



Ultracompact Precision 10.0 V/5.0 V Voltage References

ADR01/ADR02

FEATURES

- Ultracompact SC70-5¹/SOT23-5¹
- Low Temperature Coefficient, 3 ppm/°C
- Long-Term Stability, 50 ppm/1000 hr
- Line Regulation, 30 ppm/V
- Load Regulation, 50 ppm/mA
- Low Noise, 25 μ V p-p (0.1 Hz to 10 Hz)
- Low Hysteresis, 70 ppm Typical
- Wide Operating Range
 - ADR01, 15 V to 40 V
 - ADR02, 10 V to 40 V
- Quiescent Current, 1 mA Max
- High Output Current, 10 mA
- Wide Temperature Range, -40°C to +125°C
- Industry Standard REF01/REF02 Compatible²

APPLICATIONS

- Precision Data Acquisition Systems
- High Resolution Converters
- Industrial Process Control Systems
- Precision Instruments

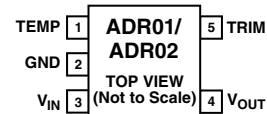
GENERAL DESCRIPTION

The ADR01 and ADR02 are precision 10 V and 5 V bandgap voltage references featuring high accuracy, high stability, and low power housed in tiny footprints SC70-5¹ and SOT23-5¹ packages. SOIC-8 versions of ADR01 and ADR02 are available for industry standard REF01 and REF02 drop in replacement². The small footprint and wide operating range make them ideal for general purpose and space constraint applications.

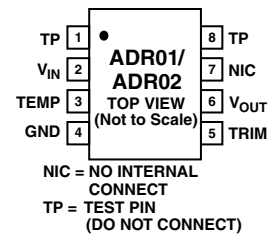
The ADR01 and ADR02 additional trim terminal can be used for fine adjustment. With an external buffer, the TEMP terminal can be used for temperature monitoring functions.

PIN CONFIGURATIONS

5-Lead SC70¹/SOT23¹



8-Lead SOIC



The ADR01 and ADR02 are compact, low drift voltage references that provide an extremely stable output voltage from a wide supply voltage range. They are available in SC70-5, SOT23-5, and SOIC-8 with A and B grades selection. All A grade parts and B grade parts of SOIC-8 are specified over the extended industrial (-40°C to +125°C) temperature range. B grade SC70-5 and SOT23 parts are specified over the commercial (0°C to 70°C) temperature range.

Table I. ADR01 and ADR02 Products

Parts	Output Voltage V _O	Initial Accuracy		Tempco ppm/°C
		mV	%	
ADR01BR	10.00	5	0.05	3
ADR01AR	10.00	10	0.1	10
ADR02BR	5.00	3	0.06	3
ADR02AR	5.00	5	0.1	10

NOTES

- ¹Please contact factory for latest information of release date.
- ²ADR01 and ADR02 are component-level compatible with REF01 and REF02 respectively. No guarantees for system-level compatibility are implied. SOIC-8 versions of ADR01/ADR02 are pin-to-pin compatible with SOIC-8 versions of REF01/REF02 respectively, with the additional temperature monitoring function.

REV. 0

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ADRO1—SPECIFICATIONS

($V_{IN} = 15\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage A Grade	V_O		9.990	10.000	10.010	V
Initial Accuracy	V_{OERR}				10	mV
	V_{OERR}				0.1	%
Output Voltage B Grade	V_O		9.995	10.000	10.005	V
Initial Accuracy	V_{OERR}				5	mV
	V_{OERR}				0.05	%
Temperature Coefficient						
A Grade	TCV_O					
SOIC-8		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$		3	10	ppm/ $^\circ\text{C}$
SOT23-5 ¹		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$			25	ppm/ $^\circ\text{C}$
SC70-5 ¹		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$			25	ppm/ $^\circ\text{C}$
B Grade						
SOIC-8		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$		1	3	ppm/ $^\circ\text{C}$
SOT23-5 ¹		$0^\circ\text{C} < T_A < 70^\circ\text{C}$			10	ppm/ $^\circ\text{C}$
SC70-5 ¹		$0^\circ\text{C} < T_A < 70^\circ\text{C}$			10	ppm/ $^\circ\text{C}$
Supply Voltage Headroom	$V_{IN} - V_O$		2			V
Line Regulation	$\Delta V_O / \Delta V_{IN}$	$V_{IN} = 15\text{ V to }40\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		7	30	ppm/V
Load Regulation	$\Delta V_O / \Delta I_{LOAD}$	$I_{LOAD} = 0\text{ mA to }10\text{ mA}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		40	70	ppm/mA
Quiescent Current	I_{IN}	No Load $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		0.65	1	mA
Voltage Noise	e_N	0.1 Hz to 10 Hz		25		$\mu\text{V p-p}$
Voltage Noise Density	e_N	1 kHz		510		$\mu\text{V}/\sqrt{\text{Hz}}$
Turn-on Settling Time	t_R			4		μs
Long Term Stability ²	ΔV_O	1000 Hours		50		ppm
Output Voltage Hysteresis	V_{O_HYS}			70		ppm
Ripple Rejection Ratio	RRR	$f_{IN} = 10\text{ kHz}$		-75		dB
Short Circuit to GND	I_{SC}			30		mA
Voltage Output at TEMP Pin	V_{TEMP}			550		mV
Temperature Sensitivity	TCV_{TEMP}			1.96		mV/ $^\circ\text{C}$

NOTES

¹Please contact factory for latest information of release date.

²The long-term stability specification is noncumulative. The drift in subsequent 1,000 hour periods is significantly lower than in the first 1,000 hour period.

Specifications subject to change without notice.

ADRO2—SPECIFICATIONS ($V_{IN} = 10\text{ V to }40\text{ V}$, $T_A = 25^\circ\text{C}$, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage A Grade	V_O		4.995	5.000	5.005	V
Initial Accuracy	V_{OERR}				5	mV
	V_{OERR}				0.1	%
Output Voltage B Grade	V_O		4.997	5.000	5.003	V
Initial Accuracy	V_{OERR}				3	mV
	V_{OERR}				0.06	%
Temperature Coefficient						
A Grade	TCV_O					
SOIC-8		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$		3	10	ppm/ $^\circ\text{C}$
SOT23-5 ¹		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$			25	ppm/ $^\circ\text{C}$
SC70-5 ¹		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$			25	ppm/ $^\circ\text{C}$
B Grade						
SOIC-8		$-40^\circ\text{C} < T_A < +125^\circ\text{C}$		1	3	ppm/ $^\circ\text{C}$
SOT23-5 ¹		$0^\circ\text{C} < T_A < 70^\circ\text{C}$			10	ppm/ $^\circ\text{C}$
SC70-5 ¹		$0^\circ\text{C} < T_A < 70^\circ\text{C}$			10	ppm/ $^\circ\text{C}$
Supply Voltage Headroom	$V_{IN} - V_O$		2			V
Line Regulation	DV_O/DV_{IN}	$V_{IN} = 15\text{ V to }40\text{ V}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		7	30	ppm/V
Load Regulation	DV_O/DI_{LOAD}	$I_{LOAD} = 0\text{ mA to }10\text{ mA}$ $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		40	70	ppm/mA
Quiescent Current	I_{IN}	No Load $-40^\circ\text{C} < T_A < +125^\circ\text{C}$		0.65	1	mA
Voltage Noise	e_N	0.1 Hz to 10 Hz		25		$\mu\text{V p-p}$
Voltage Noise Density	e_N	1 kHz		230		$\mu\text{V}/\sqrt{\text{Hz}}$
Turn-on Settling Time	t_R			4		μs
Long Term Stability ²	DV_O	1000 Hours		50		ppm
Output Voltage Hysteresis	V_{O_HYS}			70		ppm
Ripple Rejection Ratio	RRR	$f_{IN} = 10\text{ kHz}$		-75		dB
Short Circuit to GND	I_{SC}			30		mA
Voltage Output at TEMP Pin	V_{TEMP}			550		mV
Temperature Sensitivity	TCV_{TEMP}			1.96		mV/ $^\circ\text{C}$

NOTES

¹Please contact factory for latest information of release date.

²The long-term stability specification is noncumulative. The drift in subsequent 1,000 hour periods is significantly lower than in the first 1,000 hour period.

Specifications subject to change without notice.

ADR01/ADR02

ABSOLUTE MAXIMUM RATINGS¹

Supply Voltage	40 V
Output Short-Circuit Duration to GND	Indefinite
Storage Temperature Ranges	
R, RM Packages	-65°C to +150°C
Operating Temperature Ranges	
ADR01/ADR02 All A Grade	-40°C to +125°C
ADR01/ADR02 B Grade SOIC-8	-40°C to +125°C
ADR01/ADR02 B Grade SC70-5 ²	
and SOT23-5 ²	0°C to 70°C
Junction Temperature Range	
KS ² , RT ² , R Packages	-65°C to +150°C
Lead Temperature Range (Soldering, 60 sec)	300°C

Thermal Resistance

SC70-5 ² (KS)	
θ_{JA} ³	376°C/W
SOT23-5 ² (RT)	
θ_{JA} ³	230°C/W
θ_{JC}	146°C/W
SOIC-8 (R)	
θ_{JA} ³	130°C/W
θ_{JC}	43°C/W

NOTES

¹Absolute maximum ratings apply at 25°C, unless otherwise noted.

²Please contact factory for latest information on release date.

³ θ_{JA} is specified for the worst-case conditions, i.e., θ_{JA} is specified for device soldered circuit board surface mount packages.

ORDERING GUIDE

ADR01/ADR02 Products	Output Voltage V _O	Initial Accuracy		Temperature Coefficient ppm/°C	Package Description	Package Option	Top* Mark	No. of Parts Per Reel	Temperature Range (°C)
		mV	%						
ADR01AR	10	10	0.1	10	SOIC-8	SO-8	ADR01	98	-40 to +125
ADR01AR-REEL7	10	10	0.1	10	SOIC-8	SO-8	ADR01	3,000	-40 to +125
ADR01BR	10	5	0.05	3	SOIC-8	SO-8	ADR01	98	-40 to +125
ADR01BR-REEL7	10	5	0.05	3	SOIC-8	SO-8	ADR01	3,000	-40 to +125
ADR02AR	5	5	0.1	10	SOIC-8	SO-8	ADR02	98	-40 to +125
ADR02AR-REEL7	5	5	0.1	10	SOIC-8	SO-8	ADR02	3,000	-40 to +125
ADR02BR	5	3	0.06	3	SOIC-8	SO-8	ADR02	98	-40 to +125
ADR02BR-REEL7	5	3	0.06	3	SOIC-8	SO-8	ADR02	3,000	-40 to +125

*First line shows part number ADR0x. Second line shows A or B for the grade with the YYMM date code. Third line shows the lot number.

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADR01/ADR02 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high-energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



PIN FUNCTION DESCRIPTIONS

SOIC-8 Pin	SOT23-5 SC70-5 Pin	Mnemonic	Description
1, 8		TP	Test Pin. There are actual connections in TP pins but they are reserved for factory testing purposes. User should not connect anything other than dummy pads to TP pins, otherwise the device may not function properly.
2	3	V _{IN}	Input Voltage
3	1	TEMP	Temperature Pin. It varies linearly at 1.96 mV/°C and can be used to monitor the device temperature.
4	2	GND	Ground
5	5	TRIM	Trim Terminal. It can be used to adjust the output voltage.
6	4	V _{OUT}	Output Voltage
7		NIC	No Internal Connect. NICs have no internal connections.

PARAMETER DEFINITIONS

Temperature Coefficient

The change of output voltage over the operating temperature changes, and normalized by the output voltage at 25°C, expressed in ppm/°C. The equation follows:

$$TCV_o [ppm/°C] = \frac{V_o(T_2) - V_o(T_1)}{V_o(25°C) \times (T_2 - T_1)} \times 10^6 \quad (1)$$

Where:

$$V_o(25°C) = V_o \text{ at } 25°C$$

$$V_o(T_1) = V_o \text{ at Temperature 1}$$

$$V_o(T_2) = V_o \text{ at Temperature 2}$$

Line Regulation

The change in output voltage due to a specified change in input voltage. It includes the effects of self-heating. Line regulation is expressed in either percent per volt, parts-per-million per volt, or microvolts per volt change in input voltage

Load Regulation

The change in output voltage due to a specified change in load current. It includes the effects of self-heating. Load Regulation is expressed in either microvolts per milliamper, parts-per-million per milliamper, or ohms of dc output resistance.

Long-Term Stability

Typical shift of output voltage at 25°C on a sample of parts subjected to operation life test of 1000 hours at 25°C:

$$\Delta V_o = V_o(t_0) - V_o(t_1) \quad (2)$$

$$\Delta V_o [ppm] = \frac{V_o(t_0) - V_o(t_1)}{V_o(t_0)} \times 10^6 \quad (3)$$

Where:

$$V_o(t_0) = V_o \text{ at } 25°C \text{ at Time 0}$$

$$V_o(t_1) = V_o \text{ at } 25°C \text{ after 1000 Hours Operation at } 25°C$$

Thermal Hysteresis

Defined as the change of output voltage after the device is cycled through temperature from +25°C to -40°C to +25°C and back to +25°C. This is a typical value from a sample of parts put through such a cycle.

$$V_{o_HYS} = V_o(25°C) - V_{o_TC} \quad (4)$$

$$V_{o_HYS} [ppm] = \frac{V_o(25°C) - V_{o_TC}}{V_o(25°C)} \times 10^6 \quad (5)$$

Where:

$$V_o(25°C) = V_o \text{ at } 25°C$$

$$V_{o_TC} = V_o \text{ at } 25°C \text{ after temperature cycle at } +25°C \text{ to } -40°C \text{ to } +25°C \text{ and back to } +25°C.$$

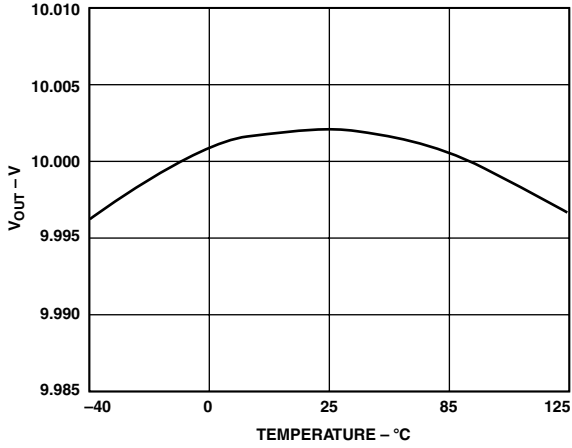
Input Capacitor

Input capacitors are not required on the ADR01/ADR02. There is no limit for the value of the capacitor used on the input, but a 1 μF to 10 μF capacitor on the input will improve transient response in applications where the supply suddenly changes. An additional 0.1 μF in parallel will also help to reduce noise from the supply.

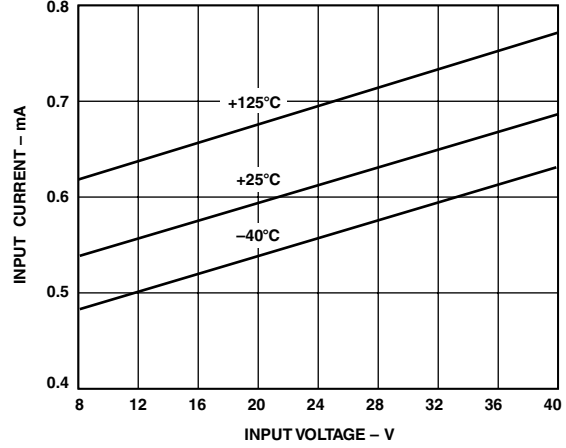
Output Capacitor

The ADR01/ADR02 do not require output capacitors for stability under any load condition. An output capacitor, typical 0.1 μF, will filter out any low-level noise voltage and will not affect the operation of the part. On the other hand, the load transient response can be improved with an additional 1 μF to 10 μF output capacitor in parallel. A capacitor here will act as a source of stored energy for sudden increase in load current. By installing an output capacitor the only parameter that will degrade is turn-on time and it depends on the size of the capacitor chosen.

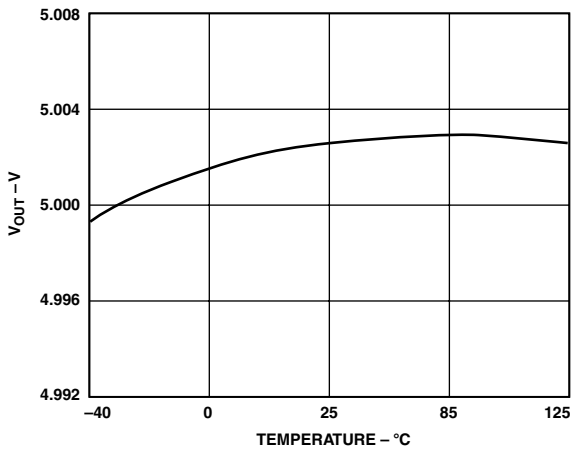
ADR01/ADR02—Typical Performance Characteristics



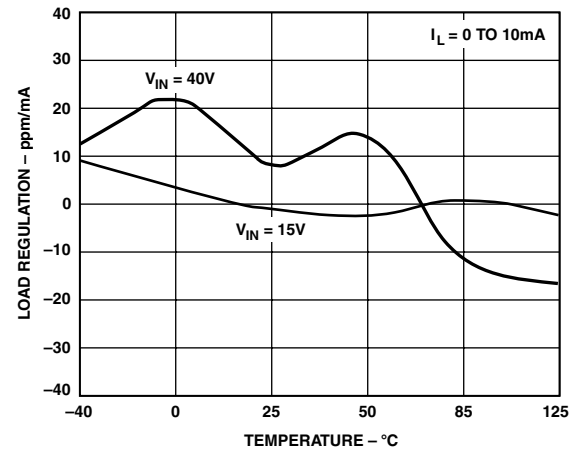
TPC 1. ADR01 Typical Output Voltage vs. Temperature



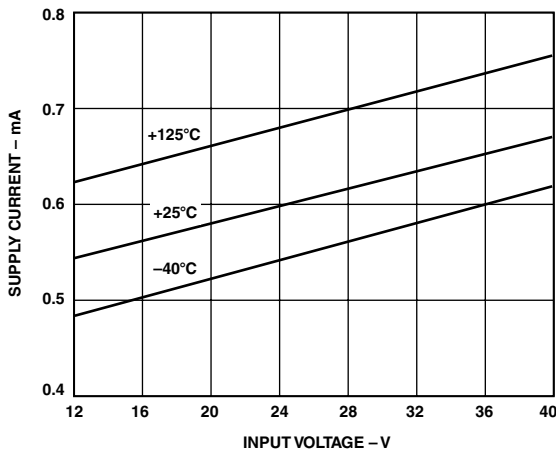
TPC 4. ADR02 Supply Current vs. Input Voltage



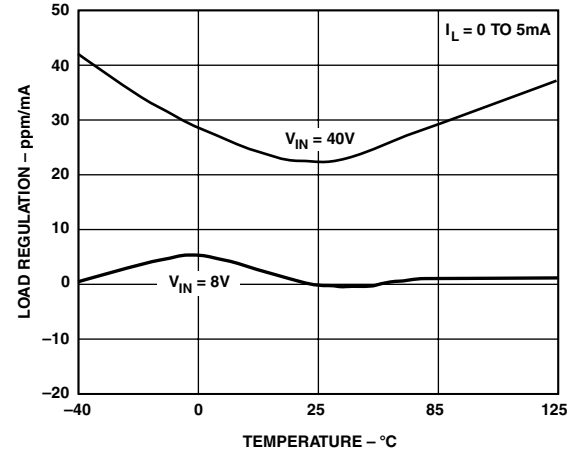
TPC 2. ADR02 Typical Output Voltage vs. Temperature



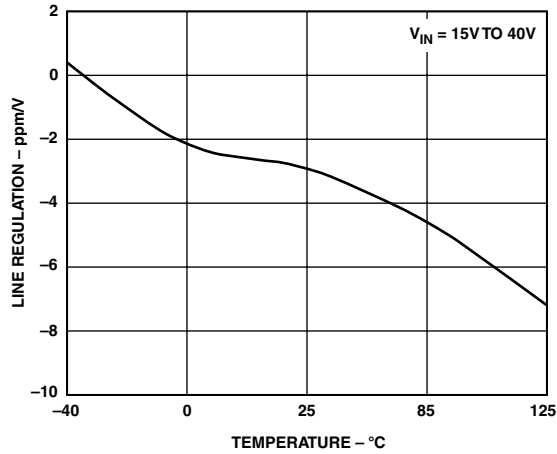
TPC 5. ADR01 Load Regulation vs. Temperature



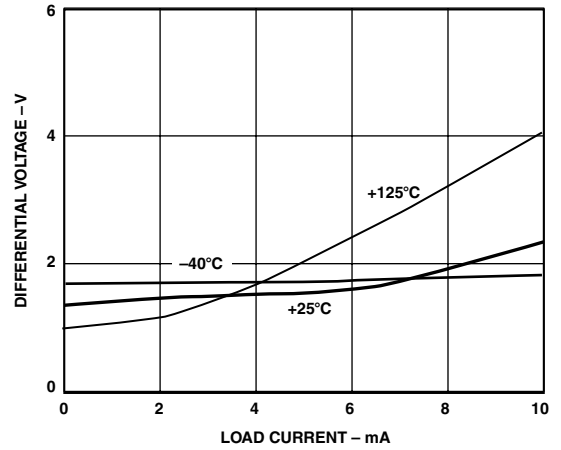
TPC 3. ADR01 Supply Current vs. Input Voltage



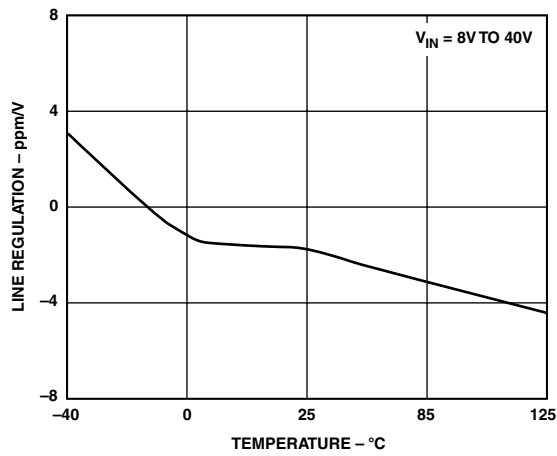
TPC 6. ADR02 Load Regulation vs. Temperature



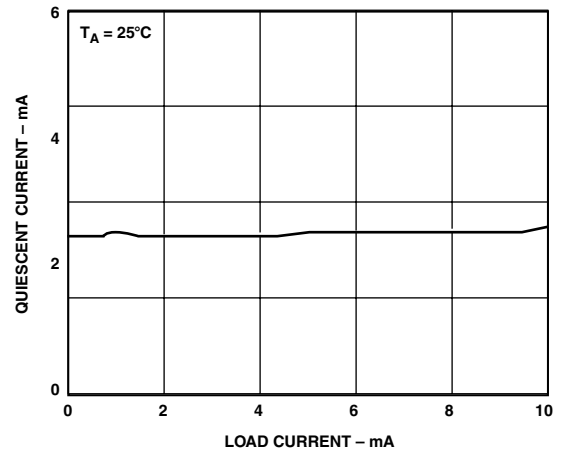
TPC 7. ADR01 Line Regulation vs. Temperature



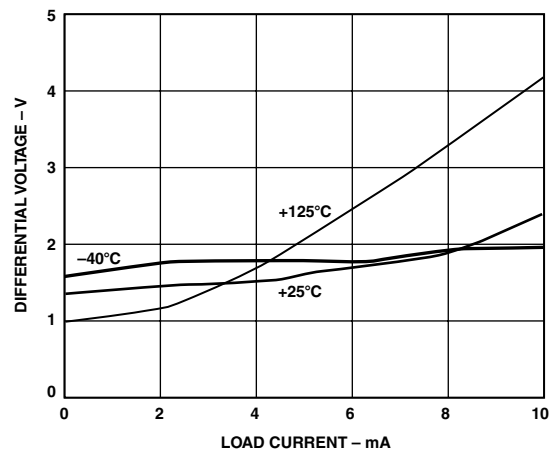
TPC 10. ADR02 Minimum Input-Output Voltage Differential vs. Load Current



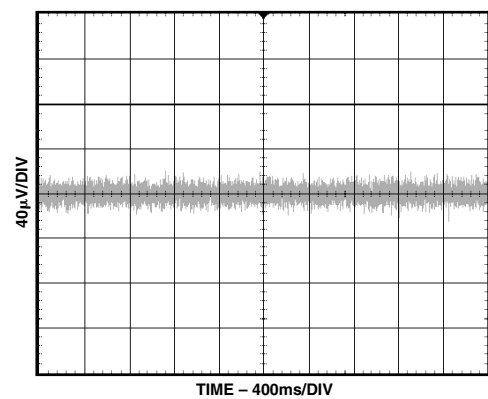
TPC 8. ADR02 Line Regulation vs. Temperature



TPC 11. ADR01 Quiescent Current vs. Load Current

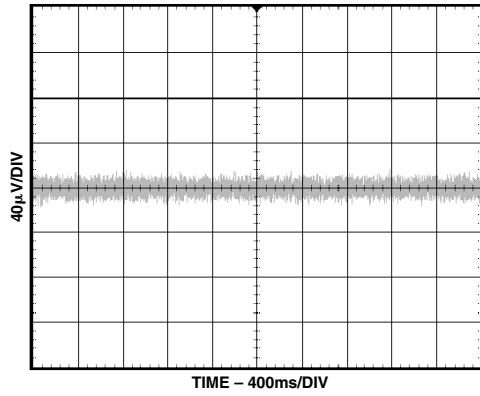


TPC 9. ADR01 Minimum Input-Output Voltage Differential vs. Load Current

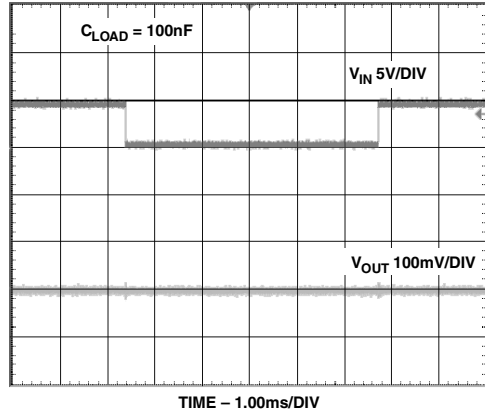


TPC 12. ADR02 Typical Noise Voltage 0.1 Hz to 10 Hz

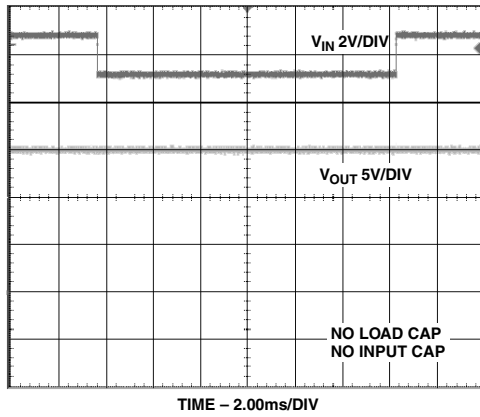
ADR01/ADR02



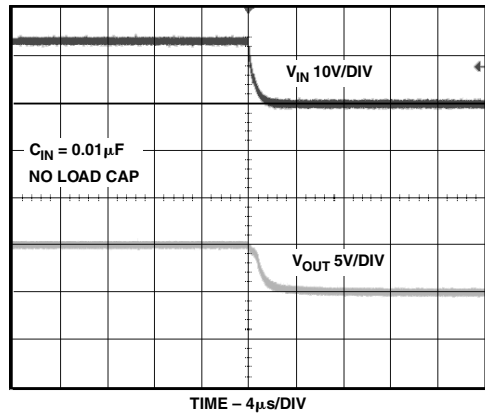
TPC 13. ADR02 Typical Noise Voltage 10 Hz to 10 kHz



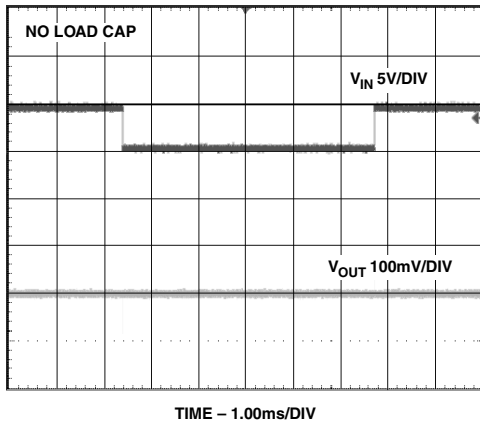
TPC 16. ADR02 Load Transient Response



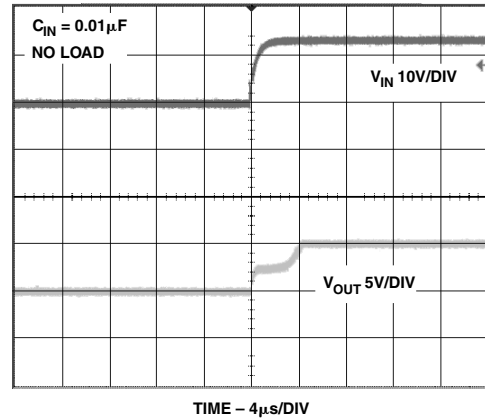
TPC 14. ADR02 Line Transient Response



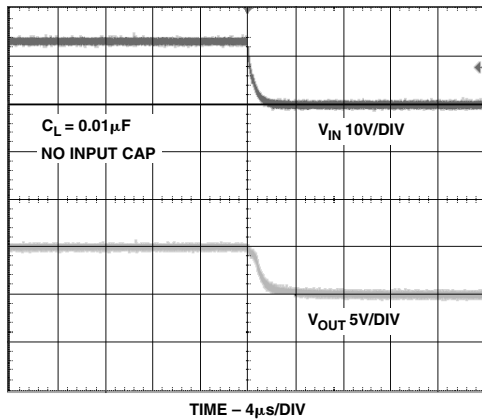
TPC 17. ADR02 Turn-On Response



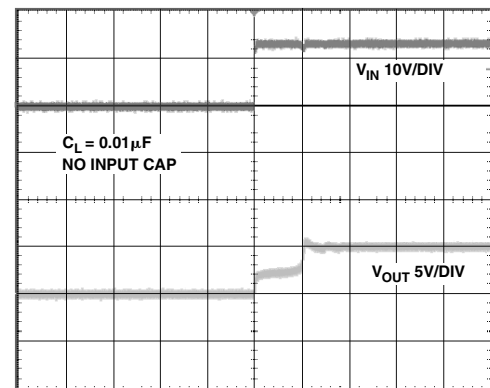
TPC 15. ADR02 Load Transient Response



TPC 18. ADR02 Turn-On Response



TPC 19. ADR02 Turn-Off Response



TPC 20. ADR02 Turn-On Response

THEORY OF OPERATION

ADR01/ADR02 represent the improved versions of the industry standard REF01/REF02, 10 V and 5 V voltage references feature with precision, low drift, and compacted footprint. The SOIC-8 version of ADR01/ADR02 is a possible drop-in replacement of REF01/REF02 sockets with improved cost and performance.

ADR01/ADR02 are standard bandgap references. The bandgap cell contains two npn transistors (Q18 and Q19) which differ in emitter area by 2x. The difference in their Vbes produces a PTAT (Proportional To Absolute Temperature) current in R14, when combined with the Vbe of Q19, produces a bandgap voltage Vbg that is almost constant in temperature. With an internal op amp and the feedback network of R5 and R6, Vo is set precisely at 10 V and 5 V for ADR01 and ADR02 respectively. Precision laser trimming of the resistors and other proprietary circuit techniques are used to enhance further the initial accuracy, temperature curvature, and drift performance.

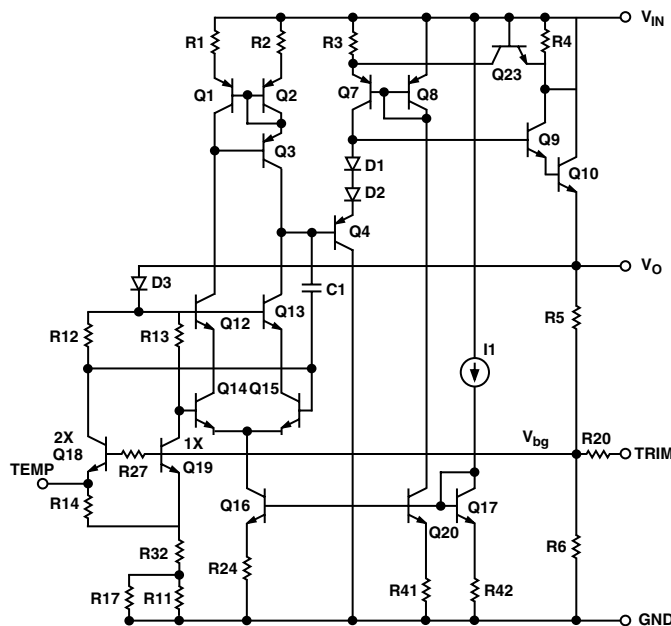


Figure 1. Simplified Schematic Diagram

In the ADR01/ADR02, the PTAT voltage is made available at the TEMP pin. It has a stable 1.96 mV/°C temperature coefficient that allows users to estimate the temperature change of the device by knowing the voltage change at the TEMP pin.

Applying the ADR01/ADR02

ADR01/ADR02 can be used without any external components to achieve the specified performance. Because of the internal op amp amplifying the bandgap cell to 10 V/5 V, power supply decoupling will help the transient response of ADR01/ADR02. As a result, 0.1 µF ceramic type of decoupling capacitors should be applied as close as possible to the input and output pins of the device. An optional 1 µF to 10 µF bypass capacitor can also be applied at the VIN node to maintain the input under transient disturbance.

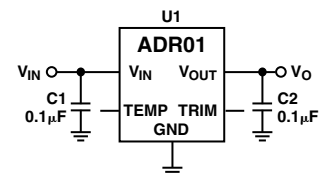


Figure 2. ADR01 Basic Configuration

Output Adjustment

The ADR01/ADR02 trim terminal can be used to adjust the output voltage over a nominal voltage. This feature allows system designer to trim system errors by setting the reference to a voltage other than 10 V/5 V. For finer adjustment, a series resistor of 470 kΩ can be added. With the configuration shown in Figure 3, ADR01 can be adjusted from 9.70 V to 10.05 V and ADR02 can be adjusted from 4.95 V to 5.02 V. Adjustment of the output does not significantly affect the temperature performance of the device provided the tempco of the resistors are relatively low.

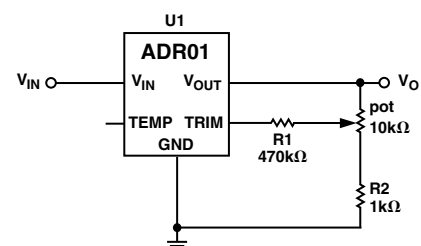


Figure 3. ADR01 Optional Trim Adjustment

ADR01/ADR02

Temperature Monitoring

As described previously, the ADR01/ADR02 provides a “TEMP” output (Pin 3) that varies Linearly with temperature. This output can be used to monitor the temperature change in the system. The voltage at V_{TEMP} is approximately 550 mV at 25°C and the temperature coefficient is approximately 1.96 mV/°C. (See Figure 4.)

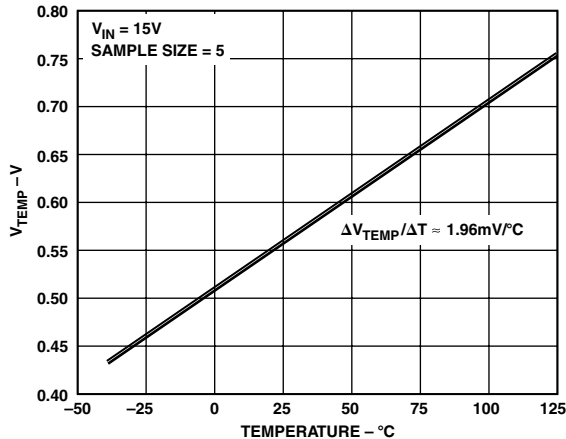


Figure 4. ADR02 Voltage at TEMP Pin vs. Temperature

For example, a delta voltage change of 39.2 mV at the TEMP pin corresponds to a 20°C change in temperature.

Be aware that the TEMP function is a convenient, rather than a precise feature. Since the voltage at the TEMP node is acquired from the bandgap core, current pulling from this pin will have a significant effect on V_{OUT} . Care must be taken to buffer the TEMP output with a suitable low bias current op amp, for example AD8601, AD820, or OP1177 (all of which would result in less than a 100 μ V change in ΔV_{OUT}), see Figure 5. Without buffering, even tens of microamp drawn from the TEMP pin can cause V_{OUT} to fall out of specification.

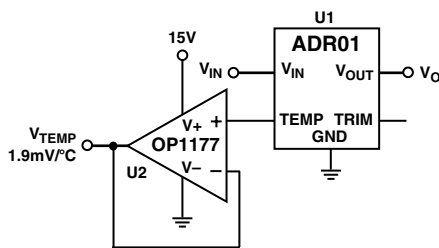


Figure 5. ADR01 Temperature Monitoring

APPLICATIONS

Negative Reference

Without using any matching resistors, a negative reference can be configured as shown in Figure 6. For the ADR01, the voltage difference between V_{OUT} and GND is 10 V. Since V_{OUT} is at virtual ground, U2 will close the loop by forcing the GND pin to be the negative reference node. U2 should be a precision op amp with a low offset voltage characteristic.

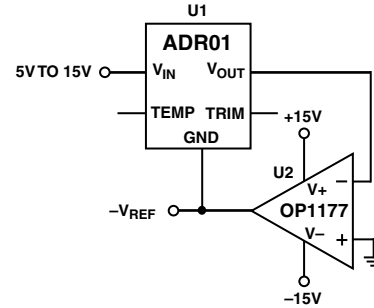


Figure 6. ADR01 Negative Reference

Low Cost Current Source

Unlike most references, the ADR01/ADR02 employs an NPN darlington in which the quiescent current remains constant with respect to the load current (TPC 11). As a result, a current source can be configured as shown in Figure 7 where $I_{SET} = (V_{OUT} - V_L)/R_{SET}$. I_L is simply the sum of I_{SET} and I_q . Although simple, I_q varies typically from 0.55 mA to 0.65 mA limiting this circuit to general purpose, rather than precision applications. To maintain a proper voltage compliance of V_L , V_{IN} should always be kept at least 15 V above V_L at a given load current for ADR01 and 10 V for ADR02.

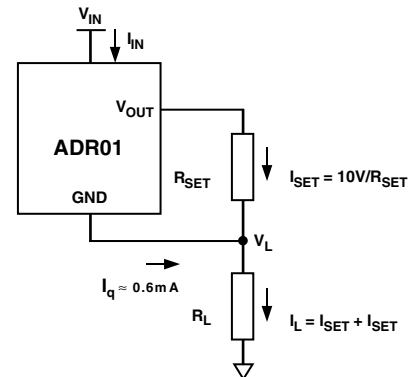


Figure 7. ADR01 Low Cost Current Source

Precision Current Source With Adjustable Output

A precision current source, on the other hand, can be implemented with the circuit shown in Figure 8. By using ADR02 and adding a mechanical or digital potentiometer, this circuit becomes an adjustable current source. If a digital potentiometer is used, the load current is simply the voltage across terminals B-to-W of the digital potentiometer divided by R_{SET} .

$$I_L = \frac{V_{REF} \times D}{R_{SET}} \quad (6)$$

where D is the decimal equivalent of the digital potentiometer input code.

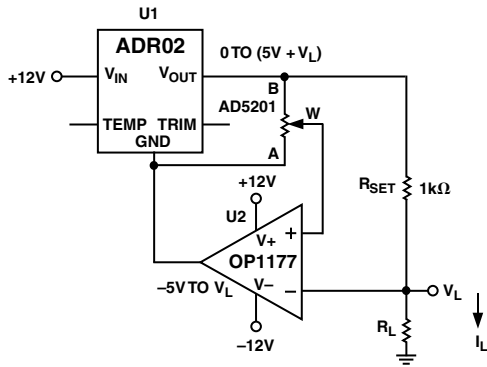


Figure 8. ADR02 Programmable 0 mA-to-5 mA Current Source

To optimize the resolution of this circuit, dual supply op amps should be used because the ground potential of ADR02 can swing from -5 V at zero scale to V_L at full scale of the potentiometer setting.

Programmable 4 mA-to-20 mA Current Transmitter

Because of its precision, adequate current handling, and small footprint, ADR01/ADR02 are suitable as the reference sources for some high-performance converter circuits. One of these applications is the multichannel 16-bit 4 mA-to-20 mA current transmitter in the industrial control market, Figure 9. This circuit employs a Howland Current Pump at the output, which yields better efficiency, less component count, and higher voltage compliance than the conventional design with op amps and MOSFETs. In this circuit, if the resistors are matched such that $R_1 = R_1'$, $R_2 = R_2'$, $R_3 = R_3'$, the load current is

$$I_L = \frac{(R_2 + R_3) / R_1}{R_3'} \times \frac{V_{REF} \times D}{2^N} \quad (7)$$

where D is similarly the decimal equivalent of the DAC input code and N is the number of bits of the DAC.

According to Equation 6, R_3' can be used to set the sensitivity. R_3' can in fact be made as small as needed to achieve the current needed within U4 output current driving capability. On the other hand, other resistors can be kept high to conserve power.

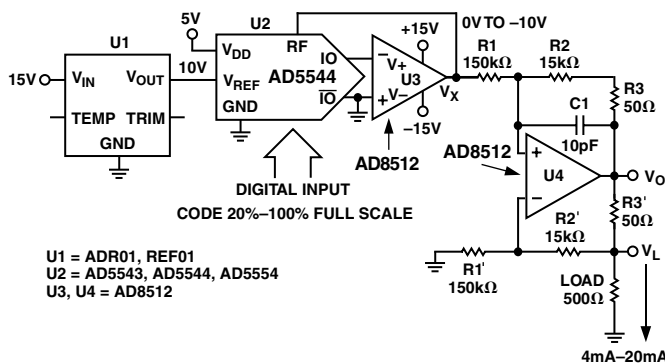


Figure 9. Programmable 4 mA-to-20 mA Transmitter

In this circuit, AD8512 is capable to deliver 20 mA and the voltage compliance approaches 15 V.

The Howland Current Pump yields potentially infinite output impedance, which is desirable. However, the trade off is the attention of resistance matching. The importance of this fact

can best be viewed from the output impedance standpoint. It can be shown that:

$$Z_O = \frac{V_t}{I_t} = \frac{R_1'}{\left(\frac{R_1' \times R_2}{R_1 \times R_2'}\right) - 1} \quad (8)$$

If the resistors are perfectly matched, Z_O is infinite. On the other hand, if they are not matched, Z_O can either be positive or negative. The latter, in theory, can cause oscillation. As a result, C1, in the range of 1 p to 10 pF is needed to prevent the oscillation.

In this circuit, ADR01 provides the stable 10.000 V reference for the Quad 16-bit DAC, AD5544. The resolution of the adjustable current is 0.3 μ A/step and the total worst case INL error is merely 4 LSB. Such error is equivalent to 1.2 μ A or 0.006% system error which is well below most systems requirement. The result is shown in Figure 10 with measurement taken at 25°C and 70°C. Total system error of 4 LSB at both 25°C and 70°C.

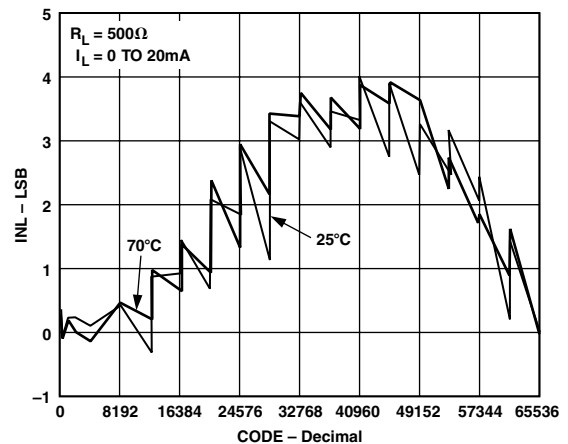


Figure 10. Result of Programmable 4 mA-to-20 mA Current Transmitter

Precision Boosted Output Regulator

A precision voltage output with boosted current capability can be realized with the circuit shown in Figure 11. In this circuit, U2 forces V_O to be equal to V_{REF} by regulating the turn-on of N1 and therefore the load current will be furnished by V_{IN} . In this configuration, a 50 mA load is achievable at V_{IN} of 15 V. Moderate heat will be generated on the MOSFET and higher current can be achieved with a replacement of larger device. In addition, for heavy capacitive load with step V_{IN} , a high current buffer may be added to enhance the transient response.

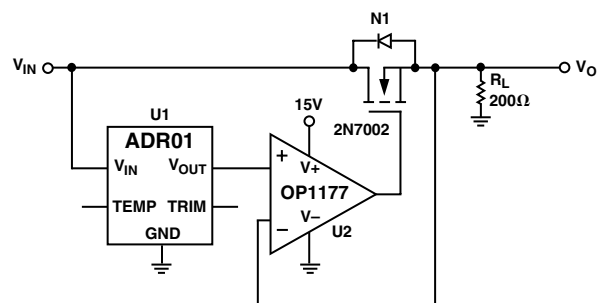


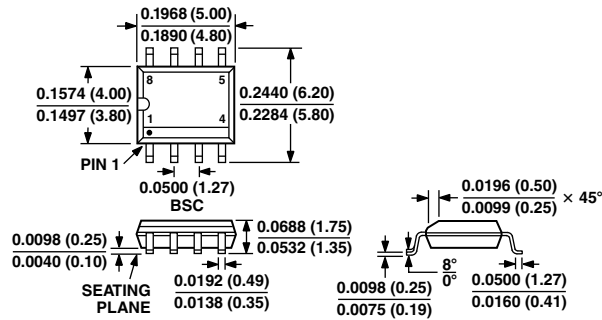
Figure 11. Precision Boosted Output Regulator

ADRO1/ADRO2

OUTLINE DIMENSIONS

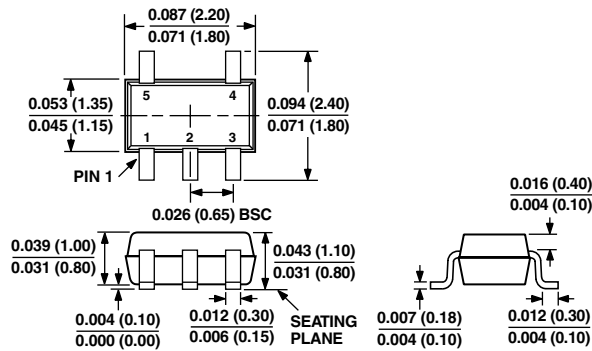
Dimensions shown in inches and (mm).

8-Lead SOIC (R-8)



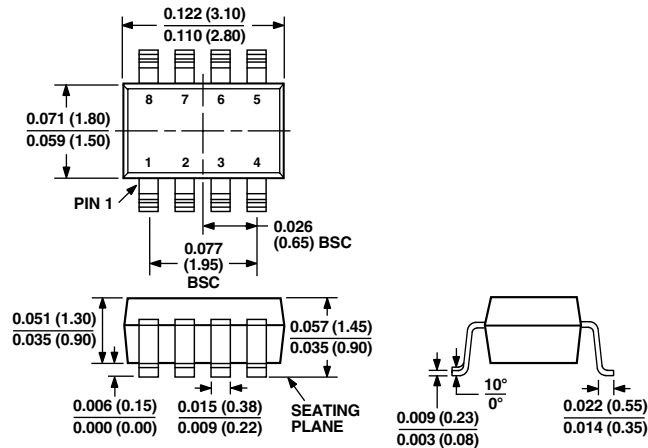
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5-Lead SC70 (KS-5)



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8-Lead (RT-8)



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