T-58-11-13

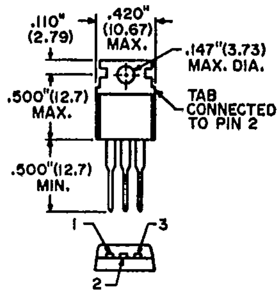
ECG® Semiconductors

ECG958, ECG960, ECG962, ECG964, ECG966, ECG968, ECG972

Three-Terminal Positive Fixed Voltage Regulators

Features

- **Output current in excess of 1 amp**
- **No external components required**
- **Internal thermal overload protection**
- **Internal short-circuit current limiting**
- **Output transistor safe-area compensation**



Pin 1 Input
Pin 2 Ground
Pin 3 Output

This series of three-terminal positive voltage regulators are monolithic integrated circuits designed as fixed-voltage regulators for a wide variety of applications. Available in seven fixed output voltage options from 5.0 to 24 volts, these regulators can be used in logic systems, instrumentation, HiFi, other solid state electronic equipment, and for local on card regulation, eliminating the distribution problems associated with single point regulation.

These regulators employ internal current limiting, thermal shutdown, and safe area compensation - making them essentially blow-out proof. With adequate heatsinking they can deliver output currents in excess of 1.0 ampere.

Although designed primarily as a fixed voltage regulator, these devices can be used with external components to obtain adjustable voltages and currents.

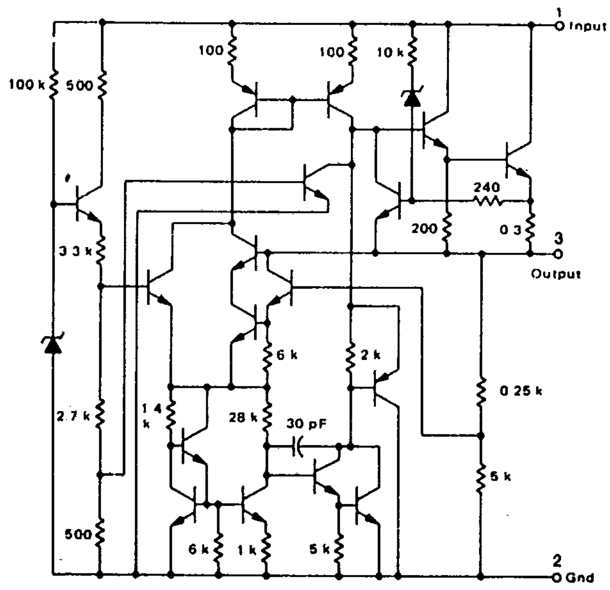
Type No.	Output Voltage
ECG958	18 Volts
ECG960	5.0 Volts
ECG962	6.0 Volts
ECG964	8.0 Volts
ECG966	12 Volts
ECG968	15 Volts
ECG972	24 Volts

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

Rating	Symbol	Value	Unit
Input Voltage 5.0 V - 18 V 24 V	V_{in}	35 40	Vdc
Power Dissipation and Thermal Characteristics* $T_A = +25°C$ Derate Above $T_A = +25°C$ Thermal Resistance, Junction to Air	P_D $1/\theta_{JA}$ θ_{JA}	Internally Limited 15.4 65	Watts mW/°C °C/W
$T_C = +25°C$ Derate Above $T_C = +95°C$ (See Fig. 1) Thermal Resistance, Junction to Case	P_D $1/\theta_{JC}$ θ_{JC}	Internally Limited 200 5.0	Watts mW/°C °C/W
Storage Junction Temperature Range	T_{stg}	−65 to +150	°C
Operating Junction Temperature Range	T_{opg}	0 to +150	°C

* Thermal resistance without a heat sink for junction to case temperature is 6°C/W. Thermal resistance for case to ambient temperature is 50°C/W.

Schematic Diagram



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.

Design Considerations

This series of 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 0.33 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 10 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.

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ECG958 (V_{in} = 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
Input Regulation (T_{opg} = +25°C) 21 Vdc≤V_{in}≤33 Vdc 24 Vdc≤V_{in}≤30 Vdc	Reg_{in}	 -- --	 25 10	 360 180	mV
Load Regulation T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A 250 mA≤I_O≤750 mA	Reg_{load}	 -- --	 55 22	 360 180	mV
Output Voltage (21 Vdc≤V_{in}≤33 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	17.1	18	18.9	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.5	8.0	mA
Quiescent Current Change 21 Vdc≤V_{in}≤33 Vdc 5.0 mA≤I_O≤1.0 A	ΔI_B	 -- --	 -- --	 1.0 0.5	mA
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	10	--	μV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	72	mV/1.0 k HRS
Ripple Rejection (f = 120 Hz, 22 Vdc≤V_{in}≤32 Vdc)	RR	--	57	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in}-V_O$	--	2.0	--	Vdc
Output Resistance (f = 1 kHz)	R_O	--	19	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.0	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

ECG960 (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
Input Regulation (T_{opg} = +25°C, I_O = 100 mA) 7.0 Vdc≤V_{in}≤25 Vdc 8.0 Vdc≤V_{in}≤12Vdc (T_{opg} = +25°C, I_O = 500 mA) 7.0 Vdc≤V_{in}≤25 Vdc 8.0 Vdc≤V_{in}≤12 Vdc	Reg_{in}	 -- -- -- --	 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}	 -- --	 40 15	 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	5.0	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≤1.0 A	ΔI_B	 -- --	 -- --	 1.3 0.5	mA
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	10	--	μV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	20	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz)	RR	--	68	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in}-V_O$	--	2.0	--	Vdc
Output Resistance (f = 1.0 kHz)	R_O	--	17	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage I_O = 5.0 mA, 0°C≤T_A≤+125°C	TCV_O	--	−1.1	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

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ECG962 (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
Input 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_{in}	 -- -- -- --	 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}	 -- --	 43 16	 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	6.0	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	--	10	--	µV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	24	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz, 9 Vdc≤V_{in}≤19 Vdc)	RR	--	65	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in}-V_O$	--	2.0	--	Vdc
Output Resistance (f = 1.0 kHz)	R_O	--	17	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage	TCV_O	--	0.8	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

ECG964 (V_{in} = 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
Input Regulation (T_{opg} = +25°C) 10.5 Vdc≤V_{in}≤25 Vdc 11 Vdc≤V_{in}≤17 Vdc	Reg_{in}	 -- --	 12 5.0	 160 80	mV
Load Regulation T_{opg} = +25°C, 5.0 mA≤I_O≤1.5 A 250 mA≤I_O≤750 mA	Reg_{load}	 -- --	 45 16	 160 80	mV
Output Voltage (10.5 Vdc≤V_{in}≤23 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	7.6	8.0	8.4	Vdc
Quiescent Current (T_{opg} = +25°C)	I_B	--	4.3	8.0	mA
Quiescent Current Change 10.5 Vdc≤V_{in}≤25 Vdc 5.0 mA≤I_O≤1.0 A	ΔI_B	 -- --	 -- --	 1.0 0.5	mA
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	10	--	µV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	32	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz, 11.5 Vdc≤V_{in}≤21.5 Vdc)	RR	--	62	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in}-V_O$	--	2.0	--	Vdc
Output Resistance (f = 1 kHz)	R_O	--	18	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage	TCV_O	--	−0.8	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

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ECG966 (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
Input Regulation	Reg_{in}				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	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≤1.0 A		--	--	0.5	
Output Noise Voltage (T_A = +25°C, 10 Hz≤f≤100 kHz)	V_N	--	10	--	µV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	48	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz, 15 Vdc≤V_{in}≤25 Vdc)	RR	--	60	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in} - V_O$	--	2.0	--	Vdc
Output Resistance (f = 1 kHz)	R_O	--	18	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage	TCV_O	--	−1.0	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

ECG968 (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
Input Regulation	Reg_{in}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
17.5 Vdc≤V_{in}≤30 Vdc		--	13	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		--	52	300	
250 mA≤I_O≤750 mA		--	20	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	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	--	10	--	µV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	60	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz, 18.5 Vdc≤V_{in}≤28.5 Vdc)	RR	--	58	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in} - V_O$	--	2.0	--	Vdc
Output Resistance (f = 1 kHz)	R_O	--	19	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage I_O = 5 mA, 0°C≤T_A≤ +125°C	TCV_O	--	−1.0	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

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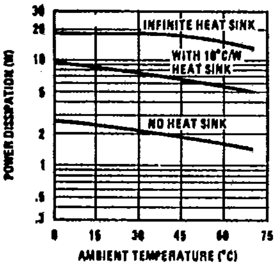
ECG972 (V_{in} = 33 V, I_O = 500 mA, 0°C<T_{opg}< +125°C unless otherwise noted.)

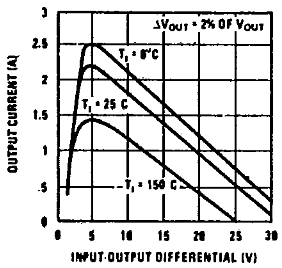
Characteristic	Symbol	Min	Typ	Max	Unit
Output Voltage (T_{opg} = +25°C)	V_O	23	24	25	Vdc
Input Regulation	Reg_{in}				mV
(T_{opg} = +25°C, I_O = 100 mA)					
27 Vdc≤V_{in}≤38 Vdc		--	31	240	
30 Vdc≤V_{in}≤36Vdc		--	14	120	
(T_{opg} = +25°C, I_O = 500 mA)					
27 Vdc≤V_{in}≤38 Vdc		--	118	480	
30 VDC≤V_{in}≤36 Vdc		--	70	240	
Load Regulation	Reg_{load}				mV
T_{opg} = +25°C, 5.0 mA≤I_O≤1.0 A		--	60	480	
250 mA≤I_O≤750 mA		--	25	240	
Output Voltage (27 Vdc≤V_{in}≤38 Vdc, 5.0 mA≤I_O≤1.0 A, P≤15 W)	V_O	22.8	24	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_{in}≤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	--	10	--	µV/V_O
Long-Term Stability	$\Delta V_O/\Delta t$	--	--	96	mV/1.0 k HRS
Ripple Rejection (I_O = 20 mA, f = 120 Hz, 28 Vdc≤V_{in}≤38 Vdc)	RR	--	54	--	dB
Input-Output Voltage Differential (Dropout Voltage) (I_O = 1.0 A, T_{opg} = +25°C)	$V_{in}-V_O$	--	2.0	--	Vdc
Output Resistance (f = 1 kHz)	R_O	--	20	--	mΩ
Short-Circuit Current Limit (T_{opg} = +25°C, V_{in} = 35 Vdc)	I_{SC}	--	0.2	--	A
Average Temperature Coefficient of Output Voltage	TCV_O	--	−1.5	--	mV/°C
Peak Output Current (T_{opg} = +25°C)	I_{max}	--	2.2	--	A

Typical Performance Characteristics

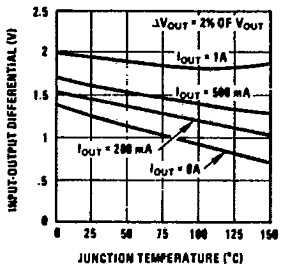
Maximum Average Power Dissipation



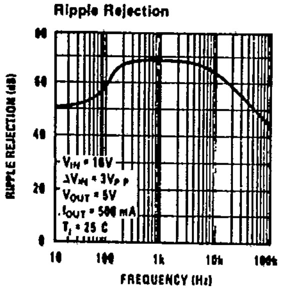
Peak Output Current



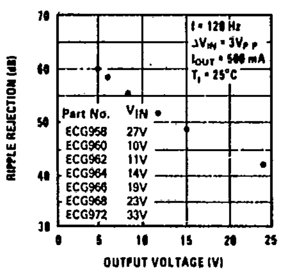
Dropout Voltage



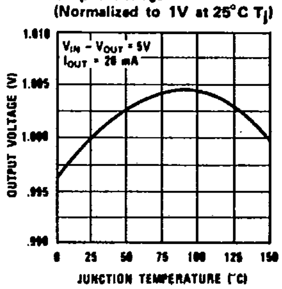
Ripple Rejection



Ripple Rejection



Output Voltage (Normalized to 1V at 25°C T_j)



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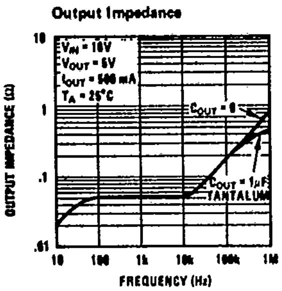
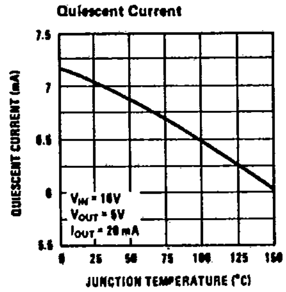
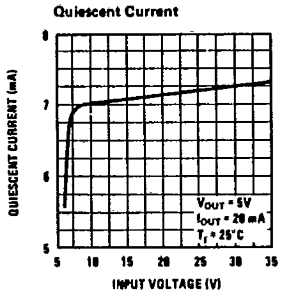
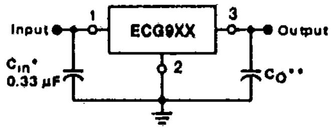






Applications

Standard Application

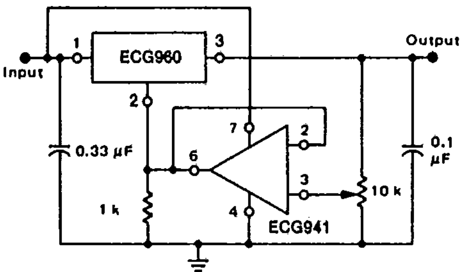


A common ground is required between the input and the output voltages. The input voltage must remain typically 2.0 V above the output voltage even during the low point on the input ripple voltage.

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

** C_O is not needed for stability; however, it does improve transient response.

Adjustable Output Regulator

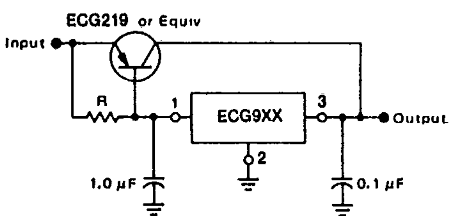


V_O, 7.0 V to 20 V

V_{IN}, $V_O \geq 2.0$ V

The addition of an operational amplifier allows adjustment to higher or intermediate values while retaining regulation characteristics. The minimum voltage obtainable with this arrangement is 2.0 volts greater than the regulator voltage.

Current Boost Regulator



The ECG9XX series can be current boosted with a PNP transistor. The ECG219 provides current to 5.0 amperes. Resistor R in conjunction with the V_{BE} of the PNP determines when the pass transistor begins conducting. This circuit is not short-circuit proof. Input-output differential voltage minimum is increased by V_{BE} of the pass transistor.

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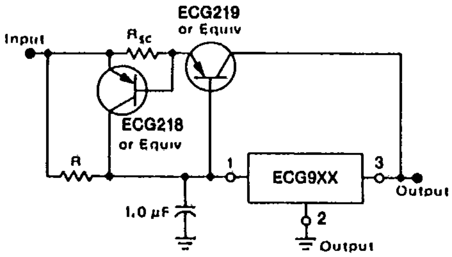
Short Circuit Protection



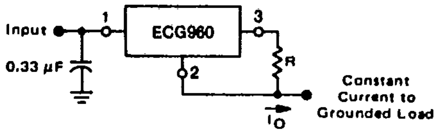
The circuit can be modified to provide supply protection against short circuits by adding a short circuit sense resistor, R_{SC}, and an additional PNP transistor. The current sensing PNP must be able to handle the short-circuit current of the three terminal regulator. Therefore, a four-ampere plastic power transistor is specified.

Current Regulator

The ECG9XX regulators can also be used as a current source when connected as above. In order to minimize dissipation the ECG960 is chosen in this application. Resistor R determines the current as follows:

$$I_O = \frac{5\,V}{R} + I_Q$$

I_Q = 1.5 mA over line and load changes



For example, a 1-ampere current source would require R to be a 5-ohm, 10-W resistor and the output voltage compliance would be the input voltage less 7 volts.