FAIRCHILD SEMICONDUCTOR®

January 2010

FL7730
Primary-Side-Controlled Dimmable LED Driver

Features

- Compatible with traditional control (TRIAC and IGBT). No need to change existing lamp infrastructure: wall switch & wire. Compatible to Non dimming lamp
- Built in HV supplying circuit for Excellent Power Factor and Current Harmonic
- Simple ,Easy and Reliable Interface
- Cost Effective Solution
- Constant-voltage (CV) and Constant-current (CC) Control Without Secondary-feedback Circuitry
- Green-mode Function: PWM Frequency Linearly Decreasing
- Fixed PWM Frequency at 65kHz with Frequency Hopping to Solve EMI Problem
- Low Start-up Current 10μA
- Low Operating Current 3.5mA
- Peak-current-mode Control in CV mode
- Cycle-by-cycle Current Limiting
- VDD Over-voltage Protection with Auto-Restart
- VDD Under-voltage Lockout (UVLO)
- Gate Output Maximum Voltage Clamped at 18V
- Fixed Over-temperature Protection with Auto_ Recovery Function.
- DIP-7 and SOP-7 Package Available

Applications

- Compatible for TRIAC and IGBT Dimming Modulation or Digital Pulse Modulation

Description

This highly integrated PWM controller, FL7730, provides several features to enhance the performance of low-power flyback converters. The patented topology of FL7730 enables most simplified circuit design especially for LED Lighting applications. A low-cost, smaller and LED lighter is thus resulted when compared to a conventional design or a linear transformer. The HV startup circuit is build inside for further power saving.

To minimize the standby power consumption, the proprietary green-mode function provides off-time modulation to linearly decrease PWM frequency under light-load conditions. This green-mode function assists the power supply to easily meet the power conservation requirement.

By using FL7730, a LED dimmer can be implemented with fewest external components and minimized cost. A typical output CV/CC characteristic envelope is shown in Figure 1.

FL7730 series controller are available in 7-pin DIP and 7-pin SOP packages.

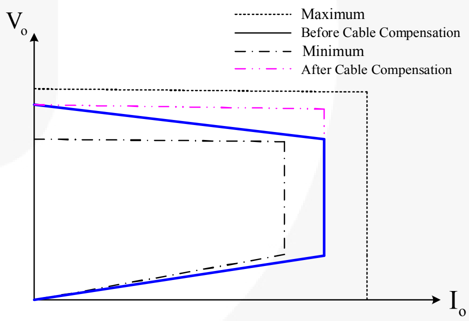


Figure 1. Typical output V-I characteristic

Ordering Information

Part Number <Orderable>	Pb-Free	Operating Temperature Range	Package	Packing Method
FL7730NY		-40℃ to +85℃	8-Lead, Dual Inline Package(DIP-7)	Tube
FL7730MY		-40℃ to +85℃	7-Lead, Small Outline Package (SOP-7)	Reel & Tape

Application Diagram

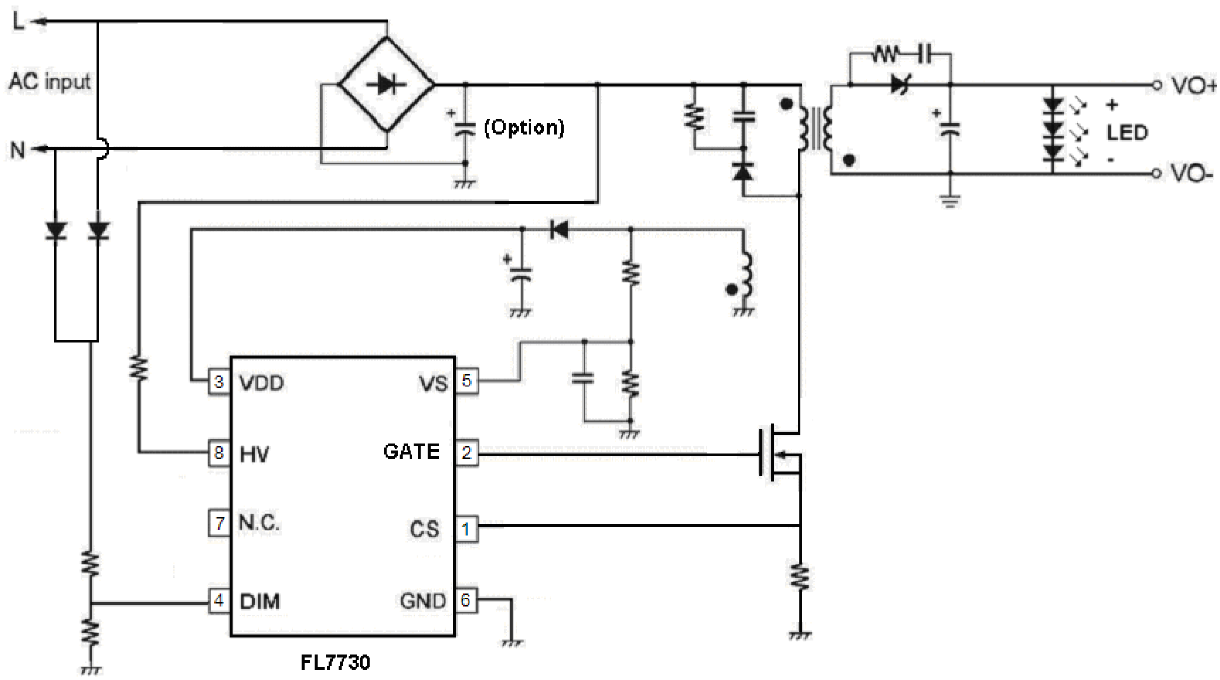


Figure 1. Typical Application

Internal Block Diagram

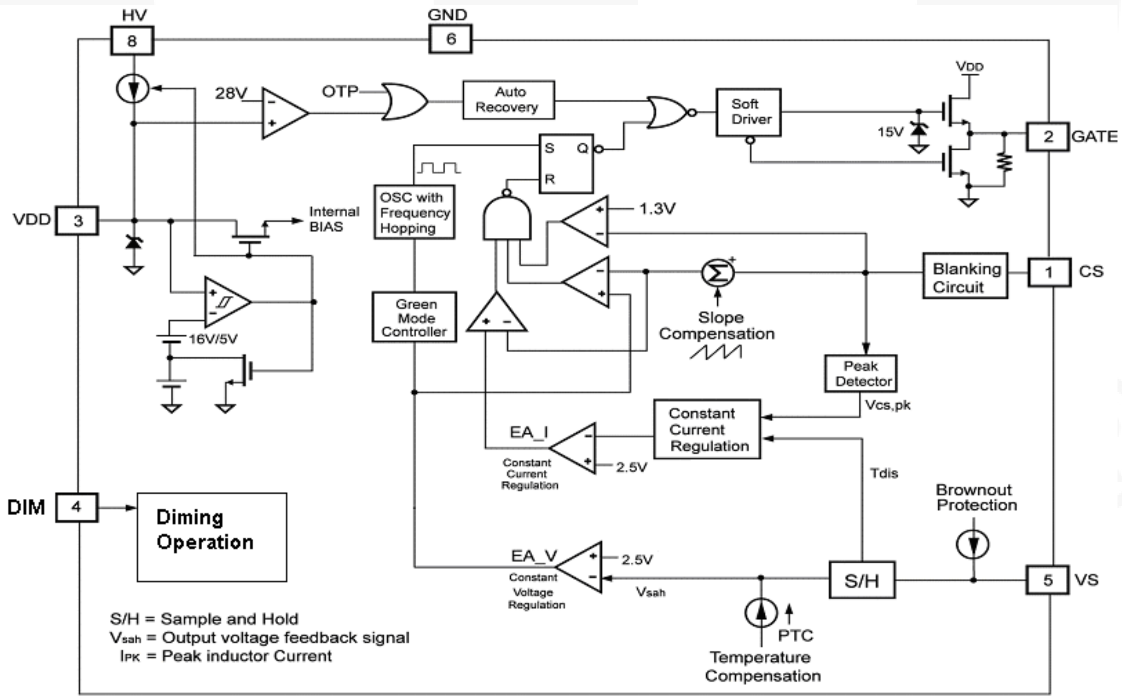


Figure 2. Functional Block Diagram

Pin Configuration

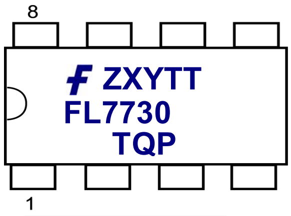


Figure 3. Pin Configuration

F: Fairchild logo
Z: Plant Code
X: Year Code
Y: Week Code
TT: Die run code
T: N=DIP
M=SOP
Q: Z=Pb free
Y=Green
P: Manufacturing flow code

Pin Definitions

Pin #	Name	Description
1	CS	**Analog input,** Current sense. Connected to a current-sense resistor for peak-current-mode control in CV mode. The current-sense signal is also provided for output-current regulation in CC mode.
2	GATE	**Driver Output,** The totem-pole output driver to drive the power MOSFET.
3	VDD	**Supply,** Power supply.
4	Dim	**Analog Input,** Dimming operation. This pin is for LED lighting dimming operation..
5	VS	**Analog input,** Voltage sense. Output-voltage-sense input for output-voltage regulation.
6	GND	**Voltage Reference,** Ground.
7	NC	
8	HV	**Analog input,** High voltage start-up.

Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter		Min.	Max.	Unit
V_{VDD}	DC Supply Voltage[오류! 참조 원본을 찾을 수 없습니다., 오류! 참조 원본을 찾을 수 없습니다.]			30	V
V_{VS}	VS Pin input voltage		-0.3	7	V
V_{CS}	CS Pin input voltage		-0.3	7	V
V_{DS}	Drain-Source Voltage			600	V
I_D	Continuous Drain Current	T_C=25℃		1	A
		T_C=100℃		0.6	A
I_{DM}	Pulsed Drain Current			4	A
E_{AS}	Single Pulse Avalanche Energy			33	mJ
I_{AR}	Avalanche Current			1	A
P_D	Power Dissipation (T_A<50°C)	DIP-8		800	mW
		SOP-7		660	
$R_{\theta JA}$	Thermal Resistance (Junction to Air)	DIP-8		113	°C /W
		SOP-7		153	
$R_{\theta JC}$	Thermal Resistance (Junction to Case)	DIP-8		67	°C /W
		SOP-7		39	
T_J	Operating Junction Temperature			150	°C
T_{STG}	Storage Temperature Range		-55	150	°C
T_L	Lead Temperature (Soldering) 10Sec			260	°C
ESD	ESD Capability, Human Body Model			2.5	KV
	ESD Capability, Machine Model			200	V

Notes:
1. Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device.
2. All voltage values, except differential voltages, are given with respect to GND pin.

Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
T_A	Operating Ambient Temperature		-40		85	°C

Electrical Characteristics

V_{DD}=15V, T_A=25℃, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
VDD SECTION						
V_{OP}	Continuously Operating Voltage				25	V
V_{DD-ON}	Turn-on Threshold Voltage		15	16	17	V
V_{DD-OFF}	Turn-Off Threshold Voltage		4.5	5	5.5	V
I_{DD-ST}	Startup current	0< V_{DD} < V_{DD-ON}-0.16V		10	20	μA
I_{DD-OP}	Operating Current	V_{DD} = 15V,V_{CS}=0V V_{VS}=0V, C_L=1nF		3.2		mA
$I_{DD-GREEN}$	Green-mode Operating Supply Current	V_{DD} =15V,V_{CS}=5.5V V_{VS}=0V, C_L=1nF		0.85	1	mA
V_{DD-OVP}	VDD Over-voltage-protection level	V_{CS}=0V, V_{VS}=0V V_{DD}=20V→OVP	27	28	29	V
$t_{D-VDDOVP}$	VDD Over-voltage-protection Debounce Time	V_{DD} = 20V→30V,V_{CS}=0V V_{VS}=0V,	90	200	500	μsec
OSCILLATOR SECTION						
F_{OSC}	FSFAN7730 Frequency: Center Frequency	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=3.5V	62	65	68	KHz
	FSFAN7730 Frequency: Frequency Hopping Range	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V	±2.2 ?	±2.7 ?	±3.2 ?	KHz
t_{FHR}	Frequency Hopping Period	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V	2.75	3	3.25	mS
$F_{OSC-N-MIN}$	Min. frequency at No-Load	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=0V	350	500	700	Hz
$F_{OSC-CM-MIN}$	Min. Frequency in CC Mode	V_{DD} = 15V, V_{CS}=0V V_{VS}=1V, V_{COMR}=0V	22	24.5	27	KHz
F_{DV}	Frequency Variation Versus V_{DD} Deviation	V_{DD} = 10, 25V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=3.5V		1	2	%
F_{DT}	Frequency Variation Versus Temp. Deviation	T_A = -30°C to 85°C			15	%
VOLTAGE-SENSE SECTION						
I_{VS-UVP}	Sink current for Brownout protection	R_{VS}=20K		150		uA
Itc	IC Compensation Bias Current	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=3.5V		9	12	uA
$V_{BIAS-COMV}$	Adaptive Bias voltage dominated by V_{COMV}	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V R_{VS}=20k	1.2	1.34	1.6	V

HV START-UP CURRENT SOURCE SECTION						
V_{HV-MIN}	Minimum Startup Voltage on HV pin				50	V
I_{HV}	Supply Current Drawn from Pin HV	V_{AC}=90V(V_{DC}=100V); V_{DD}=0V		1.2		mA
I_{HV-LC}	Leakage Current after Startup	HV=500V, V_{DD}→ V_{DD-ON}→V_{DD-OFF} +1V		10	20	uA

Electrical Characteristics

V_{DD}=15V, T_A=25℃, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
CURRENT-SENSE SECTION						
t_{PD}	Propagation Delay to GATE Output	V_{DD} = 15V, V_{CS}=1.5V pulse V_{VS}=0V, V_{COMR}=0V		90	200	nS
t_{MIN-N}	Min. On Time at No-Load	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=1V	900	1100	1400	nS
t_{MINCC}	Min. On Time in CC mode	**V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=3V**	**120**	**250**	**380**	nS
V_{SLOPE}	Slope Compensation		0.37	0.4	0.43	V
V_{TH}	Threshold Voltage for Current Limit	V_{DD} = 15V, V_{CS}=0→1.5V V_{VS}=0V, V_{COMR}=0V	1.2	1.3	1.4	V
VOLTAGE-ERROR-AMPLIFIER SECTION						
V_{VR}	Reference Voltage	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, measure V_{COMR}	2.475	2.5	2.525	V
V_N	Green-Mode Starting Voltage on COMV pin	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=2.8V→2.1V Measure V_{COMR} @F_{OSC}-2kH	2.35	2.5	2.7	V
V_G	Green-Mode Ending Voltage on COMV pin	V_{DD} = 15V, V_{CS}=5.5V V_{VS}=0V, V_{COMR}=1.3V→0.1V Measure V_{COMR} @1kHz		0.75	1.2	V
I_{V-SINK}	Output Sink Current	V_{VS}=3V, V_{COMV}=2.5V		90		μA
$I_{V-SOURCE}$	Output Source Current	V_{VS}=2V, V_{COMV}=2.5V		90		μA
V_{V-HGH}	Output High Voltage	V_{VS}=2.3V	4.5			V
CURRENT-ERROR-AMPLIFIER SECTION						
V_{IR}	Reference Voltage		2.475	2.5	2.525	V
I_{I-SINK}	Output Sink Current	V_{CS}=3V, V_{COMI}=2.5V		50		μA
$I_{I-SOURCE}$	Output Source Current	V_{CS}=0V, V_{COMI}=2.5V		50		μA
V_{I-HGH}	Output High Voltage	V_{CS}=0V	4.5			V

Electrical Characteristics

V_{DD}=8V~25V, T_A=-25°C~85°C, unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
GATE SECTION						
DCY_{MAX}	Maximum Duty Cycle	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V	60	65	70	%
V_{OL}	Output Voltage Low	V_{DD} = 20V, V_{CS}=0V V_{VS}=5V, V_{COMR}=0V Gate sinks 10mA			1.5	V
V_{OH}	Output Voltage High	V_{DD} = 0V→18V→8V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V Gate sources 1mA	5			V
V_{OH_MIN}	Output Voltage High	V_{DD} = 5.5V, I_O=1mA	4			V
t_r	Rising Time	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V C_L=1nF		200	250	nS
t_f	Falling Time	V_{DD} = 15V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V C_L=1nF		85	100	nS
V_{CLAMP}	Output Clamp Voltage	V_{DD} = 25V, V_{CS}=0V V_{VS}=0V, V_{COMR}=0V	14	15	18	V
OVER-TEMPERATURE-PROTECTION SECTION						
T_{OTP}	Threshold Temperature for OTP(1)	V_{DD} = 15V, V_{CS}=1.5V pulse V_{VS}=0V, V_{COMR}=0V	135	140	160	°C
$T_{OTP\text{-}Hys}$	Restart Junction Temperature Hysteresis		105	115	120	°C

Note:

1. Pulse Test : Pulse width ≦ 300us, Duty cycle ≦ 2%
2. Essentially independent of operating temperature
3. When the Over-temperature protection is activated, the power system will enter latch mode and output is disabled.

Functional Description

The **Phase Angle Demodulator System** (herein after called *PADS*) used in LED lighting fixture is a part of the LED Dimmer Controller. It is designed for both of the following applications:

Analog Pulse-width Demodulation (APD)

When the PADS recognizes a TRIAC or IGBT application, the PADS will define the ON time and the OFF time of the line voltage as following Figure 4 shows. The Duty (ON time) will be converted into the reference voltage V_{REF_B} . The reference voltage V_{REF_B} will adjust the brightness of LED.

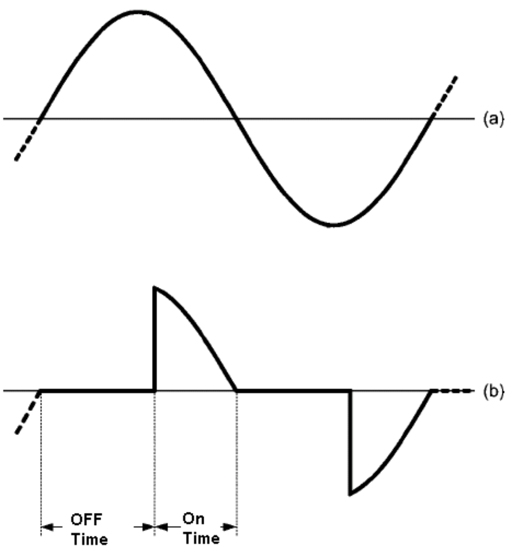


Figure 4. Line Voltage for APD application

Frequency Hopping

The patented topology of FL7730 enables most simplified circuit design especially for LED lighting applications. Without secondary feedback circuitry, the CV and CC control can still be achieved accurately. As shown in Figure 5 with the frequency-hopping, PWM operation, EMI problem can be solved by using minimized filter components. FL7730 also provides many protection functions. VDD pin is equipped with over-voltage protection, also with under-voltage lockout. Pulse-by-pulse current limiting and CC control ensure over-current protection at heavy loads. Also, the internal over-temperature-protection function shuts down the controller with auto recovery when over heated.

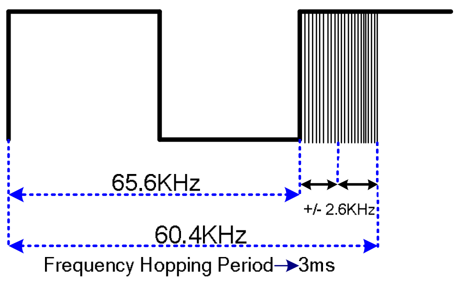


Figure 5. Frequency Hopping

Start-Up Current

For start-up, the HV pin is connected to the line input or bulk capacitor through resistor, R_{HV}, (100KΩ recommended). Typical start-up current drawn from pin HV is 1.5mA and charges the hold-up capacitor through the resistor. When the V_{DD} capacitor level reaches V_{DD-ON}, the start-up current switches off. At this moment, the V_{DD} capacitor only supplies the FL7730 to keep the V_{DD} before the auxiliary winding of the main transformer to provide the operating current.

Operating Current

The operating current has been reduced to 3.2mA. The low operating current results in higher efficiency and reduces the V_{DD} hold-up capacitance requirement. Once FL7730 enter deep-green-mode, the operating current will be reduced to 0.95mA, thus that can assist the power supply to easily meet the power conservation requirement.

Green-Mode Operation

The proprietary green-mode function provides off-time modulation to linearly decrease the PWM frequency under light-load conditions. The PWM frequency is dominated by the voltage V_{COMV} of COMV pin. When the voltage V_{COMV} is lower than about 2.5V, the PWM frequency will linearly decrease from 100KHz to 370Hz, until the voltage V_{COMV} lower than 0.6V, thus will get much better power saving to easily meet international power conservation requirements.

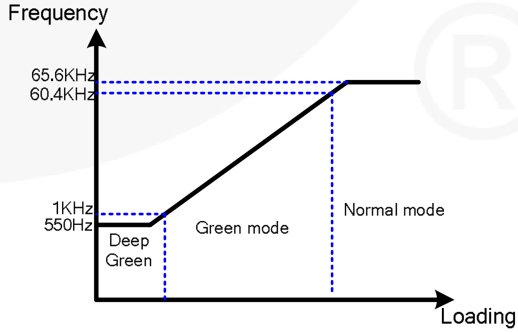


Figure 6. Green-Mode operation

Frequency vs V_{COMV}

Constant Voltage(CV) and Constant Current(CC) Operation

An innovative technique of the FL7730 can accurately achieve CV/CC characteristic output without secondary side voltage or current feedback circuitry. There has a feedback signal for CV/CC operation that is from the reflected voltage across the primary auxiliary winding, this voltage signal is proportional to secondary winding, so it provides controller the feedback signal from secondary side and achieve constant voltage output property. In constant current output operation, this voltage signal will be detected and examined by the precise constant current regulation controller, then determined the on-time of the MOSFET to control input power and provide constant current output property. With feedback voltage Vcs across current sense resistor, the controller can obtain input power of power supply. Therefore, the region of constant current output operation can be adjusted by current sense resistor.

Temperature Compensation

The FL7730 has a built in temperature compensation, in order to get better constant voltage regulation at different ambient temperature. This internal compensation current is a positive temperature coefficient (PTC) current that can compensate the forward-voltage drop of the secondary diode of varying with temperature. This variation caused output voltage rising at high temperature.

Leading-Edge Blanking

Each time the power MOSFET is switched on, a turn-on spike will inevitable occur at the sense-resistor. To avoid premature termination of the switching pulse, leading-edge blanking time is built in. Conventional RC filtering can therefore be omitted. During this blanking period, the current-limit comparator is disabled and it cannot switch off gate driver.

Under Voltage Lockout (UVLO)

The turn-on and turn-off thresholds of the FL7730 are fixed internally at 16V/5V. During start-up, the hold-up capacitor must be charged to 16V through the start-up resistor, so that the FL7730 will be enabled. The hold-up capacitor will continue to supply V_{DD} until power can be delivered from the auxiliary winding of the main transformer. V_{DD} must not drop below 5V during this start-up process. This UVLO hysteresis window ensures that hold-up capacitor will be adequate to supply V_{DD} during start-up.

VDD Over-Voltage Protection

VDD over-voltage protection has been built in to prevent damage due to over voltage conditions. When the voltage VDD exceeds 28V due to abnormal conditions, PWM output will be turned off. Over-voltage conditions are usually caused by open feedback loops.

Over Temperature Protection (OTP)

The FL7730 has a built-in temperature sensing circuit to shut down PWM output once the junction temperature exceeds 140℃. While PWM output is shut down, the V_{DD} voltage will gradually drop to the UVLO voltage. Some of the FL7730's internal circuits will be shut down, and V_{DD} will gradually start increasing again. When V_{DD} reaches 15V, all the internal circuits, including normally. If the junction temperature is still higher than 140℃, the PWM controller will be shut down immediately.

Built-in Slope Compensation

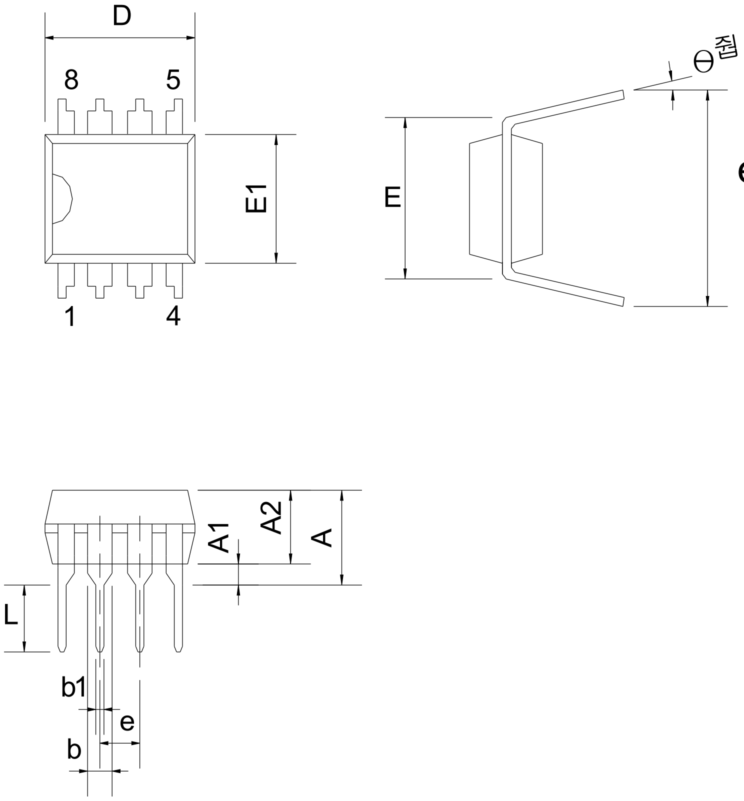
The sensed voltage across the current sense resistor is used for current mode control and pulse-by-pulse current limiting. Built-in slope compensation will improve stability and prevent sub-harmonic oscillations due to peak-current mode control. The FL7730 has a synchronized, positively-sloped ramp built-in at each switching cycle.

Noise Immunity

Noise from the current sense or the control signal can cause significant pulse width jitter, particularly in continuous-conduction mode. While slope compensation helps alleviate these problems, further precautions should still be taken. Good placement and layout practices should be followed. Avoiding long PCB traces and component leads, locating compensation and filter components near the FL7730, and increasing the power MOS gate resistance is advised.

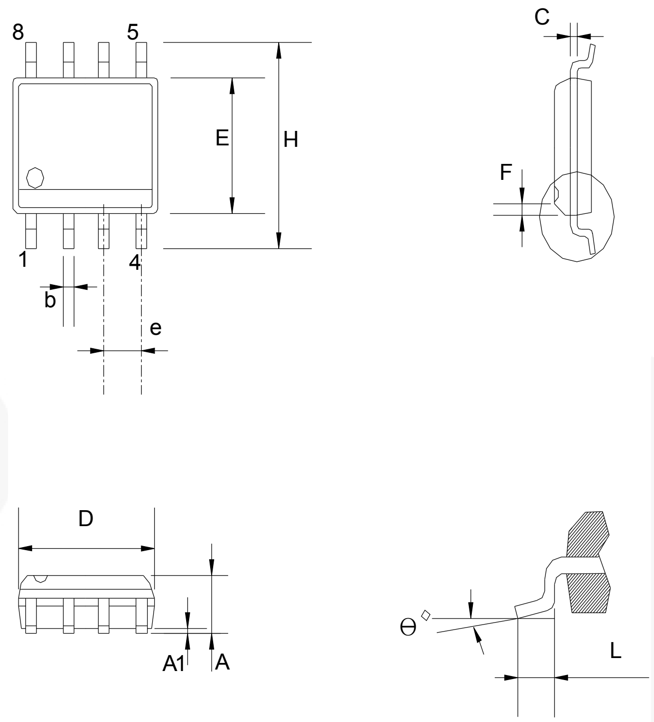
Mechanical Dimensions

8PINS-DIP(D)



Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	**1.346**		**5.334**			**0.210**
A1	**0.381**			**0.015**		
A2	**3.175**	**3.302**	**3.429**	**0.125**	**0.130**	**0.135**
b		**1.524**			**0.060**	
b1		**0.457**			**0.018**	
D	**9.017**	**9.271**	**10.16**	**0.355**	**0.365**	**0.400**
E		**7.620**			**0.300**	
E1	**6.223**	**6.350**	**6.477**	**0.245**	**0.250**	**0.255**
e		**2.540**			**0.100°**	
L	**2.921**	**3.302**	**3.810**	**0.115**	**0.130**	**0.150**
e_B	**8.509**	**9.017**	**9.525**	**0.335**	**0.355**	**0.375**
θ°	**0°**	7°	**15°**	**0°**	7°	15°

8PINS-SOP(S)



Dimensions

Symbol	Millimeter			Inch		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	**1.346**		**1.752**	**0.053**		**0.069**
A1	**0.101**		**0.254**	**0.004**		**0.010**
b		**0.406**			**0.016**	
c		**0.203**			**0.008**	
D	**4.648**		**4.978**	**0.183**		**0.196**
E	**3.810**		**3.987**	**0.150**		**0.157**
e	**1.016**	**1.270**	**1.524**	**0.040**	**0.050**	**0.060**
F		**0.381X45°**			**0.015X45°**	
H	**5.791**		**6.197**	**0.228**		**0.244**
L	**0.406**		**1.270**	**0.016**		**0.050**
θ°	**0°**		**8°**	**0°**		**8°**

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GTO™
i-Lo™
IntelliMAX™
ISOPLANAR™
MegaBuck™
MICROCOUPLER™
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MicroPak™
MillerDrive™
Motion-SPM™
OPTOLOGIC®
OPTOPLANAR®
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PDP-SPM™
Power220®
Power247®
POWEREDGE®
Power-SPM™
PowerTrench®
Programmable Active Droop™
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