T-58-11-13

ECG® Semiconductors

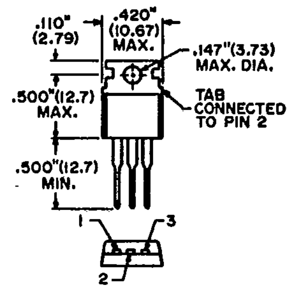
ECG959, ECG961, ECG963, ECG965, ECG967, ECG969, ECG971

Three-Terminal Negative Fixed Voltage Regulators

Features

- **No external components required**
- **Internal thermal overload protection**
- **Internal short-circuit current limiting**
- **Output transistor safe-area compensation**

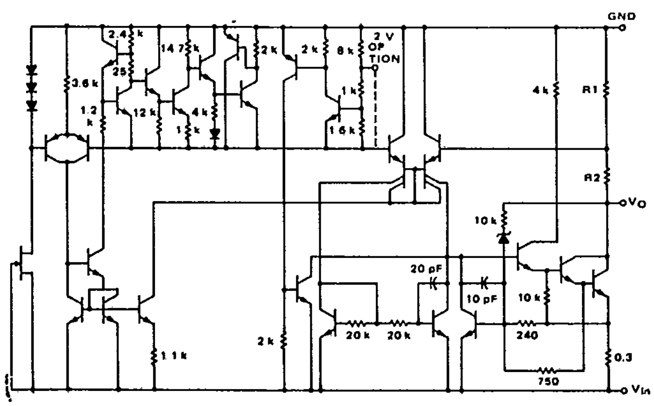
This series of fixed output negative voltage regulators are intended as complements to the popular positive voltage series devices. These negative regulators are available in seven voltage options from −5.0 to −24 volts. These regulators employ current limiting, thermal shutdown, and safe-area compensation - making them remarkably rugged under most operating conditions. With adequate heat-sinking they can deliver output currents in excess of 1.0 ampere.



Pin 1 Ground
Pin 2 Input
Pin 3 Output

Type No.	Negative Output Voltage
ECG959	−18 Volts
ECG961	−5.0 Volts
ECG963	−6.0 Volts
ECG965	−8.0 Volts
ECG967	−12 Volts
ECG969	−15 Volts
ECG971	−24 Volts

Schematic Diagram



T-58-11-13

Maximum Ratings ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Value	Unit
Input Voltage 2.0 V - 18 V 24 V	V_I	−35 −40	Vdc
Power Dissipation $T_A = +25°C$ Derate Above $T_A = +25°C$ $T_C = +25°C$ Derate Above $T_C = +95°C$ (See Fig. 1)	P_D $1/R_{\theta JA}$ P_D $1/R_{\theta JC}$	Internally Limited 15.4 Internally Limited 200	Watts mW/°C Watts mW/°C
Storage Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature Range	T_{opg}	0 to +150	°C

Thermal Characteristics

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	$R_{\theta JA}$	65	°C/W
Thermal Resistance, Junction to Case	$R_{\theta JC}$	50	°C/W

Definitions

Line Regulation—The change in output voltage for a change in the input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

Load Regulation—The change in output voltage for a change in load current at constant chip temperature.

Maximum Power Dissipation—The maximum total device dissipation for which the regulator will operate within specifications.

Quiescent Current—That part of the input current that is not delivered to the load.

Output Noise Voltage—The rms ac voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

Long Term Stability—Output voltage stability under accelerated life test conditions with the maximum rated voltage listed in the devices' electrical characteristics and maximum power dissipation.

Electrical Characteristics

ECG959 ($V_I = -27$ V, $I_O = 500$ mA, $0°C < T_{opg} < +125°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage ($T_{opg} = +25°C$)	V_O	−17.3	−18	−18.7	Vdc
Line Regulation	Reg_{line}				mV
($T_{opg} = +25°C$, $I_O = 100$ mA)					
$-21\ Vdc \geq V_I \geq -33\ Vdc$		--	25	180	
$-24\ Vdc \geq V_I \geq -30\ Vdc$		--	10	90	
($T_{opg} = +25°C$, $I_O = 500$ mA)					
$-21\ Vdc \geq V_I \geq -33\ Vdc$		--	90	360	
$-24\ Vdc \geq V_I \geq -30\ Vdc$		--	50	180	
Load Regulation	Reg_{load}				mV
$T_{opg} = +25°C$, $5.0\ mA \leq I_O \leq 1.0\ A$		--	110	360	
$250\ mA \leq I_O \leq 750\ mA$		--	65	180	
Output Voltage ($-21\ Vdc \geq V_I \geq -33\ Vdc$, $5.0\ mA \leq I_O \leq 1.0\ A$, $P \leq 15\ W$)	V_O	−17.1	--	−18.9	Vdc
Quiescent Current ($T_{opg} = +25°C$)	I_B	--	4.5	8.0	mA
Quiescent Current Change	ΔI_B				mA
$-21\ Vdc \geq V_I \leq -33\ Vdc$		--	--	1.0	
$5.0\ mA \leq I_O \leq 1.0\ A$		--	--	0.5	
Output Noise Voltage ($T_A = +25°C$, $10\ Hz \leq f \leq 100\ kHz$)	V_N	--	110	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	72	mV/1.0 k HRS
Ripple Rejection ($I_O = 20$ mA, $f = 120$ Hz)	RR	--	59	--	dB
Input-Output Voltage Differential ($I_O = 1.0$ A, $T_{opg} = +25°C$)	$\lvert V_{in} - V_O \rvert$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage $I_O = 5.0$ mA, $0°C \leq T_A \leq +125°C$	TCV_O	--	−1.0	--	mV/°C

T-58-11-13

ECG961 (V_{in} = −10 V, I_O = 500 mA, 0°C<T_{opg}<+125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−4.8	−5.0	−5.2	Vdc
Line Regulation (T_{opg} = +25°C, I_O = 100 mA) −7.0 Vdc≥V_{in}≥−25 Vdc −8.0 Vdc≥V_{in}≥−12 Vdc (T_{opg} = +25°C, I_O = 500 mA) −7.0 Vdc≥V_{in}≥−25 Vdc −8.0 Vdc≥V_{in}≥−12 Vdc	Reg_{line}	 -- -- -- --	 7.0 2.0 35 8.0	 50 25 100 50	mV
Load Regulation T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A 250 mA≤I_O≤750 mA	Reg_{load}	 -- --	 11 4.0	 100 50	mV
Output Voltage (−7.0 Vdc≥V_{in}≥−20 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−4.75	--	−5.25	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.3	8.0	mA
Quiescent Current Change −7.0 Vdc≥V_{in}≥−25 Vdc 5.0 mA≤I_O≤1.5 A	ΔI_B	 -- --	 -- --	 1.3 0.5	mA
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	40	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	20	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	70	--	dB
Input-Output Voltage Differential I_O = 1.0 A, T_{opg} = +25°C	$\|V_{in} - V_O\|$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.0	--	mV/°C

ECG963 (V_{in} = −11 V, I_O = 500 mA, 0°C<T_{opg}<+125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−5.75	−6.0	−6.25	Vdc
Line Regulation (T_{opg} = +25°C, I_O = 100 mA) −8.0 Vdc≥V_{in}≥−25 Vdc −9.0 Vdc≥V_{in}≥−13 Vdc (T_{opg} = +25°C, I_O = 500 mA) −8.0 Vdc≥V_{in}≥−25 Vdc −9.0 VDC≥V_{in}≥−13 Vdc	Reg_{line}	 -- -- -- --	 9.0 3.0 43 10	 60 30 120 60	mV
Load Regulation T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A 250 mA≤I_O≤750 mA	Reg_{load}	 -- --	 13 5.0	 120 60	mV
Output Voltage (−8.0 Vdc≥V_{in}≥−21 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−5.7	--	−6.3	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.3	8.0	mA
Quiescent Current Change −8.0 Vdc≥V_{in}≥−25 Vdc 5.0 mA≤I_O≤1.5 A	ΔI_B	 -- --	 -- --	 1.3 0.5	mA
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	45	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	24	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	65	--	dB
Input-Output Voltage Differential (I_O = 1.0 A, T_{opg} = +25°C)	$\|V_{in} - V_O\|$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.0	--	mV/°C

T-58-11-13

ECG965 ($V_I = -14$ V, $I_O = 500$ mA, 0°C<T_{opg}<+125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−7.7	−8.0	−8.3	Vdc
Line Regulation	Reg_{line}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
−10.5 Vdc≥V_I≥−25 Vdc		--	12	80	
−11 Vdc≥V_I≥−17 Vdc		--	5.0	40	
(T_{opg} = +25°C, I_O = 500 mA)					
−10.5 Vdc≥V_I≥−25 Vdc		--	50	160	
−11 VDC≥V_I≥−17 Vdc		--	22	80	
Load Regulation	Reg_{load}				mV
T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A		--	26	160	
250 mA≤I_O≤750 mA		--	9.0	80	
Output Voltage (−10.5 Vdc≥V_I≥−23 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−7.6	--	−8.4	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.3	8.0	mA
Quiescent Current Change	ΔI_B				mA
−10.5 Vdc≥V_I≥−25 Vdc		--	--	1.0	
5.0 mA≤I_O≤1.5 A		--	--	0.5	
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	52	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	32	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	62	--	dB
Input-Output Voltage Differential (I_O = 1.0 A, T_{opg} = +25°C)	$\|V_{in} - V_O\|$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.0	--	mV/°C

ECG967 ($V_{in} = -19$ V, $I_O = 500$ mA, 0°C<T_{opg}<+125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−11.5	−12	−12.5	Vdc
Line Regulation	Reg_{line}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
−14.5 Vdc≥V_{in}≥−30 Vdc		--	13	120	
−16 Vdc≥V_{in}≥−22 Vdc		--	6.0	60	
(T_{opg} = +25°C, I_O = 500 mA)					
−14.5 Vdc≥V_{in}≥−30 Vdc		--	55	240	
−16 Vdc≥V_{in}≥−22 Vdc		--	24	120	
Load Regulation	Reg_{load}				mV
T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A		--	46	240	
250 mA≤I_O≤750 mA		--	17	120	
Output Voltage (−14.5 Vdc≥V_{in}≥−27 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−11.4	--	−12.6	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.4	8.0	mA
Quiescent Current Change	ΔI_B				mA
−14.5 Vdc≥V_{in}≥−30 Vdc		--	--	1.0	
5.0 mA≤I_O≤1.5 A		--	--	0.5	
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	75	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	48	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	61	--	dB
Input-Output Voltage Differential (I_O = 1.0 A, T_{opg} = +25°C)	$\|V_{in} - V_O\|$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.0	--	mV/°C

T-58-11-13

ECG969 (V_{in} = −23 V, I_O = 500 mA, 0°C<T_{opg}< +125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−14.4	−15	−15.6	Vdc
Line Regulation	Reg_{line}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
−17.5 Vdc≥V_{in}≥ −30 Vdc		--	14	150	
−20 Vdc≥V_{in}≥ −26 Vdc		--	6.0	75	
(T_{opg} = +25°C, I_O = 500 mA)					
−17.5 Vdc≥V_{in}≥ −30 Vdc		--	57	300	
−20 VDC≥V_{in}≥ −26 Vdc		--	27	150	
Load Regulation	Reg_{load}				mV
T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A		--	68	300	
250 mA≤I_O≤750 mA		--	25	150	
Output Voltage (−17.5 Vdc≥V_{in}≥ −30 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−14.25	--	−15.75	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.4	8.0	mA
Quiescent Current Change	ΔI_B				mA
−17.5 Vdc≥V_{in}≥ −30 Vdc		--	--	1.0	
5.0 mA≤I_O≤1.5 A		--	--	0.5	
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	90	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	60	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	60	--	dB
Input-Output Voltage Differential (I_O = 1.0 A, T_{opg} = +25°C)	$\lvert V_{in} - V_O \rvert$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤ +125°C	TCV_O	--	−1.0	--	mV/°C

ECG971 (V_I = −33 V, I_O = 500 mA, 0°C<T_{opg}< +125°C unless otherwise noted.)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	−23	−24	−25	Vdc
Line Regulation	Reg_{line}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
−27 Vdc≥V_I≥ −38 Vdc		--	31	240	
−30 Vdc≥V_I≥ −36 Vdc		--	14	120	
(T_{opg} = +25°C, I_O = 500 mA)					
−27 Vdc≥V_I≥ −38 Vdc		--	118	480	
−30 Vdc≥V_I≥ −36 Vdc		--	70	240	
Load Regulation	Reg_{load}				mV
T_{opg} = +25°C, 5.0 mA≤I_O≤1.0 A		--	150	480	
250 mA≤I_O≤750 mA		--	85	240	
Output Voltage (−27 Vdc≥V_I≥ −38 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	−22.8	--	−25.2	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.6	8.0	mA
Quiescent Current Change	ΔI_B				mA
−27 Vdc≥V_I≤ −38 Vdc		--	--	1.0	
5.0 mA≤I_O≤1.0 A		--	--	0.5	
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	170	--	μV
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	96	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	56	--	dB
Input-Output Voltage Differential (I_O = 1.0 A, T_{opg} = +25°C)	$\lvert V_{in} - V_O \rvert$	--	2.0	--	Vdc
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤ +125°C	TCV_O	--	−1.0	--	mV/°C

T-58-11-13

TYPICAL CHARACTERISTICS
(T_A = +25°C unless otherwise noted.)

FIGURE 1 – MAXIMUM AVERAGE POWER DISSIPATION AS A FUNCTION OF AMBIENT TEMPERATURE

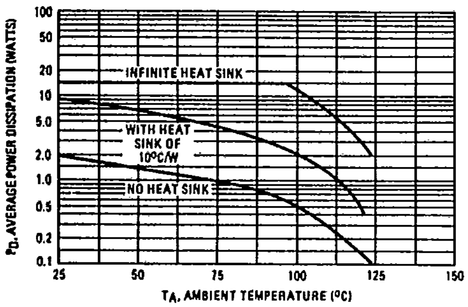


FIGURE 2 – PEAK OUTPUT CURRENT AS A FUNCTION OF INPUT-OUTPUT DIFFERENTIAL VOLTAGE

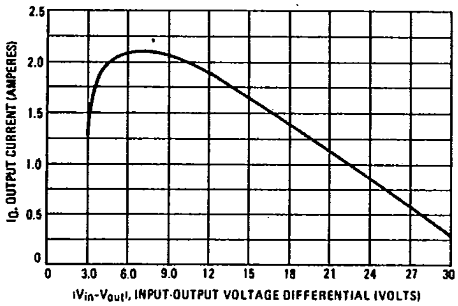


FIGURE 3 – RIPPLE REJECTION AS A FUNCTION OF FREQUENCY

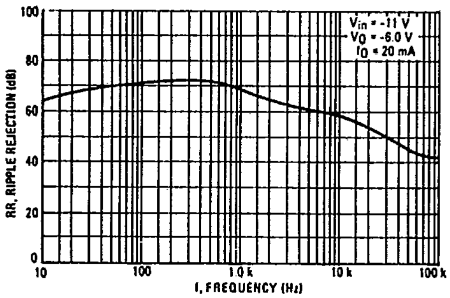


FIGURE 4 – RIPPLE REJECTION AS A FUNCTION OF OUTPUT VOLTAGES

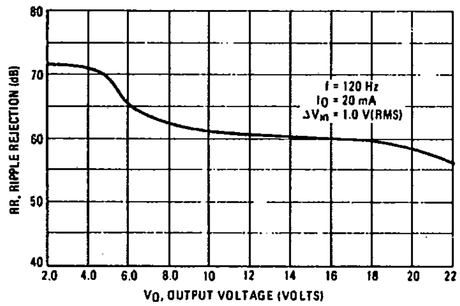


FIGURE 5 – OUTPUT VOLTAGE AS A FUNCTION OF JUNCTION TEMPERATURE

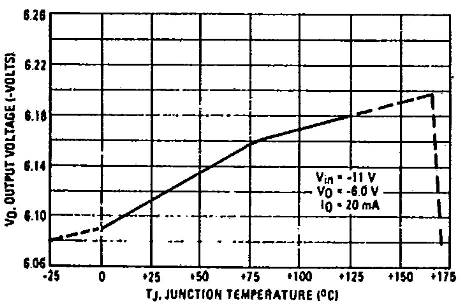
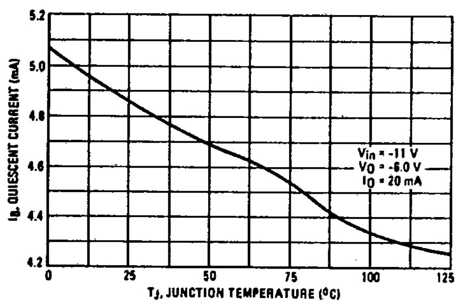


FIGURE 6 – QUIESCENT CURRENT AS A FUNCTION OF TEMPERATURE



T-58-11-13

Applications Information

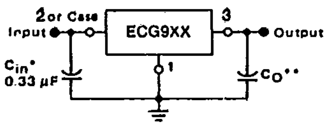
Design Considerations

These fixed voltage regulators are designed with Thermal Overload Protection that shuts down the circuit when subjected to an excessive power overload condition. Internal Short-Circuit Protection that limits the maximum current the circuit will pass, and Output Transistor Safe-Area Compensation that reduces the output short-circuit current as the voltage across the pass transistor is increased.

In many low current applications, compensation capacitors are not required. However, it is recommended that the regulator input be bypassed with a capacitor if the regulator is connected to the power supply filter with long wire lengths, or if the output load capacitance is large. An input bypass capacitor should be selected to provide good high frequency characteristics to insure stable operation under all load conditions. A 33 μF or larger tantalum, mylar, or other capacitor having low internal impedance at high frequencies should be chosen. If an aluminum electrolytic capacitor is used, its value should be 1.0 μF or larger. The bypass capacitor should be mounted with the shortest possible leads directly across the regulators input terminals. Normally good construction techniques should be used to minimize ground loops and lead resistance drops since the regulator has no external sense lead. Bypassing the output is also recommended.

Typical Applications ($T_A = +25°C$ unless otherwise noted)

Standard Application

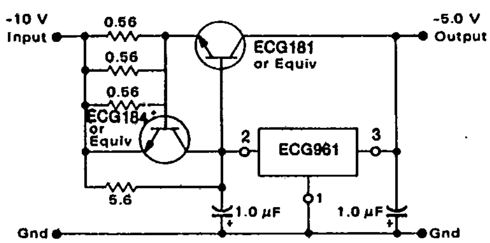


A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0 V more negative even during the high point on the input ripple voltage.

* C_{in} is required if regulator is located an appreciable distance from power supply filter.

** C_O improves stability and transient response

CURRENT BOOST REGULATOR
(-5.0 V @ 4.0 A, with 5.0 A current limiting)

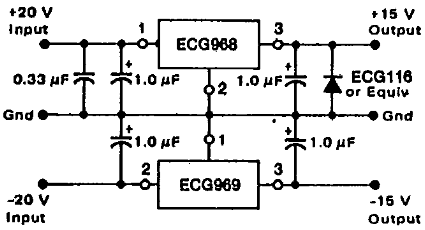


*Mounted on common heat sink

When a boost transistor is used, short-circuit currents are equal to the sum of the series pass and regulator limits, which are measured at 3.2 A and 1.8 A respectively in this case. Series pass limiting is approximately equal to $0.6\ V/R_{SC}$. Operation beyond this point to the peak current capability of the ECG961 is possible if the regulator is mounted on a heat sink; otherwise thermal shutdown will occur when the additional load current is picked up by the regulator.

T-58-11-13

OPERATIONAL AMPLIFIER SUPPLY
(±15 V @ 1.0 A)



The ECG968 and ECG969 positive and negative regulators may be connected as shown to obtain a dual power supply for operational amplifiers. A clamp diode should be used at the output of the ECG968 to prevent potential latch-up problems.