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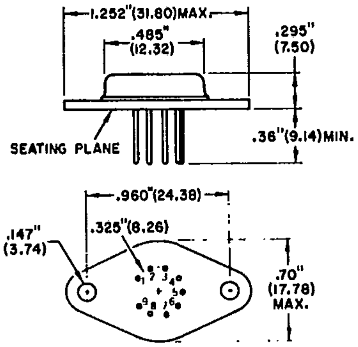
ECG® Semiconductors

ECG946

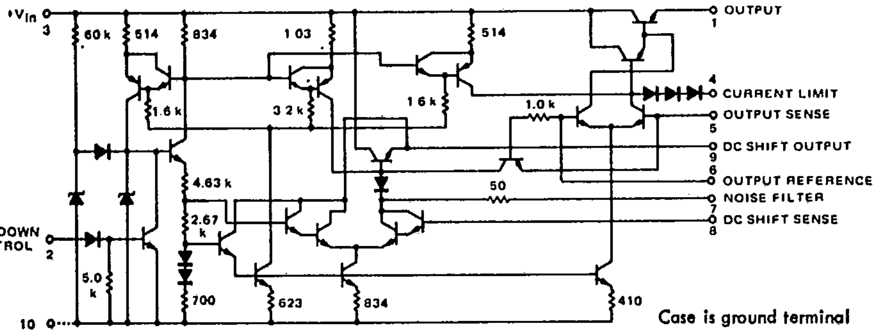
POSITIVE VOLTAGE REGULATOR

- Electronic "Shut-Down" Control and Short-Circuit Protection
- Excellent Load Regulation (Low Output Impedance = 20 milliohms typ from dc to 100 kHz)
- High Power Capability: To 17.5 Watts
- Excellent Transient Response and Temperature Stability
- High Ripple Rejection = 0.002 %/V typ
- Single External Transistor Can Boost Load Current to Greater than 10 Amperes



The ECG946 is a positive power supply voltage regulator monolithic integrated circuit, designed to deliver continuous load current up to 500 mA without use of an external power transistor. ECG946 has excellent high-frequency performance and fast response capability.

CIRCUIT SCHEMATIC



MAXIMUM RATINGS (T_C = +25°C unless otherwise noted)

Rating	Symbol	Value	Unit
Input Voltage	V_{in}	20	Vdc
Load Current	I_L	600	mA
Current, Pin 2	$I_{pin\ 2}$	10	mA
Current, Pin 9	$I_{pin\ 9}$	5.0	mA
Power Dissipation and Thermal Characteristics			
T_A = 25°C	P_D	3.0	Watts
Derate above T_A = 25°C	$1/\theta_{JA}$	24	mW/°C
Thermal Resistance, Junction to Air	θ_{JA}	41.6	°C/W
T_C = 25°C	P_D	17.5	Watts
Derate above T_C = 25°C	$1/\theta_{JC}$	140	mW/°C
Thermal Resistance, Junction to Case	θ_{JC}	7.15	°C/W
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +150	°C

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OPERATING TEMPERATURE RANGE

Ambient Temperature	T_A	0 to +75	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)
(Load Current = 100 mA unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Input Voltage (See Note 1) (0 to +75°C)	V_{in}	9.0	--	35	Vdc
Output Voltage Range	V_o	2.5	--	32	Vdc
Reference Voltage (V_{in} = 15V) (Pin 8 to ground)	V_{ref}	3.2	3.5	3.8	Vdc
Minimum Input-Output Voltage Differential (See Note 2) (R_{SC} = 0)	$V_{in}-V_o$	--	2.1	3.0	Vdc
Bias Current (V_{in} = 15V) (I_L = 1.0 mAdc, R_2 = 6.8 kΩ, $I_B = I_{in} - I_L$)	I_B	--	5.0	12	mAdc
Output Noise (C_n = 0.1 µF, f = 10 Hz to 5.0 MHz)	v_n	--	0.150	--	mV (rms)
Temperature Coefficient of Output Voltage (See Note 3) (0 to +75°C)	TC_{V_o}	--	±0.002	--	%/°C
Operating Load Current Range ($R_{SC} \leqq$ 0.3 ohms)	I_L	1.0	--	500	mAdc
Input Regulation (% change in output voltage per 1-volt change in input voltage) $Reg_{in} = \frac{V_o\ (rms)\ (100)}{v_{in}\ (rms)\ V_o}\ V_{in}\ (rms)$ (See Note 4)	Reg_{in}	--	0.003	0.030	%/V_o
Load Regulation T_J = Constant (1.0 mA $\leq I_L \leq$ 20 mA)	Reg_{load}	--	0.7	2.4	mV
T_C = 25°C (See Note 5) (1.0 mA $\leq I_L \leq$ 50 mA)		--	0.005	0.05	%
Output Impedance (See Note 6) (R_{SC} = 1.0 ohms, f = 10 kHz, V_{in} = 14 Vdc)	Z_{out}	--	35	120	milli-ohms
Shutdown Current (V_{in} = 35 Vdc) $R_3 \approx \frac{V_{in} - 1.4}{1.0\ mA}$	I_{sd}	--	140	500	µAdc

Note 1. "Minimum Input Voltage" is the minimum "total instantaneous input voltage" required to properly bias the internal zener reference diode. For output voltages greater than approximately 5.5 Vdc the minimum "total instantaneous input voltage" must increase to the extent that it will always exceed the output voltage by at least the "input-output voltage differential".

Note 2. This parameter states that ECG946 will regulate properly with the input-output voltage differential ($V_{in} - V_O$) as low as 2.7 Vdc and 3.0 Vdc respectively. Typical units will regulate properly with ($V_{in} - V_O$) as low as 2.1 Vdc as shown in the typical column.

Note 3. "Temperature Coefficient of Output Voltage" is defined as:

$$TCV_o = \frac{\pm (V_o \max - V_o \min)(100)}{2\,(75^\circ C)\,(V_o \text{ at } 25^\circ C)} = \%/^\circ C$$

The output-voltage adjusting resistors (R1 and R2) must have matched temperature characteristics in order to maintain a constant ratio independent of temperature.

Note 4. The input signal can be introduced by use of a transformer which will allow the output of an audio oscillator to be coupled in series with the dc input to the regulator. (The large ac input impedance of the regulator will not load the oscillator.) A 24 V, 1.0 ampere filament transformer with the audio oscillator connected to the 110 V primary winding is satisfactory for this test. $V_{in} \approx 1.0$ V (rms).

Note 5. Load regulation is specified for small ($\leq +17^\circ C$) changes in junction temperature. Temperature drift effect must be taken into account separately for conditions of high junction temperature changes due to the thermal feedback that exists on the monolithic chip.

$$\text{Load Regulation} = \frac{V_O|I_L = 1.0\text{ mA} - V_O|I_L = 50\text{ mA}}{V_O|I_L = 1.0\text{ mA}} \times 100$$

Note 6. The resulting low level output signal (v_o) will require the use of a tuned voltmeter to obtain a reading. Special care should be used to insure that the measurement technique does not include connection resistance, wire resistance, and wire lead inductance (i.e., measure close to the case). Avoid use of alligator clips or banana plug-jack combination.

GENERAL OPERATING INFORMATION

There is a general tendency to consider a voltage regulator as simply a dc circuit and to prepare breadboard construction accordingly. The excellent high-frequency performance and fast response capability of this integrated-circuit regulator, however, makes extra breadboarding care worthwhile when compared with the limited performance achieved in other regulators when low-frequency transistors are used in the feedback amplifier. Due to the use of VHF transistors in the integrated circuit, some VHF care (short, well-dressed leads) must be exercised in the construction and wiring of circuits ("printed-circuit" boards provide an excellent component interconnection technique).

The circuit must be grounded by a low-inductance connection to the case.

A series 4.7-kohm resistor at Pin 5 (Figure 1) will eliminate any VHF instability problems which may result from lead lengths longer than a few inches at the regulator output. The resistor body should be as close to Pin 5 as physically possible (< 1/2 inch) although the length of the lead to the load is not critical. If temperature stability is of major concern, a 4.7-kohm resistor should also be placed in series with Pin 6 in order to cancel any drift due to bias current changes.

If long input leads are used, it may be necessary to bypass Pin 3 with a 0.1-µF capacitor (to ground).

The "Shut-Down Control", Pin 2, can be actuated for all possible output voltages and any values of C_o and C_n with no damage to the circuit. This control can be used to eliminate power consumption by circuit loads which can be put in a "standby" mode, as an ac and dc "squelch" control for communications circuits, and as a dissipation control to protect the regulator under sustained output short-circuiting. As the magnitude of the input-threshold voltage at Pin 2 depends directly upon the junction temperature of the IC chip, a fixed dc voltage at Pin 2 will cause automatic shut-down for high junction temperatures. This will protect the chip, independent of the heat sinking used, the ambient temperature, or the input or output voltage levels.

Due to the small value of input current at Pin 8, the external resistors, R1 and R2, can be selected with little regard to their parallel resistance. Further, no match to a diffused-resistor temperature coefficient is required; but R1 and R2 should have the same temperature coefficient to keep their ratio independent of temperature.

C_n values in excess of 0.1 µF are rarely needed to reduce noise. In cases where more output noise can be tolerated, a smaller capacitor can be used (C_n min. $\approx$ 0.001 µF).

The connection to Pin 5 can be made by a separate lead directly to the load. Thus "remote sensing" can be achieved and undesired impedances (including that of a milliammeter used to measure I_L) can be greatly reduced in their effect on Z_{out}. A 10-ohm resistor placed from Pin 1 to Pin 5 (close to the IC) will eliminate undesirable lead-inductance effects.

Short-circuit current-limiting is achieved by selecting a value for R_{SC} which will threshold the internal diode string when the desired maximum load current flows (see Figure 5). If the device dissipation and dc safe area limits (Figure 15) are not exceeded, it can be continuously short-circuited at the output without damage.

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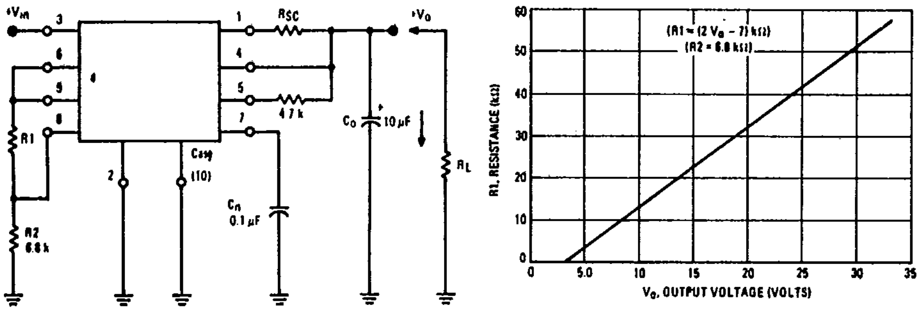
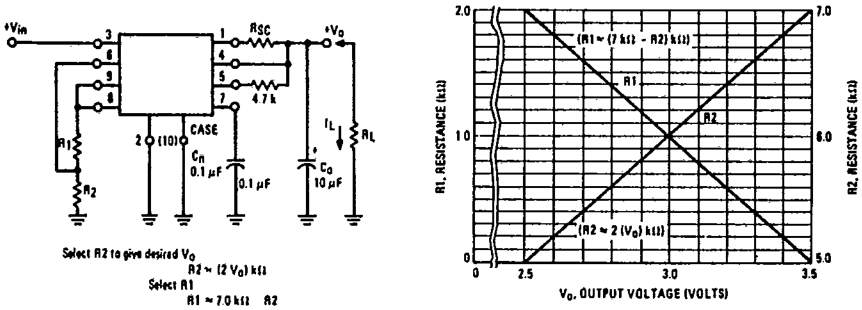
TYPICAL CONNECTIONS

FIGURE 1 – CONNECTION FOR $V_O \geq 3.5$ V



Select R1 to give desired V_O R1 ≈ (2 V_O 7.0) kΩ

FIGURE 2 – CONNECTIONS FOR $V_O \leq +3.5$ V



Select R2 to give desired V_O
R2 ≈ (2 V_O) kΩ
Select R1
R1 ≈ 7.0 kΩ R2

TYPICAL CHARACTERISTICS

Unless otherwise stated: C_n = 0.1 µF, C_O = 10 µF, $V_{O\,nom}$ = +5.0 Vdc, $V_{in\,nom}$ = +9.0 Vdc, T_C = +25°C, I_L > 200 mA

FIGURE 3 – INPUT TRANSIENT RESPONSE

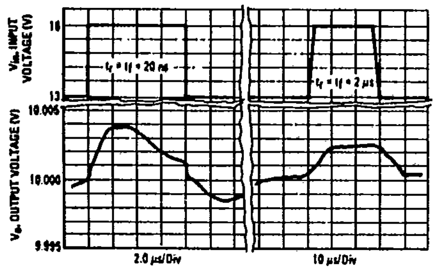


FIGURE 4 – LOAD TRANSIENT RESPONSE

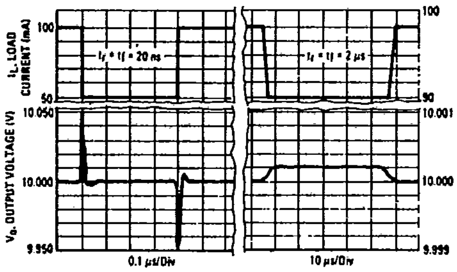


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FIGURE 5 – SHORT-CIRCUIT CURRENT versus R_{SC}

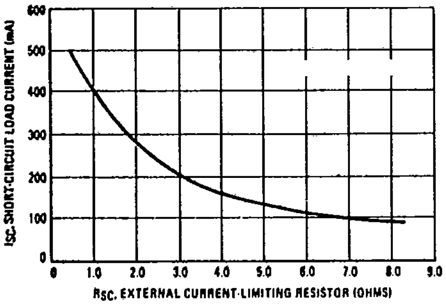

FIGURE 6 – CURRENT-LIMITING CHARACTERISTICS

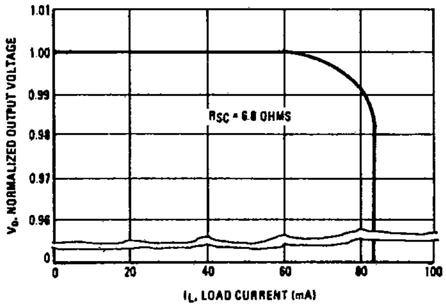

FIGURE 7 – FREQUENCY-DEPENDENCE OF OUTPUT IMPEDANCE

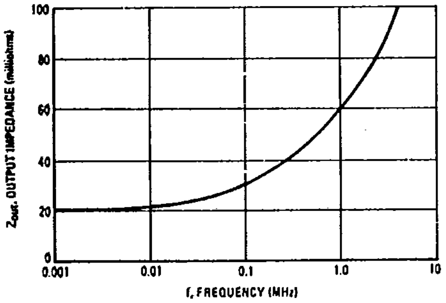

FIGURE 8 – DEPENDENCE OF OUTPUT IMPEDANCE ON OUTPUT VOLTAGE

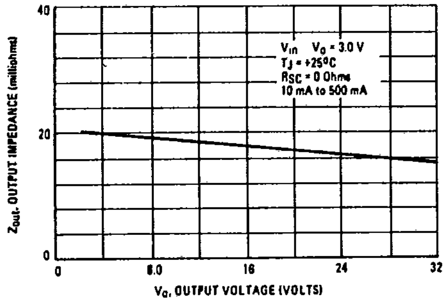

FIGURE 9 – OUTPUT IMPEDANCE versus R_{SC}

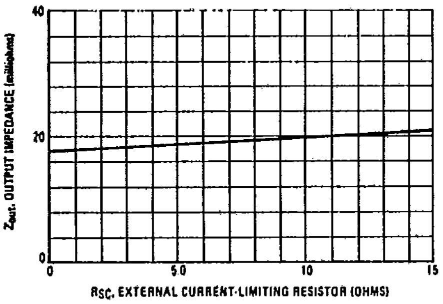

FIGURE 10 – FREQUENCY-DEPENDENCE OF INPUT REGULATION

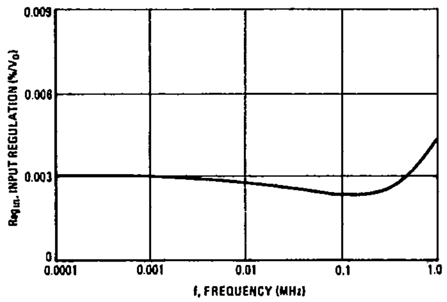

FIGURE 11 – BIAS CURRENT versus INPUT VOLTAGE

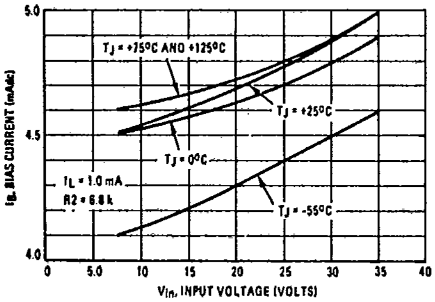

FIGURE 12 – EFFECT OF LOAD CURRENT ON INPUT-OUTPUT VOLTAGE DIFFERENTIAL

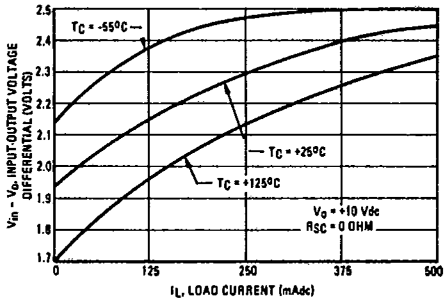

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FIGURE 13 – EFFECT OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL ON INPUT REGULATION

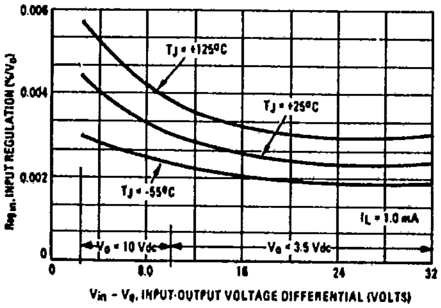


FIGURE 14 – TEMPERATURE DEPENDENCE OF SHORT-CIRCUIT LOAD CURRENT

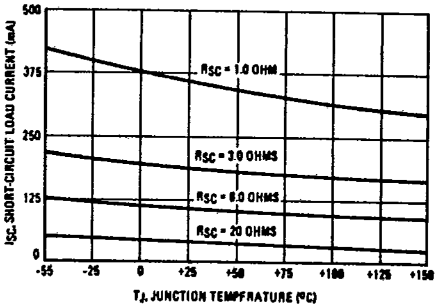
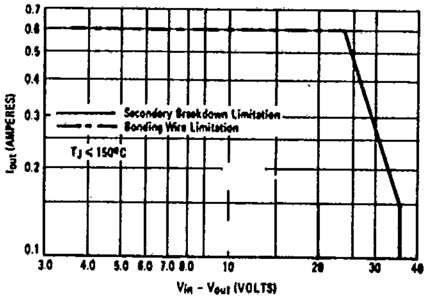


FIGURE 15 – DC SAFE OPERATING AREA



TYPICAL APPLICATIONS

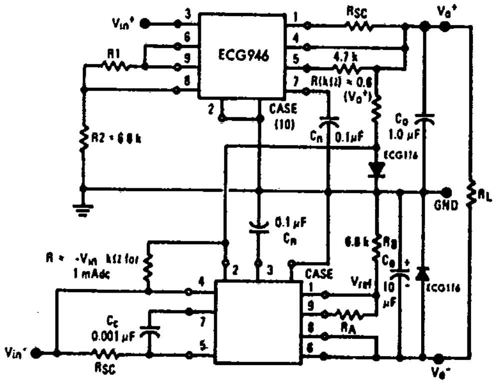


FIGURE 17 – PROVIDING TWO REGULATED OUTPUT VOLTAGES

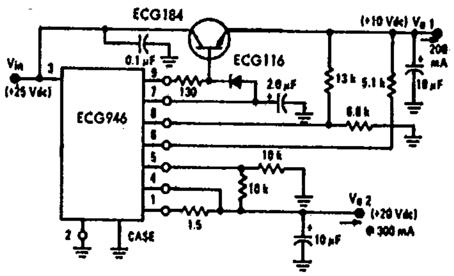
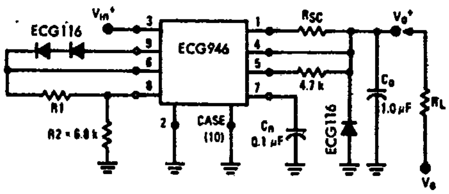


FIGURE 18



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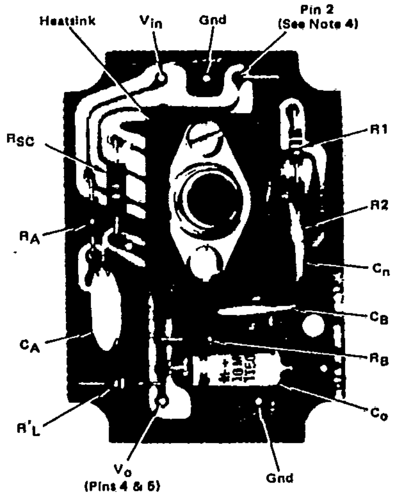
VOLTAGE REGULATOR CONSTRUCTION

The circuit layout, shown in Figure 19 for the power package IC will deliver up to 500 mA into a load.

FIGURE 19 – Regulator Layout Using Power Package For Load Currents Up To 500 mA

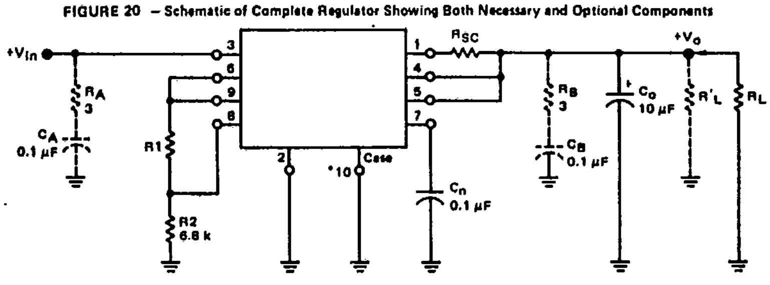


PARTS LIST

Component	Value	Description
R1	Select	1/4 Watt Carbon - See Note 1
R2	6.8 kΩ	1/4 Watt Carbon - See Note 1
R_{SC}	Select	1/2 Watt Carbon - See Note 2
$*R_A$	3Ω	1/4 Watt Carbon
$*R_B$	3Ω	1/4 Watt Carbon
$*R_L$	Select for current of 1 mA minimum	
C_o	10 µF	
C_n	0.1 µF	Ceramic Disc -
$*C_A$	0.1 µF	Ceramic Disc -
$*C_B$	0.1 µF	Ceramic Disc -
*Heatsink		
*Socket		

* Optional Parts, See Note 3 on next page.

FIGURE 20 – Schematic of Complete Regulator Showing Both Necessary and Optional Components



Case is ground.

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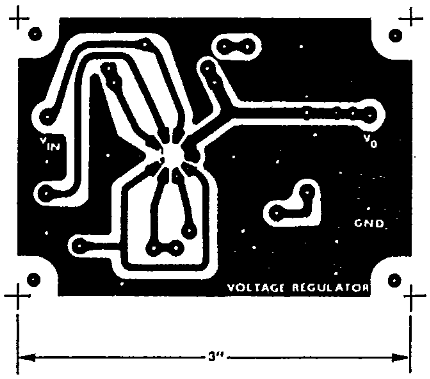
FIGURE 21 – Typical Printed Circuit Board Layout



Note 1. The value of R1 is approximately $(2 V_O - 7)$ kΩ, where V_O is the desired output voltage (3.5 V or greater). Optimum temperature stability can be achieved if R1 and R2 have the same temperature coefficient.

Note 2. R_{SC} is a current sensing resistor for short circuit protection. See Figure 5 for a "Short-Circuit Load Current versus R_{SC}" curve.

Note 3. In cases where long leads are used at the input or output of the regulator, bypass networks $R_A C_A$ and $R_B C_B$ might be necessary to eliminate parasitic oscillation.

With no load, it is possible for a charge to develop on C_O due to leakage currents. R'_L is recommended to insure a minimum load current of 1 mA.

Note 4. It is recommended that Pin 2 (shut-down control) be grounded when not in use. When used, drive current to Pin 2 must be limited to 10 mA maximum.