National Semiconductor

PRELIMINARY

LH1605/LH1605C
5 Amp, High Efficiency Switching Regulator

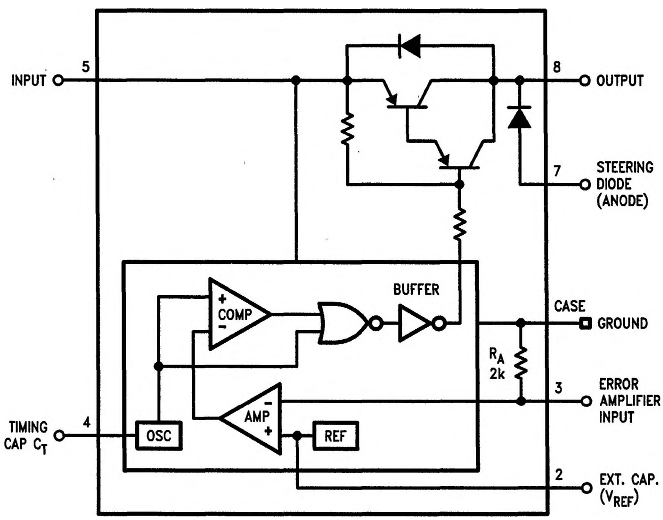
General Description

The LH1605 is a hybrid switching regulator with high output current capabilities. It incorporates a temperature-compensated voltage reference, a duty cycle modulator with the oscillator frequency programmable, error amplifier, high current-high voltage output switch, and a power diode. The LH1605 can supply up to 5A of output current over a wide range of regulated output voltage.

Features

- Step down switching regulator
- Output adjustable from 3.0V to 30V
- 5A output current
- High efficiency
- Frequency adjustable to 100 kHz
- Standard 8-pin TO-3 package

Block and Connection Diagrams



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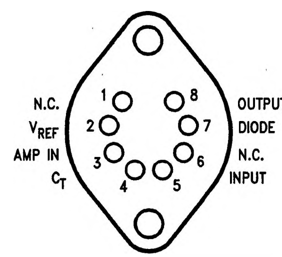
Case is Ground



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Top View

Order Number LH1605K or LH1605CK
See NS Package Number K08A

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

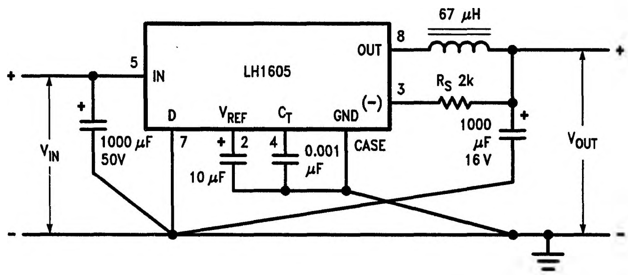
Input Voltage (V_{IN})	35V max
Output Current (I_O)	6A
Operating Temperature (T_J)	150°C
Internal Power Dissipation (P_D) (Note 1)	20W
Operating Temperature (T_A)	
LH1605C	−25°C to +85°C
LH1605	−55°C to +125°C
Storage Temperature Range (T_{STG})	−65°C to +150°C
Duty Cycle (D.C.)	20% to 80%
Steering Diode Reverse Voltage (V_R) (V_{8-7})	60V
Steering Diode Forward Current (I_D) (I_{7-8})	6A

Electrical Characteristics $T_C = 25°C$, $V_{IN} = 15V$, $V_{OUT} = 10V$ unless otherwise specified

Symbol	Characteristics	Conditions	LH1605			LH1605C			Units
			Min	Typ	Max	Min	Typ	Max	
V_{OUT}	Output Voltage Range	$V_{IN} \geq V_O + 5V$ $I_O = 2A$ (Note 2)	3.0		30	3.0		30	
V_S	Switch Saturation Voltage	$I_C = 5.0A$ $I_C = 2.0A$		1.6 1.0	2.0 1.2		1.6 1.0	2.0 1.2	
V_F	Steering Diode On Voltage	$I_D = 5.0A$ $I_D = 2.0A$		1.2 1.0	2.8 2.0		1.2 1.0	2.8 2.0	V
V_{IN}	Supply Voltage Range		10		35	10		35	
I_R	Steering Diode Reverse Current	$V_R = 25V$		0.1	5.0		0.1	5.0	μA
I_Q	Quiescent Current	$I_{OUT} = 0.2A$		20			20		mA
V_2	Voltage on Pin 2			2.5			2.5		V
$\Delta V_2/\Delta T$	V_2 Temperature Coeff.			100			100		ppm/°C
V_4	Voltage Swing—Pin 4			3.0			3.0		V
I_4	Charging Current—Pin 4			70			70		μA
R_A	Resistance Pin 3 to GND			2.0			2.0		kΩ
$\Delta R_A/\Delta T$	Resistance Temp. Coeff.			75			75		ppm/°C
t_r	Voltage Rise Time	$I_{OUT} = 2.0A$ $I_{OUT} = 5.0A$		350 500			350 500		ns
t_f	Voltage Fall Time	$I_{OUT} = 2.0A$ $I_{OUT} = 5.0A$		300 400			300 400		
t_s	Storage Time	$I_{OUT} = 5.0A$		1.5			1.5		μs
t_d	Delay Time			100			100		ns
P_D	Power Dissipation	$V_{OUT} = 10V$ $I_{OUT} = 5.0A$		16			16		W
η	Efficiency			75			75		%
θ_{JC}	Thermal Resistance (Note 1)			5.0			5.0		°C/W

Note 1: θ_{JA} is typically 30°C/W for natural convection cooling.

Note 2: V_{OUT} refers to the output voltage range of switching supply after the output LC filter as shown in the Typical Application circuit.



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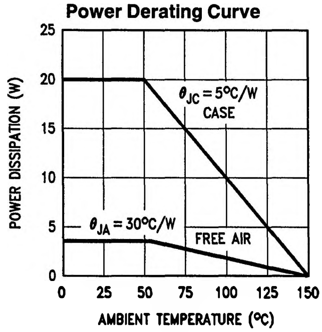
Minimum $V_{IN} - V_{OUT} = 5V$ for Proper Operation

$$R_S = \frac{2 \times 10^3 (V_{OUT} - 2.5)}{2.5}$$

$V_{IN} = 10 - 18V$
$V_{OUT} = 5V$
$I_{OUT} = 3A$ (Max)
$I_{OUT} = 1A$ (Min)
$\eta \cong 70\%$

Load Reg. = 50 mV
Line Reg. = 10 mV
Ripple = 20 mV

Power Derating Curve



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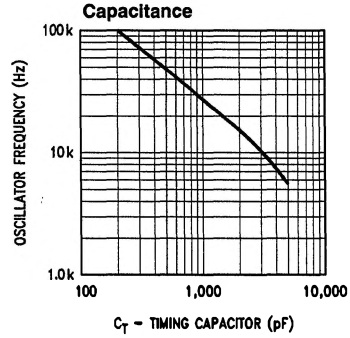
Frequency vs Timing Capacitance



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Design Equations

$$\text{Efficiency } (\eta) = \frac{P_{OUT} \times 100}{P_{IN}}$$

$$\text{Transistor DC Losses } (P_T) = I_{OUT} \times V_S \left(\frac{t_{ON}}{t_{ON} + t_{OFF}}\right)$$

$$\text{Diode DC Losses } (P_D) = I_{OUT} \times V_F \left(\frac{t_{OFF}}{t_{ON} + t_{OFF}}\right)$$

$$\text{Drive Circuit Losses } (D_L) = \frac{V_{IN}^2}{300} \times \frac{t_{ON}}{t_{ON} + t_{OFF}}$$

$$\text{Switching Losses Transistor } (P_S) = V_{IN} \times I_{OUT} \times \frac{t_r + t_f}{2(t_{ON} + t_{OFF}}$$

$$\text{Transistor Duty Cycle} = \frac{t_{ON}}{t_{ON} + t_{OFF}} = \frac{V_{OUT}}{V_{IN}}$$

$$\text{Diode Duty Cycle} = \frac{t_{OFF}}{t_{ON} + t_{OFF}} = 1 - \frac{V_{OUT}}{V_{IN}}$$

$$\text{Power Inductor } (P_L) = I_{OUT}^2 \times R_L \text{ (Winding Resistance)}$$

$$\text{Efficiency } (\eta) = \frac{V_{OUT} I_{OUT}}{V_{OUT} I_{OUT} + P_T + P_D + D_L + P_S + P_L} \times 100\%$$