μA723
PRECISION VOLTAGE REGULATOR
FAIRCHILD LINEAR INTEGRATED CIRCUITS

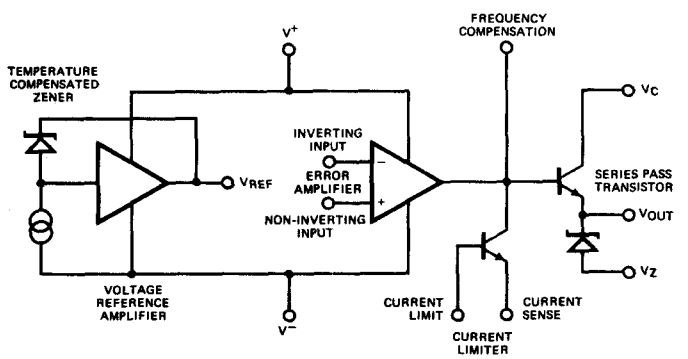
GENERAL DESCRIPTION – The μA723 is a monolithic Voltage Regulator constructed using the Fairchild Planar* epitaxial process. The device consists of a temperature compensated reference amplifier, error amplifier, power series pass transistor and current limit circuitry. Additional NPN or PNP pass elements 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.

- **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**

ABSOLUTE MAXIMUM RATINGS

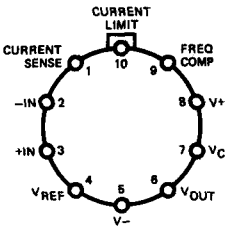
Pulse Voltage from V+ to V–, (50 ms) (μA723)	50 V
Continuous Voltage from V_+ to V_-	40 V
Input/Output Voltage Differential	40 V
Differential Input Voltage	±5 V
Voltage Between Non-Inverting Input and V_-	+8 V
Current from V_Z	25 mA
Current from V_{REF}	15 mA
Internal Power Dissipation (Note 1)	
Metal Can	800 mW
DIP	1000 mW
Storage Temperature Range	–65°C to +150°C
Operating Temperature Range	
Military (μA723)	–55°C to +125°C
Commercial (μA723C)	0°C to +70°C
Lead Temperature (Soldering, 60 s)	300°C

EQUIVALENT CIRCUIT



Notes on following pages.

CONNECTION DIAGRAMS
10-LEAD METAL CAN
(TOP VIEW)
PACKAGE OUTLINE 5F
PACKAGE CODE H

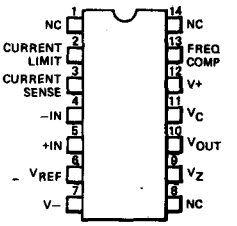


Note: Pin 5 connected to case.

ORDER INFORMATION

TYPE	PART NO.
μA723	μA723HM
μA723C	μA723HC

14-LEAD DIP
(TOP VIEW)
PACKAGE OUTLINES 6A 9A
PACKAGE CODES D P



ORDER INFORMATION

TYPE	PART NO.
μA723	μA723DM
μA723C	μA723DC
μA723C	μA723PC

*Planar is a patented Fairchild process.

μA723

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, $T_A = 25°C$, $V_{IN} = V+ = V_C = 12$ V, $V- = 0$, $V_{OUT} = 5$ V, $I_L = 1$ mA, $R_{SC} = 0$, C1 = 100 pF, $C_{ref} = 0$ and divider impedance as seen by error amplifier ≤ 10 kΩ connected as shown in Fig. 1, Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Line Regulation	$V_{IN} = 12$V to $V_{IN} = 15$V		0.01	0.1	$\%V_O$
	$V_{IN} = 12$V to $V_{IN} = 40$V		0.02	0.2	$\%V_O$
	$-55°C \leq T_A \leq +125°C$, $V_{IN} = 12$V to $V_{IN} = 15$V			0.3	$\%V_O$
Load Regulation	$I_L = 1$ mA to $I_L = 50$ mA		0.03	0.15	$\%V_O$
	$-55°C \leq T_A \leq +125°C$, $I_L = 1$ mA to $I_L = 50$ mA			0.6	$\%V_O$
Ripple Rejection	f = 50 Hz to 10 kHz		74		dB
	f = 50 Hz to 10 kHz, $C_{REF} = 5$ μF		86		dB
Average Temperature Coefficient of Output Voltage	$-55°C \leq T_A \leq +125°C$		0.002	0.015	%/°C
Short Circuit Current Limit	$R_{SC} = 10$ Ω, $V_O = 0$		65		mA
Reference Voltage		6.95	7.15	7.35	V
Output Noise Voltage	BW = 100 Hz to 10 kHz, $C_{REF} = 0$		20		μV_{rms}
	BW = 100 Hz to 10 kHz, $C_{REF} = 5$ μF		2.5		μV_{rms}
Long Term Stability			0.1		%/1000 hrs
Standby Current Drain	$I_L = 0$, $V_{IN} = 30$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

μA723C

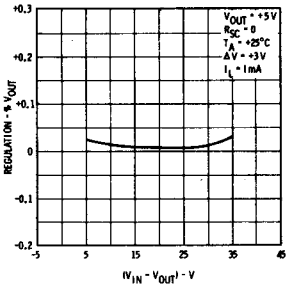
ELECTRICAL CHARACTERISTICS

Unless otherwise specified, $T_A = 25°C$, $V_{IN} = V+ = V_C = 12$ V, $V- = 0$, $V_{OUT} = 5$ V, $I_L = 1$ mA, $R_{SC} = 0$, C1 = 100 pF, $C_{ref} = 0$ and divider impedance as see by error amplifier ≤ 10 kΩ connected as shown in Fig. 1. Line and load regulation specifications are given for the condition of constant chip temperature. Temperature drifts must be taken into account separately for high dissipation conditions.

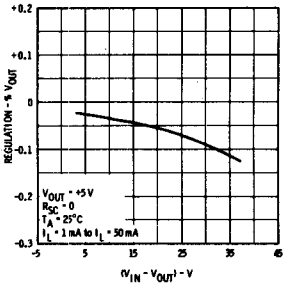
PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Line Regulation	$V_{IN} = 12$V to $V_{IN} = 15$V		0.01	0.1	$\%V_O$
	$V_{IN} = 12$V to $V_{IN} = 40$V		0.1	0.5	$\%V_O$
	$0°C \leq T_A \leq 70°C$, $V_{IN} = 12$V to $V_{IN} = 15$V			0.3	$\%V_O$
Load Regulation	$I_L = 1$ mA to $I_L = 50$ mA		0.03	0.2	$\%V_O$
	$0°C \leq T_A \leq 70°C$, $I_L = 1$ mA to $I_L = 50$ mA			0.6	$\%V_O$
Ripple Rejection	f = 50 Hz to 10 kHz		74		dB
	f = 50 Hz to 10 kHz, $C_{REF} = 5$ μF		86		dB
Average Temperature Coefficient of Output Voltage	$0°C \leq T_A \leq 70°C$		0.003	0.015	%/°C
Short Circuit Current Limit	$R_{SC} = 10$ Ω, $V_O = 0$		65		mA
Reference Voltage		6.80	7.15	7.50	V
Output Noise Voltage	BW = 100 Hz to 10 kHz, $C_{REF} = 0$		20		μV_{rms}
	BW = 100 Hz to 10 kHz, $C_{REF} = 5$ μF		2.5		μV_{rms}
Long Term Stability			0.1		%/1000 hrs
Standby Current Drain	$I_L = 0$, $V_{IN} = 30$V		2.3	4.0	mA
Input Voltage Range		9.5		40	V
Output Voltage Range		2.0		37	V
Input/Output Voltage Differential		3.0		38	V

TYPICAL PERFORMANCE CURVES FOR μA723 AND μA723C

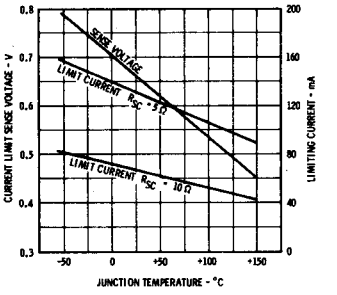
LINE REGULATION AS A FUNCTION OF INPUT/OUTPUT VOLTAGE DIFFERENTIAL



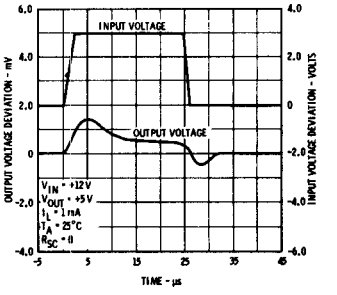
LOAD REGULATION AS A FUNCTION OF INPUT/OUTPUT VOLTAGE DIFFERENTIAL



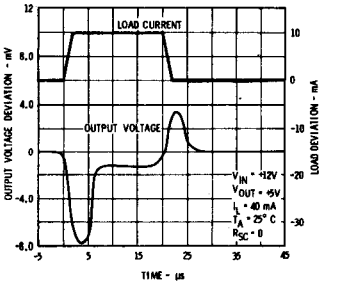
CURRENT LIMITING CHARACTERISTICS AS A FUNCTION OF JUNCTION TEMPERATURE



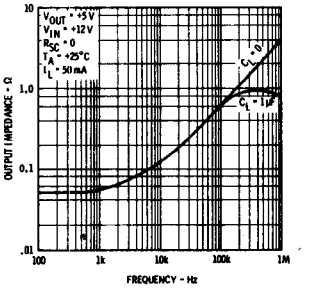
LINE TRANSIENT RESPONSE



LOAD TRANSIENT RESPONSE



OUTPUT IMPEDANCE AS A FUNCTION OF FREQUENCY



NOTES:

1. Rating applies to ambient temperatures up to 25°C. Above 25°C ambient derate based on the following thermal resistance values:

	θ_{JA}	
	TYP	MAX
TO-5	150	190
Plastic DIP	150	190
Ceramic DIP	125	160

2. L_1 is 40 turns of No. 20 enameled copper wire wound on Ferroxcube P36/22-3B7 pot core or equivalent with 0.009" air gap.
3. Figures in parentheses may be used if R_1/R_2 divider is placed on opposite side of error amp.
4. Replace R_1/R_2 in figures with divider shown in figure 13.
5. V^+ must be connected to a +3 V or greater supply.
6. For metal can applications where V_Z is required, an external 6.2 volt zener diode should be connected in series with V_{OUT}.

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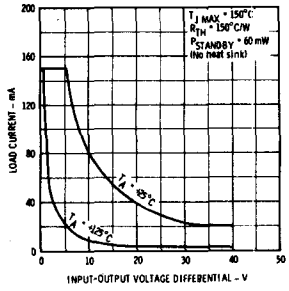
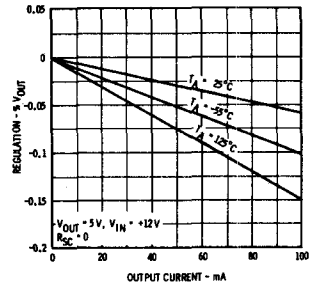
TYPICAL PERFORMANCE CURVES FOR μA723

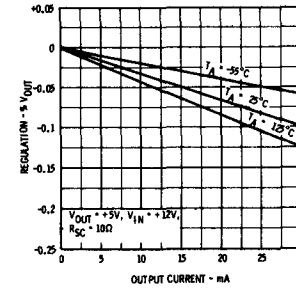
MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT-OUTPUT VOLTAGE DIFFERENTIAL



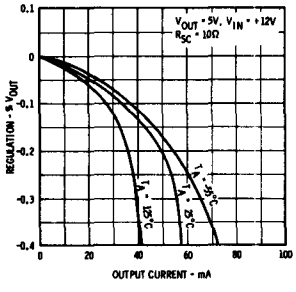
LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING



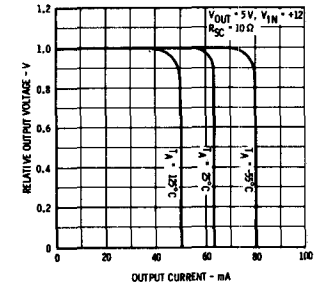
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



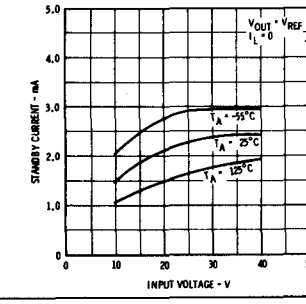
LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



CURRENT LIMITING CHARACTERISTICS

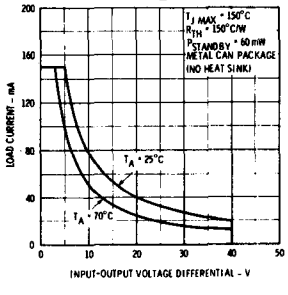


STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE

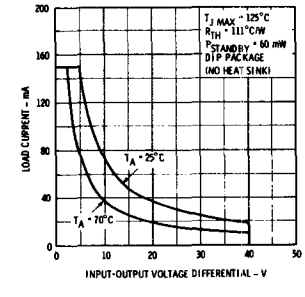


TYPICAL PERFORMANCE CURVES FOR μA723C

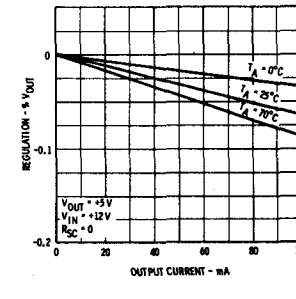
MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT/OUTPUT VOLTAGE DIFFERENTIAL



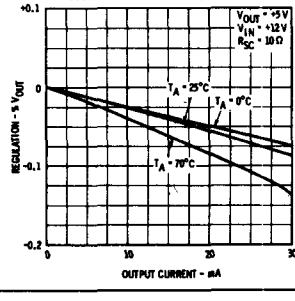
MAXIMUM LOAD CURRENT AS A FUNCTION OF INPUT/OUTPUT VOLTAGE DIFFERENTIAL



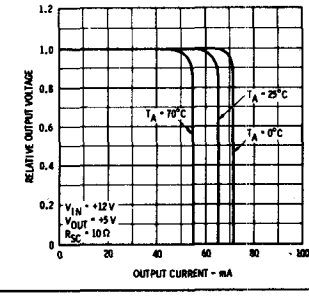
LOAD REGULATION CHARACTERISTICS WITHOUT CURRENT LIMITING



LOAD REGULATION CHARACTERISTICS WITH CURRENT LIMITING



CURRENT LIMITING CHARACTERISTICS



STANDBY CURRENT DRAIN AS A FUNCTION OF INPUT VOLTAGE

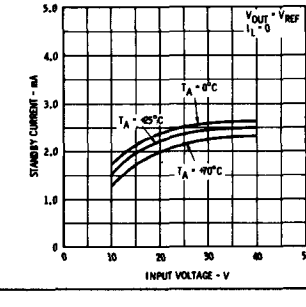


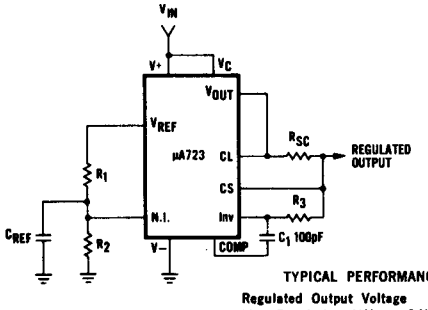
TABLE I
RESISTOR VALUES (kΩ) FOR STANDARD OUTPUT VOLTAGES

POSITIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		OUTPUT ADJUSTABLE ±10% (Note 4)			NEGATIVE OUTPUT VOLTAGE	APPLICABLE FIGURES	FIXED OUTPUT ±5%		5% OUTPUT ADJUSTABLE ±10%		
	(Note 3)	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 5)	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 $I_{KNEE} = [\frac{V_{OUT} R_3}{R_{sc} R_4} + \frac{V_{SENSE}(R_3 + R_4)}{R_{sc} R_4}]$ $I_{SHORT\ CKT} = [\frac{V_{SENSE}}{R_{sc}} \times \frac{R_3 + R_4}{R_4}]$

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



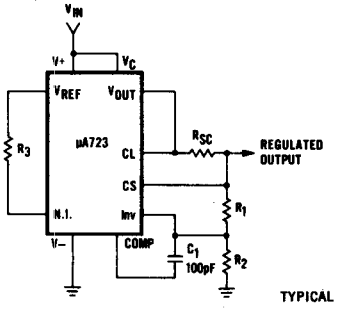
TYPICAL PERFORMANCE

Regulated Output Voltage	5 V
Line Regulation (ΔV_{IN} = 3 V)	0.5 mV
Load Regulation (ΔI_L=50 mA)	1.5 mV

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

Fig. 1

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



TYPICAL PERFORMANCE

Regulated Output Voltage	15 V
Line Regulation (ΔV_{IN} = 3 V)	1.5 mV
Load Regulation (ΔI_L=50 mA)	4.5 mV

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.

Fig. 2

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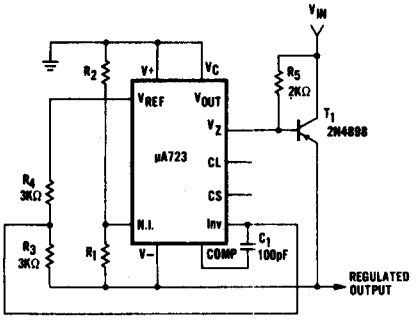
NEGATIVE VOLTAGE REGULATOR



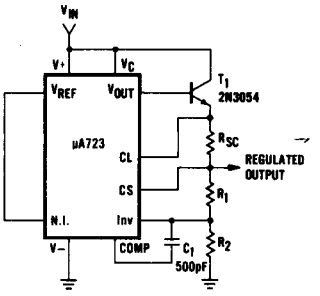
TYPICAL PERFORMANCE

Regulated Output Voltage	−15 V
Line Regulation (ΔV_{IN} = 3 V)	1 mV
Load Regulation (ΔI_L = 100 mA)	2 mV

Note 6

Fig. 3

POSITIVE VOLTAGE REGULATOR
(External NPN Pass Transistor)

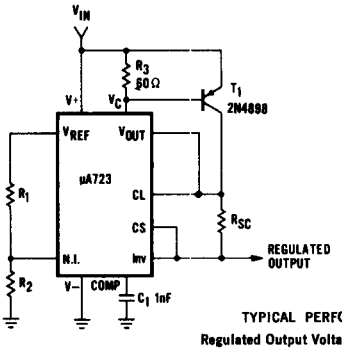


TYPICAL PERFORMANCE

Regulated Output Voltage	+15 V
Line Regulation (ΔV_{IN} = 3 V)	1.5 mV
Load Regulation (ΔI_L = 1 A)	15 mV

Fig. 4

POSITIVE VOLTAGE REGULATOR
(External PNP Pass Transistor)

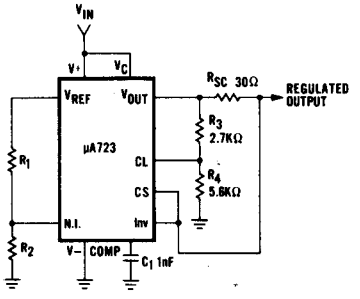


TYPICAL PERFORMANCE

Regulated Output Voltage	+5 V
Line Regulation (ΔV_{IN} = 3 V)	0.5 mV
Load Regulation (ΔI_L = 1 A)	5 mV

Fig. 5

FOLDBACK CURRENT LIMITING

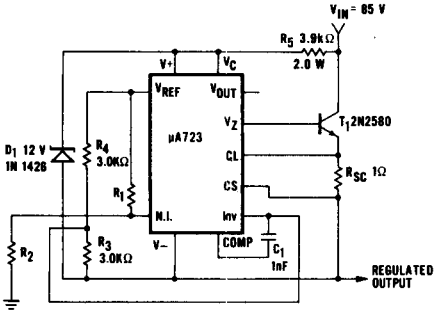


TYPICAL PERFORMANCE

Regulated Output Voltage	+5 V
Line Regulation (ΔV_{IN} = 3 V)	0.5 mV
Load Regulation (ΔI_L = 10 mA)	1 mV
Short Circuit Current	20 mA

Fig. 6

POSITIVE FLOATING REGULATOR



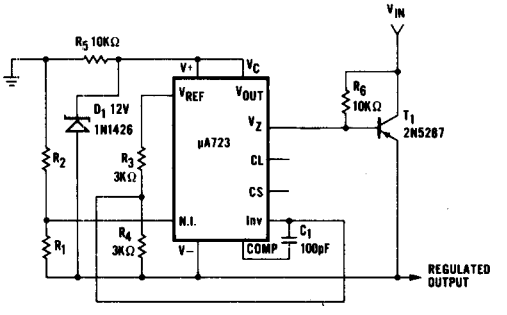
TYPICAL PERFORMANCE

Regulated Output Voltage	+50 V
Line Regulation (ΔV_{IN} = 20 V)	15 mV
Load Regulation (ΔI_L = 50 mA)	20 mV

Note 6

Fig. 7

NEGATIVE FLOATING REGULATOR



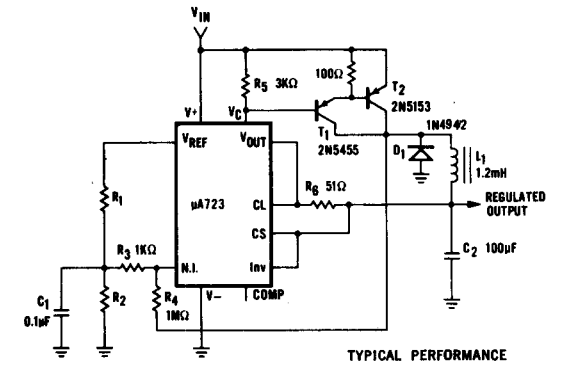
TYPICAL PERFORMANCE

Regulated Output Voltage	−100 V
Line Regulation (ΔV_{IN} = 20 V)	30 mV
Load Regulation (ΔI_L=100 mA)	20 mV

Note 6

Fig. 8

POSITIVE SWITCHING REGULATOR



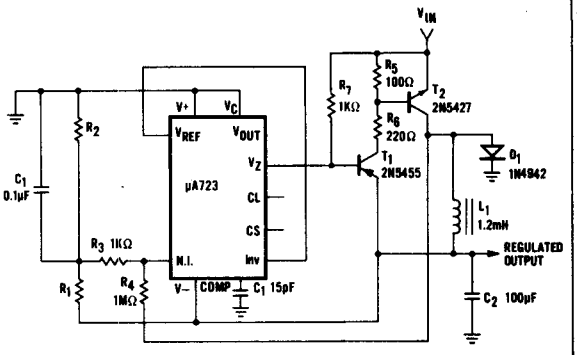
TYPICAL PERFORMANCE

Regulated Output Voltage	+5 V
Line Regulation (ΔV_{IN} = 30 V)	10 mV
Load Regulation (ΔI_L = 2 A)	80 mV

Note 2

Fig. 9

NEGATIVE SWITCHING REGULATOR



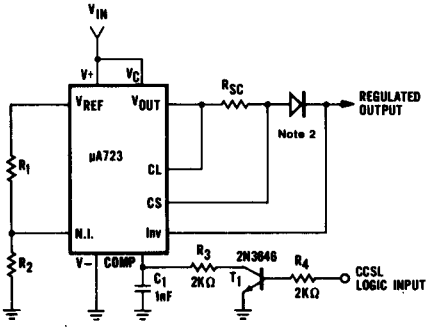
TYPICAL PERFORMANCE

Regulated Output Voltage	−15 V
Line Regulation (ΔV_{IN} = 20 V)	8 mV
Load Regulation (ΔI_L = 2 A)	6 mV

Notes 2, 6

Fig. 10

REMOTE SHUTDOWN REGULATOR WITH CURRENT LIMITING



Note 1: Current limit transistor may be used for shutdown if current limiting is not required.

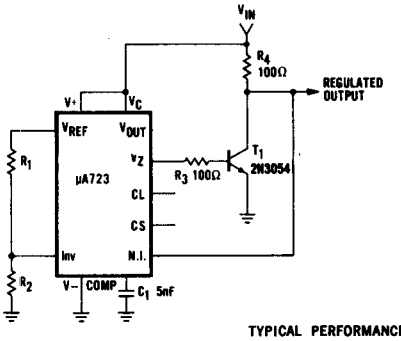
2: Add if Vout > 10V

TYPICAL PERFORMANCE

Regulated Output Voltage	+5 V
Line Regulation (ΔV_{IN} = 3 V)	0.5 mV
Load Regulation (ΔI_L=50 mA)	1.5 mV

Fig. 11

SHUNT REGULATOR



TYPICAL PERFORMANCE

Regulated Output Voltage	+5 V
Line Regulation (ΔV_{IN} = 10 V)	0.5 mV
Load Regulation (ΔI_L = 100 mA)	1.5 mV

Note 6

Fig. 12

OUTPUT VOLTAGE ADJUST

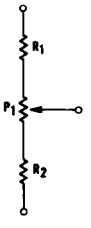
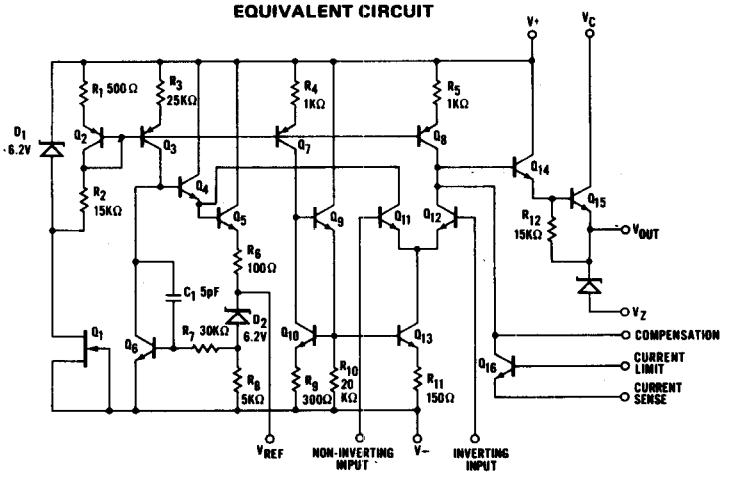


Fig. 13

EQUIVALENT CIRCUIT



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