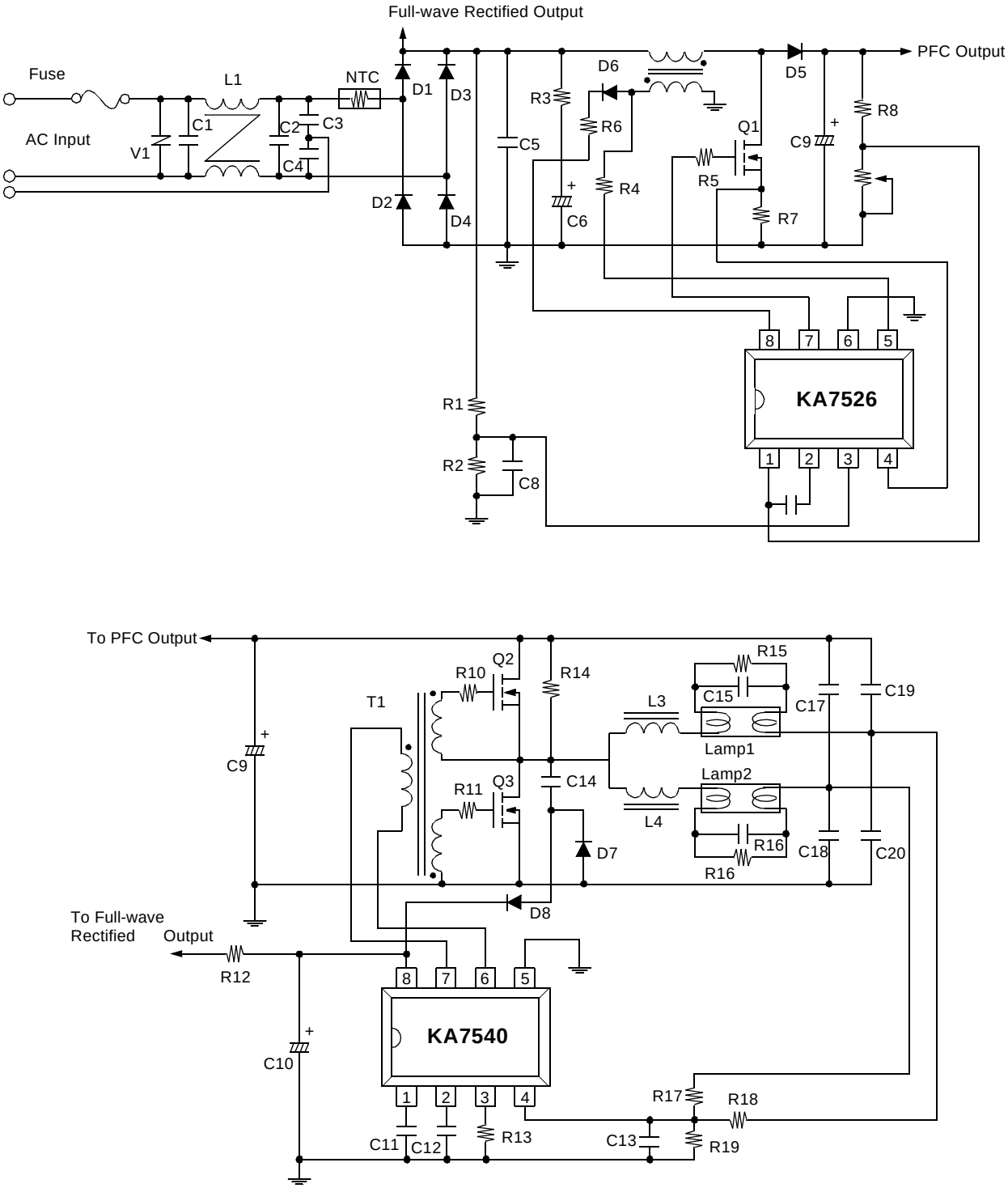
So, the explicit equation for the dimming frequency is as following.

$$f_{swdim} = \frac{50 \times 10^{-6} + \frac{2 - \frac{Vdim}{5}}{6 \times R_S}}{Ct \times 4.25}$$

If the dimming pin is open, the dimming pin voltage becomes 10V due to the internal 100μA current source, which is equivalent to the normal full lighting output case.

APPLICATION CIRCUIT

<90 ~ 265V_{AC} Input, 400V_{DC}, 32W×2 Lamps Ballast>



COMPONENT LISTING

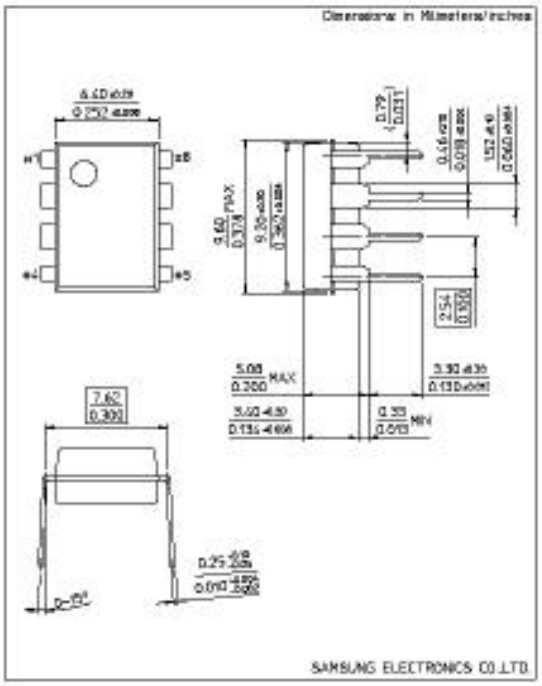
Reference	Value	Part number	Manufacturer
R1	2.2MΩ–F, 1/4W	26mm Type	ABCO
R2	11kΩ–F, 1/4W	26mm Type	ABCO
R3, R12	13kΩ–J, 1/4W	26mm Type	ABCO
R4	22kΩ–J, 1/4W	26mm Type	ABCO
R5, 10, 11	47Ω–J, 1/4W	26mm Type	ABCO
R6	3.3Ω, 1/4W	26mm Type	ABCO
R7	1Ω–J, 1W	–	ABCO
R8	1MΩ–F, 1/4W	26mm Type	ABCO
R9	10kΩ Variable Resistor	26mm Type	ABCO
R13	22kΩ–F, 1/4W	26mm Type	ABCO
R14	180kΩ–J, 1/4W	26mm Type	ABCO
R15, R16	330kΩ–J, 1/4W	26mm Type	ABCO
R17, R18	680kΩ–J, 1/4W	26mm Type	ABCO
R19	8kΩ–J, 1/4W	26mm Type	ABCO
C1, 2	0.15μF, 630V	MEP-CAP	WOOYANG
C3, 4	2200pF, 3000V	Y-CAP	SAMSUNG
C5	0.22μF, 630V	MPE-CAP	WOOYANG
C6	22μF, 35V	Electrolytic	SAMSUNG
C7, 11	0.22μF, 25V	Ceramic	DONGLE
C8	0.01μF, 25V	Ceramic	DONGLE
C9	47μF, 450V	Electrolytic	SAMSUNG
C10	33μF, 35V	Electrolytic	SAMSUNG
C12	240pF, 25V	Ceramic	DONGLE
C13	0.1μF, 25V	Ceramic	DONGLE
C14	1500pF, 630V	PPF-CAP	WOOYANG
C15, 16	6800pF, 1000V	PPF-CAP	WOOYANG
C17, 18, 19, 20	6800pF, 630V	PPF-CAP	WOOYANG
D1, 2, 3, 4	1000V, 1A	IN4007GP	GI
D5	1000V, 1.5A	RGP15J	GI
D6, 7, 8	75V, 150mA	IN4148	ROHM

COMPONENT LISTING (Continued)

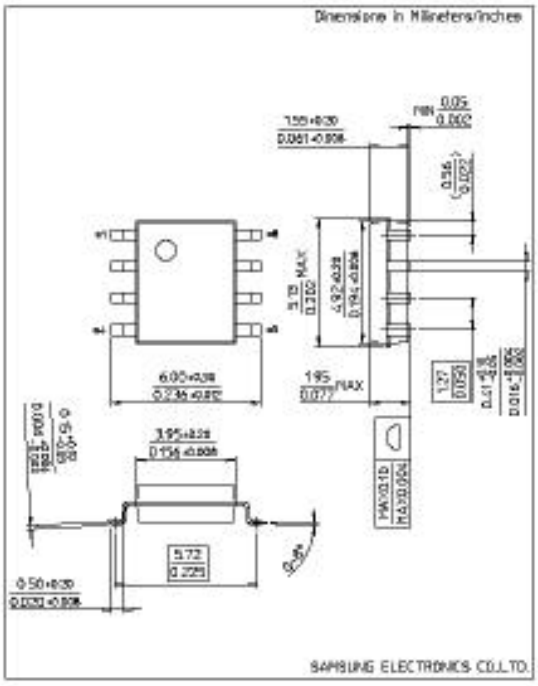
Reference	Value	Part number	Manufacturer
L1	–	BSF2125	NAMYANG
L2	0.45mH	EI2820	NAMYANG
L3, 4	3.1mH	EI2820	NAMYANG
T1	–	EI2820	NAMYANG
Fuse	–	52NM250V, 3A	SAMSUNG
V1	430V	INR140, 431	ILJIN
Q1, 2, 3	500V, 4.5A	IRF830	SAMSUNG

PACKAGE DIMENTSION

8-DIP-300



8-SOP-225



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PRODUCT STATUS DEFINITIONS

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