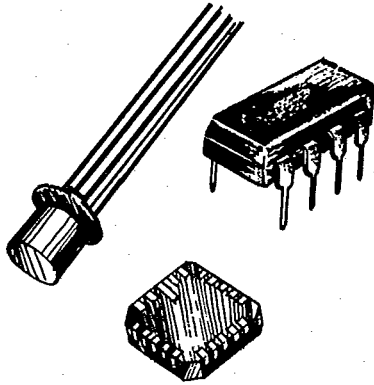


# TELEDYNE SEMICONDUCTOR

T-58-07

## REF-01

### +10V PRECISION VOLTAGE REFERENCE



#### Features

- 10V Output ..... ±0.3% Max.
- Adjustment Range ..... ±3% Min.
- Low Supply Current ..... 1.4mA Max.
- No External Components
- Short Circuit Proof
- Laser-Trimmed to High Accuracies
- Output Sources or Sinks Current

#### Applications

- Precision Regulators
- A/D and D/A Converters
- Constant Current Sources
- V to F Converters

#### General Description

The REF-01 is a 10V precision bandgap voltage reference which provides a stable output voltage over a wide range of operating conditions, i.e. input voltage, output current, ambient temperature, etc. The output voltage can be adjusted over a 3% range. The device can also be stacked to provide higher value voltage references, such as 20, 30, 100V, etc., as long as the total available output current is not exceeded. REF-01 is available in commercial and military temperature ranges.

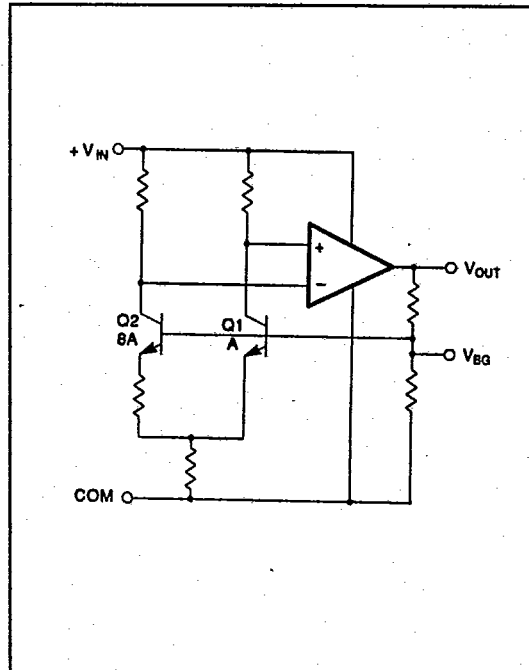
#### Ordering Information<sup>1</sup>

$T_A = 25^\circ\text{C}$ $\Delta V_{OS} \text{ Max}$ (mV)	Package					Oper. Temp. Range
	T0-89 8-pin	Hermetic DIP 8-pin	Plastic DIP 8-pin	Plastic SOIC 8-pin	LCC	
± 30	REF01AJ <sup>2</sup>	REF01AZ <sup>2</sup>				MIL
± 30	REF01EJ	REF01EZ				COM
± 50	REF01J <sup>2</sup>	REF01Z <sup>2</sup>			REF01RC/883	MIL
± 50	REF01HJ	REF01HZ	REF01HP	REF01HS		COM
± 100	REF01CJ	REF01CZ	REF01CP	REF01CS		COM

Notes: <sup>1</sup>All commercial and industrial temperature range parts are available with burn-in.

<sup>2</sup>For devices processed in total compliance to MIL-STD-883, add/883 after part number. Consult factory for 883 data sheet.

#### Functional Diagram

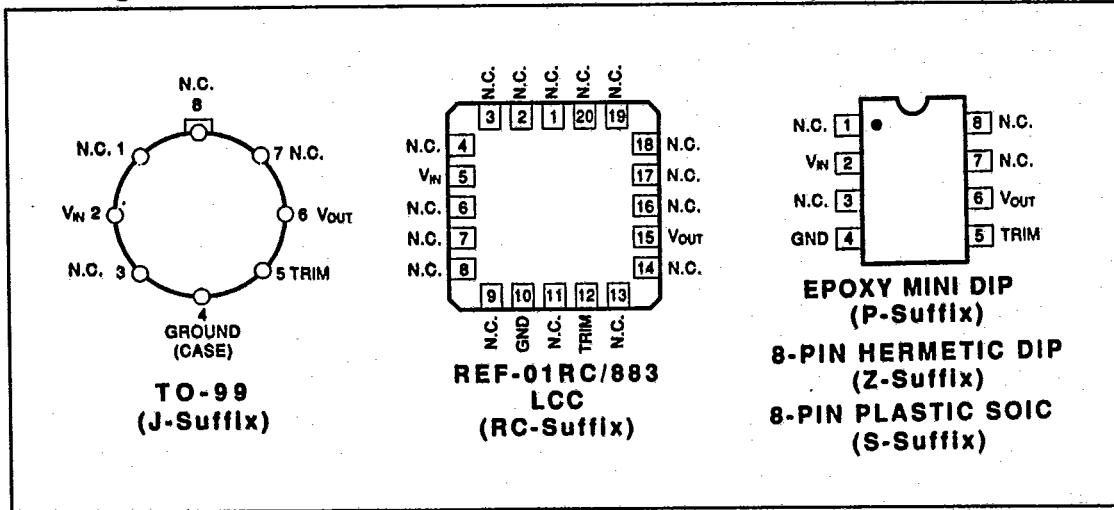


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**+10V PRECISION VOLTAGE REFERENCE**

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**Pin Configuration**



**Absolute Maximum Ratings<sup>1</sup>**

- Input Voltage
  - REF-01, A, E, H, RC, All DICE ..... 40V
  - REF-01C ..... 30V
- Power Dissipation<sup>2</sup> ..... 500mW
- Output Short-Circuit Duration (to Ground or V<sub>IN</sub>) ..... Indefinite
- Storage Temperature Range
  - J, RC, and Z Packages ..... -65°C to +125°C
  - P Package ..... -65°C to +125°C
- Operating Temperature Range
  - REF-01A, REF-01, REF-01RC ..... -55°C to +125°C
  - REF-01E, REF-01H, REF-01C ..... 0°C to +70°C

DICE Junction Temperature (T<sub>J</sub>) ..... -65°C to +150°C  
 Lead Temperature (Soldering, 60 sec.) ..... 300°C

**Notes:** <sup>1</sup>Absolute maximum ratings apply to both packaged parts and DICE, unless otherwise noted.  
<sup>2</sup>See table for maximum ambient temperature rating and derating factor.

PACKAGE TYPE	MAXIMUM AMBIENT TEMPERATURE FOR RATING	DERATE ABOVE MAXIMUM AMBIENT TEMPERATURE
TO-99 (J)	80°C	7.1mW/°C
8-Pin Hermetic DIP (Z)	75°C	6.7mW/°C
8-Pin Plastic DIP (P)	36°C	5.6mW/°C
LCC (RC)	72°C	7.8mW/°C

**Electrical Characteristics:** V<sub>IN</sub> = +15V, T<sub>A</sub> = 25°C, unless otherwise indicated.

SYMBOL	PARAMETER	CONDITIONS	REF-01A/E			REF-01/H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>O</sub>	Output Voltage	I <sub>L</sub> = 0	9.97	10.00	10.03	9.95	10.00	10.05	V
ΔV <sub>trim</sub>	Output Adjustment Range	R <sub>p</sub> = 10kΩ	±3.0	±3.3		±3.0	±3.3		%
e <sub>ripple</sub>	Output Voltage Noise	0.1Hz to 10Hz (Note 6)		20	30		20	30	μV <sub>p-p</sub>
	Line Regulation (Note 4)	V <sub>IN</sub> = 13V to 33V		0.006	0.010		0.006	0.010	%/V
	Load Regulation (Note 4)	I <sub>L</sub> = 0 to 10mA		0.005	0.008		0.006	0.010	%/mA
t <sub>ON</sub>	Turn-on Settling Time	To ±0.1% of final value		5			5		μs
I <sub>BY</sub>	Quiescent Supply Current	No Load		1.0	1.4		1.0	1.4	mA
I <sub>L</sub>	Load Current		10	21		10	21		mA
I <sub>S</sub>	Sink Current		-5	-10		-5	-10		mA
I <sub>SC</sub>	Short-Circuit Current	V <sub>O</sub> = 0		30			30		mA

## NEW PRODUCT INFORMATION

## REF-01

**Electrical Characteristics:**  $V_{IN} = +15V$ ,  $-55^{\circ}C \leq T_A \leq +125^{\circ}C$  and  $I_L = 0mA$ , unless otherwise indicated.

SYMBOL	PARAMETER	CONDITIONS	REF-01A/E			REF-01/H			UNITS
			MIN	TYP	MAX	MIN	TYP	MAX	
$\Delta V_{OT}$	Output Voltage Change with Temperature (Notes 1, 2)	$0^{\circ}C \leq T_A \leq +70^{\circ}C$ $-55^{\circ}C \leq T_A \leq +125^{\circ}C$	0.02 0.06	0.06 0.15		0.07 0.18	0.17 0.45	%	
$TCV_O$	Output Voltage Temperature Coefficient	(Note 3)	3.0	8.5		10.0	25.0	ppm/ $^{\circ}C$	
	Change in $V_O$ Temperature Coefficient with Output Adjustment	$R_p = 10k\Omega$	0.7			0.7		ppm/%	
	Line Regulation ( $V_{IN} = 13V$ to $33V$ ) (Note 4)	$0^{\circ}C \leq T_A \leq +70^{\circ}C$ $-55^{\circ}C \leq T_A \leq +125^{\circ}C$	0.007 0.009	0.012 0.015		0.007 0.009	0.012 0.015	%/V	
	Load Regulation ( $I_L = 0$ to $8mA$ ) (Note 4)	$0^{\circ}C \leq T_A \leq +70^{\circ}C$ $-55^{\circ}C \leq T_A \leq +125^{\circ}C$	0.008 0.007	0.010 0.012		0.007 0.009	0.012 0.015	%/V	

Notes: 1.  $\Delta V_{OT}$  is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of  $10V$ :

$$\Delta V_{OT} = \left| \frac{V_{MAX} - V_{MIN}}{10V} \right| \times 100$$

2.  $\Delta V_{OT}$  specification applies trimmed to  $+10.000V$  or untrimmed.

3.  $TCV_O$  is defined as  $\Delta V_{OT}$  divided by the temperature range, i.e.,

$$TCV_O (0^{\circ} \text{ to } +70^{\circ}C) = \frac{\Delta V_{OT} (0^{\circ} \text{ to } +70^{\circ}C)}{70^{\circ}C}$$

$$\text{and } TCV_O (-55^{\circ} \text{ to } +125^{\circ}C) = \frac{\Delta V_{OT} (-55^{\circ} \text{ to } +125^{\circ}C)}{180^{\circ}C}$$

4. Line and Load Regulation specifications include the effect of self-heating.

5. Guaranteed by design.

6. Sample tested.

**Electrical Characteristics:**  $V_{IN} = +15V$ ,  $T_A = 25^{\circ}C$ , unless otherwise indicated.

SYMBOL	PARAMETER	CONDITIONS	MIN	REF-01C	MAX	UNITS
				TYP		
$V_O$	Output Voltage	$I_L = 0mA$	9.90	10.00	10.10	V
$\Delta V_{trim}$	Output Adjustment Range	$R_p = 10k\Omega$	$\pm 2.7$	$\pm 3.3$		%
$\epsilon_{pp-p}$	Output Voltage Noise	0.1Hz to 10Hz (Note 6)		25	35	$\mu V_{pp}$
	Line Regulation (Note 4)	$V_{IN} = 13V$ to $30V$		0.009	0.015	%/V
	Load Regulation (Note 4)	$I_L = 0$ to $8mA$ $I_L = 0$ to $4mV$		0.008 0.006	0.015 0.015	%/mA
$t_{ON}$	Turn-on Setting Time	To $\pm 0.1\%$ of final value		5		$\mu s$
$I_{SY}$	Quiescent Supply Current	No Load		1.0	1.6	mA
$I_L$	Load Current		8	21		mA
$I_S$	Sink Current		-5	-10		mA
$I_{SC}$	Short-Circuit Current	$V_O = 0$		30		mA

**Electrical Characteristics:**  $V_{IN} = +15V$ ,  $0^{\circ}C \leq T_A \leq +70^{\circ}C$ , unless otherwise indicated.

SYMBOL	PARAMETER	CONDITIONS	MIN	REF-01C	MAX	UNITS
				TYP		
$\Delta V_{OT}$	Output Voltage Change with Temperature	(Notes 1 and 2)		0.14	0.45	%
$TCV_O$	Output Voltage Temperature Coefficient	(Note 3)		20	65	ppm/ $^{\circ}C$

**+10V PRECISION VOLTAGE REFERENCE**

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**Electrical Characteristics (cont.):**  $V_{IN} = +15V, 0^{\circ}C \leq T_A \leq +70^{\circ}C$ , unless otherwise indicated.

SYMBOL	PARAMETER	CONDITIONS	MIN	REF-01C TYP	MAX	UNITS
	Change in $V_O$ Temperature Coefficient with Output Adjustment	$R_p = 10k\Omega$		0.7		ppm/%
	Line Regulation (Note 4)	$V_{IN} = 13V$ to $30V$		0.011	0.018	%/V
	Load Regulation (Note 4)	$I_L = 0$ to $5mA$		0.008	0.018	%/mA

**Notes:** 1.  $\Delta V_{OT}$  is defined as the absolute difference between the maximum output voltage and the minimum output voltage over the specified temperature range expressed as a percentage of 10V:

$$\Delta V_{OT} = \left| \frac{V_{MAX} - V_{MIN}}{10V} \right| \times 100$$

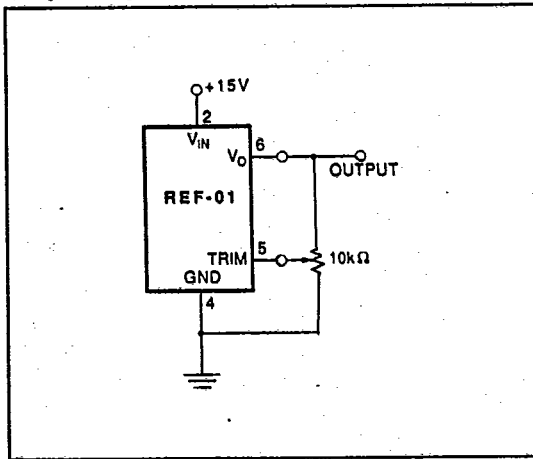
2.  $\Delta V_{OT}$  specification applies trimmed to +10.000V or untrimmed.

3.  $TCV_O$  is defined as  $\Delta V_{OT}$  divided by the temperature range, i.e.,

$$TCV_O = \frac{\Delta V_{OT}}{70^{\circ}C}$$

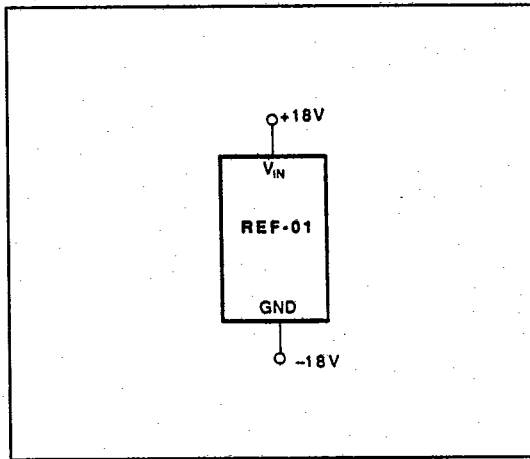
- 4. Line and Load Regulation specifications include the effect of self-heating.
- 5. Guaranteed by design.
- 6. Sample tested.

**Output Adjustment**



The REF-01 trim terminal can be used to adjust the output voltage over a  $10V \pm 300mV$  range. This feature allows the system designer to trim system errors by setting the reference to a voltage other than 10V. Of course, the output can also be set to exactly 10.000V, or to 10.240V for binary applications.

**Burn-In Circuit**

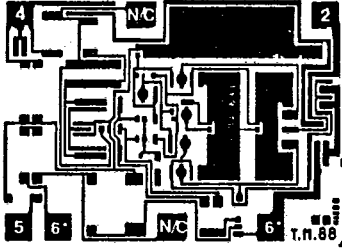


Adjustment of the output does not significantly affect the temperature performance of the device. The temperature coefficient change is approximately 0.7 ppm/°C for 100mV of output adjustment.

## NEW PRODUCT INFORMATION

REF-01

## Bonding Diagram



- 2. V<sub>IN</sub>
- 4. GND
- 5. TRIM
- 6. V<sub>OUT</sub>\*

\*The two bonding pads are connected to pin 6.

DIE SIZE 0.067 x 0.05 inch, 3550 sq. mils  
(1.702 x 1.27mm, 2.16 sq. mm)

## Reference Stack with Excellent Line Regulation

Three REF-01s can be stacked to yield 10,000, 20,000, and 30,000V outputs. An additional advantage is near-perfect line regulation of the 10.0V and 20.0V output. A 32V to 60V input change produces an output change which is less than the noise voltage of the devices. A load bypass resistor ( $R_S$ ) provides a path for the supply current ( $I_{SY}$ ) of the 20,000V regulator.

In general, any number of REF-01s can be stacked this way. For example, ten devices will yield outputs of 10, 20, 30, . . . 100V. The line voltage can range from 105V to 130V. However, care must be taken to ensure that the total load currents do not exceed the maximum usable current (typically 21mA).

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