

T0-5
INDUS.TEMP (1-24 65°
25-99 52°
104-225 50°
DIP (+.50 more))

SEPTEMBER 1968

μA723

PRECISION VOLTAGE REGULATOR

FAIRCHILD LINEAR INTEGRATED CIRCUITS

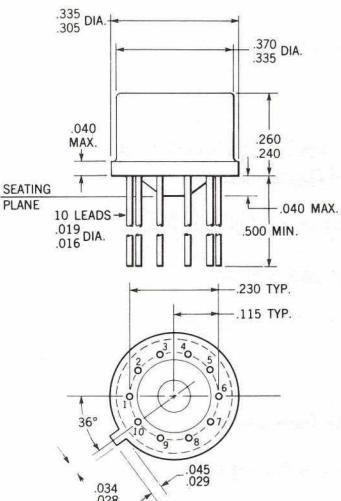
- POSITIVE OR NEGATIVE SUPPLY OPERATION
- SERIES, SHUNT, SWITCHING OR FLOATING OPERATION
- .01% LINE AND LOAD REGULATION
- OUTPUT VOLTAGE ADJUSTABLE FROM 2 TO 37 VOLTS
- OUTPUT CURRENT TO 150 mA WITHOUT EXTERNAL PASS TRANSISTOR

GENERAL DESCRIPTION — The μA723 is a monolithic voltage regulator constructed on a single silicon chip using the Fairchild Planar® epitaxial process. The device consists of a temperature compensated reference amplifier, error amplifier, power series pass transistor and current limit circuitry. Additional NPN or PNP pass elements may be used when output currents exceeding 150 mA are required. Provisions are made for adjustable current limiting and remote shutdown. In addition to the above, the device features low standby current drain, low temperature drift and high ripple rejection. The μA723 is intended for use with positive or negative supplies as a series, shunt, switching or floating regulator. Applications include laboratory power supplies, isolation regulators for low level data amplifiers, logic card regulators, small instrument power supplies, airborne systems and other power supplies for digital and linear circuits.

ABSOLUTE MAXIMUM RATINGS

Pulse Voltage from V ⁺ to V ⁻ (50 msec)	50 V
Continuous Voltage from V ⁺ to V ⁻	40 V
Input-Output Voltage Differential	40 V
Maximum Output Current	150 mA
Current from V _{REF}	15 mA
Internal Power Dissipation (Note 1)	800 mW
Operating Temperature Range	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
Lead Temperature (Soldering, 60 sec.)	300°C

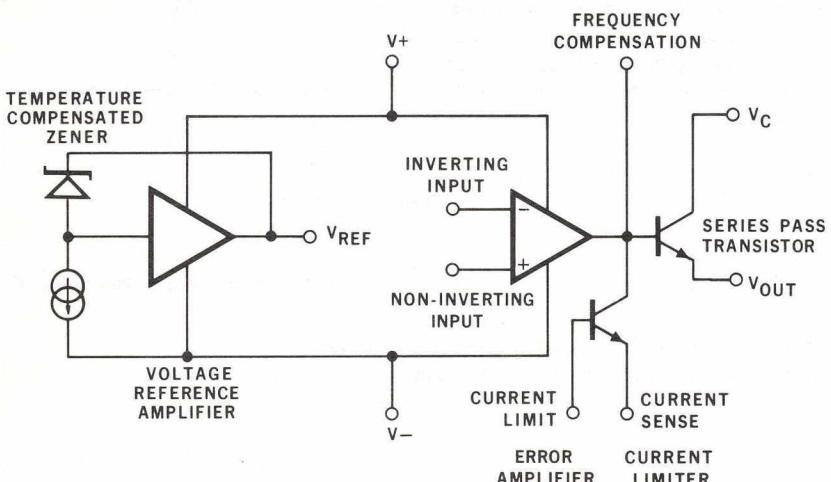
PHYSICAL DIMENSIONS



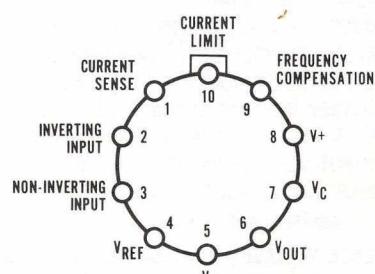
NOTES: All dimensions in inches
Leads are gold-plated Kovar
Package weight is 1.32 grams

ORDER PART NO. U5R7723312

EQUIVALENT CIRCUIT



CONNECTION DIAGRAM TOP VIEW



Note: Pin 5 is connected to case

*Planar is a patented Fairchild process.

313 FAIRCHILD DRIVE, MOUNTAIN VIEW, CALIFORNIA, (415) 962-5011, TWX: 910-379-6435

FAIRCHILD
SEMICONDUCTOR
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION

FAIRCHILD LINEAR INTEGRATED CIRCUITS μ A723

ELECTRICAL CHARACTERISTICS (Note 2)

PARAMETER (see definitions)	CONDITIONS	MIN.	TYP.	MAX.	UNITS
Line Regulation	$V_{IN} = 12 \text{ V}$ to $V_{IN} = 15 \text{ V}$.01	0.1	% V_{OUT}
	$V_{IN} = 12 \text{ V}$ to $V_{IN} = 40 \text{ V}$.02	0.2	% V_{OUT}
	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$, $V_{IN} = 12 \text{ V}$ to $V_{IN} = 15 \text{ V}$		0.3	0.3	% V_{OUT}
Load Regulation	$I_L = 1 \text{ mA}$ to $I_L = 50 \text{ mA}$.03	0.15	% V_{OUT}
	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$, $I_L = 1 \text{ mA}$ to $I_L = 50 \text{ mA}$			0.6	% V_{OUT}
Ripple Rejection	$f = 50 \text{ Hz}$ to 10 kHz , $C_{REF} = 0$		74		dB
	$f = 50 \text{ Hz}$ to 10 kHz , $C_{REF} = 5 \mu\text{F}$		86		dB
Average Temperature Coefficient of Output Voltage	$-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$.002	.015	%/ $^{\circ}\text{C}$
Short Circuit Current Limit	$R_{SC} = 10 \Omega$, $V_{OUT} = 0$		65		mA
Reference Voltage		6.95	7.15	7.35	V
Output Noise Voltage	$BW = 100 \text{ Hz}$ to 10 kHz , $C_{REF} = 0$		20		μV_{rms}
	$BW = 100 \text{ Hz}$ to 10 kHz , $C_{REF} = 5 \mu\text{F}$		2.5		μV_{rms}
Long Term Stability			0.1		%/1000 hrs
Standby Current Drain	$I_L = 0$, $V_{IN} = 30 \text{ V}$		2.3	3.5	mA
Input Voltage Range		9.5		40	V
Output Voltage Range		2.0		37	V
Input-Output Voltage Differential		3.0		38	V

DEFINITION OF TERMS

LINE REGULATION — The percentage change in output voltage for a specified change in input voltage.

LOAD REGULATION — The percentage change in output voltage for a specified change in load current.

RIPPLE REJECTION — The ratio of the peak to peak input ripple voltage to the peak to peak output ripple voltage.

AVERAGE TEMPERATURE COEFFICIENT OF OUTPUT VOLTAGE — The percentage change in output voltage for a specified change in ambient temperature.

SHORT CIRCUIT CURRENT LIMIT — The output current of the regulator with the output shorted to the negative supply.

REFERENCE VOLTAGE — The output of the reference amplifier measured with respect to the negative supply.

OUTPUT NOISE VOLTAGE — The rms output noise voltage with constant load and no input ripple.

STANDBY CURRENT DRAIN — The supply current drawn by the regulator with no output load and no reference voltage load.

INPUT VOLTAGE RANGE — The range of supply voltage over which the regulator will operate.

OUTPUT VOLTAGE RANGE — The range of output voltage over which the regulator will operate.

INPUT-OUTPUT VOLTAGE DIFFERENTIAL — The range of voltage difference between the supply voltage and the regulated output voltage over which the regulator will operate.

SENSE VOLTAGE — The voltage between current sense and current limit terminals necessary to cause current limiting.

TRANSIENT RESPONSE — The closed-loop step function response of the regulator under small-signal conditions.

NOTES:

(1) Derate linearly at $6.8 \text{ mW}/^{\circ}\text{C}$ for operation at ambient temperatures above 25°C .

(2) Unless otherwise specified, $T_A = 25^{\circ}\text{C}$, $V_{IN} = V^+ = V_C = 12 \text{ V}$, $V^- = 0$, $V_{out} = 5 \text{ V}$, $I_L = 1 \text{ mA}$, $R_{SC} = 0$, $C_L = 100 \text{ pF}$, $C_{REF} = 0$ and divider impedance as seen by error amplifier $\leq 10 \text{ k}\Omega$ connected as shown in Fig. 1.

(3) L_1 is 40 turns of #20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with $0.009"$ air gap.

(4) Figures in parentheses may be used if R_1/R_2 divider is placed on opposite of error amp.

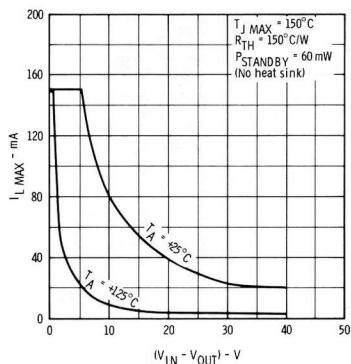
(5) Replace R_1/R_2 in figures with divider shown in figure 13.

(6) V^+ must be connected to a $+3 \text{ V}$ or greater supply.

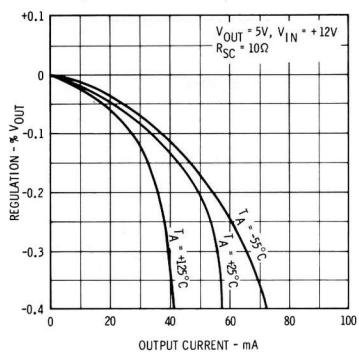
FAIRCHILD LINEAR INTEGRATED CIRCUITS μ A723

TYPICAL PERFORMANCE CURVES

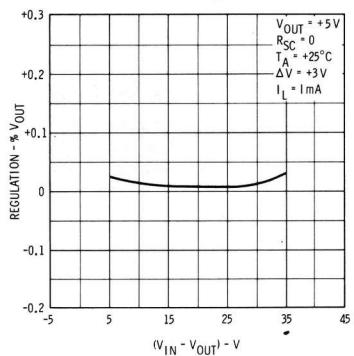
MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL



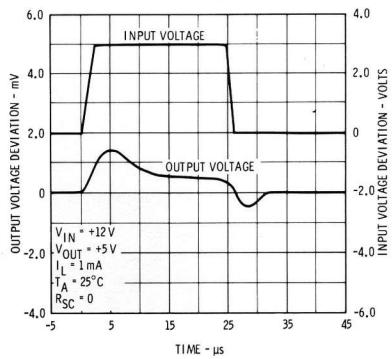
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



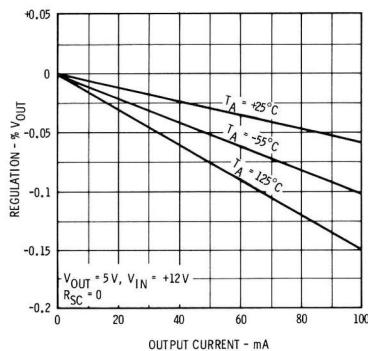
LINE REGULATION AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL



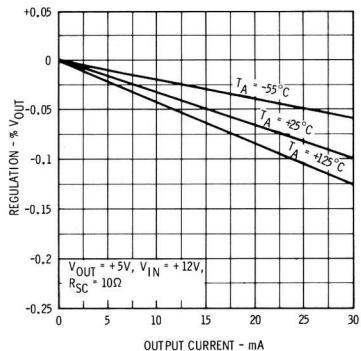
LINE TRANSIENT RESPONSE



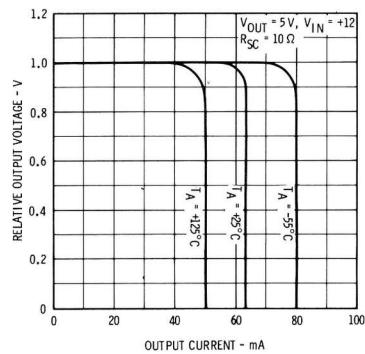
LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING



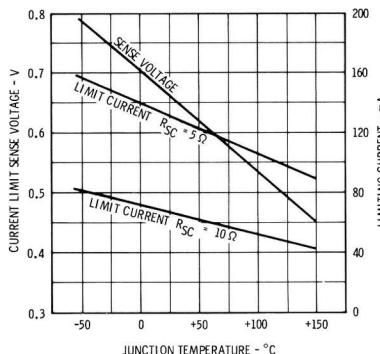
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



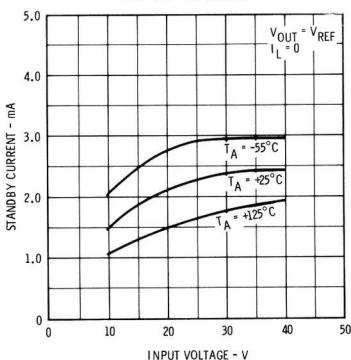
CURRENT LIMITING CHARACTERISTICS



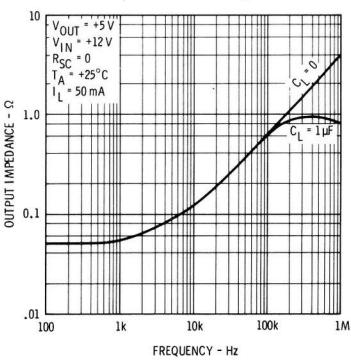
CURRENT LIMITING CHARACTERISTICS AS A FUNCTION OF JUNCTION TEMPERATURE



STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE



OUTPUT IMPEDANCE AS A FUNCTION OF FREQUENCY



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TABLE I
RESISTOR VALUES ($k\Omega$) FOR STANDARD OUTPUT VOLTAGES

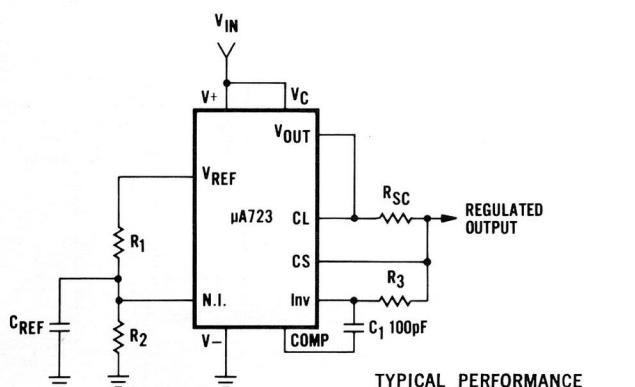
POSITIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT $\pm 5\%$		OUTPUT ADJUSTABLE $\pm 10\%$ (Note 5)			NEGATIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT $\pm 5\%$		5% OUTPUT ADJUSTABLE $\pm 10\%$		
		(Note 4)	R_1	R_2	R_1	P_1	R_2		R_1	R_2	R_1	P_1	R_2
+3.0	1, 5, 6, 9, 12 (4)	4.12	3.01	1.8	0.5	1.2	+100	7	3.57	102	2.2	10	91
+3.6	1, 5, 6, 9, 12 (4)	3.57	3.65	1.5	0.5	1.5	+250	7	3.57	255	2.2	10	240
+5.0	1, 5, 6, 9, 12 (4)	2.15	4.99	.75	0.5	2.2	-6 (note 6)	3, (10)	3.57	2.43	1.2	0.5	.75
+6.0	1, 5, 6, 9, 12 (4)	1.15	6.04	0.5	0.5	2.7	-9	3, 10	3.48	5.36	1.2	0.5	2.0
+9.0	2, 4, (5, 6, 12, 9)	1.87	7.15	.75	1.0	2.7	-12	3, 10	3.57	8.45	1.2	0.5	3.3
+12	2, 4, (5, 6, 9, 12)	4.87	7.15	2.0	1.0	3.0	-15	3, 10	3.65	11.5	1.2	0.5	4.3
+15	2, 4, (5, 6, 9, 12)	7.87	7.15	3.3	1.0	3.0	-28	3, 10	3.57	24.3	1.2	0.5	10
+28	2, 4, (5, 6, 9, 12)	21.0	7.15	5.6	1.0	2.0	-45	8	3.57	41.2	2.2	10	33
+45	7	3.57	48.7	2.2	10	39	-100	8	3.57	97.6	2.2	10	91
+75	7	3.57	78.7	2.2	10	68	-250	8	3.57	249	2.2	10	240

TABLE II
FORMULAE FOR INTERMEDIATE OUTPUT VOLTAGES

Outputs from +2 to +7 volts [Figures 1, 5, 6, 9, 12, (4)] $V_{OUT} = [V_{REF} \times \frac{R_2}{R_1 + R_2}]$	Outputs from +4 to +250 volts [Figure 7] $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R_2 - R_1}{R_1}] ; R_3 = R_4$	Current Limiting $I_{LIMIT} = \frac{V_{SENSE}}{R_{sc}}$
Outputs from +7 to +37 volts [Figures 2, 4, (5, 6, 9, 12)] $V_{OUT} = [V_{REF} \times \frac{R_1 + R_2}{R_2}]$	Outputs from -6 to -250 volts [Figures 3, 8, 10] $V_{OUT} = [\frac{V_{REF}}{2} \times \frac{R_1 + R_2}{R_1}] ; R_3 = R_4$	Foldback Current Limiting $I_{KNEE} = [\frac{V_{OUT} R_3}{R_{sc} R_4} + \frac{V_{SENSE} (R_3 + R_4)}{R_{sc} R_4}]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{sc}} \times \frac{R_3 + R_4}{R_4}]$

Figure 1

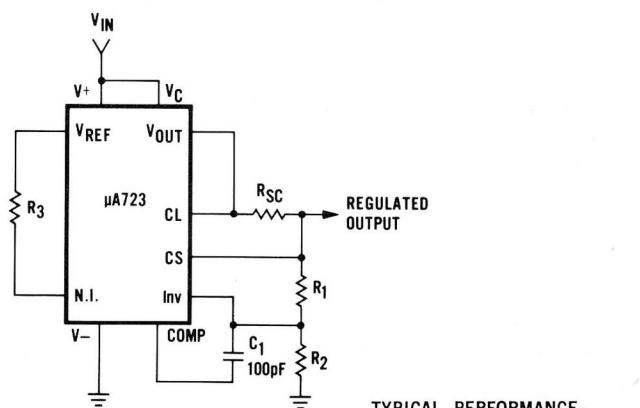
BASIC LOW VOLTAGE REGULATOR
($V_{out} = 2$ to 7 Volts)



Note: $R_3 = \frac{R_1 R_2}{R_1 + R_2}$ for minimum temperature drift.

Figure 2

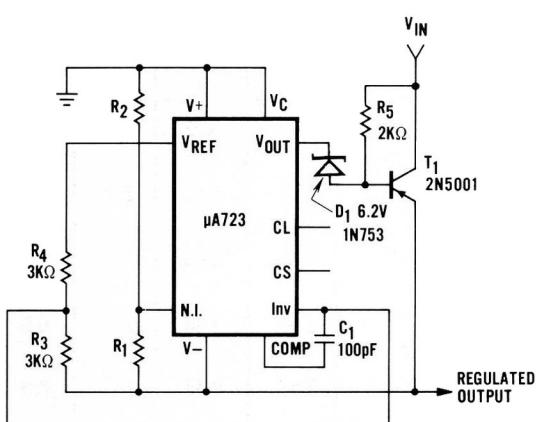
BASIC HIGH VOLTAGE REGULATOR
($V_{out} = 7$ to 37 Volts)



Note: $R_3 = \frac{R_1 R_2}{R_1 + R_2}$ for minimum temperature drift.
 R_3 may be eliminated for minimum component count.

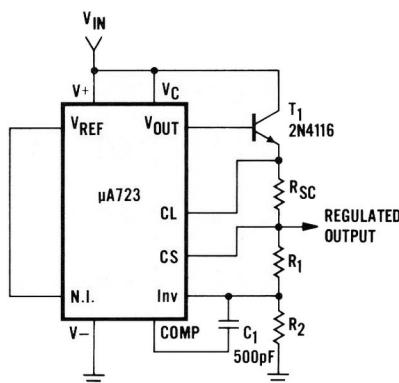
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Figure 3
NEGATIVE VOLTAGE REGULATOR



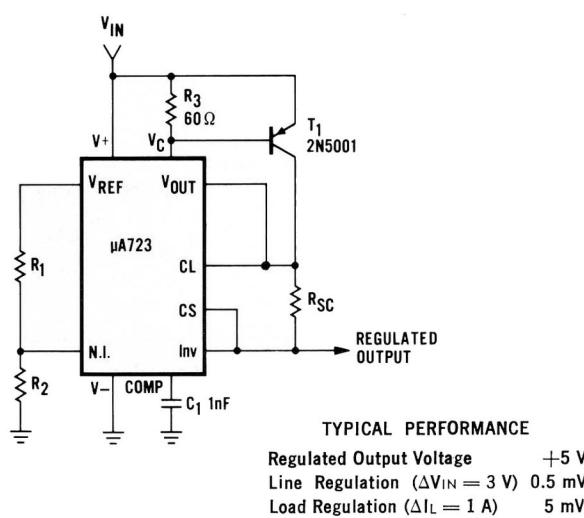
TYPICAL PERFORMANCE
Regulated Output Voltage -15 V
Line Regulation ($\Delta V_{IN} = 3\text{ V}$) 1 mV
Load Regulation ($\Delta I_L = 100\text{ mA}$) 2 mV

Figure 4
**POSITIVE VOLTAGE REGULATOR
(External NPN Pass Transistor)**



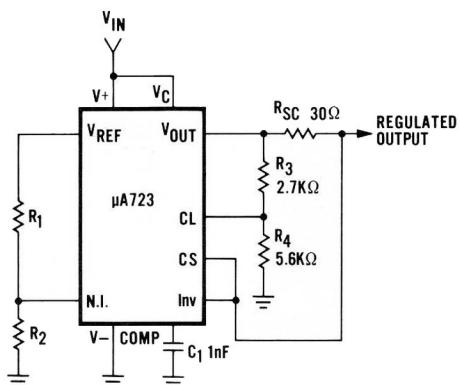
TYPICAL PERFORMANCE
Regulated Output Voltage $+15\text{ V}$
Line Regulation ($\Delta V_{IN} = 3\text{ V}$) 1.5 mV
Load Regulation ($\Delta I_L = 1\text{ A}$) 15 mV

Figure 5
**POSITIVE VOLTAGE REGULATOR
(External PNP Pass Transistor)**



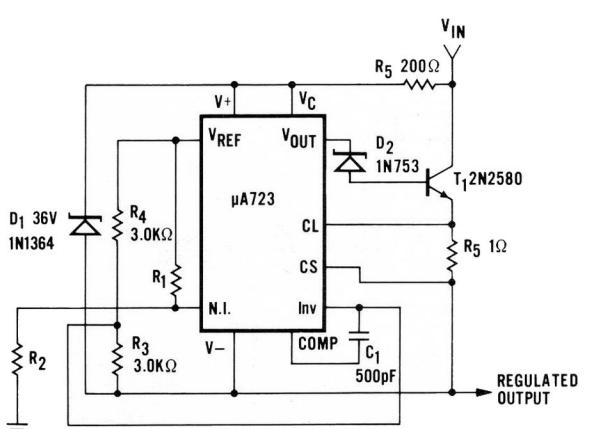
TYPICAL PERFORMANCE
Regulated Output Voltage $+5\text{ V}$
Line Regulation ($\Delta V_{IN} = 3\text{ V}$) 0.5 mV
Load Regulation ($\Delta I_L = 1\text{ A}$) 5 mV

Figure 6
FOLDBACK CURRENT LIMITING



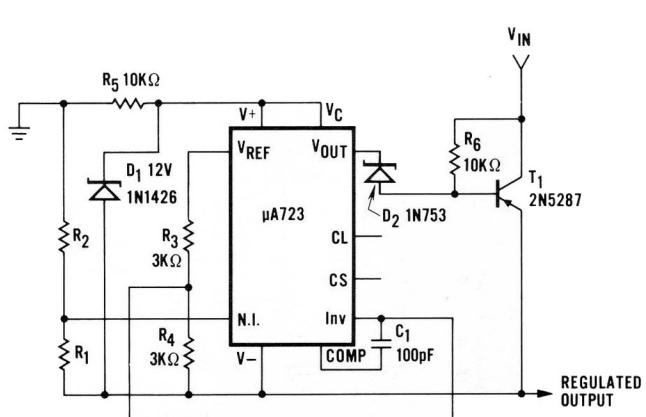
TYPICAL PERFORMANCE
Regulated Output Voltage $+5\text{ V}$
Line Regulation ($\Delta V_{IN} = 3\text{ V}$) 0.5 mV
Load Regulation ($\Delta I_L = 10\text{ mA}$) 1 mV
Current Limit Knee 20 mA

Figure 7
POSITIVE FLOATING REGULATOR



TYPICAL PERFORMANCE
Regulated Output Voltage $+50\text{ V}$
Line Regulation ($\Delta V_{IN} = 20\text{ V}$) 15 mV
Load Regulation ($\Delta I_L = 50\text{ mA}$) 20 mV

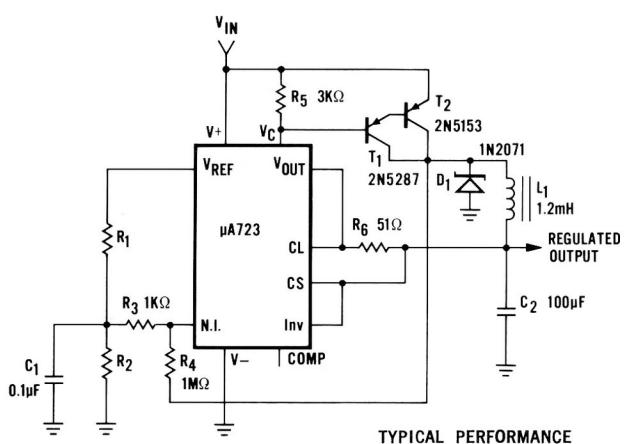
Figure 8
NEGATIVE FLOATING REGULATOR



TYPICAL PERFORMANCE
Regulated Output Voltage -100 V
Line Regulation ($\Delta V_{IN} = 20\text{ V}$) 30 mV
Load Regulation ($\Delta I_L = 100\text{ mA}$) 20 mV

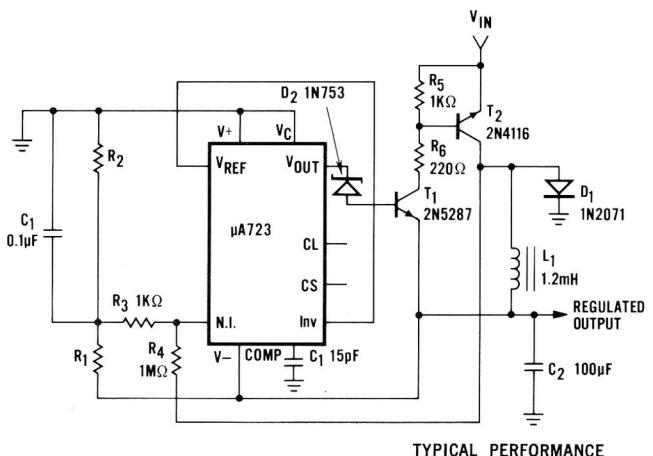
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Figure 9
POSITIVE SWITCHING REGULATOR



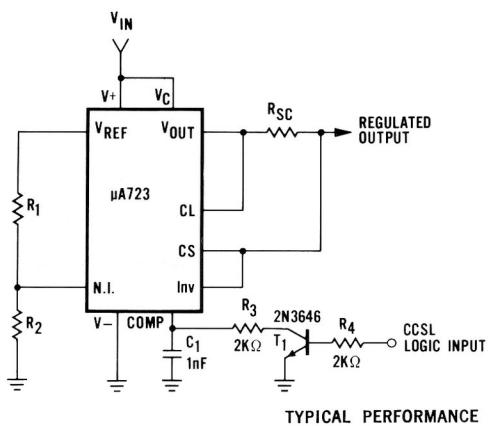
Note 3

Figure 10
NEGATIVE SWITCHING REGULATOR



Note 3

Figure 11
REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING



Note: Current limit transistor may be used for shutdown if current limiting is not required.

Figure 12
SHUNT REGULATOR

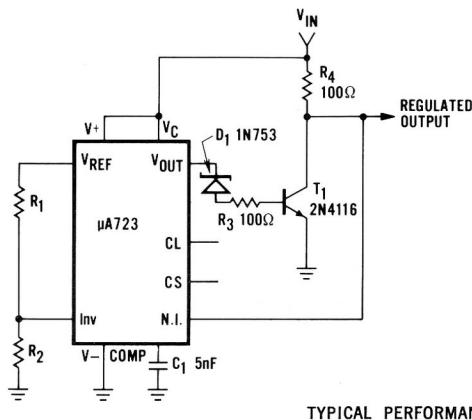


Figure 13
OUTPUT VOLTAGE ADJUST

