MAX6325/MAX6341/MAX6350

1ppm/°C, Low-Noise, +2.5V/+4.096V/+5V Voltage References

General Description

The MAX6325/MAX6341/MAX6350 are low-noise, precision voltage references with extremely low, 0.5ppm/°C typical temperature coefficients and excellent, ±0.02% initial accuracy. These devices feature buried-zener technology for lowest noise performance. Load-regulation specifications are guaranteed for source and sink currents up to 15mA. Excellent line and load regulation and low output impedance at high frequencies make them ideal for high-resolution data-conversion systems up to 16 bits.

The MAX6325 is set for a 2.5V output, the MAX6341 is set for a 4.096V output, and the MAX6350 is set for a 5V output. All three provide for the option of external trimming and noise reduction.

19-1203; Rev 1; 1/01

Applications

High-Resolution Analog-to-Digital and Digital-to-Analog Converters

High-Accuracy Reference Standard

High-Accuracy Industrial and Process Control

Digital Voltmeters

ATE Equipment

Precision Current Sources

Features

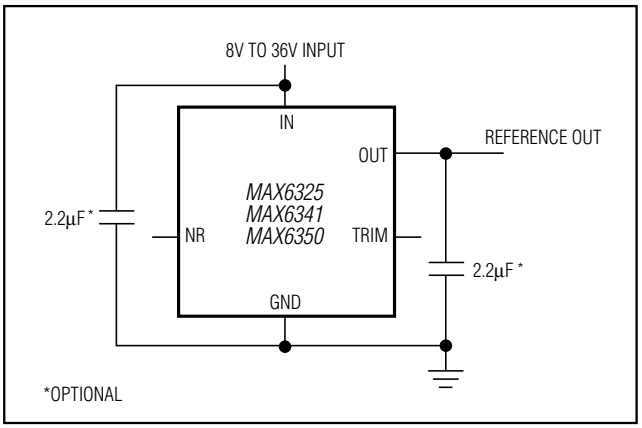
- **Ultra Low, 1ppm/°C Max Tempco**
- **Very Low, 1.5µVp-p Noise (0.1Hz to 10Hz) (MAX6325)**
- **±0.02% Initial Accuracy (MAX6350)**
- **±15mA Output Source and Sink Current**
- **Low, 18mW Power Consumption (MAX6325)**
- **Industry-Standard Pinout**
- **Optional Noise Reduction and Voltage Trim**
- **Excellent Transient Response**
- **8-Pin SO Package Available**
- **Low, 30ppm/1000hr Long-Term Stability**
- **Stable for All Capacitive Loads**

Ordering Information

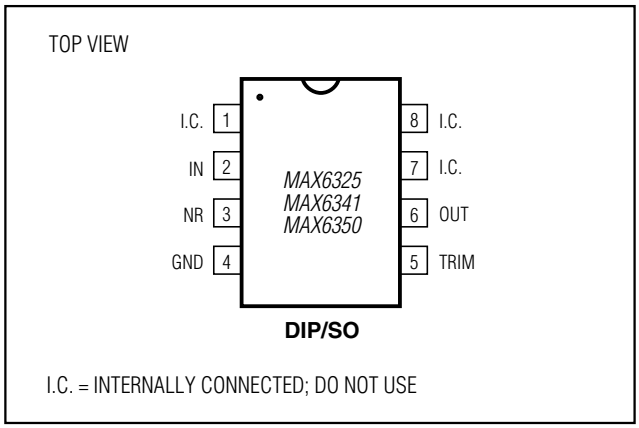
PART	TEMP. RANGE	PIN-PACKAGE	MAX TEMPCO (ppm/°C)
MAX6325CPA	0°C to +70°C	8 Plastic DIP	1.0
MAX6325CSA	0°C to +70°C	8 SO	1.0
MAX6325EPA	-40°C to +85°C	8 Plastic DIP	1.5
MAX6325ESA	-40°C to +85°C	8 SO	1.5
MAX6325MJA	-55°C to +125°C	8 CERDIP	2.5

Ordering Information continued at end of data sheet.

Typical Operating Circuit



Pin Configuration



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

19-1203; Rev 1; 1/01

ABSOLUTE MAXIMUM RATINGS

(Voltages Referenced to GND)
IN .....-0.3V to 40V
OUT, TRIM.....-0.3V to 12V
NR.....-0.3V to 6V
OUT Short-Circuit to GND Duration (V_{IN} ≤ 12V).....Continuous
OUT Short-Circuit to GND Duration (V_{IN} ≤ 40V) 5s
OUT Short-Circuit to IN Duration (V_{IN} ≤ 12V) .....Continuous
Continuous Power Dissipation (T_A = +70°C)
8-Pin Plastic DIP (derate 9.09mW/°C above +70°C) 727mW
8-Pin SO (derate 5.88mW/°C above +70°C).....471mW
8-Pin CERDIP (derate 8.00mW/°C above +70°C).....640mW
Operating Temperature Ranges
MAX63_ _ C_ A.....0°C to +70°C
MAX63_ _ E_ A.....-40°C to +85°C
MAX63_ _ MJA.....-55°C to +125°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s).....+300°C

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—MAX6325

(V_{IN} = +10V, I_{OUT} = 0mA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		C, E, M	8		36	V
Output Voltage	V_{OUT}	MAX6325	+25°C	2.499	2.500	2.501	V
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	MAX6325C_A	C		0.5	1.0	ppm/°C
		MAX6325E_A	E		0.75	1.5	
		MAX6325MJA	M		1.0	2.5	
Line Regulation (Note 2)	$\Delta V_{OUT}/\Delta V_{IN}$	8V ≤ V_{IN} ≤ 10V	+25°C		10	18	ppm/V
			C			30	
			E			35	
			M			45	
		10V ≤ V_{IN} ≤ 36V	+25°C		2	5	
			C			7	
			E			8	
			M			10	
Load Regulation (Note 2)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0mA ≤ I_{OUT} ≤ 15mA	C		1	6	ppm/mA
			E		1	7	
			M		3	15	
		Sinking: -15mA ≤ I_{OUT} ≤ 0mA	C		1	6	
			E		1	7	
			M		10	30	
Supply Current	I_{IN}		+25°C		1.8	2.7	mA
			C, E, M			3.0	
Trim-Adjustment Range	ΔV_{OUT}	(Figure 1)	C, E, M	±15	±25		mV
Turn-On Settling Time	t_{ON}	To ±0.01% of final value	+25°C		5		µs
Output Noise Voltage (Note 3)	e_n	0.1Hz ≤ f ≤ 10Hz	+25°C		1.5		µVp-p
		10Hz ≤ f ≤ 1kHz	+25°C		1.3	2.8	μV_{RMS}
Temperature Hysteresis		(Note 4)	+25°C		20		ppm
Long-Term Stability	$\Delta V_{OUT}/t$		+25°C		30		ppm/ 1000hr

ELECTRICAL CHARACTERISTICS—MAX6341

(V_{IN} = +10V, I_{OUT} = 0mA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		C, E, M	8		36	V
Output Voltage	V_{OUT}	MAX6341	+25°C	4.095	4.096	4.097	V
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	MAX6341C_A	C		0.5	1.0	ppm/°C
		MAX6341E_A	E		0.75	1.5	
		MAX6341MJA	M		1.0	2.5	
Line Regulation (Note 2)	$\Delta V_{OUT}/\Delta V_{IN}$	8V ≤ V_{IN} ≤ 10V	+25°C		10	18	ppm/V
			C			30	
			E			35	
			M			45	
		10V ≤ V_{IN} ≤ 36V	+25°C		2	5	
			C			7	
			E			8	
			M			10	
Load Regulation (Note 2)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0mA ≤ I_{OUT} ≤ 15mA	C		1	6	ppm/mA
			E		1	7	
			M		3	9	
		Sinking: -15mA ≤ I_{OUT} ≤ 0mA	C		1	6	
			E		1	7	
			M		7	18	
Supply Current	I_{IN}		+25°C		1.9	2.9	mA
			C, E, M			3.2	
Trim-Adjustment Range	ΔV_{OUT}	(Figure 1)	C, E, M	±24	±40		mV
Turn-On Settling Time	t_{ON}	To ±0.01% of final value	+25°C		8		µs
Output Noise Voltage (Note 3)	e_n	0.1Hz ≤ f ≤ 10Hz	+25°C		2.4		µVp-p
		10Hz ≤ f ≤ 1kHz	+25°C		2.0	4.0	μV_{RMS}
Temperature Hysteresis		(Note 4)	+25°C		20		ppm
Long-Term Stability	$\Delta V_{OUT}/t$		+25°C		30		ppm/ 1000hr

ELECTRICAL CHARACTERISTICS—MAX6350

(V_{IN} = +10V, I_{OUT} = 0mA, T_A = T_{MIN} to T_{MAX}, unless otherwise noted. Typical values are at T_A = +25°C.)

PARAMETER	SYMBOL	CONDITIONS	T_A	MIN	TYP	MAX	UNITS
Input Voltage Range	V_{IN}		C, E, M	8		36	V
Output Voltage	V_{OUT}	MAX6350	+25°C	4.999	5.000	5.001	V
Output Voltage Temperature Coefficient (Note 1)	TCV_{OUT}	MAX6350C_A	C		0.5	1.0	ppm/°C
		MAX6350E_A	E		0.75	1.5	
		MAX6350MJA	M		1.0	2.5	
Line Regulation (Note 2)	$\Delta V_{OUT}/\Delta V_{IN}$	8V ≤ V_{IN} ≤ 10V	+25°C		10	18	ppm/V
			C			30	
			E			35	
			M			45	
		10V ≤ V_{IN} ≤ 36V	+25°C		2	5	
			C			7	
			E			8	
			M			10	
Load Regulation (Note 2)	$\Delta V_{OUT}/\Delta I_{OUT}$	Sourcing: 0mA ≤ I_{OUT} ≤ 15mA	C		1	6	ppm/mA
			E		1	7	
			M		2	9	
		Sinking: -15mA ≤ I_{OUT} ≤ 0mA	C		1	6	
			E		1	7	
			M		6	15	
Supply Current	I_{IN}		+25°C		2.0	3.0	mA
			C, E, M			3.3	
Trim-Adjustment Range	ΔV_{OUT}	(Figure 1)	C, E, M	±30	±50		mV
Turn-On Settling Time	t_{ON}	To ±0.01% of final value	+25°C		10		µs
Output Noise Voltage (Note 3)	e_n	0.1Hz ≤ f ≤ 10Hz	+25°C		3.0		µVp-p
		10Hz ≤ f ≤ 1kHz	+25°C		2.5	5.0	μV_{RMS}
Temperature Hysteresis		(Note 4)	+25°C		20		ppm
Long-Term Stability	$\Delta V_{OUT}/t$		+25°C		30		ppm/ 1000hr

Note 1: Temperature coefficient is measured by the box method; i.e., the maximum ΔV_{OUT} is divided by $\Delta T \times V_{OUT}$.

Note 2: Line regulation (ΔV_{OUT} / ($V_{OUT} \times \Delta V_{IN}$)) and load regulation ($\Delta V_{OUT}$ / ($V_{OUT} \times \Delta I_{OUT}$)) are measured with pulses and do not include output voltage changes due to die-temperature changes.

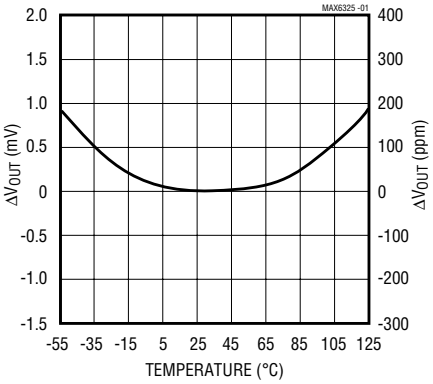
Note 3: Noise specifications are guaranteed by design.

Note 4: Temperature hysteresis is specified at T_A = +25°C by measuring V_{OUT} before and after changing temperature by +25°C, using the plastic DIP package.

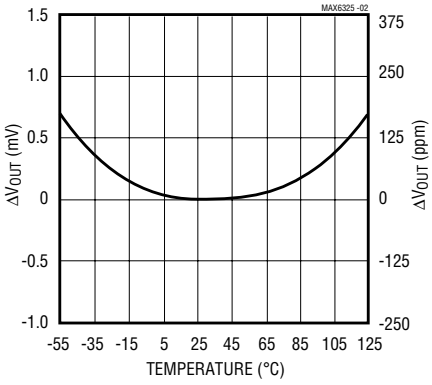
Typical Operating Characteristics

(V_{IN} = +10V, I_{OUT} = 0mA, T_A = +25°C, unless otherwise noted.)

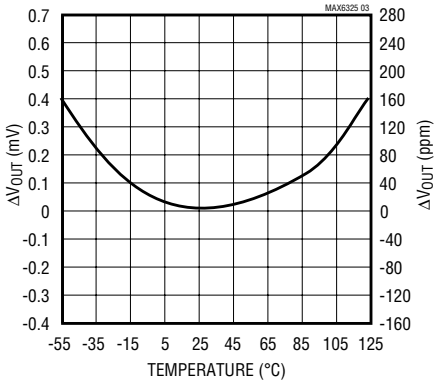
MAX6350
NORMALIZED OUTPUT VOLTAGE vs. TEMPERATURE



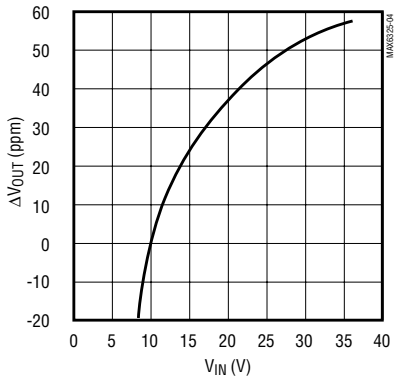
MAX6341
NORMALIZED OUTPUT VOLTAGE vs. TEMPERATURE



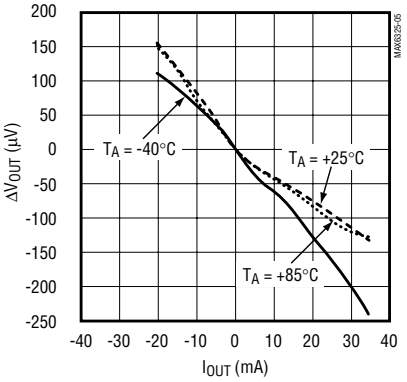
MAX6325
NORMALIZED OUTPUT VOLTAGE vs. TEMPERATURE



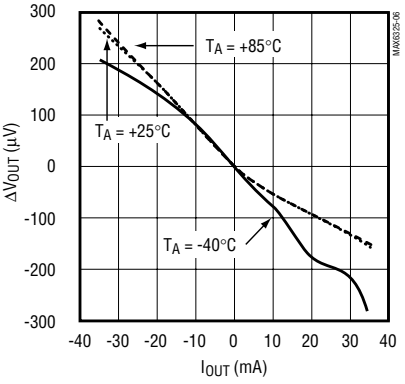
CHANGE IN OUTPUT VOLTAGE vs. INPUT VOLTAGE



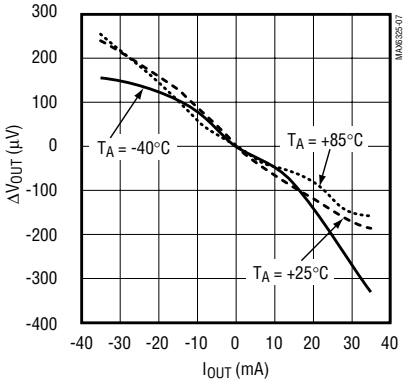
MAX6325
CHANGE IN OUTPUT VOLTAGE vs. OUTPUT CURRENT



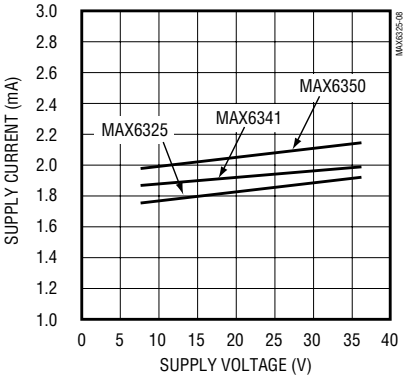
MAX6341
CHANGE IN OUTPUT VOLTAGE vs. OUTPUT CURRENT



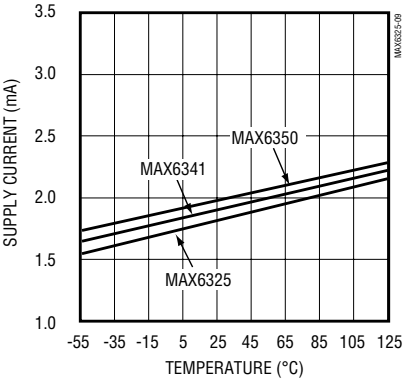
MAX6350
CHANGE IN OUTPUT VOLTAGE vs. OUTPUT CURRENT



SUPPLY CURRENT vs. SUPPLY VOLTAGE



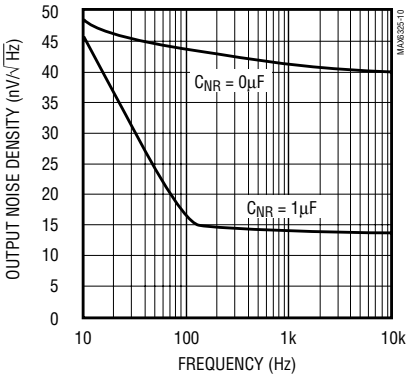
SUPPLY CURRENT vs. TEMPERATURE



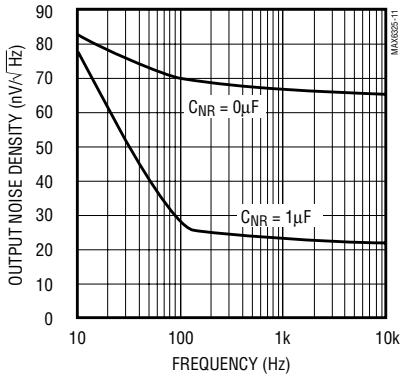
Typical Operating Characteristics (continued)

(V_{IN} = +10V, I_{OUT} = 0mA, T_A = +25°C, unless otherwise noted.)

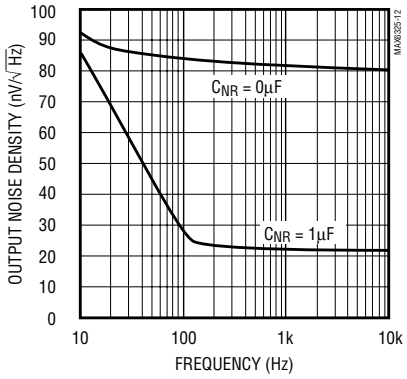
MAX6325 OUTPUT NOISE-VOLTAGE DENSITY vs. FREQUENCY



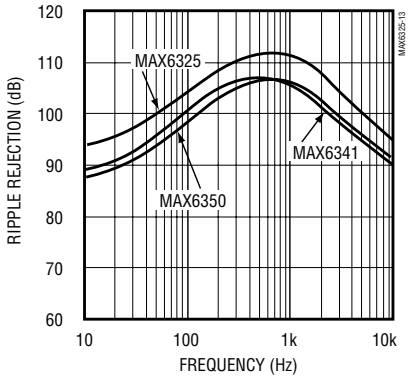
MAX6341 OUTPUT NOISE-VOLTAGE DENSITY vs. FREQUENCY



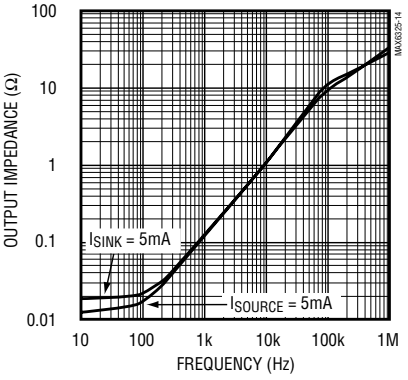
MAX6350 OUTPUT NOISE-VOLTAGE DENSITY vs. FREQUENCY



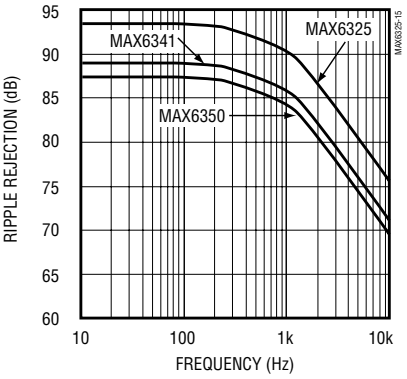
RIPPLE REJECTION vs. FREQUENCY (C_{NR} = 1µF)



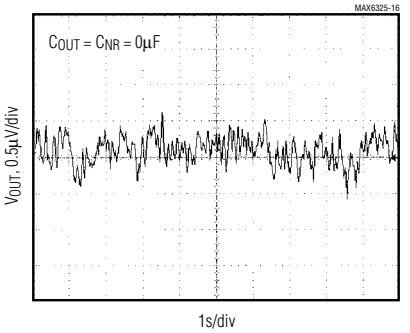
OUTPUT IMPEDANCE vs. FREQUENCY



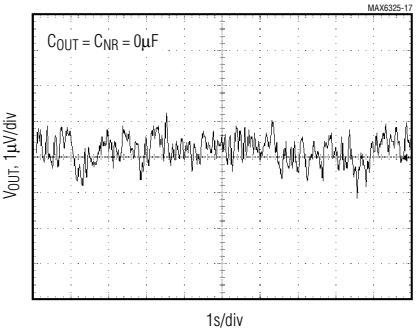
RIPPLE REJECTION vs. FREQUENCY (C_{NR} = 0µF)



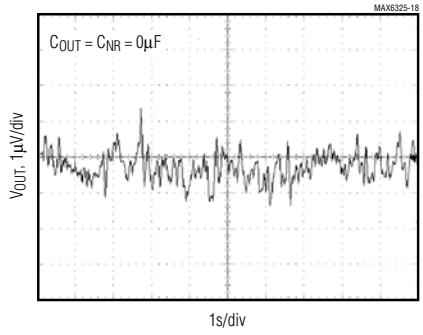
MAX6325 0.1Hz to 10Hz NOISE



MAX6341 0.1Hz to 10Hz NOISE



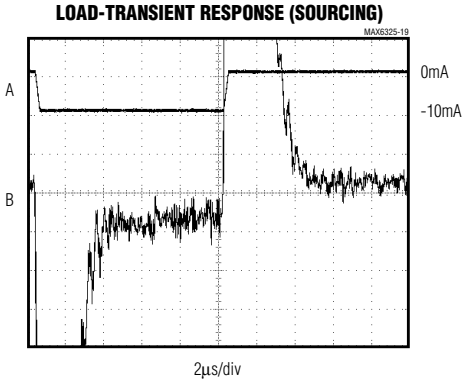
MAX6350 0.1Hz to 10Hz NOISE



Typical Operating Characteristics (continued)

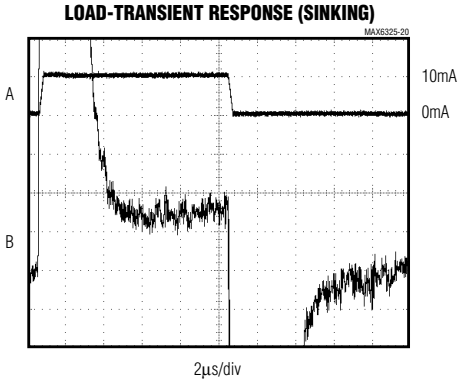
(V_{IN} = +10V, I_{OUT} = 0mA, T_A = +25°C, unless otherwise noted.)

LOAD-TRANSIENT RESPONSE (SOURCING)



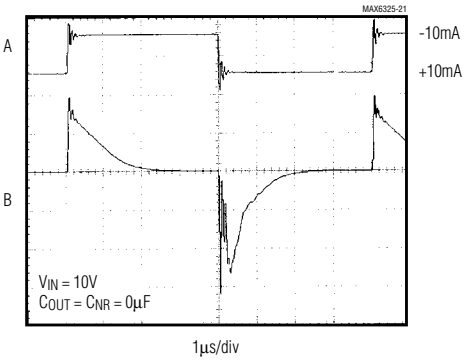
A: I_{OUT}, 10mA/div (SOURCING)
B: V_{OUT}, 500µV/div

LOAD-TRANSIENT RESPONSE (SINKING)



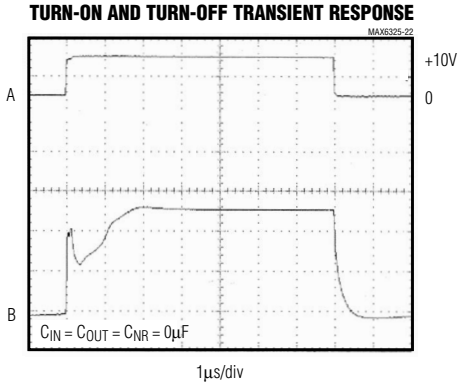
A: I_{OUT}, 10mA/div (SINKING)
B: V_{OUT}, 500µV/div

LOAD-TRANSIENT RESPONSE



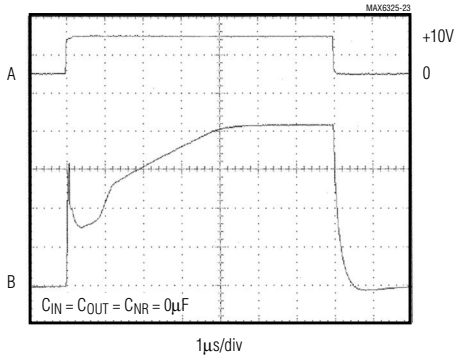
A: I_{OUT} (±10mA SOURCE AND SINK), 20mA/div, AC COUPLED
B: V_{OUT}, 20mV/div, AC COUPLED

MAX6325
TURN-ON AND TURN-OFF TRANSIENT RESPONSE



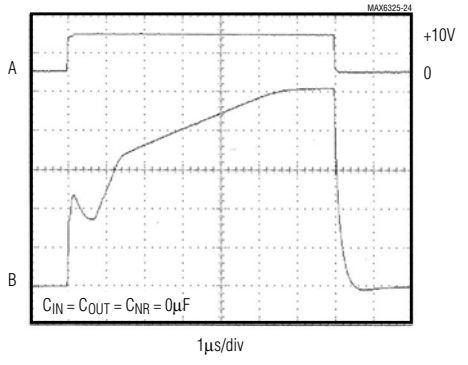
A: V_{IN}, 10V/div
B: V_{OUT}, 1V/div

MAX6341
TURN-ON AND TURN-OFF TRANSIENT RESPONSE



A: V_{IN}, 10V/div
B: V_{OUT}, 1V/div

MAX6350
TURN-ON AND TURN-OFF TRANSIENT RESPONSE



A: V_{IN}, 10V/div
B: V_{OUT}, 1V/div

Pin Description

PIN	NAME	FUNCTION
1, 7, 8	I.C.	Internally Connected. **Do not use**.
2	IN	Positive Power-Supply Input
3	NR	Noise Reduction. Optional capacitor connection for wideband noise reduction. Leave open if not used (Figure 2).
4	GND	Ground
5	TRIM	External Trim Input. Allows ±1% output adjustment (Figure 1). Leave open if not used.
6	OUT	Voltage Reference Output

Detailed Description

Temperature Stability

The MAX6325/MAX6341/MAX6350 are highly stable, low-noise voltage references that use a low-power temperature-compensation scheme to achieve laboratory-standard temperature stability. This produces a nearly flat temperature curve, yet does not require the power associated with heated references.

The output voltage can be trimmed a minimum of 0.6% by connecting a 10kΩ potentiometer between OUT and GND, and connecting its tap to the TRIM pin, as shown in Figure 1. The external trimming does not affect temperature stability.

Noise Reduction

To augment wideband noise reduction, add a 1µF capacitor to the NR pin (Figure 2). Larger values do not improve noise appreciably (see *Typical Operating Characteristics*).

Noise in the power-supply input can affect output noise, but can be reduced by adding an optional bypass capacitor to the IN pin and GND.

Bypassing

The MAX6325/MAX6341/MAX6350 are stable with capacitive load values from 0µF to 100µF, for all values of load current. Adding an output bypass capacitor can help reduce noise and output glitching caused by load transients.

Applications Information

Negative Regulator

Figure 3 shows how both a +5V and -5V precision reference can be obtained from a single, unregulated +5V supply. A MAX865 generates approximately ±9V to operate the MAX6350 reference and MAX400 inverting amplifier. The +5V is inverted by the ultra-low offset MAX400 op amp. Resistor R1 is optional, and may be used to trim the ±5V references. R2 and R4 should be matched, both in absolute resistance and temperature coefficient. R3 is optional, and is adjusted to set the -5V reference.

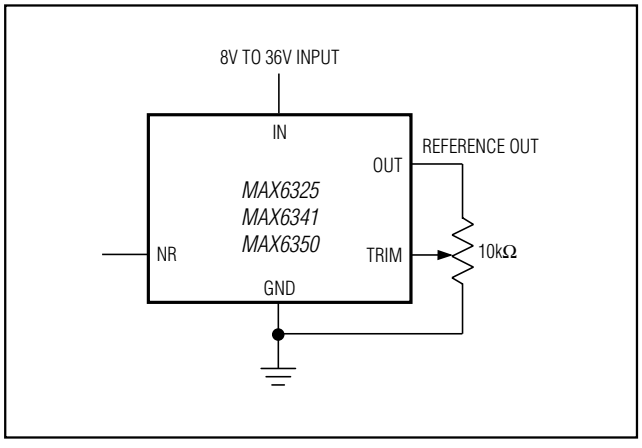


Figure 1. Output Voltage Adjustment

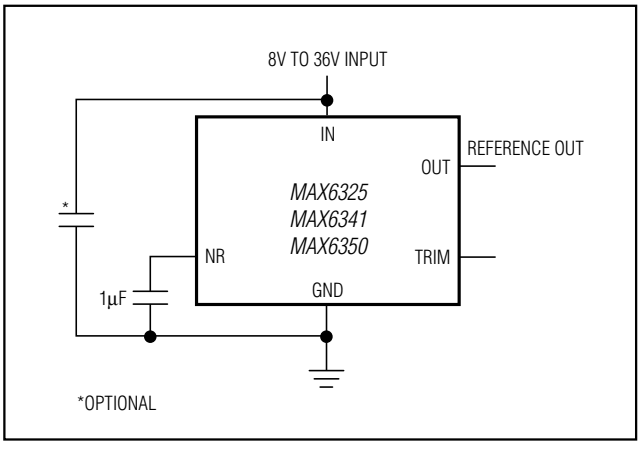


Figure 2. Noise-Reduction Capacitor

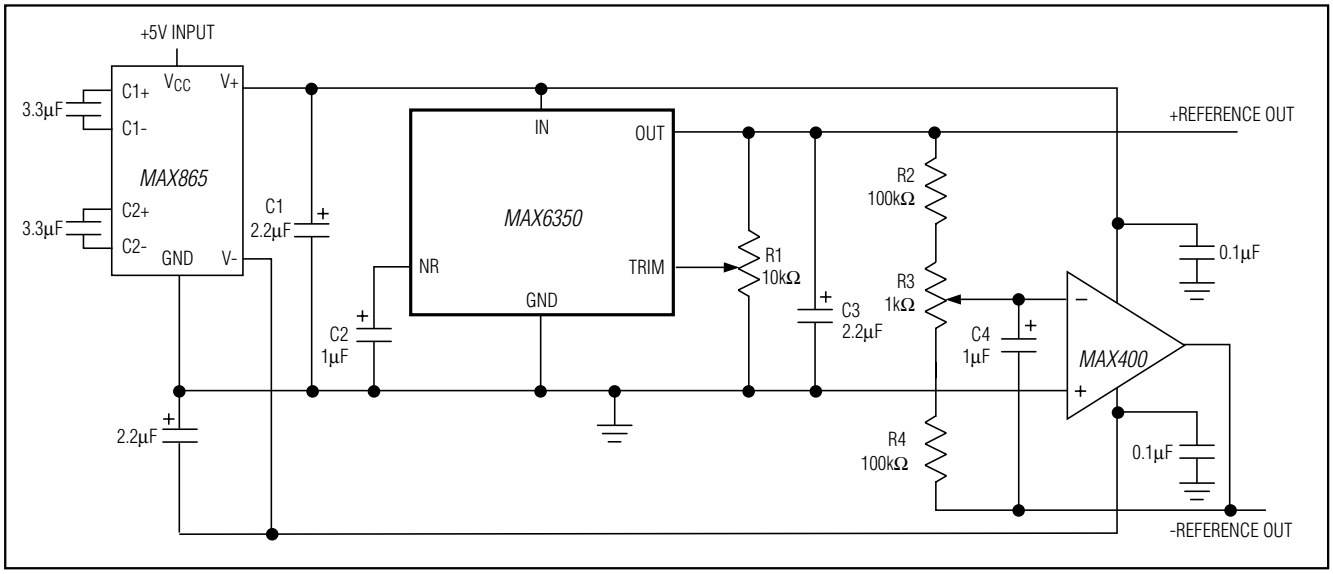


Figure 3. +5V and -5V References from a Single +5V Supply

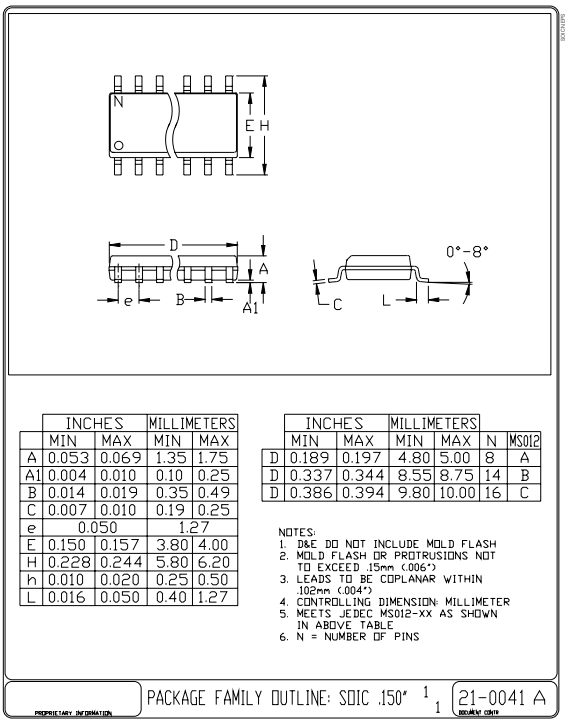
Ordering Information (continued)

PART	TEMP. RANGE	PIN-PACKAGE	MAX. TEMPCO (ppm/°C)
MAX6341CPA	0°C to +70°C	8 Plastic DIP	1.0
MAX6341CSA	0°C to +70°C	8 SO	1.0
MAX6341EPA	-40°C to +85°C	8 Plastic DIP	1.5
MAX6341ESA	-40°C to +85°C	8 SO	1.5
MAX6341MJA	-55°C to +125°C	8 CERDIP	2.5
MAX6350CPA	0°C to +70°C	8 Plastic DIP	1.0
MAX6350CSA	0°C to +70°C	8 SO	1.0
MAX6350EPA	-40°C to +85°C	8 Plastic DIP	1.5
MAX6350ESA	-40°C to +85°C	8 SO	1.5
MAX6350MJA	-55°C to +125°C	8 CERDIP	2.5

Chip Information

TRANSISTOR COUNT: 435

Package Information

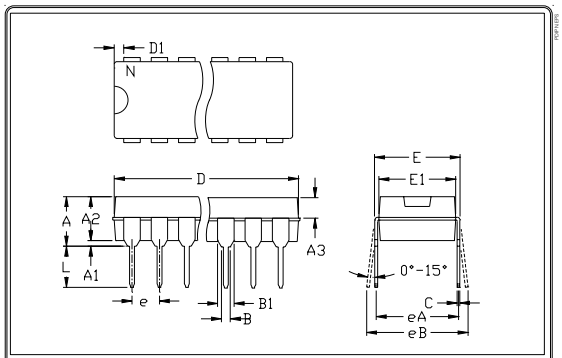


	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
4. CONTROLLING DIMENSION: MILLIMETER
5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
6. N = NUMBER OF PINS

PROPRIETARY INFORMATION | PACKAGE FAMILY OUTLINE: SOIC .150" | 1/1 | 21-0041 A



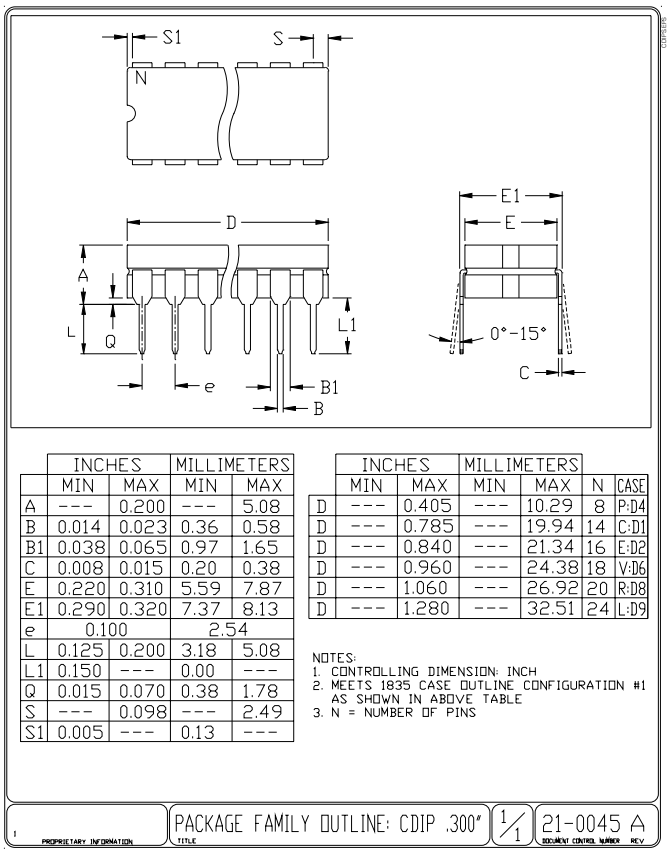
	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.200	---	5.08
A1	0.015	---	0.38	---
A2	0.125	0.175	3.18	4.45
A3	0.055	0.080	1.40	2.03
B	0.016	0.022	0.41	0.56
B1	0.045	0.065	1.14	1.65
C	0.008	0.012	0.20	0.30
D1	0.005	0.080	0.13	2.03
E	0.300	0.325	7.62	8.26
E1	0.240	0.310	6.10	7.87
e	0.100	---	2.54	---
eA	0.300	---	7.62	---
eB	---	0.400	---	10.16
L	0.115	0.150	2.92	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

PROPRIETARY INFORMATION | PACKAGE FAMILY OUTLINE: PDIP .300" | 1/1 | 21-0043 A

Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	---	0.200	---	5.08
B	0.014	0.023	0.36	0.58
B1	0.038	0.065	0.97	1.65
C	0.008	0.015	0.20	0.38
E	0.220	0.310	5.59	7.87
E1	0.290	0.320	7.37	8.13
e	0.100		2.54	
L	0.125	0.200	3.18	5.08
L1	0.150	---	0.00	---
Q	0.015	0.070	0.38	1.78
S	---	0.098	---	2.49
S1	0.005	---	0.13	---

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	CASE
D	---	0.405	---	10.29	8	P:D4
D	---	0.785	---	19.94	14	C:D1
D	---	0.840	---	21.34	16	E:D2
D	---	0.960	---	24.38	18	V:D6
D	---	1.060	---	26.92	20	R:D8
D	---	1.280	---	32.51	24	L:D9

NOTES:
1. CONTROLLING DIMENSION: INCH
2. MEETS 1835 CASE OUTLINE CONFIGURATION #1 AS SHOWN IN ABOVE TABLE
3. N = NUMBER OF PINS

PROPRIETARY INFORMATION	TITLE		DOCUMENT CONTROL NUMBER	REV.
	PACKAGE FAMILY OUTLINE: CDIP .300"	1/1	21-0045	A

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