National Semiconductor

LM168/LM268/LM368 Precision Voltage Reference

General Description

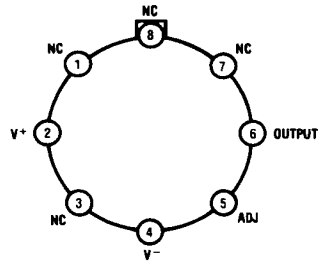
The LM168/LM368 are precision, monolithic, temperature-compensated voltage references. The LM168 makes use of thin-film technology enhanced by the discrete laser trimming of resistors to achieve excellent Temperature coefficient (Tempco) of V_{OUT} (as low as 5ppm/°C), along with tight initial tolerance, (as low as 0.02%). The trim scheme is such that individual resistors are cut open rather than being trimmed (partially cut), to avoid resistor drift caused by electromigration in the trimmed area. The LM168 also provides excellent stability vs. changes in input voltage and output current (both sourcing and sinking). This device is available in output voltage options of 5.0V and 10.0V and will operate in both series or shunt mode. Also see the LM368-2.5 data sheet for a 2.5V output. The devices are short circuit proof when sourcing current. A trim pin is made available for fine trimming of V_{OUT} or for obtaining intermediate values without greatly affecting the Tempco of the device.

Features

- 300 μA operating current
- Low output impedance
- Excellent line regulation (.0001%/V typical)
- Single-supply operation
- Externally trimmable
- Low temperature coefficient
- Operates in series or shunt mode
- 10.0V or 5.0V
- Excellent initial accuracy (0.02% typical)

Connection Diagram

Metal Can Package



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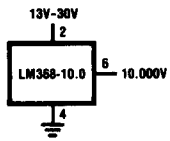
Top View

*case connected to V−

Order Number LM168BYH-10, LM168BYH-5.0, LM268BYH-10, LM268BYH-5.0, LM368YH-10, LM368YH-5.0, LM368H-10, LM368H-5.0
See NS Package Number H08C

Typical Applications

Series Regulator



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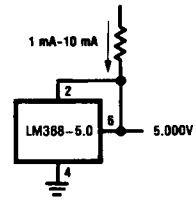
Shunt Regulator



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Absolute Maximum Ratings (Note 8)

Input Voltage (Series Mode)	35V
Reverse Current (Shunt Mode)	50 mA
Power Dissipation	600 mW
Storage Temperature Range	−60°C to +150°C
Operating Temperature Range	
LM168	−55°C to +125°C
LM268	−40°C to +85°C
LM368	0°C to +70°C

Soldering Information

TO-5 (H) Package, 10 sec. +300°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" (Appendix D) for other methods of soldering surface mount devices.

Electrical Characteristics (Note 1)

Parameter	Conditions	LM168/LM268/LM368			
		Typical	Tested Limit (Note 2)	Design Limit (Note 3)	Units (Max. unless noted)
V_{OUT} Error: LM168B, LM268B		±0.02	±0.05		%
LM368		±0.02	±0.1		%
Line Regulation	$(V_{OUT} + 3V) \le V_{IN} \le 30V$	±0.0001	±0.0005		%/V
Load Regulation	$0\ mA \le I_{SOURCE} \le 10\ mA$	±0.0003	±0.001		%/mA
(Note 4)	$-10\ mA \le I_{SINK} \le 0\ mA$	±0.003	±0.008		%/mA
Thermal Regulation	T = 20 mS (Note 5)	±0.005	±0.01		%/100 mW
Quiescent Current		250	350		μA
Change of Quiescent Current vs. V_{IN}	$(V_{OUT} + 3V) \le V_{IN} \le 30V$	3	5		μA/V
Temperature Coefficient of V_{OUT} (see graph): LM168BY	$-55°C \le T_A \le 125°C$	±5	±10		ppm/°C
(Note 6) LM268BY	$-40°C \le T_A \le 85°C$	±7.5	±15		ppm/°C
LM368Y	$0°C \le T_A \le 70°C$	±11	±20		ppm/°C
LM368	$0°C \le T_A \le 70°C$	±15		±30	ppm/°C
Short Circuit Current	$V_{OUT} = 0$	30	70	100	mA
Noise: 10.0V: 0.1 - 10Hz		30			uVp-p
100Hz - 10 kHz		1100			$nV/\sqrt{Hz}$
6.2V: 0.1 - 10Hz		20			uVp-p
100Hz - 10 kHz		700			$nV/\sqrt{Hz}$
5.0V: 0.1 - 10Hz		16			uVp-p
100Hz - 10 kHz		575			$nV/\sqrt{Hz}$
V_{OUT} Adjust Range: 10.000V	$0V \le V_{PIN5} \le V_{OUT}$	4.5-17.0		6.0-15.5	V min.
5.000V		4.4-7.0		4.5-6.0	V min.

Note 1: Unless otherwise noted, these specifications apply: $T_A = 25°C$, $V_{IN} = 15V$, $I_{LOAD} = 0$, $0 \le C_L \le 200$ pF. Circuit is operating in Series Mode. Or, circuit is operating in Shunt Mode, $V_{IN} = +15V$ or $V_{IN} = V_{OUT}$, $TA = +25°C$, $I_{LOAD} = -1.0$ mA, $0 \le C_L \le 200$ pF.

Note 2: Tested Limits are guaranteed and 100% tested in production.

Note 3: Design Limits are guaranteed (but not 100% production tested) over the indicated temperature and supply voltage ranges. These limits are not used to calculate outgoing quality levels.

Note 4: The LM168 has a Class B output, and will exhibit transients at the crossover point. This point occurs when the device is asked to sink approximately 120 μA. In some applications it may be advantageous to preload the output to either V_{IN} or Ground, to avoid this crossover point.

Note 5: Thermal Regulation is defined as the change in the output Voltage at a time T after a step change in power dissipation of 100 mW.

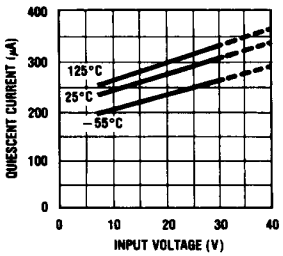
Note 6: Temperature Coefficient of V_{OUT} is defined as the worst case delta-V_{OUT} measured at Specified Temperatures divided by the total span of the Specified Temperature Range (See graphs). There is no guarantee that the Specified Temperatures are exactly at the minimum or maximum deviation.

Note 7: In metal can (H), θ_{J-C} is 75°C/W and θ_{J-A} is 150°C/W.

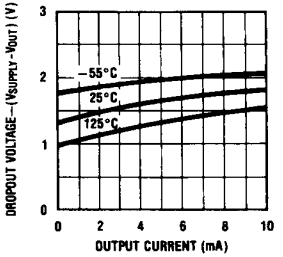
Note 8: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications do not apply when operating the device beyond its Rated Operating Conditions (see Note 1 and Conditions).

Typical Performance Characteristics (Note 1)

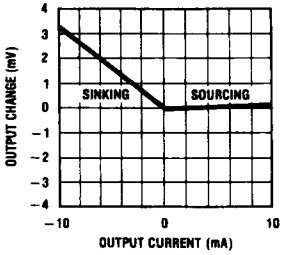
Quiescent Current vs. Input Voltage and Temperature



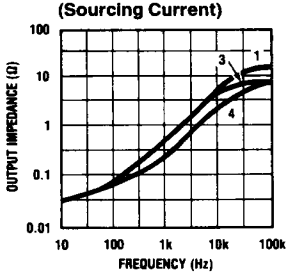
Dropout Voltage vs. Output Current (Series Mode Sourcing Current)



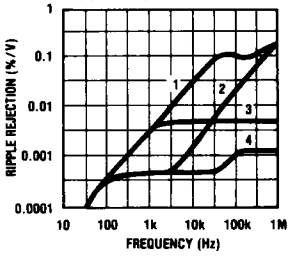
Output Change vs. Output Current



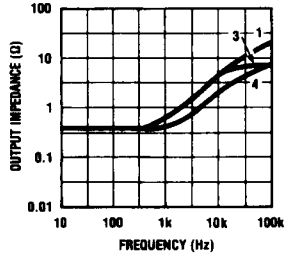
Output Impedance vs. Frequency (Sourcing Current)



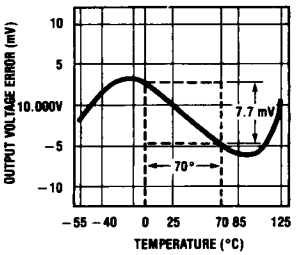
Ripple Rejection vs. Frequency



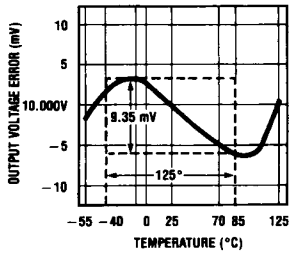
Output Impedance vs. Frequency (Sinking Current)



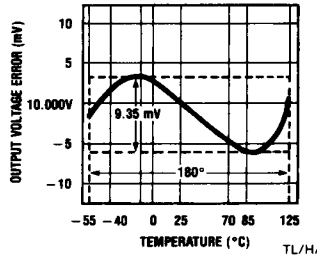
Temperature Coefficient: LM368-10 (Curve A)



Temperature Coefficient: LM268-10 (Curve B)



Temperature Coefficient: LM168-10 (Curve C)



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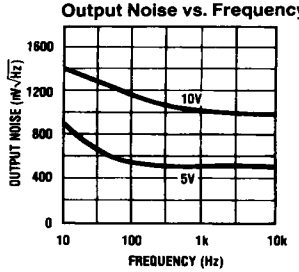
Typical Temperature Coefficient Calculations:

LM368-10 (see Curve A)
T.C. = 7.7 mV/(70° × 10V)
= 11 × 10E-6 = 11ppm/°C

LM268-10 (see Curve B)
T.C. = 9.35 mV/(125° × 10V)
= 7.5 × 10E-6 = 7.5ppm/°C

LM168-10 (see Curve C)
T.C. = 9.35 mV/(180° × 10V)
= 5.2 × 10E-6 = 5.2ppm/°C

Output Noise vs. Frequency



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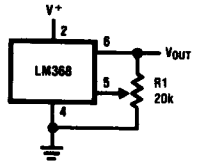
(1) LM368 alone.
(2) with 0.01 μf Mylar, Trim to Gnd.
(3) with 10Ω in series with 10 μf, V_{OUT} to Gnd.
(4) with Both.

Typical Applications

Wide Range Trimmable Regulator



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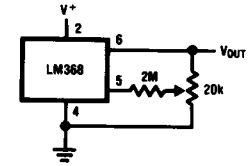
Narrow Range Trimmable Regulator (±1% min.)



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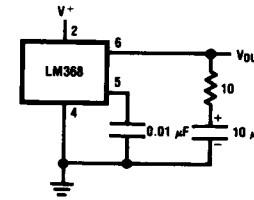
Improved Noise Performance



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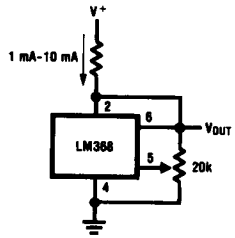
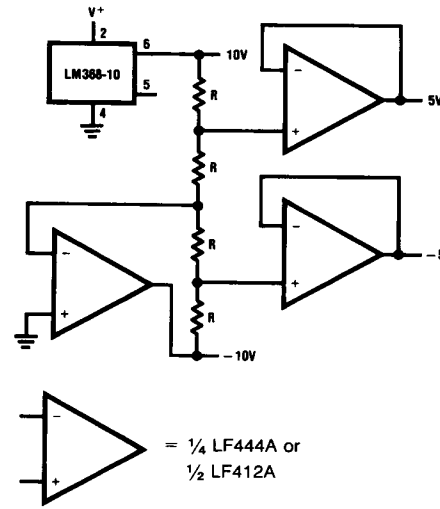
Adjustable Zener



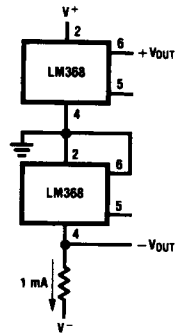
TL/H/5522–9

± 10V, ± 5V References



TL/H/5522–12

± Reference

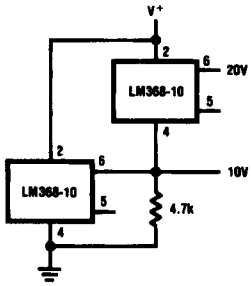


TL/H/5522–11

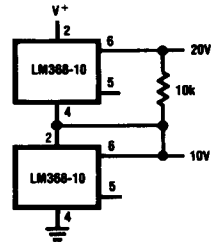
R = Thin Film Resistor Network,
±0.05% Matching and 5ppm Tracking
(Beckman 694-3-R-10K-A),
(Caddock T-914-10K-100-05)
or similar.

Typical Applications (Continued)

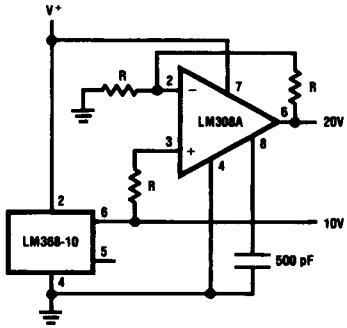
Multiple Output Voltages



TL/H/5522–13



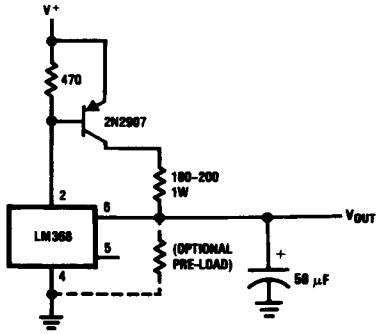
TL/H/5522–14



TL/H/5522–15

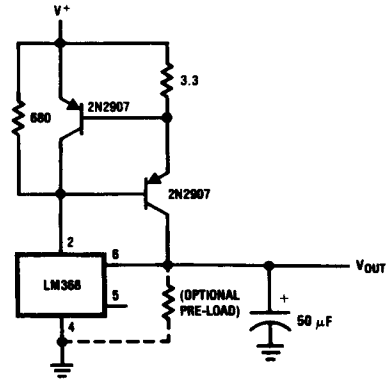
R = Thin Film Resistor Network
0.05% Matching and 5ppm Tracking
(Beckman 694-3-R-10K-A),
(Caddock T-914-10K-100-05)
or similar.

Reference with Booster



TL/H/5522–16

100 mA Boosted Reference



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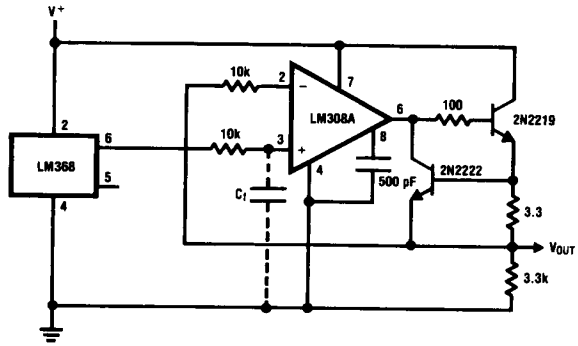
Typical Applications (Continued)

Buffered High-Current Reference with Filter



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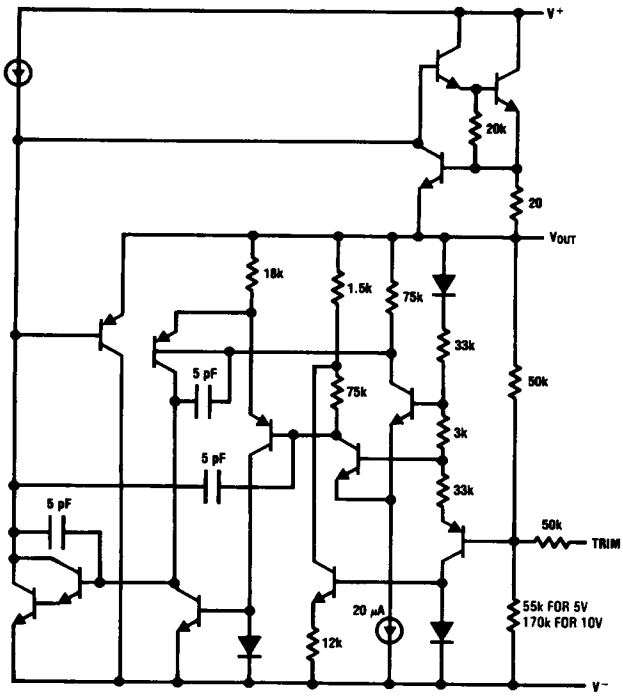
Simplified Schematic Diagram



TL/H/5522–6

*Reg. U.S. Pat. Off.