Micro-Power, High-Accuracy Voltage References

Preliminary Technical Data

ADR3412/3420/3425/3430/3433/3440/3450

FEATURES

Initial accuracy: ± 0.1%
Max. temp. coefficient: 10 ppm / °C
Operating temperature: -40°C – +125 °C
Output current: +10 mA source / -3 mA sink
Low quiescent current: 70 µA (max)
Low dropout voltage: 200 mV @ 2 mA
Output noise (0.1 – 10 Hz): < 10 µV$_{p-p}$@ 1.25 V
SOT23-6 package

APPLICATIONS

Precision data acquisition systems
High-resolution data converters
Industrial instrumentation
Medical devices
Automotive controls
Battery-powered devices

GENERAL DESCRIPTION

The ADR34xx series of devices are low-cost, low-power, high precision voltage references, featuring ± 0.1% initial accuracy, low operating current and low output noise in a small SOT23 package.

For high accuracy, output voltage and temperature coefficient are trimmed digitally during final assembly using Analog Devices' proprietary Digi-Trim technology. Stability and reliability are further improved by the devices' low output voltage hysteresis and low long-term output voltage drift.

Furthermore, the low operating current of the device (70 µA max) facilitates usage in low-power devices, while its low output noise helps maintain signal integrity in critical signal processing systems.

ADR34xx series references are available in a wide range of output voltages, all of which are specified over the industrial temperature range of -40°C to +125 °C.

PIN CONFIGURATION

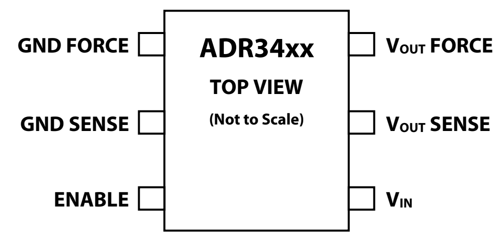

Figure 1. 6-Lead SOT23

Table 1. Selection Guide

Model	Output Voltage (V)	Input Voltage Range (V)
ADR3412	1.200	2.3 – 5.5
ADR3420	2.048	2.3 – 5.5
ADR3425	2.500	2.7 – 5.5
ADR3430	3.000	3.2 – 5.5
ADR3433	3.300	3.5 – 5.5
ADR3440	4.096	4.3 – 5.5
ADR3450	5.000	5.2 – 5.5

Rev. PrB

One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
Fax: 781.461.3113

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SPECIFICATIONS

ADR3412 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 2.3 to 5.5 V, I_L = 0, T_A = 25°C.

Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			1.200		V
INITIAL ACCURACY	V_{OERR}				±0.1	%
					±1.2	mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V		5	20	ppm / V
		V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		40	150	ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA		12	20	ppm / mA
		I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C			50	ppm / mA
QUIESCENT CURRENT	I_Q				70	µA
		-40°C ≤ T_A ≤ +125°C			90	µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			1.1	V
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY	I_L					
Sinking					-3	mA
Sourcing					10	mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			9	10	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			1.5		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			140		µs

ADR3420 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 2.3 to 5.5 V, I_L = 0, T_A = 25°C.

Table 3.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			2.048		V
INITIAL ACCURACY	V_{OERR}				±0.1	%
					±2.1	mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V		5	20	ppm / V
		V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		40	150	ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA		12	20	ppm / mA
		I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C			50	ppm / mA
QUIESCENT CURRENT	I_Q				70	µA
		-40°C ≤ T_A ≤ +125°C			90	µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY	I_L					
Sinking					-3	mA
Sourcing					10	mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			TBD	17.1	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			TBD		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ADR3425 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 2.7 to 5.5 V, I_L = 0, T_A = 25°C.

Table 4.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			2.500		V
INITIAL ACCURACY	V_{OERR}				±0.1 ±2.5	% mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		5 40	20 150	ppm / V ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C		12	20 50	ppm / mA ppm / mA
QUIESCENT CURRENT	I_Q	 -40°C ≤ T_A ≤ +125°C			70 90	µA µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY Sinking Sourcing	I_L				 -3 10	 mA mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			TBD	20.9	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			TBD		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ADR3430 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 3.2 to 5.5 V, I_L = 0, T_A = 25°C.

Table 5.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			3.000		V
INITIAL ACCURACY	V_{OERR}				±0.1 ±3.0	% mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		5 40	20 150	ppm / V ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C		12	20 50	ppm / mA ppm / mA
QUIESCENT CURRENT	I_Q	 -40°C ≤ T_A ≤ +125°C			70 90	µA µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY Sinking Sourcing	I_L				 -3 10	 mA mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			TBD	25	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			TBD		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ADR3433 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 3.5 to 5.5 V, I_L = 0, T_A = 25°C.

Table 6.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			3.300		V
INITIAL ACCURACY	V_{OERR}				±0.1	%
					±3.3	mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V		5	20	ppm / V
		V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		40	150	ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA		12	20	ppm / mA
		I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C			50	ppm / mA
QUIESCENT CURRENT	I_Q				70	µA
		-40°C ≤ T_A ≤ +125°C			90	µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY	I_L					
Sinking					-3	mA
Sourcing					10	mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			TBD	27.5	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			TBD		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ADR3440 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 4.3 to 5.5 V, I_L = 0, T_A = 25°C.

Table 7.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			4.096		V
INITIAL ACCURACY	V_{OERR}				±0.1	%
					±4.1	mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	$\Delta V_O / \Delta V_{IN}$	V_{IN} = 2.4 V to 5.5 V		5	20	ppm / V
		V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		40	150	ppm / V
LOAD REGULATION	$\Delta V_O / \Delta I_L$	I_L = -3 mA to +10 mA		12	20	ppm / mA
		I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C			50	ppm / mA
QUIESCENT CURRENT	I_Q				70	µA
		-40°C ≤ T_A ≤ +125°C			90	µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY	I_L					
Sinking					-3	mA
Sourcing					10	mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			TBD	34.2	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			TBD		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ADR3450 ELECTRICAL CHARACTERISTICS

Unless otherwise noted, V_{IN} = 5.2 to 5.5 V, I_L = ? mA, T_A = 25°C.

Table 8.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
OUTPUT VOLTAGE	V_{OUT}			5.000		V
INITIAL ACCURACY	V_{OERR}				±0.1 ±5.0	% mV
TEMPERATURE COEFFICIENT	TCV_{OUT}				10	ppm / °C
LINE REGULATION	ΔV_O / ΔV_{IN}	V_{IN} = 2.4 V to 5.5 V V_{IN} = 2.4 V to 5.5 V , -40°C ≤ T_A ≤ +125°C		5 40	20 150	ppm / V ppm / V
LOAD REGULATION	ΔV_O / ΔI_L	I_L = -3 mA to +10 mA I_L = -3 mA to +10 mA , -40°C ≤ T_A ≤ +125°C		12	20 50	ppm / mA ppm / mA
QUIESCENT CURRENT	I_Q	 -40°C ≤ T_A ≤ +125°C			70 90	µA µA
DROPOUT VOLTAGE	V_{DO}	I_L = 2 mA, T_A = -40°C ≤ T_A ≤ +125°C			200	mV
RIPPLE REJECTION RATIO	RRR	f_{IN} = 10 kHz		TBD		dB
OUTPUT CURRENT CAPACITY Sinking Sourcing	I_L				 -3 10	 mA mA
OUTPUT VOLTAGE NOISE	e_{Np-p}			33	41.7	μV_{p-p}
OUTPUT VOLTAGE NOISE DENSITY	e_N			5.5		μV_{RMS}
OUTPUT VOLTAGE HYSTERESIS	ΔV_{OUT_HYS}	T_A = +25°C → -40°C → +125°C → +25°C		50		ppm
LONG-TERM STABILITY	ΔV_{OUT_LTD}	1000 hours @ 25°C		50		ppm
TURN-ON SETTLING TIME	t_R			TBD		µs

ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Table 9.

Parameter	Rating
Supply Voltage	5.5 V
Operating Temperature Range	-40°C to +125°C
Storage Temperature Range	-65°C to +125°C
Junction Temperature Range	-65°C to +150°C

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those indicated in the operational section of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

THERMAL RESISTANCE

θ_{JA} is specified for the worst-case conditions; that is, a device soldered in a circuit board for surface-mount packages.

Table 10. Thermal Resistance

Package Type	θ_{JA}	θ_{JC}	Unit
			°C/W

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

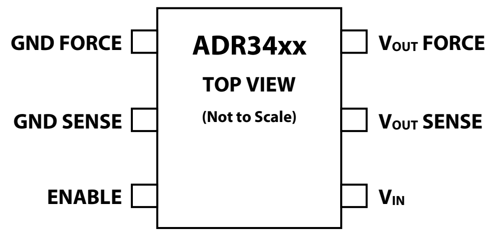

Figure 2. ADR34xx Pin Configuration

Table 11. Pin Function Descriptions

Pin No.	Mnemonic	Description
1	GND SENSE	Ground sense connection
2	GND FORCE	Ground force connection
3	ENABLE	Enables or disables the device
4	V_{IN}	Input voltage connection
5	V_{OUT} SENSE	Reference voltage output sensing connection (connect directly to the voltage input of load devices)
6	V_{OUT} FORCE	Reference voltage output

TYPICAL PERFORMANCE CHARACTERISTICS

TBD

Figure 3

TBD

Figure 4

TBD

Figure 5

TBD

Figure 6

TBD

Figure 7

TERMINOLOGY

Dropout Voltage (V_{DO})

Dropout voltage, sometimes referred to as supply voltage headroom or supply-output voltage differential, is defined as the minimum voltage differential between the input and output necessary for the device to operate:

$$V_{DO} = (V_{IN} - V_{OUT})_{min} \Big|_{I_L = \text{constant}}$$

Since the dropout voltage depends upon the current passing through the device, it is always specified for a given load current.

Temperature Coefficient (TCV_O)

The temperature coefficient relates the change in output voltage to the change in ambient temperature of the device, as normalized by the output voltage at 25°C. This parameter is expressed in ppm/°C and can be determined by the following equation:

$$TCV_{OUT} = \frac{V_{OUT}(T_2) - V_{OUT}(T_1)}{V_{OUT}(25°C) \times (T_2 - T_1)} \times 10^6 \ \text{[ppm/°C]}$$

where:

$V_{OUT}(25°C)$ = output voltage at 25°C

$V_{OUT}(T_1)$ = output voltage at temperature 1

$V_{OUT}(T_2)$ = output voltage at temperature 2

Thermally Induced Output Voltage Hysteresis (ΔV_{OUT_HYS})

Thermally induced output voltage hysteresis represents the change in output voltage after the device is exposed to a specified temperature cycle. This may be expressed as either a shift in voltage or a difference in ppm from the nominal output:

$$V_{OUT\_HYS} = V_{OUT}(25°C) - V_{OUT\_TC} \ \text{[V]}$$

$$V_{OUT\_HYS} = \frac{V_{OUT}(25°C) - V_{OUT\_TC}}{V_{OUT}(25°C)} \times 10^6 \ \text{[ppm]}$$

where:

$V_{OUT}(25°C)$ = output voltage at 25°C

V_{OUT_TC} = output voltage after temperature cycling

Long-term Stability (ΔV_{OUT_LTD})

Long-term stability refers to the shift in output voltage at 25°C after 1000 hours of operation in a +25°C environment. This may also be expressed as either a shift in voltage or a difference in ppm from the nominal output:

$$\Delta V_{OUT\_LTD} = |V_{OUT}(t_1) - V_{OUT}(t_0)| \ \text{[V]}$$

$$\Delta V_{OUT\_LTD} = \left|\frac{V_{OUT}(t_1) - V_{OUT}(t_0)}{V_{OUT}(t_0)}\right| \times 10^6 \ \text{[ppm]}$$

where,

$V_{OUT}(t_0)$ = V_{OUT} at 25°C at time 0

$V_{OUT}(t_1)$ = V_{OUT} at 25°C after 1000 hours of operation at 25°C

Line Regulation

Line regulation refers to the change in output voltage in response to a given change in input voltage, and is expressed in either percent per volt, ppm per volt, or µV per volt change in input voltage. This parameter accounts for the effects of self-heating.

Load Regulation

Load regulation refers to the change in output voltage in response to a given change in load current, and is expressed in either µV per mA, ppm per mA, or ohms of DC output resistance. This parameter accounts for the effects of self-heating.

THEORY OF OPERATION

TBD

LONG-TERM STABILITY

One of the key parameters of the ADR34xx series of references is long-term stability. Regardless of output voltage, internal testing during development showed a typical drift of approximately 50 ppm after 1,000 hours of continuous, non-loaded operation in a +25°C environment.

It is important to understand that long-term stability is not guaranteed by design, and that the output from the device may shift beyond the typical 50 ppm specification at any time, especially during the first 200 hours of operation. For systems that require highly stable output over long periods of time, the designer should consider burning-in the devices prior to use to minimize the amount of output drift exhibited by the reference over time. Refer to application note AN-713 for more information regarding the effects of long-term drift and how it can be minimized.

POWER DISSIPATION

The ADR34xx series voltage references are capable of sourcing up to 10 mA of load current at room temperature across the rated input voltage range. However, when used in applications subject to high ambient temperatures, the input voltage and load current should be carefully monitored to ensure that the device does not exceeded its maximum power dissipation rating. The maximum power dissipation of the device can be calculated via the following equation:

$$P_D = \frac{T_j - T_A}{\theta_{JA}} \ \text{[W]}$$

where,

P_D = device power dissipation
T_j = device junction temperature
T_A = ambient temperature
θ_{JA} = package (junction-to-air) thermal resistance

Due to this relationship, acceptable load current in high-temperature conditions may be less than the maximum current-sourcing capability of the device. In no case should the part be operated outside of its maximum power rating as doing so may result in premature failure or permanent damage to the device.

APPLICATIONS

BASIC VOLTAGE REFERENCE CONNECTION

(insert circuit diagram)

The circuit shown in figure XX illustrates the basic configuration for the ADR34xx family. Decoupling capacitors should be connected according to the guidelines below.

INPUT AND OUTPUT CAPACITORS

A 1 µF to 10 µF electrolytic or ceramic capacitor can be connected to the input to improve transient response in applications where the supply voltage may fluctuate. An additional 0.1 µF ceramic capacitor should be connected in parallel in order to reduce supply noise.

While the IC will function stably without a capacitor connected to the output, connecting a 0.1 µF ceramic capacitor to the output is highly recommended to improve stability and filter out low-level voltage noise. An additional 1 µF to 10 µF electrolytic or ceramic capacitor can be added in parallel to improve transient performance in response to sudden changes in load current; however, the designer should keep in mind that doing so will increase the turn-on time of the device.

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OUTLINE DIMENSIONS

TBD

Figure 8.

ORDERING GUIDE

Model	Temperature Range	Package Description	Package Option

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