Description

HY7700 is a PWM high-efficiency LED driver controller IC. It allows efficient operation of High Brightness （HB） LED(s) from voltage sources ranging from 9VDC up to 450VDC. HY7700 controls an external MOSFET at variable switching frequency up to 300 kHz. The constant off-time can be programmed using a single resistor. The LED string is driven at constant current rather than constant voltage, thus providing constant light output and enhanced reliability. The output current can be programmed between a few milliamps and up to more than 1.0A

.

Features

- **n** >90% efficiency.
- **n** 9V to 450V input Range.
- **n** Constant Current LED driver.
- **n** More than 1.0A output applications.
- **n** PWM Low-Frequency Dimming via Enable pin.
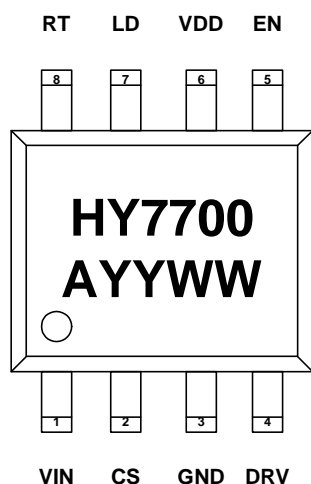- **n** Input Voltage Surge ratings up to 450V.

Applications

- **n** DC/DC LED Driver Application.
- **n** RGB backlighting LED driver.
- **n** Back lighting of flat panel displays.
- **n** LED Lighting Application
- **n** Automotive LED Lighting Application.

Typical Applications Circuit

HY7700 V1.0
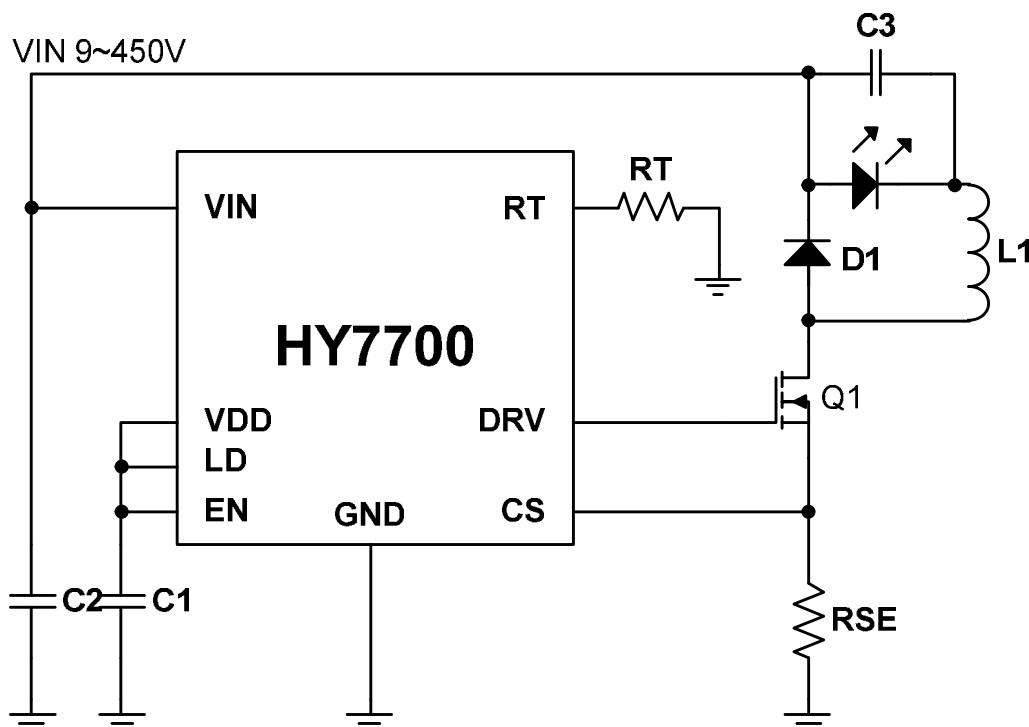
Marking Information & Pin Configuration

A : Assembly Location
YY : Year
WW : Weekly

Pin Definition

PIN NUMBER	PIN SYMBOL	PIN DESCRIPTION
1	VIN	Power Supply
2	CS	Output current set input. Connect a resistor from CS to GND to set the LED bias current. $I_{LED} = 0.25 / RSE$
3	GND	Ground
4	DRV	Output gate driver for an external N-Channel MOSFET.
5	EN	Enable pin, high active with dimming function.
6	VDD	Internal regulator output which must connect a low ESR bypass capacitor to ground.
7	LD	Current sense threshold setting.
8	RT	When a resistor connects between RT and GND, HY7700 operates in constant frequency mode. When a resistor connects between RT and DRV, HY7700 operates in constant off-time mode.

HY7700 V1.0

Block Diagram
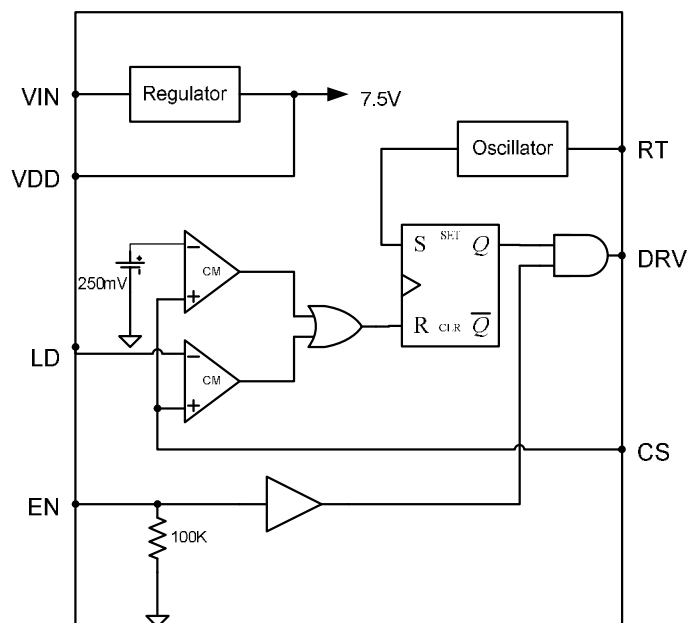
ABSOLUTE MAXIMUM RATINGS

RATING	VALUE	UNIT
VIN to GND	-0.5 to 450	**V**
CS, LD, EN, DRV, RT	-0.5 to (VDD+0.3)	**V**
VDD to GND	12	**V**
Junction Temperature Range	-40 to 150	℃
Storage Temperature Range	-65 to 150	℃
Thermal Impedance: SOP-8	128	**℃/W**
Continuous Power Dissipation TA =+25℃ : SOP-8	830	**mW**
ESD Protection HBM	2000	**V**

HY7700 V1.0

ELECTRICAL CHARACTERISTICS

(TA = 25°C, UNLESS OTHERWISE SPECIFIED)

PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Input DC supply voltage range	V_{INDC}	DC input voltage	9		450	V
Shut-Down mode supply current	V_{DP}	Pin EN to GND,VIN=9V		0.5	1.0	mA
Internally regulated voltage	VDD	VIN = 9 – 450V, I_{DD} = 0, Pin DRV open	7.0	7.5	8.0	V
Maximal pin V_{DD} voltage	VDDmax	When an external voltage applied to pin VDD			13.5	V
VDD current available for external circuit	IDD(ext)	VIN = 9 – 450V			1.0	mA
VDD under-voltage lockout threshold	UVLO	VIN rising	6.45	6.7	6.95	V
VDD under voltage lockout hysteresis	△UVLO	VIN falling		500		mV
Pin EN input low voltage	VEN(lo)	VIN = 9 - 450V			1.0	V
Pin EN input high voltage	VEN(hi)	VIN = 9 - 450V	2.4			V
Pin EN pull-down resistance	RLN	VEN =5 V	50	100	150	KΩ
Current sense pull-in threshold voltage	VCS(hi)	@ TA =-40°C to +85°C	225	250	275	mV
DRV high output voltage	VDRV(hi)	IOUT = -10 mA	VDD-0.3		VDD	V
DRV low output voltage	VDRV(lo)	IOUT = 10 mA	0		0.3	V
Oscillator Frequency	fosc	RT = 1.00 MΩ RT = 223 KΩ	20 80	25 100	30 120	KHz
Linear Dimming pin voltage range	VLD	@ TA ≦ 85°C , VIN = 12V	0		250	mV
Current sense blanking interval	TBLANK	VCS = 0.55 V_{LD}, V_{LD} = V_{DD}	150	215	280	nS
Delay from CS trip to DRV lo	tDELAY	VIN = 12V, VLD = 0.15, VCS = 0 to 0.22V after TBLANK			300	nS
DRV output rise time	tRISE	C_{DRV} = 500pF, 10% to 90% V_{DRV}		30	50	nS
DRV output fall time	tFALL	C_{DRV} = 500pF, 90% to 10% V_{DRV}		30	50	nS

HY7700 V1.0

APPLICATION INFORMATION

The HY7700 is optimized to drive buck LED drivers using open-loop peak current mode control. This method of control enables fairly accurate LED current control without the need for high side current sensing or the design of any closed loop controllers. The IC uses very few external components and enables both Linear and PWM dimming of the LED current.

A resistor connected to the RT pin programs the off-time of operation (or the frequency). The oscillator produces pulses at regular intervals. These pulses set the SR flip-flop in the HY7700 which causes the gate driver to turn on. The same pulses also start the blanking timer which inhibits the reset input of the SR flip flop and prevent false turn-offs due to the turn-on spike. When the FET turns on, the current through the inductor starts ramping up. This current flows through the external sense resistor RSE and produces a ramp voltage at the CS pin. The comparators are constantly comparing the CS pin voltage to both the voltage at the LD pin and the internal 250mV. Once the blanking timer is complete, the output of these comparators is allowed to reset the flip flop. When the output of either one of the two comparators goes high, the flip flop is reset and the gate output goes low. The gate goes low until the SR flip flop is set by the oscillator. Assuming a 30% ripple in the inductor, the current sense resistor RSE can be set using:

$$RSE = \frac{0.25\text{V (or LD)}}{1.15 \times I_{LED}(A)}$$

Constant frequency peak current mode control has an inherent disadvantage - at duty cycles greater than 0.5, the control scheme goes into sub harmonic oscillations. To prevent this, an artificial slope is typically added to the current sense waveform. This slope compensation scheme will affect the accuracy of the LED current in the present form. However, a constant off-time peak current control scheme does not have this problem and can easily operate at duty cycles greater then and also gives inherent input voltage rejection making the LED current almost insensitive to input voltage variations. But, it leads to variable frequency operation and the frequency range depends greatly on the input and output voltage variation HY7700 makes it easy to switch between the two modes of operation by changing one connection (see oscillator section).

Input Voltage Regulator

The HY7700 can be powered directly from its VIN pin and can work from 9-450 VDC at its VIN pin. When a voltage is applied at the VIN pin, the HY7700 maintains a constant 7.5V at the VDD pin. This voltage is used to power the IC and any external resistor dividers needed to control the IC. The VDD pin must be bypassed by a low ESR capacitor to provide a low impedance path for the high frequency current of the output gate driver. The HY7700 can also be operated by supplying a voltage at the VDD pin greater than the internally regulated voltage. This will turn off the internal linear regulator of the IC

- 5 -

and the HY7700 will operate directly off the voltage supplied at the VDD pin. Please note that this external voltage at the VDD pin should not exceed 12V.

Although the V_{IN} pin of the HY7700 is rated up to 450V, the actual maximum voltage that can be applied is limited by the power dissipation in the IC. For example, if an 8-pin SOIC (junction to ambient thermal resistance $R_{\theta, j-a}$ = 128 °C/W) HY7700 draws about I_{IN} = 2mA from the VIN pin, and has a maximum allow able temperature rise of the junction temperature limited to about ΔT = 100 °C , the maximum voltage at the V_{IN} pin would be:

$$RSE = \frac{\Delta T}{R_{q,j-a}} \times \frac{1}{I_{IN}} = \frac{100°C}{128°C/W} \times \frac{1}{2mA} = 390V$$

In these cases, to operate the HY7700 from higher input voltages, a Zener diode can be added in series with the V_{IN} pin to divert some of the power loss from the HY7700 to the Zener diode. In the above example, using a 100V zener diode will allow the circuit to easily work up to 450V. The input current drawn from the VIN pin is a sum of the 1.0mA current drawn by the internal circuit and the current drawn by the gate driver (which in turn depends on the switching frequency and the gate charge of the external MOSFET).

$$I_{IN} \approx 1.0mA + Q_G \times f_s$$

In the above equation, f_S is the switching frequency and Q_G is the gate charge of the external MOSFET (which can be obtained from the datasheet of the MOSFET).

Current Sense

The current sense input of the HY7700 goes to the non-inverting inputs of two comparators. The inverting terminal of one comparator is tied to an internal 250mV reference whereas the inverting terminal of the other comparator is connected to the LD pin. The outputs of both these comparators are fed into an OR gate and the output of the OR gate is fed into the reset pin of the flip-flop. Thus, the comparator which has the lowest voltage at the inverting terminal determines when the DRV output is turned off.

The outputs of the comparators also include a 150-280ns blanking time which prevents spurious turn-offs of the external MOSFET due to the turn-on spike normally present in peak current mode control. In rare cases, this internal blanking might not be enough to filter out the turn-on spike. In these cases, an external RC filter needs to be added between the external sense resistor (RSE) and the CS pin.

Please note that the comparators are fast (with a typical 80ns response time). Hence these comparators are more susceptible to be triggered by noise than the comparators of the HY7700. A proper layout minimizing external inductances will prevent false triggering of these comparators.

HY7700 V1.0

Oscillator

. The oscillator in the HY7700 is controlled by a single resistor connected at the RT pin. The equation governing the oscillator time period t_{osc} is given by:

$$t_{osc}(us) = \frac{RT(K\Omega) + 22}{25}$$

If the resistor is connected between RT and GND, HY7700 operates in a constant frequency mode and the above equation determines the time-period. If the resistor is connected between RT and DRV, the HY7700 operates in a constant off-time mode and the above equation determines the off-time.

DRV Output

The DRV output of the HY7700 is used to drive an external MOSFET. It is recommended that the DRV charge of the external MOSFET be less than 25nC for switching frequency $\leq$ 100kHz and less than 15nC for switching frequency > 100kHz.

Linear Dimming

The Linear Dimming pin is used to control the LED current. There are two cases when it may be necessary to use the Linear Dimming pin.

► In some cases, it may not be possible to find the exact RSE value required to obtain the LED current when the internal 250mV is used. In these cases, an external voltage divider from the V_{DD} pin can be connected to the LD pin to obtain a voltage (less than 250mV) corresponding to the desired voltage across RSE.

► Linear dimming may be desired to adjust the current level to reduce the intensity of the LED(s). In these cases, an external 0-250mV voltage can be connected to the LD pin to adjust the LED current during operation. To use the internal 250mV, the LD pin can be connected to V_{DD} .

Note: Although the LD pin can be pulled to GND, the output current will not go to zero. This is due to the presence of a minimum on-time (which is equal to the sum of the blanking time and the delay to output time) which is about 450ns. This will cause the MOSFET to be on for a minimum of 450ns and thus the LED current when LD = GND will not be zero. This current is also dependent on the input voltage, inductance value, and forward voltage of the LED and circuit parasites. To get zero LED current, the EN pin has to be used.

PWM Dimming

PWM Dimming can be achieved by driving the EN pin with a low frequency square wave signal. When the PWM signal is zero, the gate driver is turned off and when the EN signal if high, the gate driver is enabled. Since the EN signal does not turn off the other parts of the IC, the response of the HY7700 to the EN signal is almost instantaneous. The rate of rise and fall of the LED current is thus determined solely by the rise and fall times of the inductor current. To disable PWM dimming and enable the HY7700 permanently, connect the EN pin to V_{DD}.

HY7700 V1.0

Package Outline Dimensions
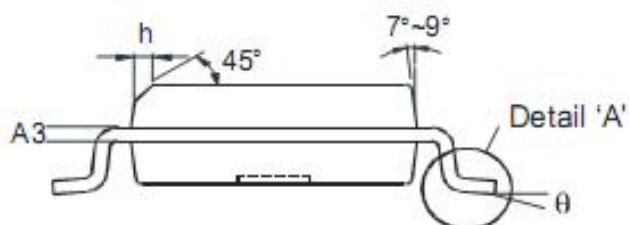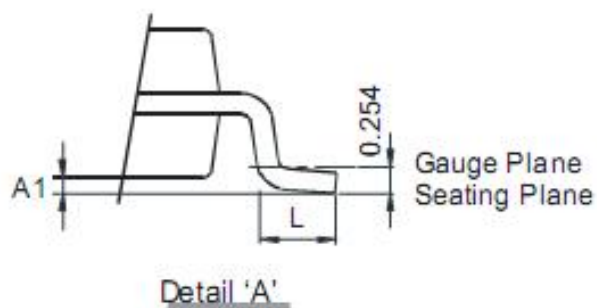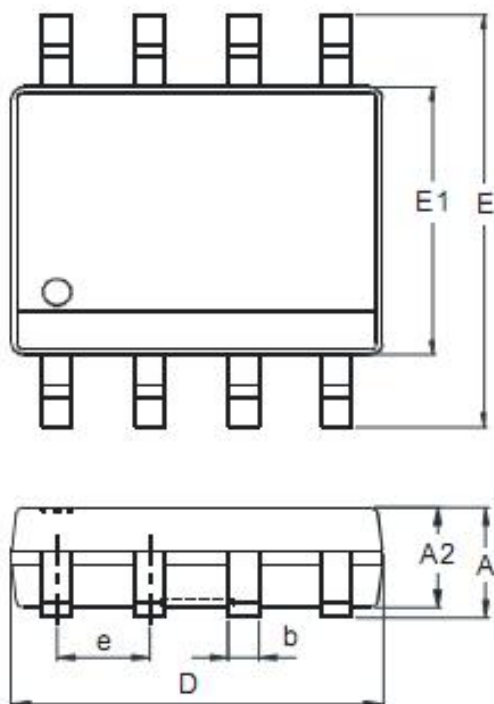
SOP-8L		
Dim	Min	Max
A	-	1.75
A1	0.10	0.20
A2	1.30	1.50
A3	0.15	0.25
b	0.3	0.5
D	4.85	4.95
E	5.90	6.10
E1	3.85	3.95
e	1.27 Typ	
h	-	0.35
L	0.62	0.82
θ	0°	8°
All Dimensions in mm		

HY7700 V1.0

ORDERING INFORMATION

$$\underline{HY7700} \; \underline{\textcolor{red}{S8}} \; \underline{\textcolor{blue}{R}}$$

Circuit Type

Package Type
S8 : SOP-8L

Shipping
R: Tape & Reel

ORDERING REMEMBER	OUTPUT VOLTAGE	PACKAGE	SHIPPING
HY7700S8R	N/A	SOP-8L	2,500 Units/ Tape & Reel

HY7700 V1.0