

# LH1605/LH1605C

## 5 Amp, High Efficiency Switching Regulator

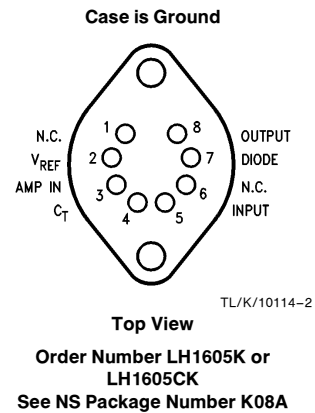
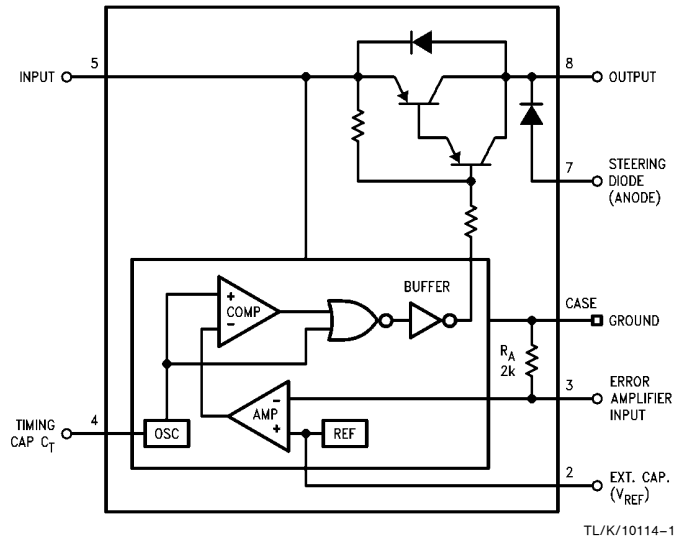
### General Description

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



LH1605/LH1605C 5 Amp, High Efficiency Switching Regulator

## 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

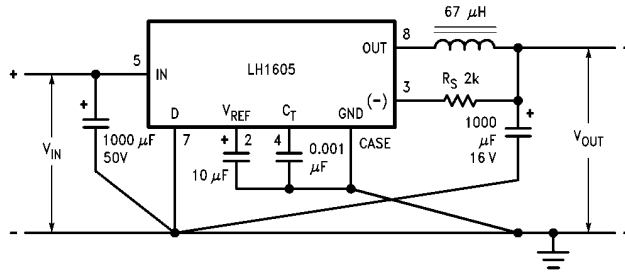
Storage Temperature Range ( $T_{STG}$ )	-65°C to +150°C
Duty Cycle (D.C.)	20% to 80%
Steering Diode Reverse Voltage ( $V_R$ ) ( $V_{8-7}$ )	60V
Steering Diode Forward Current ( $I_D$ ) ( $I_{7-8}$ )	6A

## Electrical Characteristics $T_C = 25^\circ\text{C}$ , $V_{IN} = 15\text{V}$ , $V_{OUT} = 10\text{V}$ unless otherwise specified

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

Note 1:  $\theta_{JA}$  is typically 30 $^\circ\text{C}/\text{W}$  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.



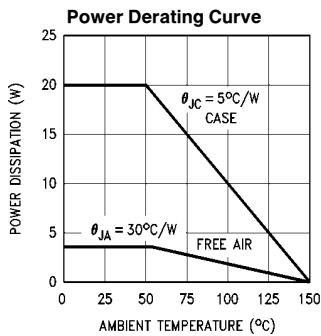
TL/K/10114-3

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

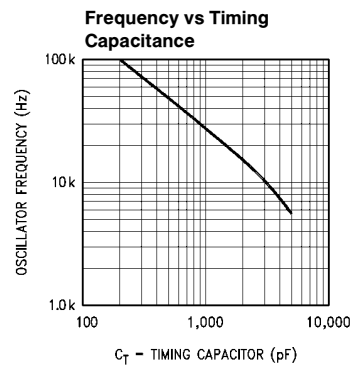
$$R_S = \frac{2 \times 10^3 (V_{OUT} - 2.5)}{2.5}$$

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

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



TL/K/10114-4



TL/K/10114-5

**Design Equations**

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

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

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

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

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

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

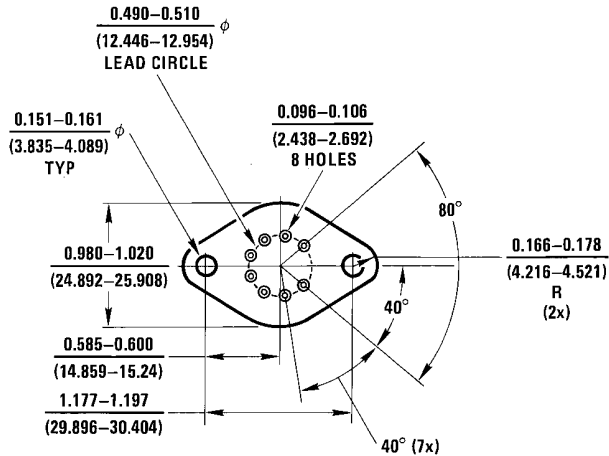
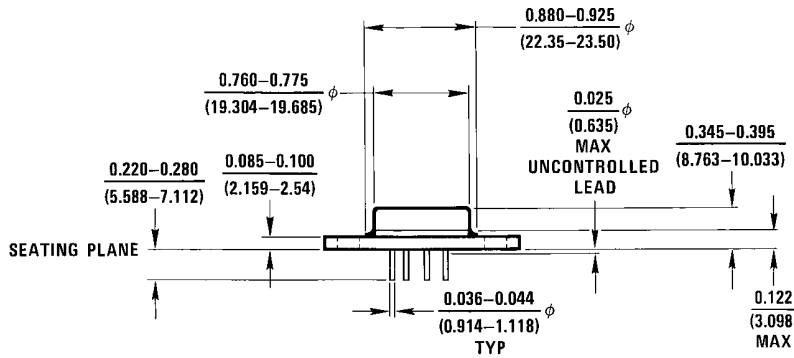
$$\text{Diode Duty Cycle} = \frac{t_{OFF}}{t_{ON} + t_{OFF}} = 1 - \frac{V_{OUT}}{V_{IN}}$$

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

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

**Physical Dimensions** inches (millimeters)

Lit. # 106377



K08A (REV C)

**8-Lead TO-3 Metal Can Package (K)**  
NS Package Number K08A

**LIFE SUPPORT POLICY**

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.



**National Semiconductor Corporation**  
1111 West Bardin Road  
Arlington, TX 76017  
Tel: 1(800) 272-9959  
Fax: 1(800) 737-7018

**National Semiconductor Europe**  
Fax: (+49) 0-180-530 85 86  
Email: cnjwge@tevm2.nsc.com  
Deutsch Tel: (+49) 0-180-530 85 85  
English Tel: (+49) 0-180-532 78 32  
Français Tel: (+49) 0-180-532 93 58  
Italiano Tel: (+49) 0-180-534 16 80

**National Semiconductor Hong Kong Ltd.**  
19th Floor, Straight Block,  
Ocean Centre, 5 Canton Rd.  
Tsimshatsui, Kowloon  
Hong Kong  
Tel: (852) 2737-1600  
Fax: (852) 2736-9960

**National Semiconductor Japan Ltd.**  
Tel: 81-043-299-2309  
Fax: 81-043-299-2408

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.