19-1115; Rev 2; 11/04

Pin-Programmable, Precision Voltage Reference

General Description

Maxim's MX584 is a temperature-compensated, bandgap voltage reference which provides pin-programmable output voltages of +10.00V, +7.50V, +5.00V, and +2.50V. External components are not required for these outputs, but if other voltages are desired, they can be programmed with external resistors.

Laser trimming minimizes output error as well as temperature drift, to as low as 10mV and 15ppm/°C with the MX584K.

The input voltage range of the MAX584 is 4.5V to 30V. The reference also includes a STROBE input which shuts down the reference output. Typical current drain when ON is 750µA. This drops to about 100µA when the reference is strobed OFF.

The MX584 is designed for use with 8- to 14-bit A/D and D/A converters as well as data acquisition systems. It is available in 8-lead TO-99 metal cans, plastic DIPS, CERDIPS, and SO packages.

Applications

CMOS DAC Reference

A/D Converter Reference

Measurement Instrumentation

Data Loggers

Precision Analog Systems

Programmable Offset for PGAs

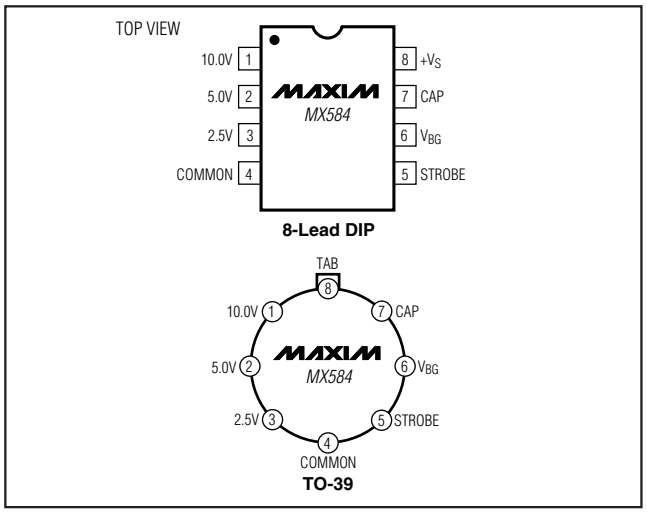
Features

- **+10.0V, +7.5V, +5.0V, +2.5V Programmable Outputs**
- **±10mV Tolerance at +10V (MX584K)**
- **Low Tempco: 15ppm/°C, max (MAX584K)**
- **No External Components or Trims**
- **Short-Circuit Proof**
- **Output Sources and Sinks Current**
- **10mA Output Current**

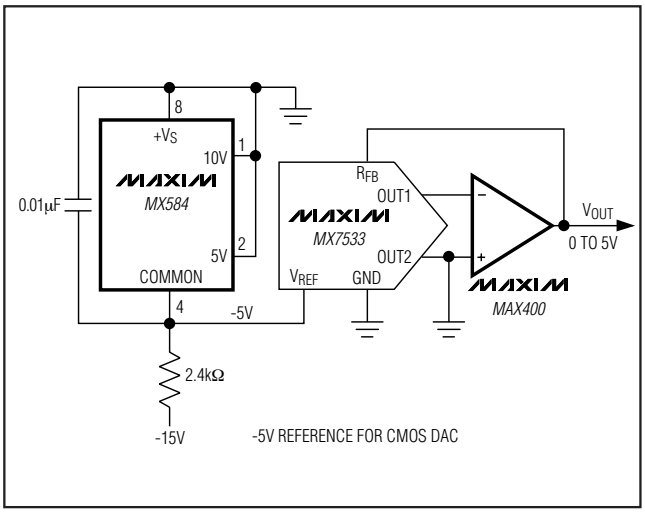
Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	ERROR
MX584JH	0°C to +70°C	8 TO-99 Can	±30mV
MX584KH	0°C to +70°C	8 TO-99 Can	±10mV
MX584JN	0°C to +70°C	8 PDIP	±30mV
MX584KN	0°C to +70°C	8 PDIP	±10mV
MX584JCSA	0°C to +70°C	8 SO	±30mV
MX584KCSA	0°C to +70°C	8 SO	±10mV
MX584JESA	-40°C to +85°C	8 SO	±30mV
MX584KESA	-40°C to +85°C	8 SO	±10mV
MX584JC/D	0°C to +70°C	8 Dice	±30mV
MX584SH	-55°C to +125°C	8 TO-99 Can	±30mV
MX584TH	-55°C to +125°C	8 TO-99 Can	±10mV
MX584SQ	-55°C to +125°C	8 CERDIP	±30mV
MX584TQ	-55°C to +125°C	8 CERDIP	±10mV

Pin Configuration



Typical Operating Circuit



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

Pin-Programmable, Precision Voltage Reference

ABSOLUTE MAXIMUM RATINGS

Input Voltage (V_{IN} to COMMON) ..... -0.3V, +40V
Continuous Power Dissipation
- Metal Can (derate 6.7mW/°C above +60°C) 600mW
- CERDIP (derate 8mW/°C above +75°C) 600mW
- Plastic DIP (derate 6mW/°C above +75°C) 450mW
- SO (derate 5.3mW/°C above +75°C) 400mW

Output Short-Circuit Duration (Note 1) ..... Indefinite
Operating Temperature Range
- Commercial (J, K) ..... 0°C to +70°C
- Military (S, T) ..... -55°C to +125°C
- Extended (J, K) ..... -40°C to +85°C

Storage Temperature Range ..... -65°C to +150°C
Lead Temperature (soldering, 10s) ..... +300°C
Die Junction Temperature (T_J) ..... -55°C to +150°C
Thermal Resistance, Junction to Ambient
- Metal Can ..... +150°C/W
- CERDIP ..... +125°C/W
- Plastic DIP ..... +160°C/W
- SO ..... +170°C/W

Note 1: Absolute maximum power dissipation must not be exceeded.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{IN} = +15V, T_A = +25°C, unless otherwise noted.)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Output Voltage Tolerance		I_L = 0mA, at Pin 1	V_{OUT} = +10V, MAX584J/S			±30	mV
			MAX584K/T			±10	
			V_{OUT} = +7.5V, MAX584J/S			±22	
			MAX584K/T			±8	
			V_{OUT} = +5.0V, MAX584J/S			±15	
			MAX584K/T			±6	
			V_{OUT} = +2.5V, MAX584J/S			±7.5	
			MAX584K/T			±3.5	
Output Voltage Temperature Coefficient		MX584J/S, all outputs				30	ppm/°C
		MX584K, all outputs				15	
		MX584KE, all outputs				20	
		MX584JE, all outputs				30	
		MX584T, +10V, +7.5V, +5V out				15	
		+2.5V out				20	
Differential Tempco Between Outputs		MX584K/T			3		ppm/°C
		MX584J/S			5		
Quiescent Supply Current	I_Q	I_L = 0mA			750	1000	µA
Quiescent Current Tempco					1.5		µA/°C
Turn-On Settling Time	t_{ON}	To ±1%			200		µs
Noise	$e_{n(P-P)}$	0.1Hz to 10Hz			50		$µV_{P-P}$
Long-Term Stability		Noncumulative			25		ppm/khrs
Short-Circuit Current	I_{SC}				30		mA
Line Regulation		No load	(V_{OUT} + 2.5V) < V_{IN} < +15V		0.005		%/V
			+15V < V_{IN} < +30V		0.002		

ELECTRICAL CHARACTERISTICS (continued)

(V_{IN} = +15V, T_A = +25°C, unless otherwise noted.)

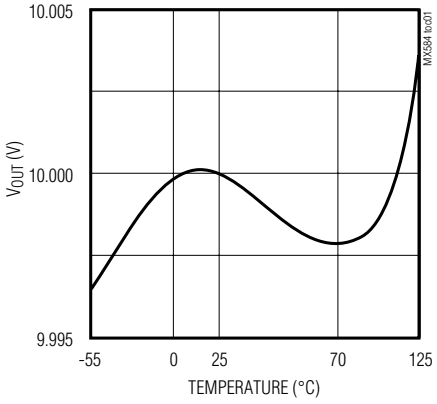
PARAMETER		SYMBOL	CONDITIONS			MIN	TYP	MAX	UNITS
Load Regulation			I_L = 0mA to 5mA				30		ppm/mA
Output Current	Source	I_L	V_{IN} > V_{OUT} + 2.5V	T_A = +25°C		10			mA
				T_{MIN} to T_{MAX}		5			
	Sink (Note 2)			T_{MIN} to T_{MAX}	MX584J/K	5			
					MX584S/T	0.2			
				T_A = -55°C to +85°C	MX584S/T	5			

Note 2: C_{LOAD} ≥10nF. See the *Output Current* section.

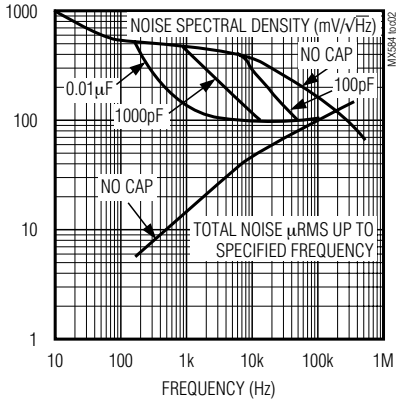
Typical Operating Characteristics

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

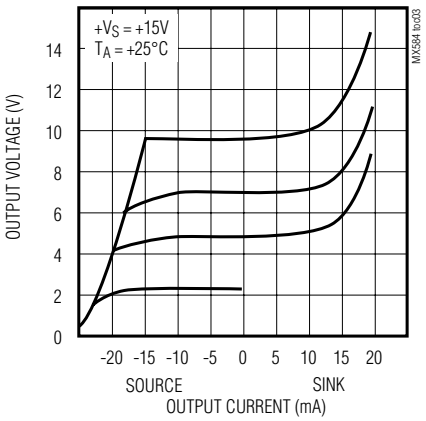
TYPICAL TEMPERATURE CHARACTERISTICS



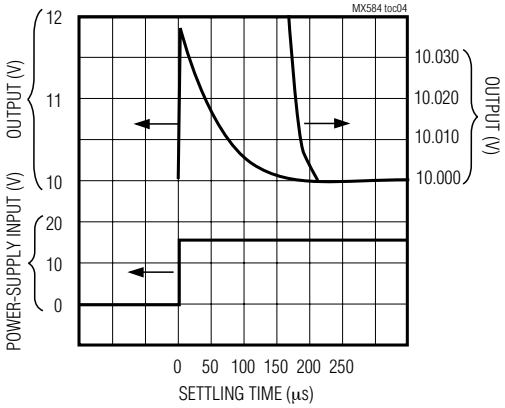
SPECTRAL NOISE DENSITY AND RMS NOISE vs. FREQUENCY



OUTPUT VOLTAGE vs. SINK AND SOURCE CURRENT



POWER-ON SETTLING CHARACTERISTICS



Pin-Programmable, Precision Voltage Reference

Detailed Description

As shown in Figure 1, most applications of the MX584 require no external components. Connections to $+V_S$ and COMMON (COMMON is also tied to the case in the TO-99 metal package) with all other pins unconnected result in a buffered +10.00V output at pin 1. The other pretrimmed voltages are obtained by strapping pins as shown in Table 1. If one or more external buffer amplifiers are connected to the programming pins (pins 2, 3), multiple outputs can be obtained from one reference.

Other Output Voltages

The MX584 can be adjusted to a different output voltage by adding one or more resistors as in Figure 2. As the diagram shows, the reference can be thought of as a 1.215V bandgap followed by a noninverting amplifier. If R1 and R2 are used alone, the adjustment range is widest but the resolution of the trim may be too coarse, even when a multi-turn trip pot is used.

When adding external resistors, output voltages well above 10V can be obtained. R2 should therefore be chosen carefully since it sets the maximum output voltage. R2's resistance should not be so low as to jeopardize other circuits if R1 is misadjusted.

The fixed output voltages can also be varied by connecting only one resistor, as in the dashed lines in Figure 2. Connecting R3 alone raises V_{OUT} while R4 alone lowers it. These resistors (or potentiometers) must have very low temperature coefficients if accuracy over temperature is to be unaffected by the adjustment.

If fine adjustment of the output is all that is required, the circuit of Figure 3 is recommended. It provides good stability and resolution for a trim range of ±200mV. If the 2.5V output is adjusted, R2 should be connected to V_{BG}, pin 6, and the trim range should be limited to ±100mV.

Voltage Temperature Coefficient

The temperature characteristic of the MX584 consistently follows an "S-curve" as shown in the *Typical Operating Characteristics*. A five-point 100% test guarantees compliance with -55°C to +125°C specifications and a three-point 100% test guarantees 0°C to +70°C specifications.

The tolerance specifications in the *Electrical Characteristics* table state the maximum deviation from the reference's initial value at +25°C. By adding the maximum deviation for a given device to its initial tolerance, the total possible error is determined.

Table 1. Programming Pin Connections

OUTPUT VOLTAGE (V)	PROGRAMMING (OUTPUT ON PIN 1)
10	Pins 2 and 3 are unconnected
7.5	Connect pins 2 and 3 together
5.0	Connect pins 2 and 1 together
2.5	Connect pins 3 and 1 together

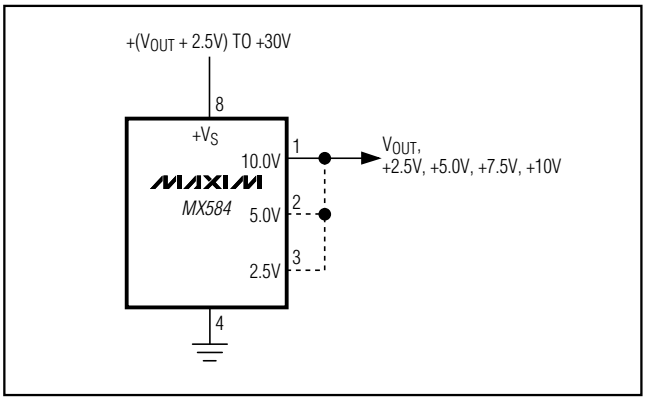


Figure 1. Basic Connection for Positive Outputs

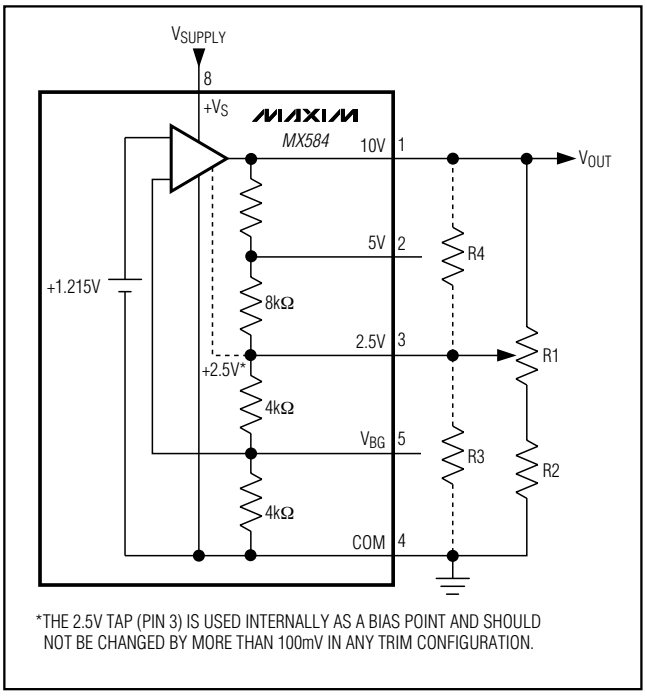


Figure 2. Variable Output Options

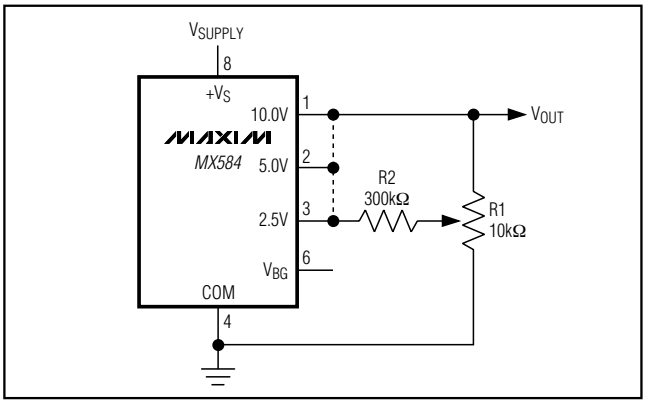


Figure 3. Fine Adjustment of Output Voltage (±200mV)

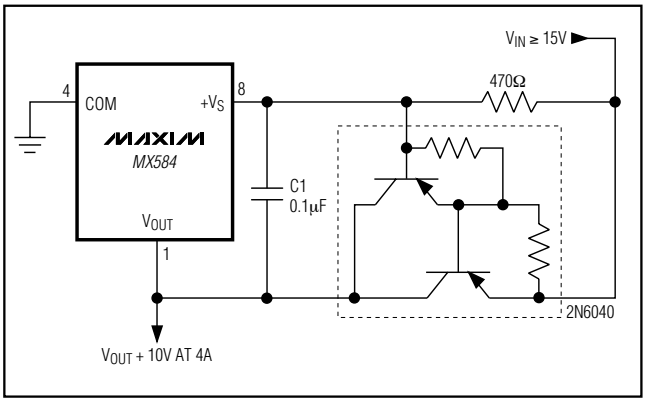


Figure 6. High-Current Precision Supply

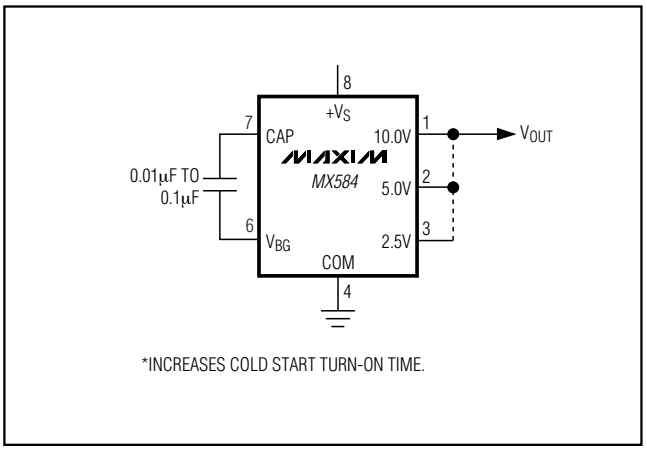


Figure 4. Additional Noise Filtering with an External Capacitor

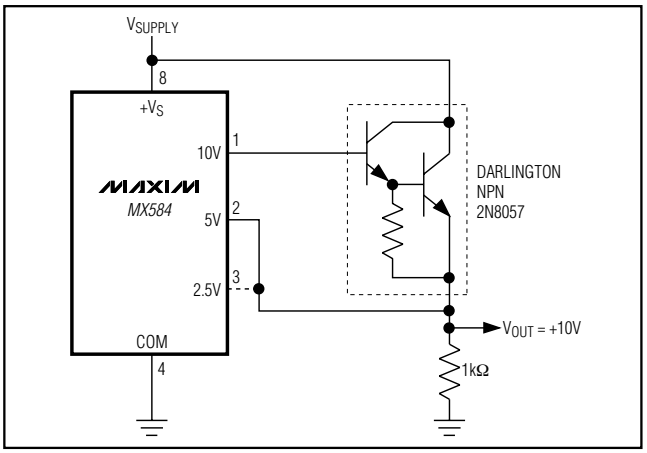


Figure 7. NPN Output Current Booster

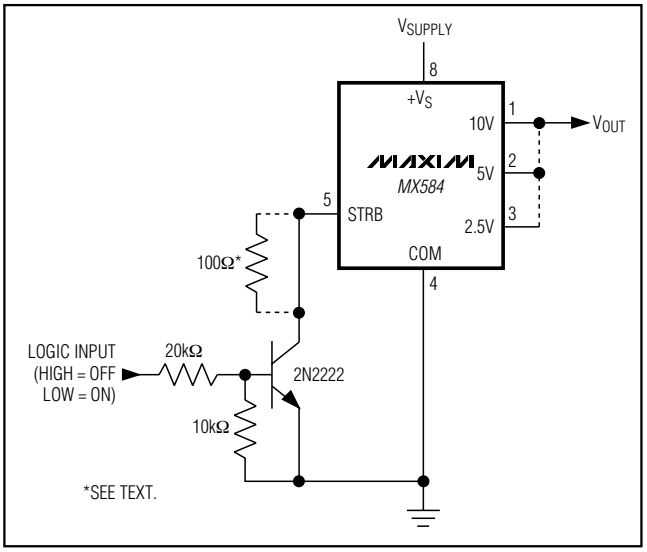


Figure 5. Use of Strobe Terminal

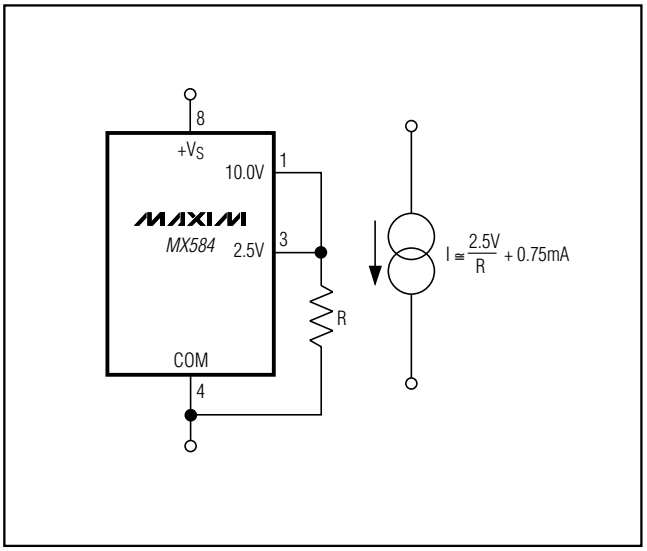


Figure 8. Precision Current Limiter

Pin-Programmable, Precision Voltage Reference

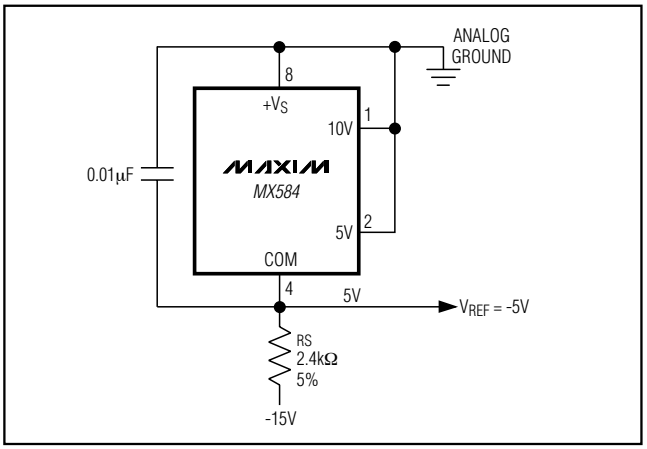


Figure 9. Two-Terminal -5V Reference

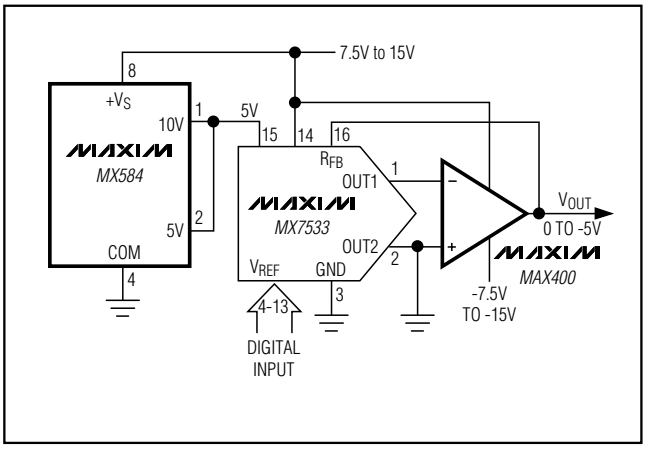


Figure 10. Low-Power, 10-Bit CMOS DAC Connection

Output Current

The MX584 is capable of sinking as well as sourcing current. The circuit is also protected for output shorts to either +VS or ground (COMMON). The output's voltage versus current characteristic is shown in the *Typical Operating Characteristics* section. For applications that require the MX584 to sink current, maintain a load capacitance of 10nF or greater for proper operation.

Dynamic Performance

The turn-on settling performance of the MX584 is shown in the *Typical Operating Characteristics*. Both coarse and fine transient response is shown. The reference typically settles to 1mV (10V output) within 180µs after power is applied.

Noise Filtering

The bandwidth of the MX584's output amplifier can be limited by connecting a capacitor between the CAP and VBG pins (see Figure 4). Typical values range from 0.01µF to 0.1µF. The reduction of wideband and feedthrough noise is plotted in a graph in the *Typical Operating Characteristics* section.

Strobe Input

The STROBE input, pin 5, zeroes the reference output when it is pulled LOW. If no current is pulled from STROBE, operation is normal. The threshold of the input is 200mV, so an open-drain n-channel FET or open-collector transistor driven from logic is recommended (see Figure 5). The current-sinking ability should be at least 500µA and the leakage current should be 5µA or less. While shut down, the MX584 should not be required to source or sink current unless a 0.7V residual output is acceptable. If the reference is required to sink transient current while shut down, the current flowing out of STROBE should be limited with 100Ω as shown in the dashed connection in Figure 5.

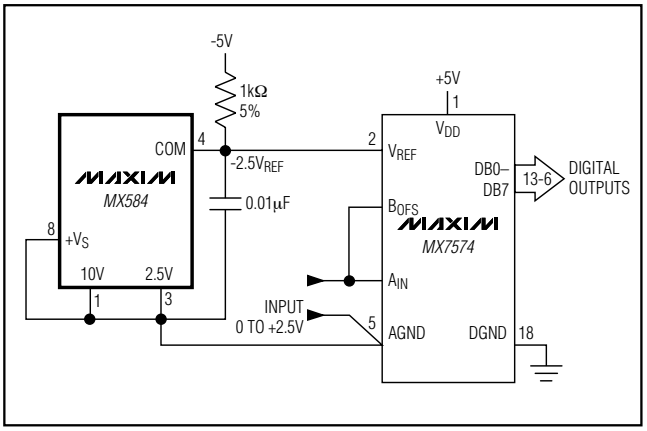


Figure 11. MX584 as Negative 2.5V Reference for a CMOS ADC

Applications Information

Precision High-Current Reference

A PNP power transistor, or Darlington, is easily connected to the MX584 to greatly increase its output current. The circuit in Figure 6 provides a +10V output at up to 4A. If the load has a significant capacitive component, C1 should be added. If the load is purely resistive, high-frequency supply rejection is improved without C1. An NPN output transistor or Darlington can also be used to boost output current as shown in Figure 7.

Current Limiter

By adding a single resistor as shown in Figure 8, the MX584 is turned into a precision current limiter for

applications where the driving voltage is 5V to 40V. The programmed current ranges from 0.75mA to 5mA.

Negative 10V Reference

In applications which require a -10V, -7.5V, -5.0V, or -2.5V reference, the MX584 can be connected as a two-terminal device and biased like a zener diode. The circuit is shown in Figure 9. $+V_S$ and V_{OUT} are connected to the analog ground bus, and the MX584's COMMON pin is connected, through a resistor, to the negative supply. With 1mA flowing in the reference, the output voltage is typically 2mV greater than what is obtained with the conventional, positive hook-up.

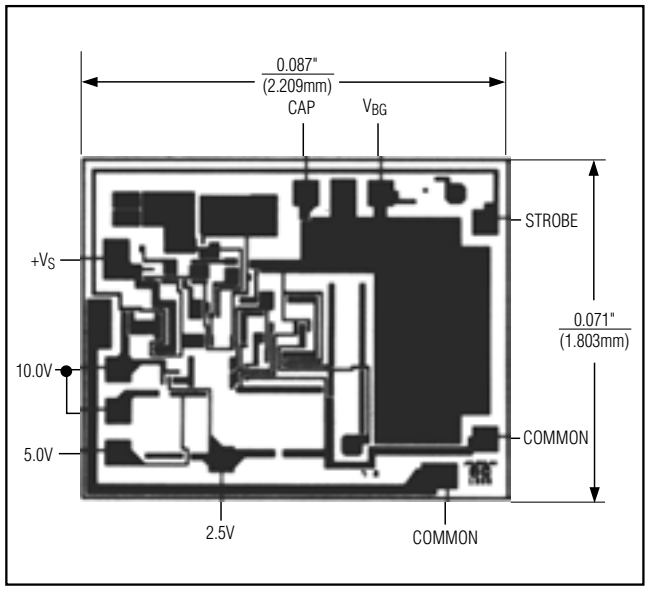
When using the 2-terminal connection, the load and the bias resistor must be selected so that the current flowing in the reference is maintained between 1mA and 5mA. The operating temperature range for this connection is limited to -55°C to +85°C.

Reference for DACs and ADCs

The MX584 is well suited for use with a wide variety of DACs, especially CMOS DACs. Figure 10 shows a circuit in which an MX7533 10-bit DAC outputs 0 to -5V when using a +5V reference. For a positive DAC output, the MX584 can be configured as a two-terminal negative reference as well by using the connection of Figure 9.

In Figure 11, an MX7574 CMOS ADC uses an MX584, connected for -2.5V, as its reference input so that the system can operate from ±5V power. The analog input range for the circuit is 0V to +2.5V.

Chip Topography



Chip Information

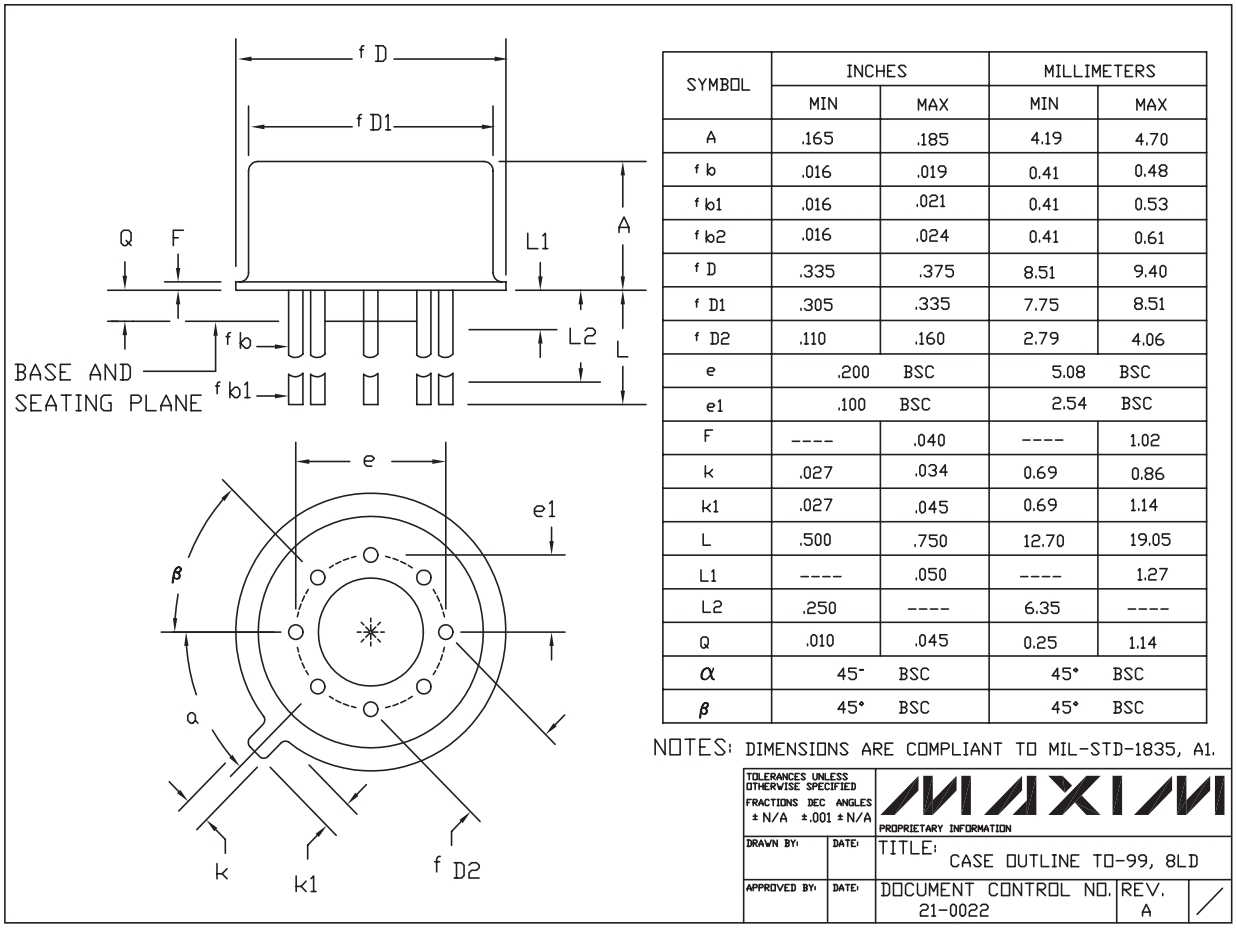
TRANSISTOR COUNT: 72

SUBSTRATE CONNECTED TO GND

Pin-Programmable, Precision Voltage Reference

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)



TO-99, 8LD .EPS

SYMBOL	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	.165	.185	4.19	4.70
f b	.016	.019	0.41	0.48
f b1	.016	.021	0.41	0.53
f b2	.016	.024	0.41	0.61
f D	.335	.375	8.51	9.40
f D1	.305	.335	7.75	8.51
f D2	.110	.160	2.79	4.06
e	.200 BSC		5.08 BSC	
e1	.100 BSC		2.54 BSC	
F	----	.040	----	1.02
k	.027	.034	0.69	0.86
k1	.027	.045	0.69	1.14
L	.500	.750	12.70	19.05
L1	----	.050	----	1.27
L2	.250	----	6.35	----
Q	.010	.045	0.25	1.14
α	45° BSC		45° BSC	
β	45° BSC		45° BSC	

NOTES: DIMENSIONS ARE COMPLIANT TO MIL-STD-1835, A1.

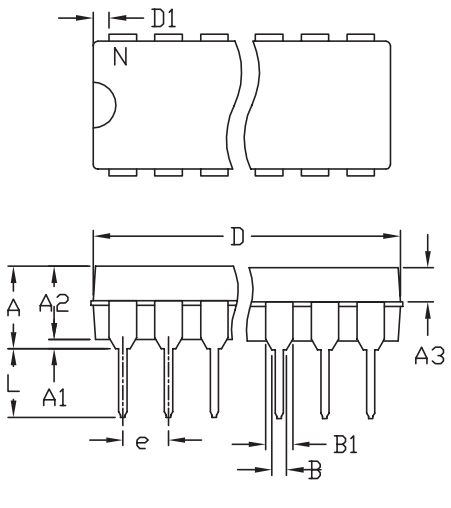
TOLERANCES UNLESS OTHERWISE SPECIFIED FRACTIONS DEC ANGLES ± N/A ±.001 ± N/A		MAXIM PROPRIETARY INFORMATION	
DRAWN BY:	DATE:	TITLE: CASE OUTLINE TO-99, 8LD	
APPROVED BY:	DATE:	DOCUMENT CONTROL NO. 21-0022	REV. A

Pin-Programmable, Precision Voltage Reference

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

PDIPN.EPS



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.180	---	4.572
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.015	0.022	0.381	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.014	0.2	0.355
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100 BSC.		2.54 BSC.	
eA	0.300 BSC.		7.62 BSC.	
eB	0.400 BSC.		10.16 BSC.	
L	0.115	0.150	2.921	3.81

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS001
D	0.348	0.390	8.84	9.91	8	AB
D	0.735	0.765	18.67	19.43	14	AC
D	0.745	0.765	18.92	19.43	16	AA
D	0.885	0.915	22.48	23.24	18	AD
D	1.015	1.045	25.78	26.54	20	AE
D	1.14	1.265	28.96	32.13	24	AF
D	1.360	1.380	34.54	35.05	28	*5

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. CONTROLLING DIMENSION: MILLIMETER
4. MEETS JEDEC MS001-XX AS SHOWN IN ABOVE TABLE
5. SIMILIAR TO JEDEC MO-058AB
6. N = NUMBER OF PINS

MAXIM 120 SAN GABRIEL DR SUNNYVALE CA 94086 FAX (408) 737 7194 PROPRIETARY INFORMATION

PACKAGE FAMILY OUTLINE: PDIP .300" TITLE

1/1

21-0043 D DOCUMENT CONTROL NUMBER REV

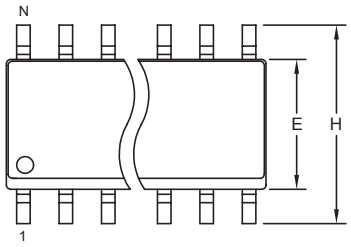
Pin-Programmable, Precision Voltage Reference

Package Information (continued)

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to **www.maxim-ic.com/packages**.)

SOICN .EPS

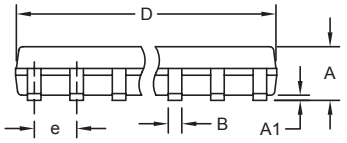
	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050 BSC		1.27 BSC	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
L	0.016	0.050	0.40	1.27



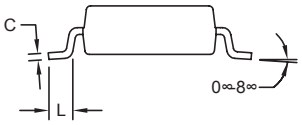
TOP VIEW

VARIATIONS:

	INCHES		MILLIMETERS			
DIM	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	AA
D	0.337	0.344	8.55	8.75	14	AB
D	0.386	0.394	9.80	10.00	16	AC



FRONT VIEW



SIDE VIEW

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH.
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED 0.15mm (.006").
3. LEADS TO BE COPLANAR WITHIN 0.10mm (.004").
4. CONTROLLING DIMENSION: MILLIMETERS.
5. MEETS JEDEC MS012.
6. N = NUMBER OF PINS.

DALLAS SEMICONDUCTOR MAXIM

PROPRIETARY INFORMATION

TITLE: PACKAGE OUTLINE, .150" SOIC

APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0041	B	1/1

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