National Semiconductor

PRELIMINARY

LM168/LM268/LM368 Precision Voltage Reference

General Description

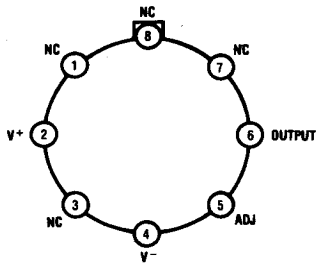
The LM168/LM368 are precision, monolithic, temperature-compensated voltage references. The LM168 makes use of thin-film technology enhanced by the discrete laser trimming of resistors to achieve excellent Temperature coefficient (Tempco) of V_{OUT} (as low as 5ppm/°C), along with tight initial tolerance, (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 several output voltage options including 5.0V, 6.2V, and 10.0V and will operate in both series or shunt mode. 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
- 10.0, 6.2, or 5.0 volts
- Excellent initial accuracy (0.02% typical)
- Replaces 1N821-1N827 zeners

Connection Diagram

Metal Can Package



TL/H/5522–1

Top View

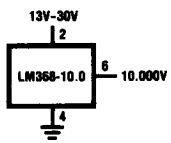
*case connected to V−

Order Number LM168BYH-10, LM168BYH-6.2, LM168BYH-5.0, LM268BYH-10, LM268BYH-6.2, LM268BYH-5.0, LM368YH-10, LM368YH-6.2, LM368YH-5.0, LM368H-10, LM368H-6.2, LM368H-5.0

See NS Package Number H08C

Typical Applications

Series Regulator



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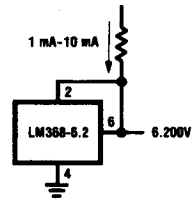
Shunt Regulator



TL/H/5522–3

(Replaces 1N827-type Zener)

Absolute Maximum Ratings

Input Voltage (Series Mode)	35V	Operating Temperature Range	
Reverse Current (Shunt Mode)	50 mA	LM168	−55°C to +125°C
Power Dissipation	600 mW	LM268	−40°C to +85°C
Storage Temperature Range	−60°C to +150°C	LM368	0°C to +70°C
		Lead Temperature (Soldering, 10 sec.)	300°C

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	R_{TRIM} = 100k	4.5-17.0		6.0-15.5	V min.
6.200V		4.0-9.5		5.0-8.5	V min.
5.000V		3.5-7.0		4.0-6.0	V min.

Note 1: Unless otherwise noted, these specifications apply: T_A = 25°C, V_{IN} = 15V, I_{LOAD} = 0, Circuit is operating in Series Mode.

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.

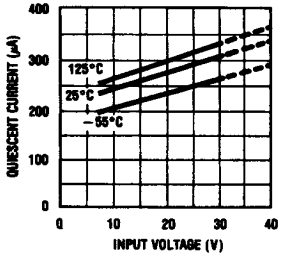
Note 4: The LM168 has a Class B output, and will exhibit transients at the crossover point. This point occurs when the device is asked to sink approximately 120 μA. In some applications it may be advantageous to preload the output to either V_{IN} or Ground, to avoid this crossover point.

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.

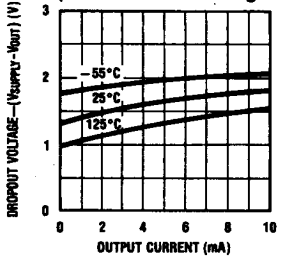
Note 6: Temperature Coefficient of V_{OUT} is defined as the worst case delta-V_{OUT} measured at Specified Temperatures divided by the total span of the Specified Temperature Range (See graphs). There is no guarantee that the Specified Temperatures are exactly at the minimum or maximum deviation.

Typical Performance Characteristics (Note 1)

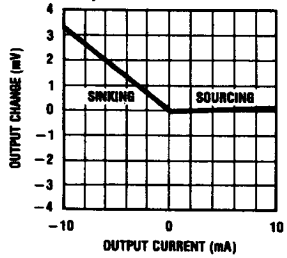
Quiescent Current vs. Input Voltage and Temperature



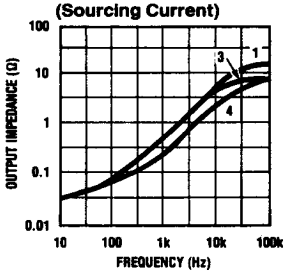
Dropout Voltage vs. Output Current (Series Mode Sourcing Current)



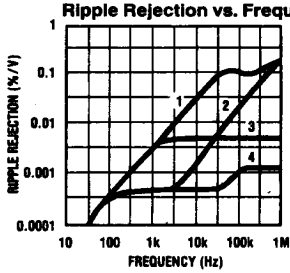
Output Change vs. Output Current



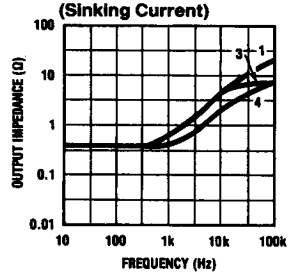
Output Impedance vs. Frequency (Sourcing Current)



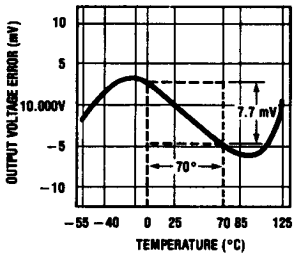
Ripple Rejection vs. Frequency



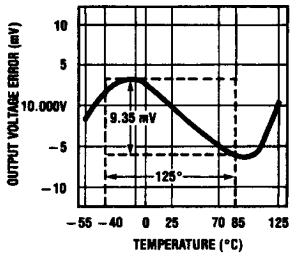
Output Impedance vs. Frequency (Sinking Current)



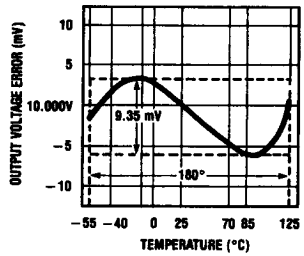
Temperature Coefficient: LM368-10 (Curve A)



Temperature Coefficient: LM268-10 (Curve B)



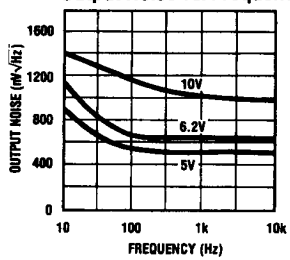
Temperature Coefficient: LM168-10 (Curve C)



TL/H/5522–4

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

Output Noise vs. Frequency



Typical Temperature Coefficient Calculations:

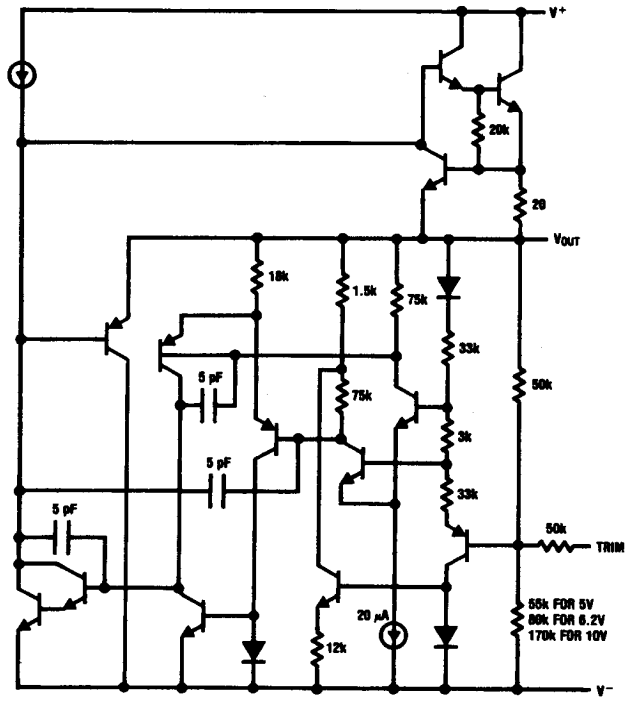
LM368-10 (see Curve A)
T.C. = 7.7 mV/(70° × 10V)
= 11 × 10E-6 = 11ppm/°C

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

TL/H/5522–5

Simplified Schematic Diagram

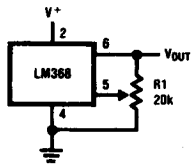


TL/H/5522–6

*Reg. U.S. Pat. Off.

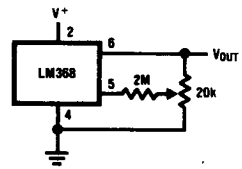
Typical Applications

Wide Range Trimmable Regulator



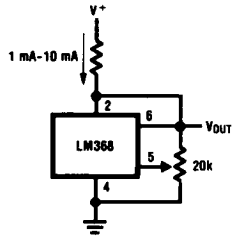
TL/H/5522–7

Narrow Range Trimmable Regulator (±1% min.)



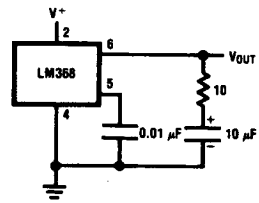
TL/H/5522–8

Adjustable Zener



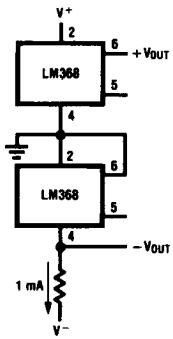
TL/H/5522–9

Improved Noise Performance



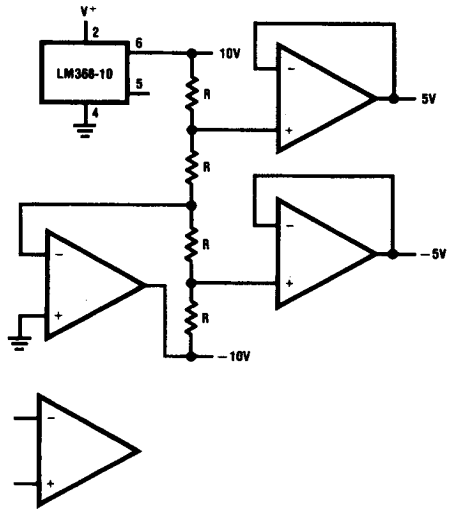
TL/H/5522–10

± Reference



TL/H/5522–11

±10V, ±5V References

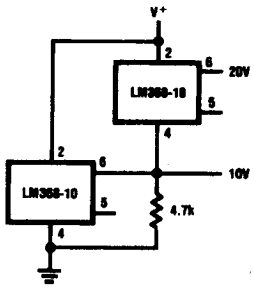


TL/H/5522–12

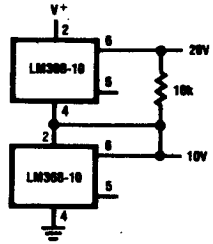
R = Thin Film Resistor Network,
±0.05% Matching and 5ppm Tracking
(Beckman 694-3-R-10K-A),
(Caddock T-914-10K-100-05)
or similar.

Typical Applications (Continued)

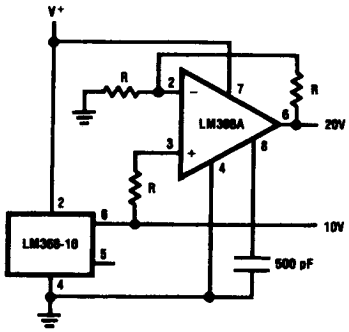
Multiple Output Voltages



TL/H/5522–13



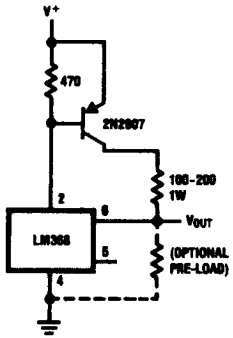
TL/H/5522–14



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.

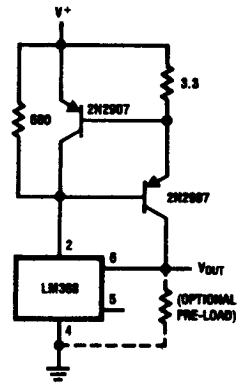
TL/H/5522–15

Reference with Booster



TL/H/5522–16

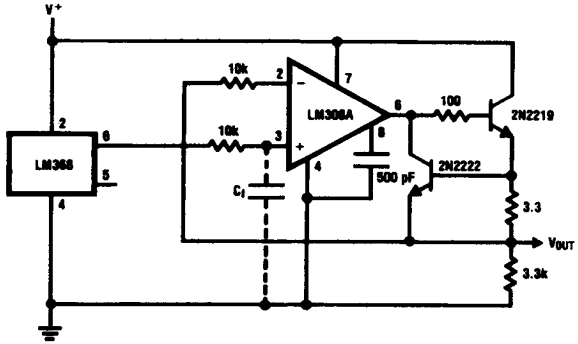
100 mA Boosted Reference



TL/H/5522–17

Typical Applications (Continued)

Buffered High-Current Reference with Filter



TL/H/5522–18