NCP4300A

Dual Operational Amplifier and Voltage Reference

The NCP4300A is a monolithic integrated circuit specifically designed to control the output current and voltage levels of switch mode battery chargers and power supplies. This device contains a precision 2.6 V shunt reference and two operational amplifiers. Op–Amp 1 is designed to perform voltage control and has its non–inverting input internally connected to the reference. Op–Amp 2 is designed for current control and has both inputs uncommitted. The NCP4300A offers the power converter designer a control solution that features increased precision with a corresponding reduction in system complexity and cost. This device is available in an 8–lead surface mount package.

Features

Operational Amplifier

- Low Input Offset Voltage: 0.5 mV
- Input Common Mode Voltage Range Includes Ground
- Low Supply Current: 210 µA/Op–Amp (@V_{CC} = 5.0 V)
- Medium Unity Gain Bandwidth: 0.7 MHz
- Large Output Voltage Swing: 0 V to V_{CC} – 1.5 V
- Wide Power Supply Voltage Range: 3.0 V to 35 V

Voltage Reference

- Fixed Output Voltage Reference: 2.60 V
- High Precision Over Temperature: 1.0%
- Wide Sink Current Range: 80 µA to 80 mA

Typical Applications

- Battery Charger
- Switch Mode Power Supply

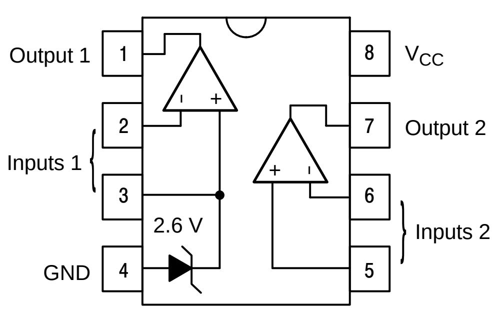

Figure 1. Functional Block Diagram

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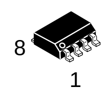
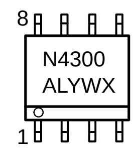
MARKING DIAGRAM

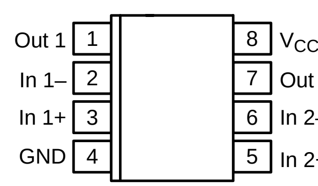


SO–8
D SUFFIX
CASE 751



A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
X = Option Code = A

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Package	Shipping
NCP4300ADR2	SO–8	2500/Tape & Reel

ABSOLUTE MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage (V_{CC} to GND)	V_{CC}	36	V
ESD Protection Voltage at any Pin (Human Body Model)	V_{ESD}	2.0 K (min)	V
Op–Amp 1 and 2 Input Voltage Range (Pins 2, 5, 6)	V_{IR}	–0.6 to V_{CC} +0.6	V
Op–Amp 2 Input Differential Voltage Range (Pins 5, 6)	V_{IDR}	V_{CC} to GND	V
Voltage Reference Cathode Current (Pin 3)	I_K	100	mA
Maximum Junction Temperature	T_J	150	°C
Operating Ambient Temperature Range	T_A	0 to 105	°C
Storage Temperature Range	T_{stg}	–55 to 150	°C

THERMAL CHARACTERISTICS

Rating	Symbol	Value	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	155	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	45	°C/W

TYPICAL ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Total Supply Current, excluding Current in the Voltage Reference V_{CC} = 5.0 V, no load; 0°C ≤ T_A ≤ 105°C	I_{CC}	–	0.42	0.8	mA

Op–Amp 1 (Op–amp with non–inverting input connected to the internal Vref)
(V_{CC} = 5.0 V, V_{out} = 1.4 V, T_A = 25°C, unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Input Offset Voltage T_A = 25°C T_A = 0°C to 105°C	V_{IO}	 – –	 0.5 –	 2.0 3.0	mV
Input Offset Voltage Temperature Coefficient T_A = 0°C to 105°C	$\Delta V_{IO}/\Delta T$	–	7.0	–	µV/°C
Input Bias Current (Inverting input only) T_A = 25°C T_A = 0°C to 105°C	I_{IB}	 – –	 –50 –	 –150 –150	nA
Large Signal Voltage Gain (V_{CC} = 15 V, R_L = 2.0 kΩ, V_{out} = 1.4 V to 11.4 V) T_A = 25°C T_A = 0°C to 105°C	A_{VOL}	 50 25	 100 –	 – –	V/mV
Power Supply Rejection (V_{CC} = 5.0 V to 30 V)	PSRR	40	90	–	dB
Output Source Current (V_{CC} = 15 V, V_{out} = 2.0 V, V_{ID} = +1.0 V)	I_{O+}	10	16	–	mA
Output Sink Current (V_{CC} = 15 V, V_{out} = 2.0 V, V_{ID} = –1.0 V)	I_{O-}	10	25	–	mA
Output Voltage Swing, High (V_{CC} = 30 V, R_L = 10 kΩ, V_{ID} = +1.0 V) T_A = 25°C T_A = 0°C to 105°C	V_{OH}	 27 27	 28 –	 – –	V
Output Voltage Swing, Low (R_L = 10 kΩ, V_{ID} = –1.0 V) T_A = 25°C T_A = 0°C to 105°C	V_{OL}	 – –	 17 –	 100 100	mV
Slew Rate (V_{in} = 0.5 to 2.0 V, V_{CC} = 15 V, R_L = 2.0 kΩ, A_v = 1.0, C_L = 100 pF)	SR	0.3	0.5	–	V/µs
Unity Gain Bandwidth (V_{CC} = 30 V, R_L = 2.0 kΩ, C_L = 100 pF, V_{in} = 0.5 Vpp @ f = 70 kHz)	BW	0.3	0.7	–	MHz
Total Harmonic Distortion (f = 1.0 kHz, A_V = 10, R_L = 2.0 kΩ, V_{CC} = 30 V, V_{out} = 2.0 V_{PP})	THD	–	0.02	–	%

TYPICAL ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Op–Amp 2 (Independent op–amp) (V_{CC} = 5.0 V, V_{out} = 1.4 V, T_A = 25°C, unless otherwise noted)					
Input Offset Voltage T_A = 25°C T_A = 0°C to 105°C	V_{IO}	 – –	 0.5 –	 2.0 3.0	mV
Input Offset Voltage Temperature Coefficient T_A = 0°C to 105°C	$\Delta V_{IO}/\Delta T$	–	7.0	–	µV/°C
Input Offset Current T_A = 25°C T_A = 0°C to 105°C	I_{IO}	 – –	 2.0 –	 30 30	nA
Input Bias Current T_A = 25°C T_A = 0°C to 105°C	I_{IB}	 – –	 –50 –	 –150 –150	nA
Input Common Mode Voltage Range (V_{CC} = 0 V to 35 V)	V_{ICR}	–	0 to V_{CC} –1.5	–	V
Large Signal Voltage Gain (V_{CC} = 15 V, R_L = 2.0 kΩ, V_{out} = 1.4 V to 11.4 V) T_A = 25°C T_A = 0°C to 105°C	A_{VOL}	 50 25	 100 –	 – –	V/mV
Power Supply Rejection (V_{CC} = 5.0 V to 30 V)	PSRR	40	90	–	dB
Common Mode Rejection (V_{CM} = 0 V to 3.5 V) T_A = 25°C T_A = 0°C to 105°C	CMRR	 40 30	 60 –	 – –	dB
Output Source Current (V_{CC} = 15 V, V_{out} = 2.0 V, V_{ID} = +1.0 V)	I_{O+}	10	16	–	mA
Output Sink Current (V_{CC} = 15 V, V_{out} = 2.0 V, V_{ID} = –1.0 V)	I_{O-}	10	25	–	mA
Output Voltage Swing, High (V_{CC} = 30 V, R_L = 10 kΩ, V_{ID} = +1.0 V) T_A = 25°C T_A = 0°C to 105°C	V_{OH}	 27 27	 28 –	 – –	V
Output Voltage Swing, Low (R_L = 10 kΩ, V_{ID} = –1.0 V) T_A = 25°C T_A = 0°C to 105°C	V_{OL}	 – –	 17 –	 100 100	mV
Slew Rate (V_{in} = 0.5 to 3.0 V, V_{CC} = 15 V, R_L = 2.0 kΩ, A_v = 1.0, C_L = 100 pF)	SR	0.3	0.5	–	V/µs
Unity Gain Bandwidth (V_{CC} = 30 V, R_L = 2.0 kΩ, C_L = 100 pF, V_{in} = 0.5 Vpp @ f = 70 kHz)	BW	0.3	0.7	–	MHz
Total Harmonic Distortion (f = 1.0 KHz, A_V = 10, R_L = 2.0 kΩ, V_{CC} = 30 V, V_{out} = 2.0 V_{PP})	THD	–	0.02	–	%
Voltage Reference					
Reference Voltage (I_K = 10 mA) T_A = 25°C T_A = 0°C to 105°C	V_{ref}	 – 2.574	 2.60 2.60	 – 2.626	V
Reference Input Voltage Deviation Over Full Temperature Range (I_K = 10 mA, T_A = 0°C to 105°C)	ΔV_{ref}	–	5.0	22	mV
Minimum Cathode Current for Regulation	$I_{K(min)}$	–	55	80	µA
Dynamic Impedance T_A = 25°C, I_K = 1.0 to 80 mA, f < 1.0 KHz T_A = 0°C to 125°C, I_K = 1.0 mA to 60 mA, f < 1.0 KHz	$\|Z_{KA}\|$	 – –	 0.3 –	 0.5 0.6	Ω

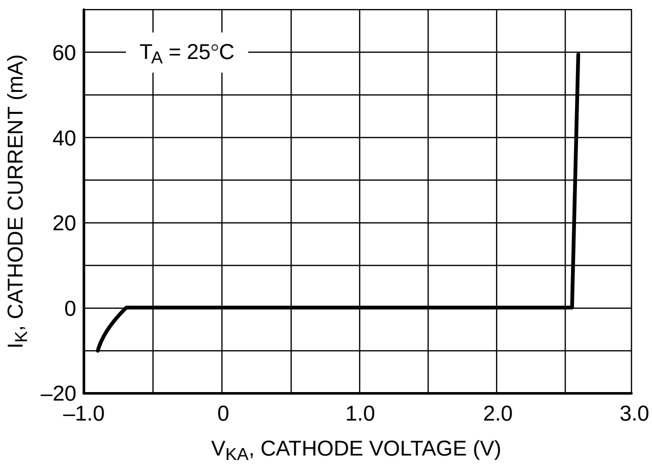


Figure 2. Reference Cathode Current vs. Cathode Voltage

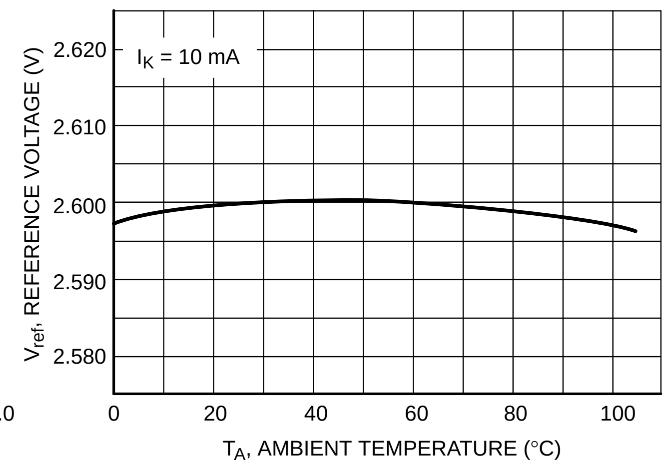


Figure 3. Reference Voltage vs. Ambient Temperature

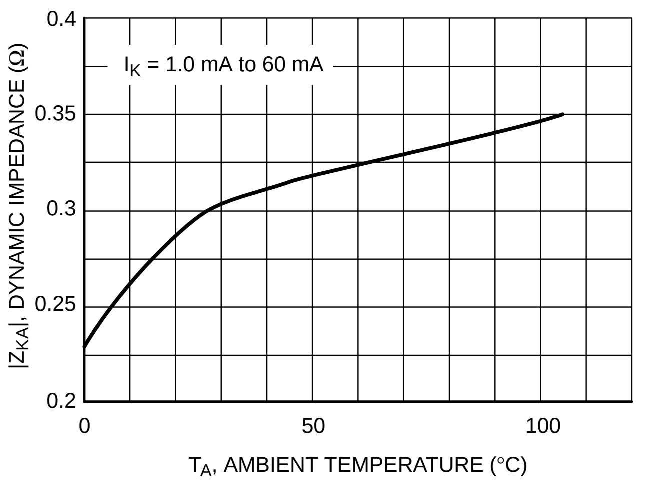


Figure 4. Reference Dynamic Impedance vs. Ambient Temperature

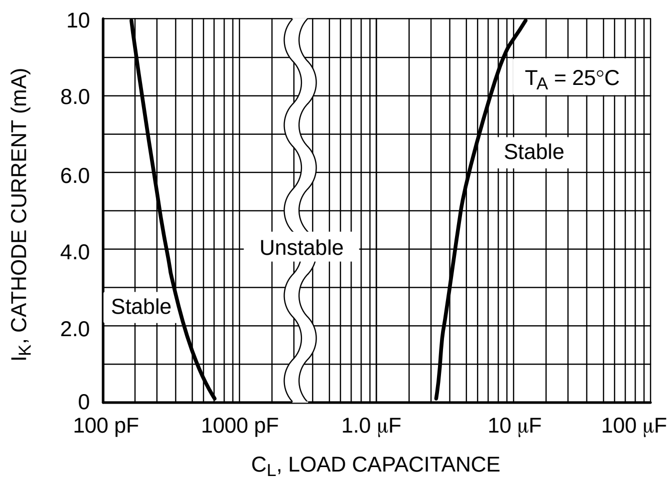


Figure 5. Reference Stability vs. Load Capacitance

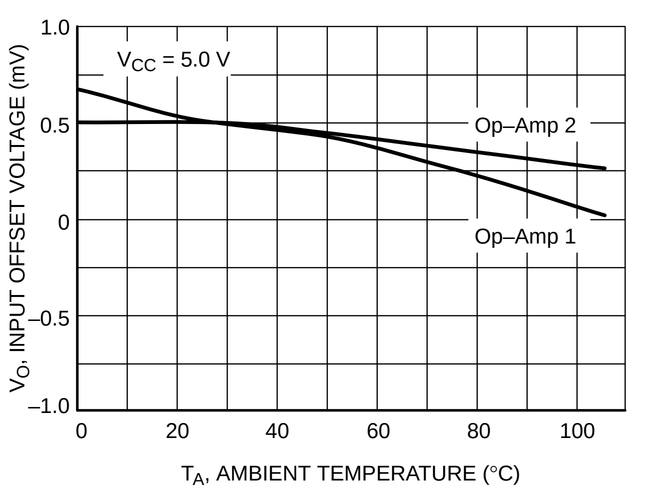


Figure 6. Input Offset Voltage vs. Ambient Temperature

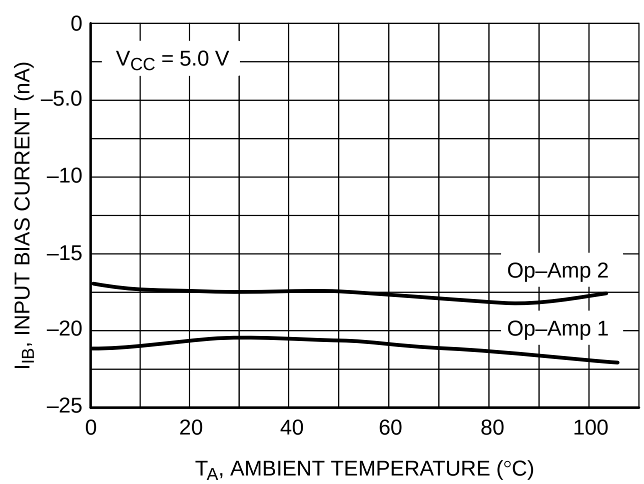


Figure 7. Input Bias Current vs. Ambient Temperature

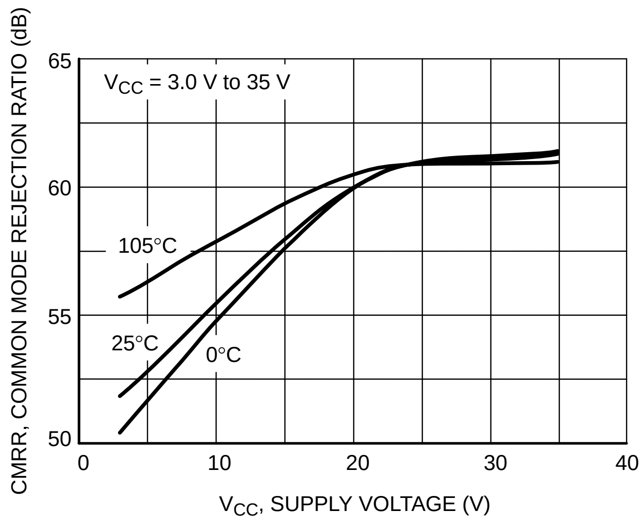


Figure 8. Common Mode Rejection Ratio vs. Supply Voltage

DETAILED OPERATING DESCRIPTION

INTRODUCTION

Power supplies and battery chargers require precise control of output voltage and current in order to prevent catastrophic damage to the system connected. Many present day power sources contain a wide assortment of building blocks and glue devices to perform the required sensing for proper regulation. Typical feedback loop circuits may consist of a voltage and current amplifier, summing circuitry and a reference. The NCP4300A contains all of these basic functions in a manner that is easily adaptable to many of the various power source–load configurations.

OPERATING DESCRIPTION

The NCP4300A is an analog regulation control circuit that is designed to simultaneously close the voltage and current feedback loops in power supply and battery charger applications. This device can control the feedback loop in either constant–voltage (CV) or constant–current (CC) mode with smooth crossover. A concise description of the integrated circuit blocks is given in below. The functional block diagram of the IC is shown in Figure 1.

Internal Reference

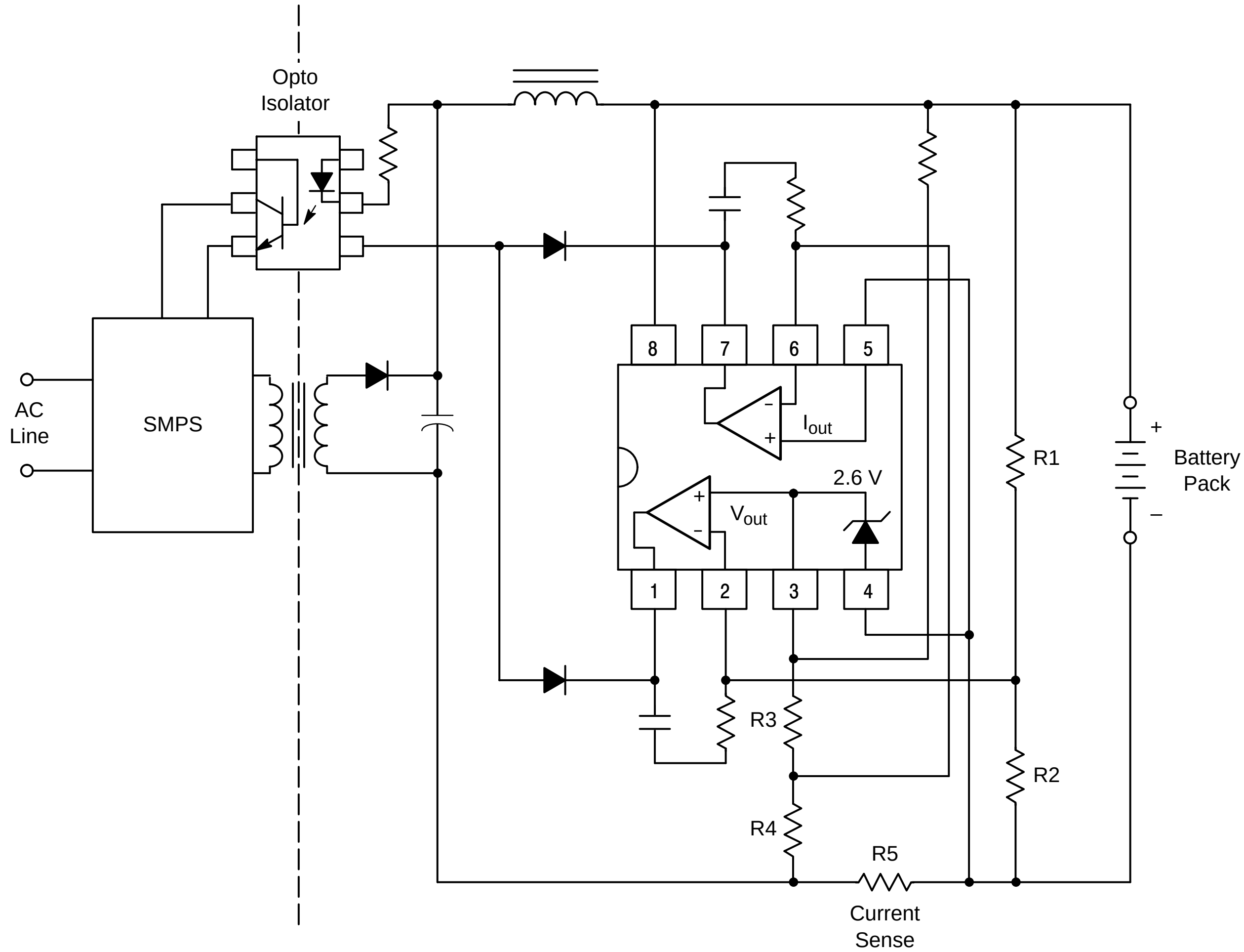
An internal precision band gap reference is used to set the 2.6 V voltage threshold and current threshold setting. The reference is initially trimmed to a ±0.5% tolerance at T_A = 25°C and is guaranteed to be within ±1.0% over an ambient temperature range of 0°C to 105°C.

Voltage Sensing Operational Amplifier (Op–Amp 1)

The internal Op–Amp 1 is designed to perform the voltage control function. The non–inverting input of the op–amp is connected to the precision voltage reference internally. The inverting input of the op–amp monitors the voltage information derived from the system output. As the control threshold is internally connected to the voltage reference, the voltage regulation threshold is fixed at 2.6 V. For any output voltage from 2.6 V up to the maximum limit can be configurated with an external resistor divider. The output terminal of Op–Amp 1 (pin 1) provides the error signal for output voltage control. The output pin also provides a means for external compensation.

Independent Operational Amplifier (Op–Amp 2)

The internal Op–Amp 2 is configurated as a general purpose op–amp with all terminals available for the user. With the low offset voltage provided, 0.5 mV, this op–amp can be used for current sensing in a constant current regulator.



The above circuit demonstrates the use of the NCP4300A in a constant–current constant–voltage switch mode battery charger application. The charging current level is set by resistors R3, R4, and R5. The reference voltage is divided down by resistors R3 and R4 to create an offset voltage at pin 6. This results in a high state at the op amp output, pin 7. As the battery pack charge current increases, a proportional increasing voltage is developed across R5 that will eventually cancel out the pin 6 offset voltage. This will cause the op amp output to sink current from the opto isolator diode, and control the SMPS block in a constant–current mode. Resistors R1 and R2 divide the battery pack voltage down to the 2.6 V reference level. As the battery pack voltage exceeds the desired programmed level, the voltage at pin 2 will become slightly greater than pin 3. This will cause the op amp output to sink current from the opto isolator diode, and control the SMPS block in a constant–voltage mode. The formulas for programming the output current and voltage are given below.

$$I_{out} = \frac{V_{ref}}{\left(\frac{R3}{R4} + 1\right) R5} \qquad V_{out} = \left(\frac{R1}{R2} + 1\right) V_{ref}$$

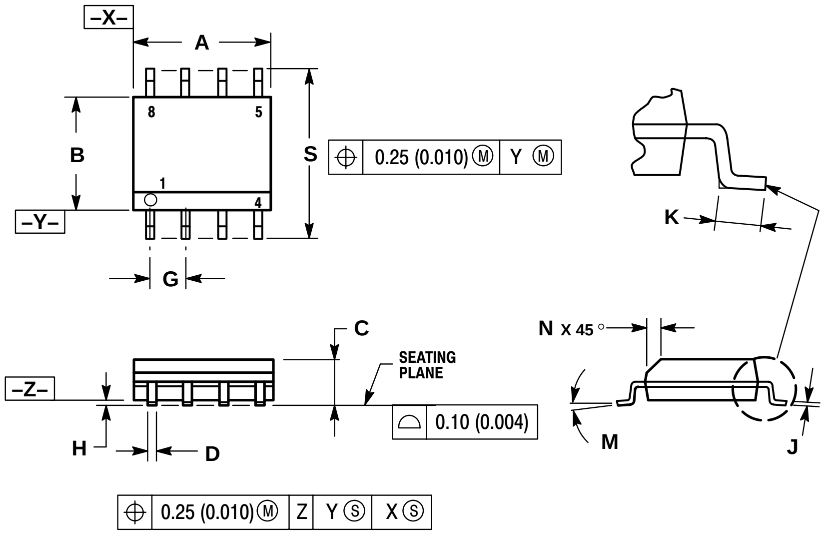
With: $R3 = 30\text{ k}$, $R4 = 1.2\text{ k}$, $R5 = 0.1$, $I_{out} = 1.0\text{ A}$

With: $R1 = 4.7\text{ k}$, $R2 = 3.6\text{ k}$, $V_{out} = 6.0\text{ V}$

Figure 9. Constant–Current Constant–Voltage Switch Mode Battery Charger

PACKAGE DIMENSIONS

SO–8
D SUFFIX
CASE 751–07
ISSUE W



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

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