

T-58-11-23

ECG[®]

Semiconductors

ECG970

Adjustable Voltage
Regulator

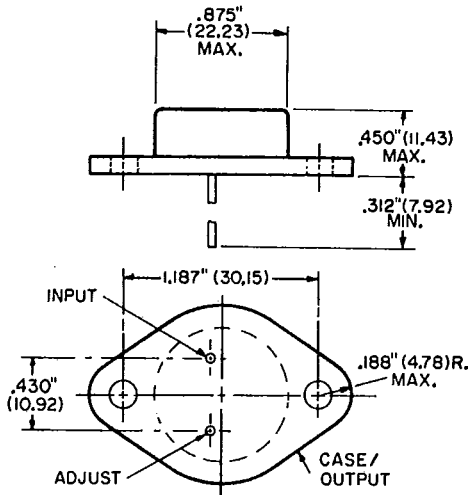
Features

- Adjustable output down to 1.2V
- Guaranteed 3A output current
- Line regulation typically 0.005%/V
- Load regulation typically 0.1%
- Guaranteed thermal regulation
- Current limit constant with temperature
- 100% electrical burn-in in thermal limit
- Eliminates the need to stock many voltages
- 86dB ripple rejection

The ECG970 is an adjustable 3-terminal positive voltage regulator capable of supplying in excess of 3A over a 1.2V to 33V output range. It is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, both line and load regulation are comparable to discrete designs. Also, it is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the ECG970 offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated far from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are dif-



icult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators or discrete designs, the ECG970 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the ECG970 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

Absolute Maximum Ratings

Power Dissipation	Internally Limited
Input—Output Voltage Differential	35V
Operating Temperature	0°C to +125°C
Storage Temperature	-65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

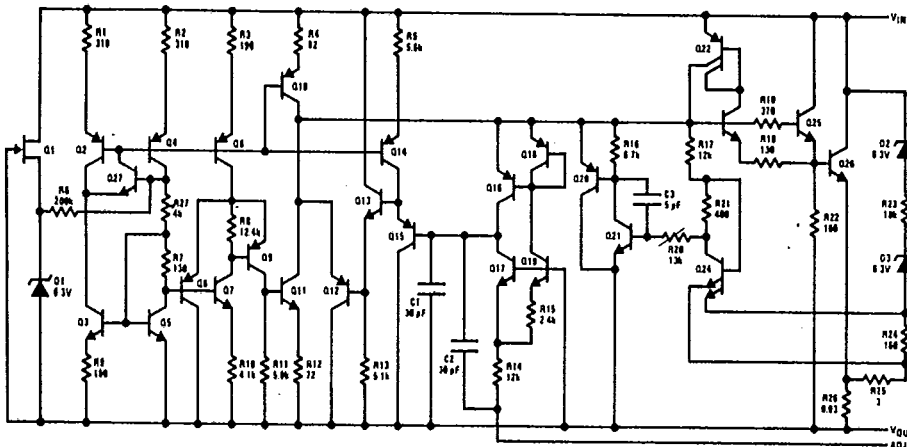
Electrical Characteristics (Note 1)

Characteristic	Conditions	Min	Typ	Max	Units
Line Regulation	$T_A = 25^\circ\text{C}$, $3\text{V} \leq V_{IN} - V_{OUT} \leq 35\text{V}$ (Note 2)		0.005	0.03	%/V
Load Regulation	$T_A = 25^\circ\text{C}$, $10\text{mA} \leq I_{OUT} \leq 3\text{A}$ $V_{OUT} \leq 5\text{V}$ (Note 2) $V_{OUT} \geq 5\text{V}$ (Note 2)		5 0.1	25 0.5	mV %
Thermal Regulation	20ms Pulse		0.002	0.03	%/W
Adjustment Pin Current			50	100	μA
Adjustment Pin Current Change	$10\text{mA} \leq I_L \leq 3\text{A}$ $3\text{V} \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$		0.2	5	μA
Reference Voltage	$3 \leq (V_{IN} - V_{OUT}) \leq 35\text{V}$ $10\text{mA} \leq I_{OUT} \leq 3\text{A}$, $P \leq 30\text{W}$	1.20	1.25	1.30	V
Line Regulation	$3\text{V} \leq V_{IN} - V_{OUT} \leq 35\text{V}$ (Note 2)		0.02	0.07	%/V
Load Regulation	$10\text{mA} \leq I_{OUT} \leq 3\text{A}$ (Note 2) $V_{OUT} \leq 5\text{V}$ $V_{OUT} \geq 5\text{V}$		20 0.3	70 1.5	mV %
Temperature Stability	$T_{MIN} \leq T_J \leq T_{MAX}$		1		%
Minimum Load Current	$V_{IN} - V_{OUT} = 35\text{V}$		3.5	10	mA
Current Limit	$V_{IN} - V_{OUT} \leq 10\text{V}$ $V_{IN} - V_{OUT} = 30\text{V}$, $T_J = +25^\circ\text{C}$	3.0 0.25	4.5 1		A A
RMS Output Noise, % of V_{OUT}	$T_A = 25^\circ\text{C}$, $10\text{Hz} \leq f \leq 10\text{kHz}$		0.003		%
Ripple Rejection Ratio	$V_{OUT} = 10\text{V}$, $f = 120\text{Hz}$ $C_{ADJ} = 10\mu\text{F}$	66	65 86		dB dB
Long Term Stability	$T_A = 125^\circ\text{C}$		0.3	1	%
Thermal Resistance, Junction to Case				1.5	$^\circ\text{C}/\text{W}$

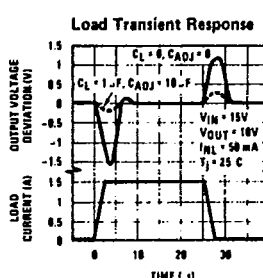
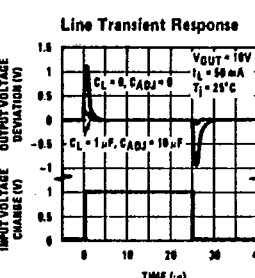
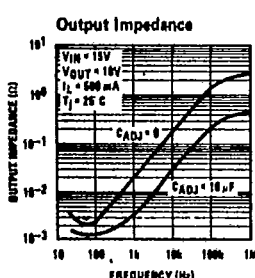
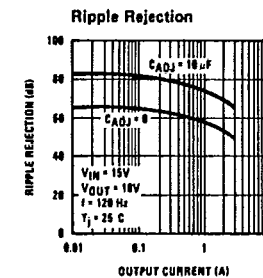
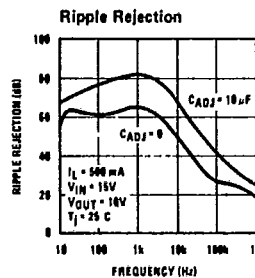
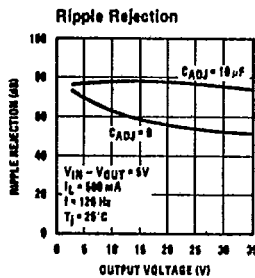
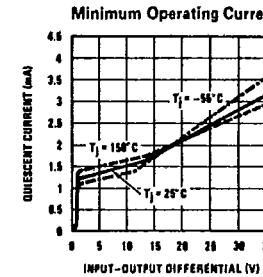
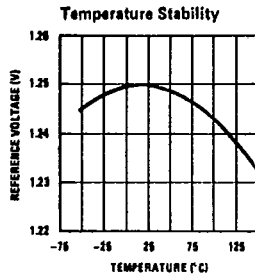
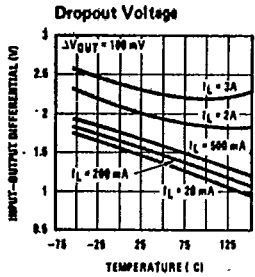
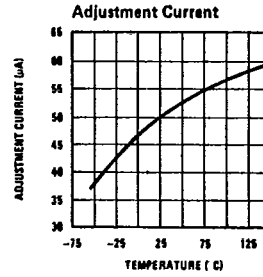
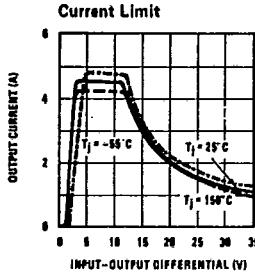
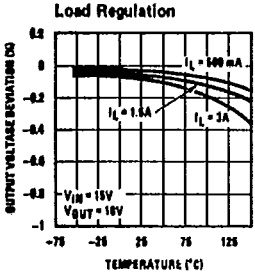
Note 1: Unless otherwise specified, these specifications apply - $0^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$, $V_{IN} - V_{OUT} = 5\text{V}$ and $I_{OUT} = 1.5\text{A}$. Although power dissipation is internally limited, these specifications are applicable for power dissipations up to 30W.

Note 2: Regulation is measured at constant junction temperature. Changes in output voltage due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Schematic



Typical Performance Characteristics



Application Hints

In operation, the ECG970 develops a nominal 1.25V reference voltage, V_{REF} , between the output and adjustment terminal. The reference voltage is impressed across program resistor R1 and, since the voltage is constant, a constant current I_1 then flows through the output set resistor R2, giving an output voltage of

$$V_{OUT} = V_{REF} \left(1 + \frac{R_2}{R_1} \right) + I_{ADJ} R_2$$

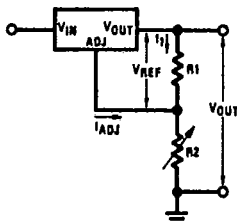


Figure 1.

Since the 50 μ A current from the adjustment terminal represents an error term, the ECG970 was designed to minimize I_{ADJ} and make it very constant with line and load changes. To do this, all quiescent operating current is returned to the output establishing a minimum load current requirement. If there is insufficient load on the output, the output will rise.

External Capacitors

An input bypass capacitor is recommended. A 0.1 μ F disc or 1 μ F solid tantalum on the input is suitable input bypassing for almost all applications. The device is more sensitive to the absence of input bypassing when adjustment or output capacitors are used but the above values will eliminate the possibility of problems.

The adjustment terminal can be bypassed to ground on the ECG970 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 μ F bypass capacitor 86dB ripple rejection is obtainable at any output level. Increases over 10 μ F do not appreciably improve the ripple rejection at frequencies above 120Hz. If the bypass capacitor is used, it is sometimes necessary to include protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.

In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 μ F in aluminum electrolytic to equal 1 μ F solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5MHz. For this reason 0.01 μ F disc may seem to work better than a 0.1 μ F disc as a bypass.

Although the ECG970 is stable with no output capacitors, like any feedback circuit, certain values of external capacitance can cause excessive ringing. This occurs with values between 500pF and 5000pF. A 1 μ F solid tantalum (or 25 μ F aluminum electrolytic) on the output swamps this effect and insures stability.

Load Regulation

The ECG970 is capable of providing extremely good load regulation but a few precautions are needed to obtain maximum performance. The current set resistor connected between the adjustment terminal and the output terminal should be tied directly to the output of the regulator rather than near the load. This eliminates line drops from appearing effectively in series with the reference and degrading regulation. For example, a 15V regulator with 0.05 Ω resistance between the regulator and load will have a load regulation due to line resistance of 0.05 Ω x I_L . If the set resistor is connected near the load the effective line resistance will be 0.05 Ω (1 + R2/R1) or in this case, 11.5 times worse.

Figure 2 shows the effect of resistance between the regulator and the set resistor.

Protection Diodes

When external capacitors are used with any IC regulator it is sometimes necessary to add protection diodes to prevent the capacitors from discharging through low current points

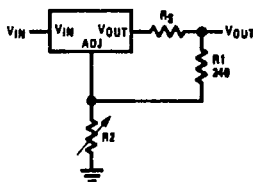


Figure 2. Regulator with Line Resistance in Output Lead

into the regulator. Most 10µF capacitors have low enough internal series resistance to deliver 20A spikes when shorted. Although the surge is short, there is enough energy to damage parts of the IC.

When an output capacitor is connected to a regulator and the input is shorted, the output capacitor will discharge into the output of the regulator. The discharge current depends on the value of the capacitor, the output voltage of the regulator, and the rate of decrease of V_{IN}. In the ECG970, this discharge path is through a large junction that is able to sustain 25A surge with no problem. This is not true of other types of positive regulators. For output capacitors of 25µF or less, there is no need to use diodes.

The bypass capacitor on the adjustment terminal can discharge through a low current junction. Discharge occurs when either the input or output is shorted. Internal to the ECG970 is a 50Ω resistor which limits the

peak discharge current. No protection is needed for output voltages of 25V or less and 10µF capacitance. Figure 3 shows an ECG970 with protection diodes included for use with outputs greater than 25V and high values of output capacitance.

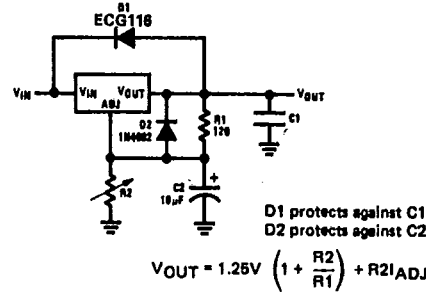
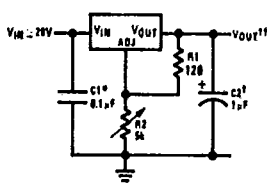


Figure 3. Regulator with Protection Diodes

Typical Applications

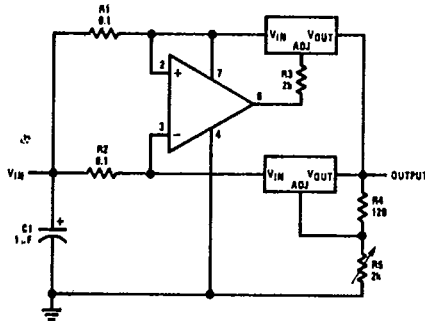
1.2V-25V Adjustable Regulator



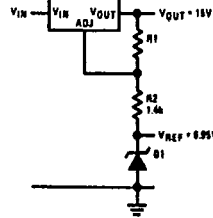
†Optional—Improves transient response
*Needed if device is far from filter capacitors

$$V_{OUT} = 1.25V \left(1 + \frac{R2}{R1} \right)$$

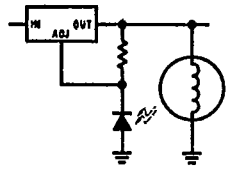
6A Regulator



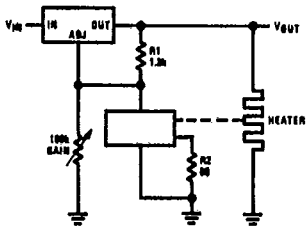
Regulator and Voltage Reference



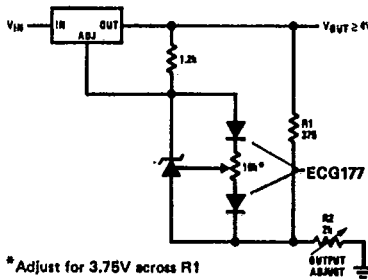
Light Controller



Temperature Controller



Precision Power Regulator with Low Temperature Coefficient

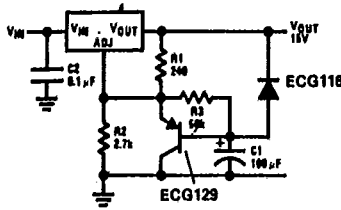


* Adjust for 3.75V across R1

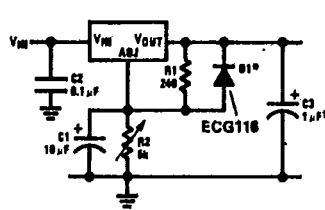
Typical Applications (Continued)

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Slow Turn-ON 15V Regulator

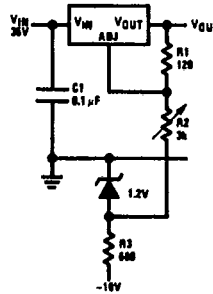


Adjustable Regulator with Improved Ripple Rejection

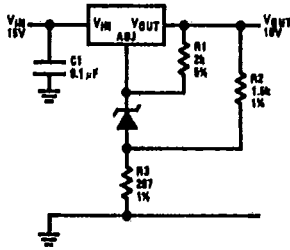


†Solid tantalum
*Discharges C1 if output is shorted to ground

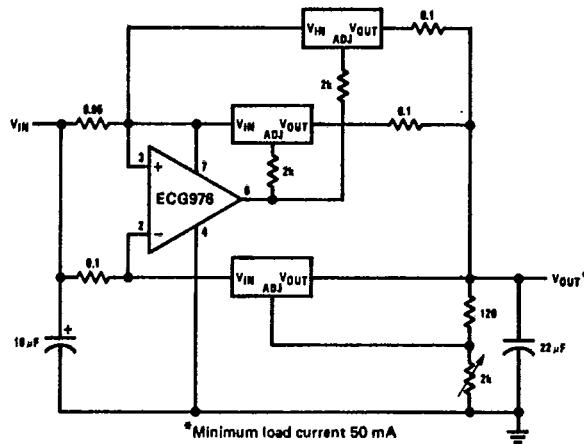
0 to 30V Regulator



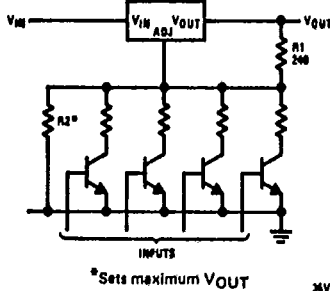
High Stability 10V Regulator



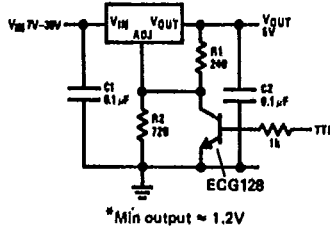
10A Regulator



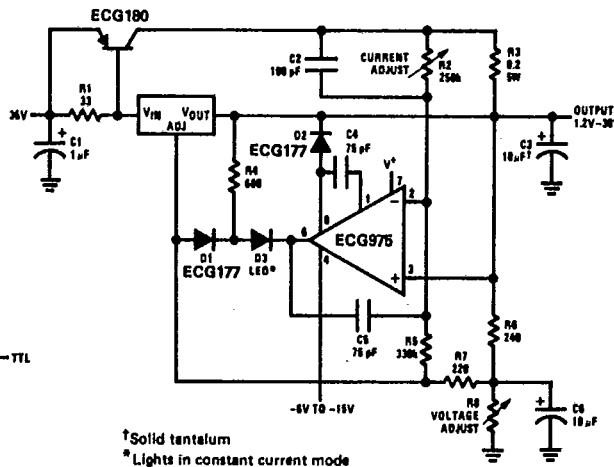
Digitally Selected Outputs



5V Logic Regulator with Electronic Shutdown*



5A Constant Voltage/Constant Current Regulator



Typical Applications (Continued)

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