

# Wideband RMS-DC Converter Building Block

## FEATURES

- 300MHz 3dB Bandwidth
- 1% Accuracy DC-50MHz
- 2% to 100MHz
- Bandwidth Flat Over Input Voltage Range
- 50:1 Crest Factor
- 20:1 Dynamic Range
- 35V Peak Input
- Thermally Based Operation
- Fully Specified Thermal and Electrical Parameters
- Standard IC Packages
- Resistive Inputs

## APPLICATIONS

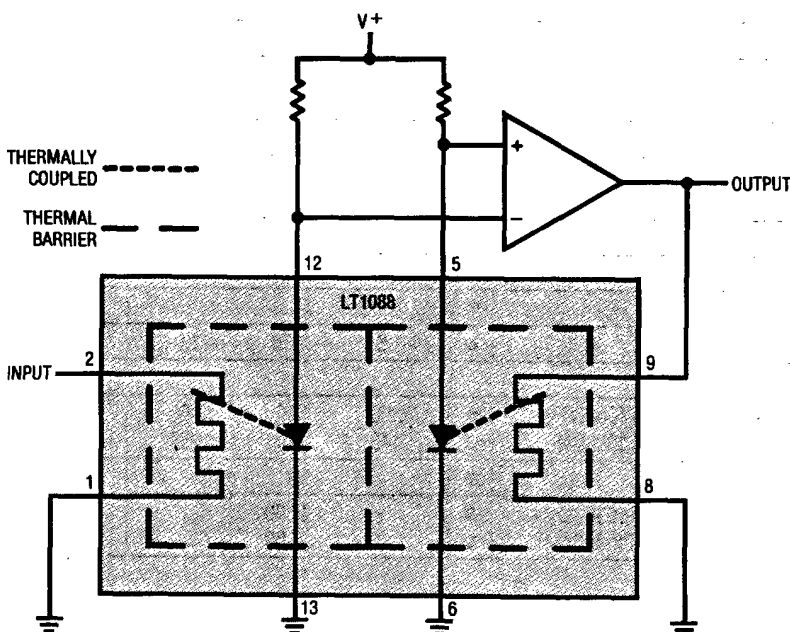
- Wideband RMS Voltmeters
- RF Leveling Loops
- Wideband AGC
- High Crest Factor Measurements
- SCR Power Monitoring

## DESCRIPTION

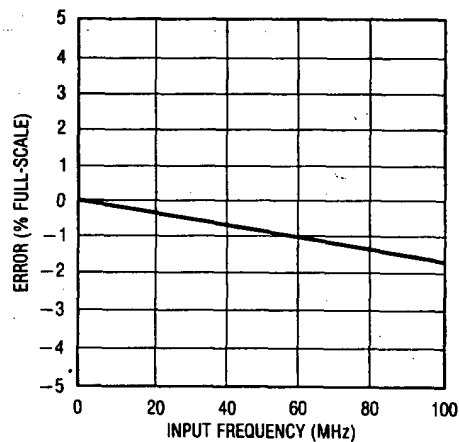
The LT1088 is a thermally based RMS-DC converter building block. It converts the input waveform to heat. Using external circuitry, the thermal signal is expressed as a DC output voltage.

LTC's proprietary thermal packaging process permits accurate thermal signal processing in a standard IC package. The thermal method provides far greater bandwidth than RMS converters based on logarithmic computing techniques. The LT1088's high voltage breakdown allows crest factor measurements of 50:1 and operation over a 20:1 input dynamic range. Resistive inputs of 50Ω or 250Ω accommodate drive from a wide variety of sources.

Simplified RMS-DC Converter



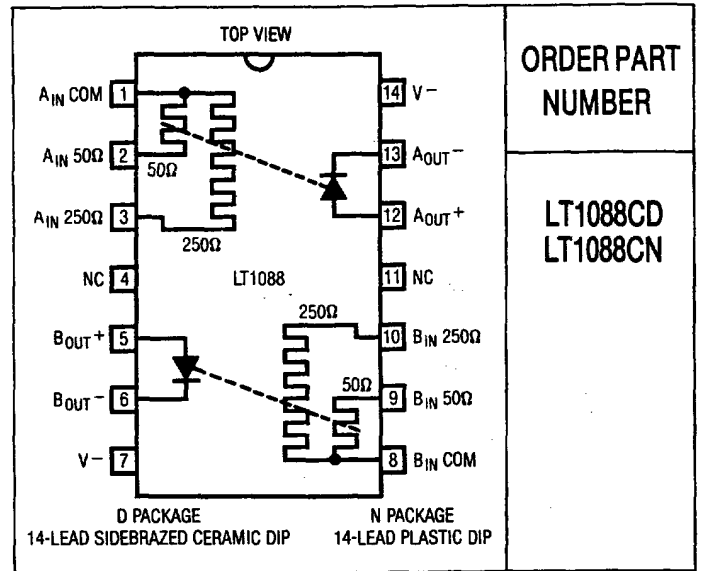
Accuracy vs Frequency (50Ω Input)



**ABSOLUTE MAXIMUM RATINGS**

Voltage on Any Pin .....  $V^- + 40V$  to  $V^-$   
 Voltage from Channel A to Channel B ..... 100V  
 Reverse Diode Voltage ..... 3.5V  
 Forward Diode Current ..... 15mA  
 Input Power (25°C) ..... 0.375W  
 Peak Input Power (30 sec) ..... 0.435W  
 Derate Power at  $-3mW/^\circ C$  above 25°C  
 Maximum Die Temperature ..... 150°C  
 Peak Die Temperature (30 sec) ..... 175°C  
 Functional Temperature Range .....  $-55^\circ C$  to  $125^\circ C$   
 Operating Temperature Range .....  $-40^\circ C$  to  $85^\circ C$   
 Lead Temperature (Soldering, 10 sec) ..... 300°C

**PACKAGE/ORDER INFORMATION**



**ELECTRICAL CHARACTERISTICS**  $T_A = 25^\circ C$ , unless otherwise noted (See Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS		
<b>Input Heaters</b>							
50Ω Input		40	50	60	Ω		
250Ω Input		200	250	300	Ω		
50Ω Temperature Coefficient		●	2000		ppm/°C		
250Ω Temperature Coefficient		●	2000		ppm/°C		
50Ω Temperature Coefficient Match	Input A to Input B	●	30	500	ppm		
250Ω Temperature Coefficient Match	Input A to Input B	●	30	500	ppm		
Resistance Matching	50Ω Inputs		2	10	%		
	250Ω Inputs		2	10	%		
250Ω to 50Ω Ratio Match		-15	0	5	%		
250Ω to 50Ω Ratio Match Temperature Coefficient		●	50		ppm/°C		
<b>Output Diodes</b>							
Forward Voltage	$I = 5mA$	0.6	0.7	0.8	V		
Forward Voltage Match	Out A to Out B; $I = 5mA$	●	5		mV		
Voltage Temperature Coefficient	$I = 5mA$	●	-1.6	-1.75	-1.9	mV/°C	
<b>Thermal Characteristics</b>							
Thermal Resistance	Either Die to Ambient	LT1088CD	●	200	300	400	°C/W
		LT1088CN	●	140	210	280	°C/W
Thermal Matching	Channel A to Channel B	●	30			°C/W	
Thermal Cross Talk	Channel A to Channel B	LT1088CD	●	2500			°C/W
		LT1088CN	●	1750			°C/W

The ● denotes specifications which apply over full operating temperature range.

Note 1: All electrical testing conducted at 25°C.

# TYPICAL PERFORMANCE CHARACTERISTICS

Figure 4's Response vs Frequency—500Ω Input

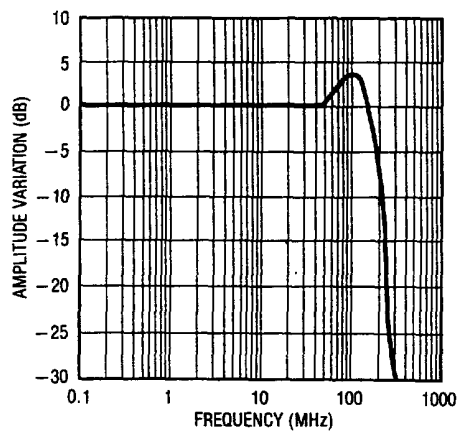
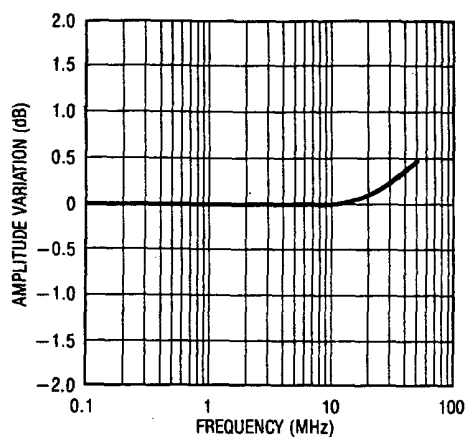
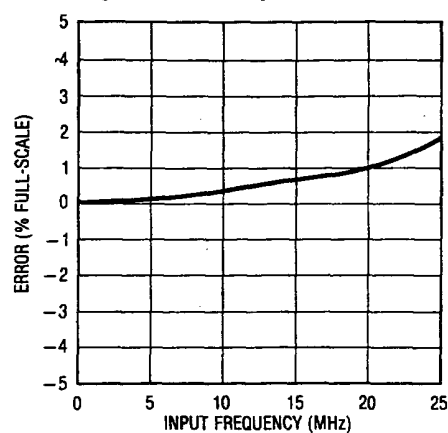


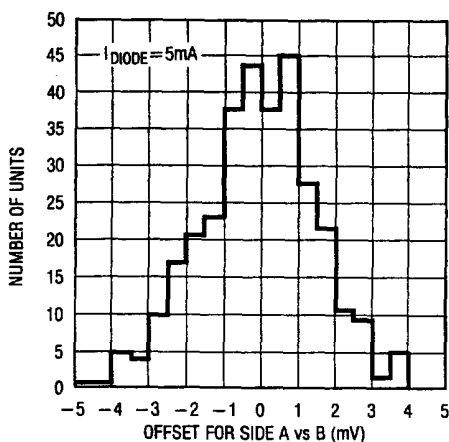
Figure 4's Response vs Frequency—250Ω Input



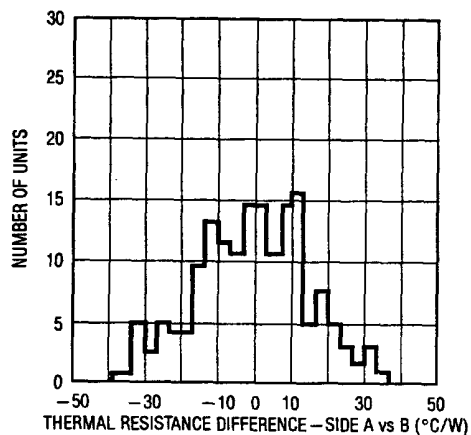
Accuracy vs Frequency for Figure 4—250Ω Input



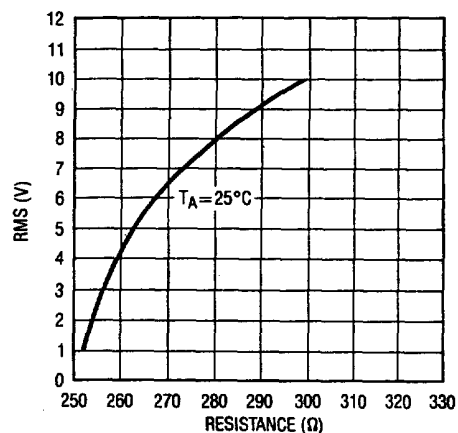
Distribution of Diode Offset Voltage



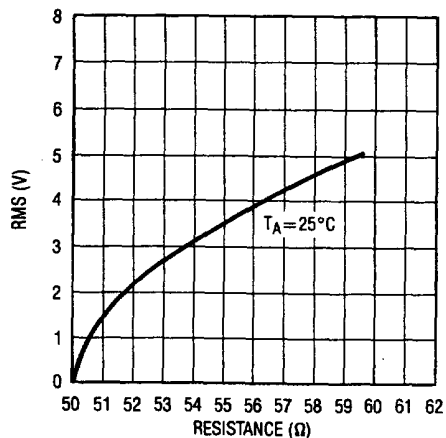
Distribution of Thermal Resistance



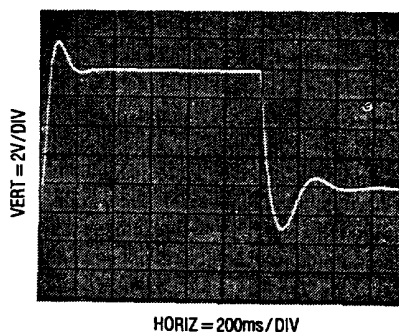
Heater Resistance vs RMS Volts—250Ω Heater



Heater Resistance vs RMS Volts—500Ω Heater



Figures 4's Settling Time (LT1088CD)



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# APPLICATIONS INFORMATION

## Pin Functions

**A<sub>IN</sub> 50Ω, B<sub>IN</sub> 50Ω, A<sub>IN</sub> 250Ω, B<sub>IN</sub> 250Ω (Pins 2, 9, 3, 10):** Heater input pins. Input and servo amplifier are connected to these pins. Since the LT1088 is symmetrical, either channel A or B may be used as the input. For higher input impedance, the 50Ω and 250Ω heaters may be series connected. No heater pin may be below V<sup>-</sup> or more than 40V above V<sup>-</sup>. Maximum heater dissipation must not exceed the absolute maximum ratings.

**A<sub>IN</sub> COM, B<sub>IN</sub> COM (Pins 1, 8):** Common point for the 50Ω and 250Ω input heaters, usually tied to ground.

**A<sub>OUT</sub><sup>+</sup>, B<sub>OUT</sub><sup>+</sup> (Pins 12, 5):** High side of the temperature sensing diodes. Normally they are driven at 5mA from the positive supply. No diode pin may be below V<sup>-</sup> or more than 40V above V<sup>-</sup>.

**A<sub>OUT</sub><sup>-</sup>, B<sub>OUT</sub><sup>-</sup> (Pins 13, 6):** Low side of the temperature sensing diodes. These pins are normally tied to ground. No diode pin may be below V<sup>-</sup> or more than 40V above V<sup>-</sup>.

**V<sup>-</sup> (Pins 7, 14):** These pins must be the most negative potential of the circuit, usually tied to ground.

## Parasitic Diodes

As with all bipolar ICs the LT1088 contains parasitic diodes which must not be forward biased. The parasitic diodes, marked with asterisks, appear in Figure 1. The

dashed lines indicate that all points of the heaters are parasitically diode connected to V<sup>-</sup>.

## Thermal Considerations

Because the LT1088's operation depends on thermal symmetry, it is sensitive to external temperature gradients. This is particularly the case for small inputs, which cause the device to run very close to ambient temperature. The device should be mounted in an area which is isothermal and free of drafts. Power generating components should be kept away from the LT1088 and particular caution taken in fan cooled equipment. Under normal conditions no thermal baffle or enclosure is required. Under no circumstances should a heat sink be used.

## Heater Protection

Most LT1088 failures will be caused by excessive heater drive. Input power (25°C) is specified at 375mW with 30 second excursions to 435mW permitted. These figures are derated by -3mW/°C above 25°C. Figure 2 plots safe operating limits for input duty cycle vs input voltage. Accidental heater overdrives can damage or destroy the LT1088. In situations where overdrive may occur, some form of heater protection should be employed. Suggested circuits appear in the applications section.

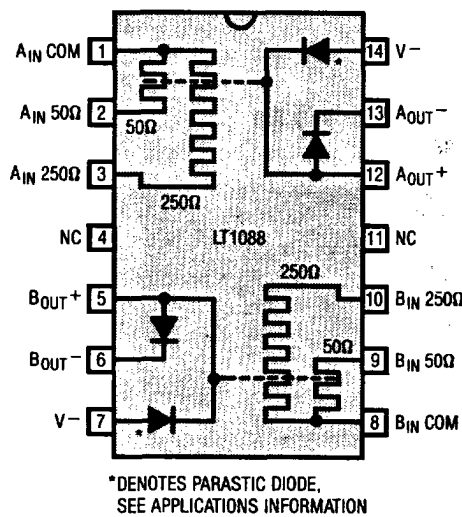


Figure 1

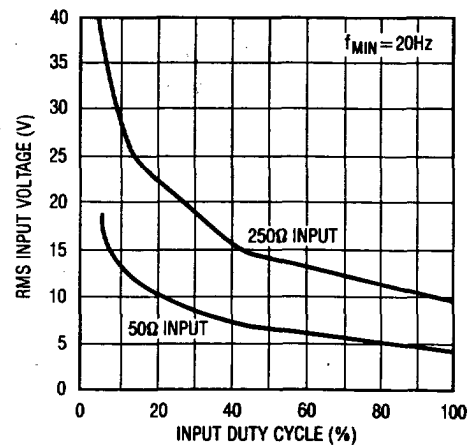


Figure 2. Safe Operating Limits

## APPLICATIONS INFORMATION

### Filtering

The LT1088's thermal time constant provides effective low pass filtering. Low frequency cut-off is set by servo loop time constants. For the 3300pF value given in the basic RMS-DC application, the circuit begins to follow the input below about 50Hz. Normally, this is not a problem, because the LT1088's primary application will be at high frequency. Lower frequency operation is obtainable by increasing the 3300pF value, although settling time will increase proportionally.

### Crest Factor

Crest factor is defined as the ratio of peak input voltage to RMS value. Crest factor performance is set by IC breakdown limits and the usable low input power range. Breakdown limits are a function of processing. The usable low input power range is a basic signal-to-noise conflict. Low input power produces small amounts of signal. This makes accurate, stable discrimination between desired inputs and ambient thermal phenomena uncertain and noisy. These constraints set crest factor at 50:1 for the 50 $\Omega$  input and 40:1 for the 250 $\Omega$  input.

### Layout

At frequencies above 10MHz, input connections require care. Parasitic inductance builds quickly in wire runs, so

the LT1088's input heater lead should be *directly* connected to the source to be measured. It is also wise to shield the input line from the rest of the circuit. The heater common should be returned directly to a ground plane. An additional precaution is to mount the 0.01 $\mu$ F bypass capacitors right at the LT1088 package. These units minimize the effects of RF pick-up by the temperature sensing diodes.

### Accuracy

Amplitude measurement at high frequency to significant accuracy is difficult because of parasitic effects. At frequencies much above 5MHz, small parasitic capacitive and inductive terms become important. The accuracy figures quoted for the applications circuits were taken against certified standards utilizing direct and transfer techniques. Thermal transfer standards (Fluke Model 540B with A-55 converters) certified to 50MHz were used as references. The data above 50MHz was also taken with these references, although the individual units used had not been certified at these frequencies. The accuracy of units of this type which have been certified is normally inside the tolerances listed, so there is good probability the data is valid.

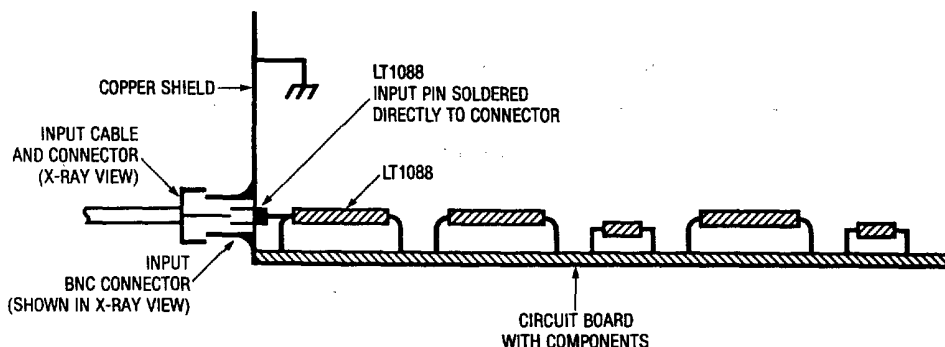


Figure 3. Typical Evaluation Layout

APPLICATIONS INFORMATION

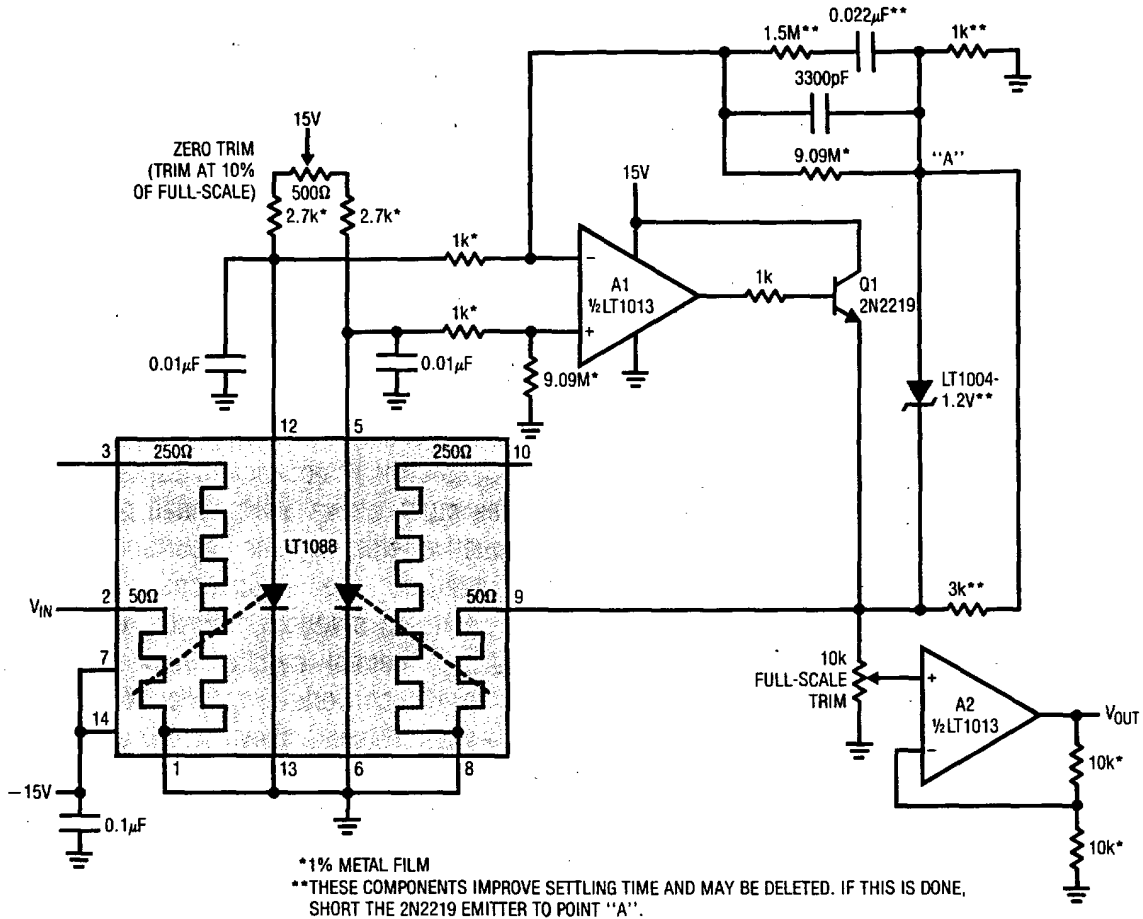


Figure 4. Basic RMS-DC Converter

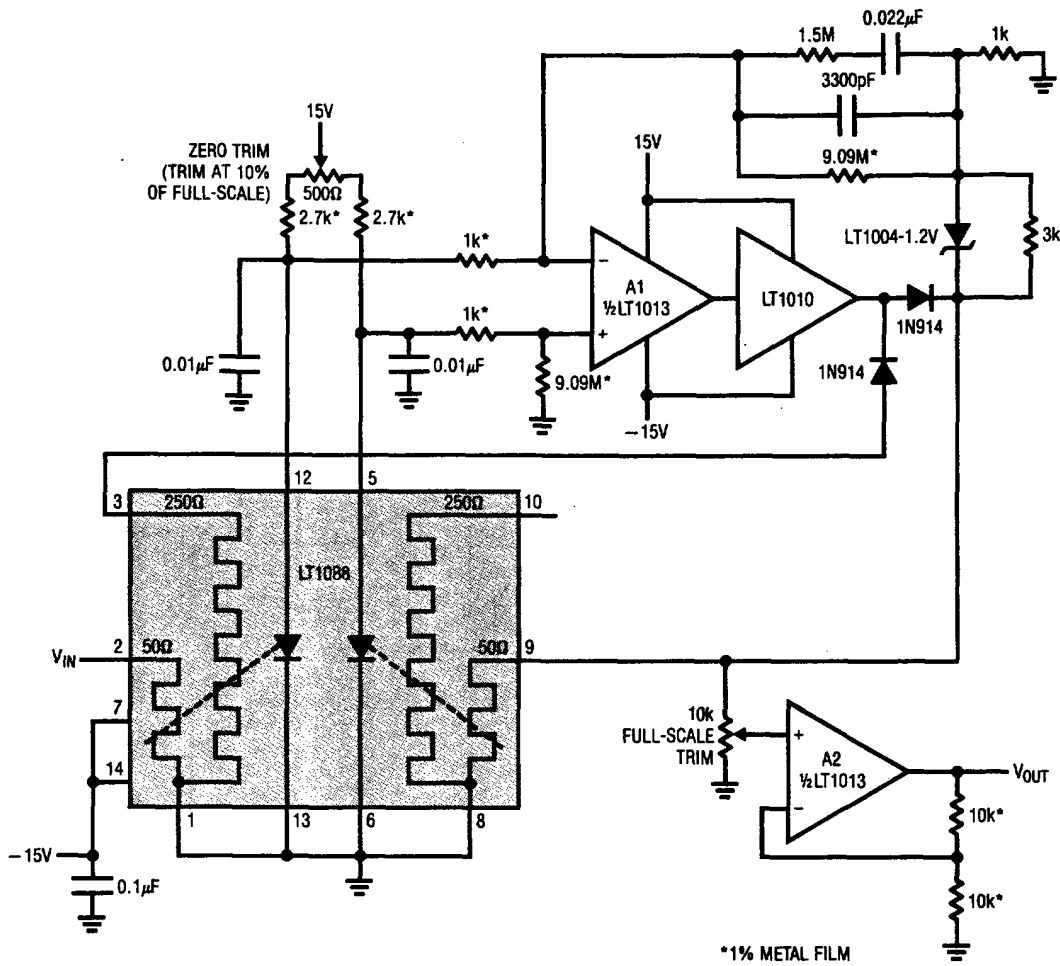
Figure 4's Typical Specifications

Accuracy:	Crest Factor:
50Ω Input	50Ω Input ..... 50:1
DC to 50MHz ..... 1% FS	250Ω Input ..... 40:1
DC to 100MHz ..... 2% FS	3dB Bandwidth ..... 300MHz
250Ω Input	Full-Scale Settling Time (1%) ..... 500ms (LT1088CD)
DC to 20MHz ..... 1% FS	..... 710ms (LT1088CN)
Temperature Effect on Accuracy ..... 100ppm/°C	Input Voltage Range (25°C)
Dynamic Range ..... 20:1 (LT1088CD)/14:1 (LT1088CN)	50Ω Input ..... 4.25V
	250Ω Input ..... 9.5V



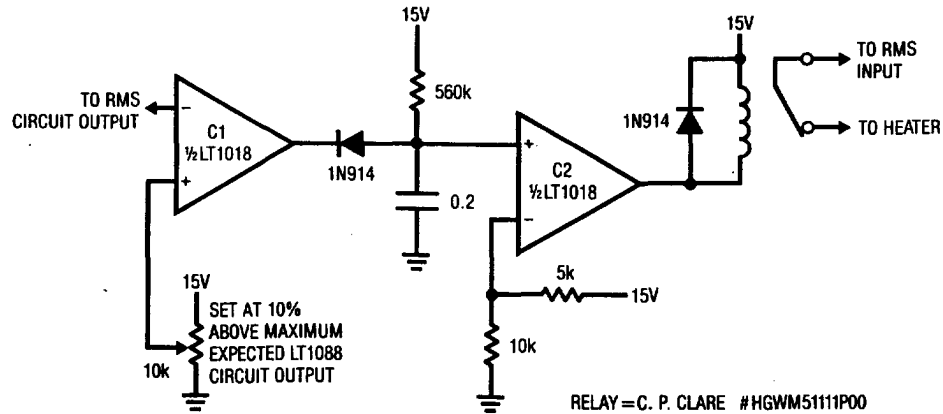
APPLICATIONS

Fast Settling RMS-DC Converter

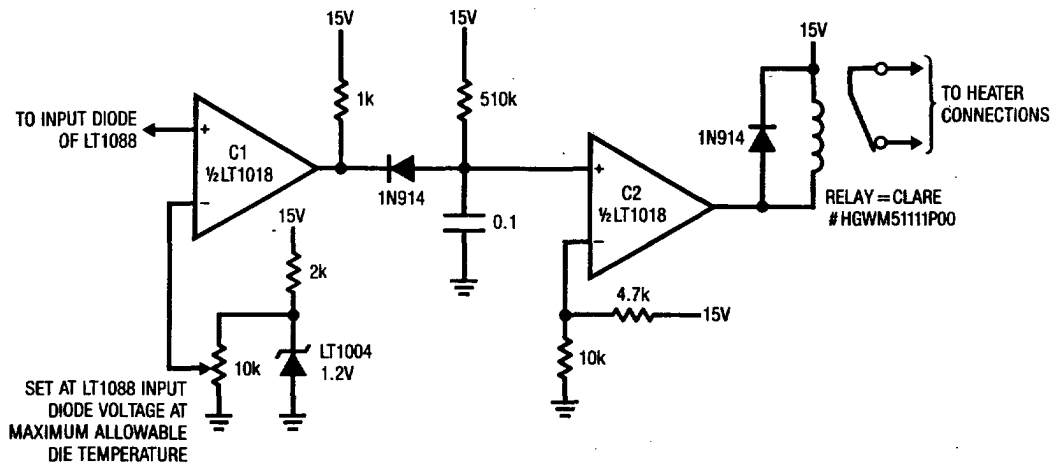


# APPLICATIONS

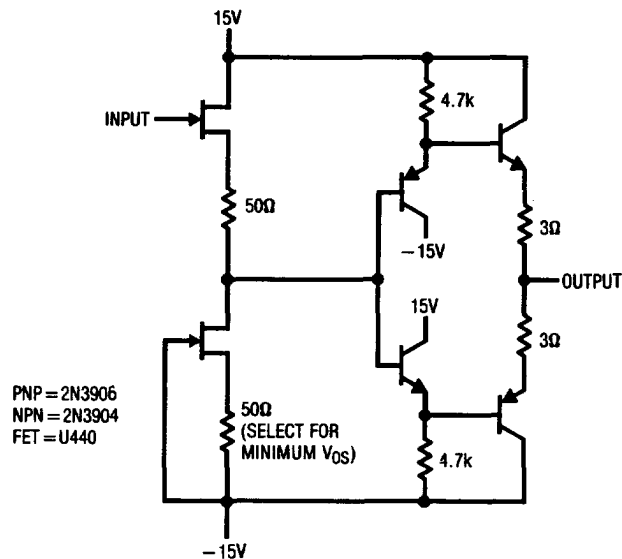
**Servo-Sensed Heater Protection Circuit ( $\approx 50\text{ms}$  Response)**



**Diode Sensed Heater Protection Circuit ( $\approx 15\text{ms}$  Response)**



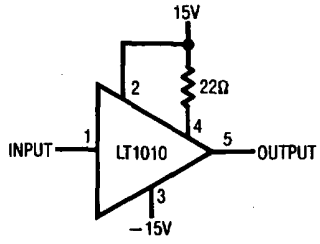
**Discrete Input Buffer for the LT1088**



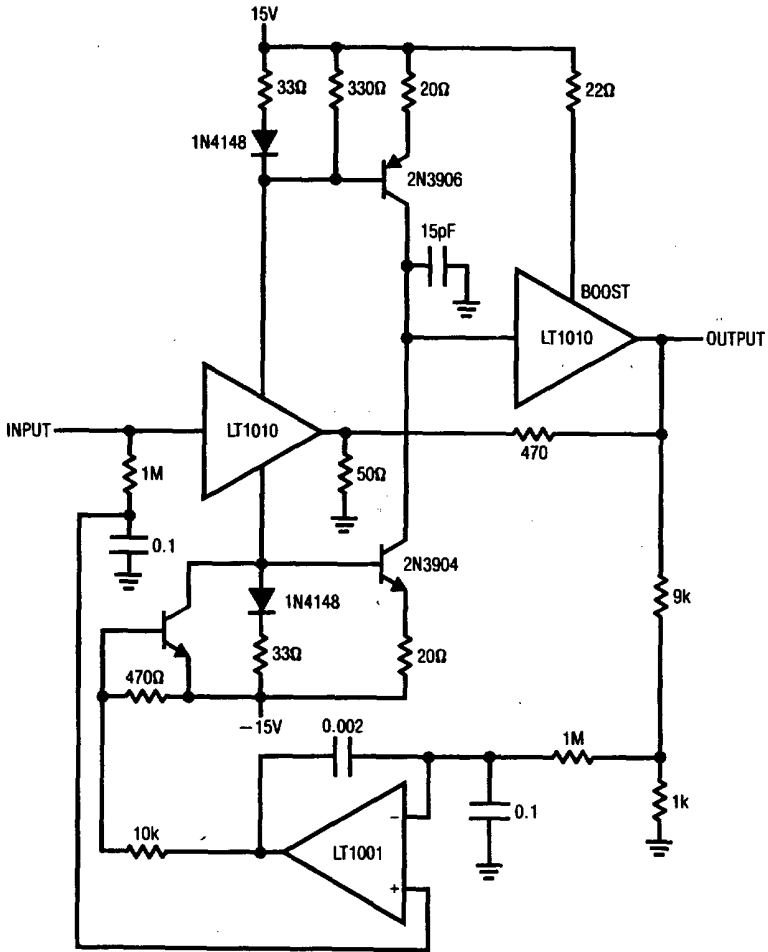


# APPLICATIONS

LT1010 Buffer†



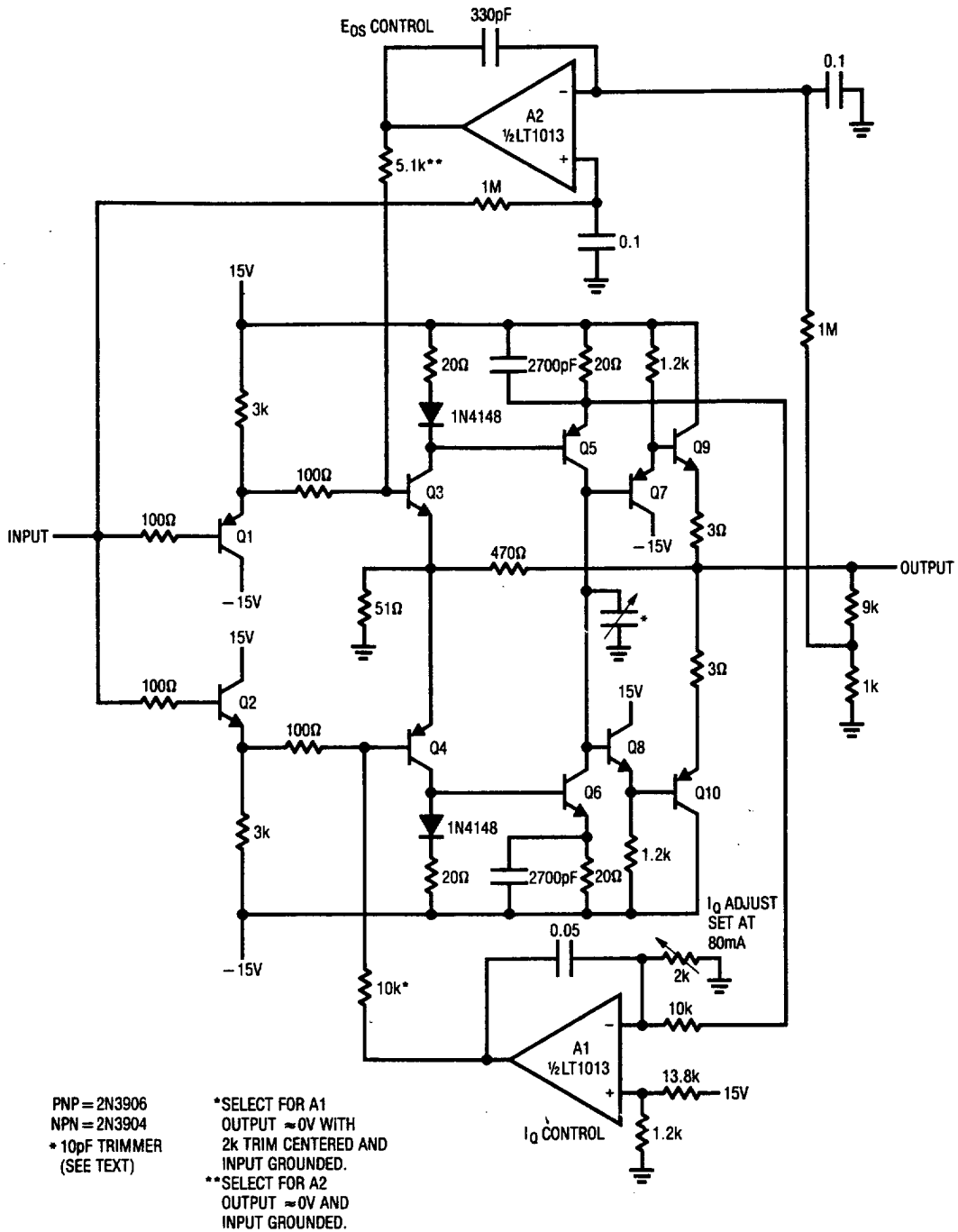
LT1010 Buffer with Gain of 10†



† See Summary of Buffer Characteristics table for buffer speed.

APPLICATIONS

Wideband Discrete Buffer with Gain = 10†



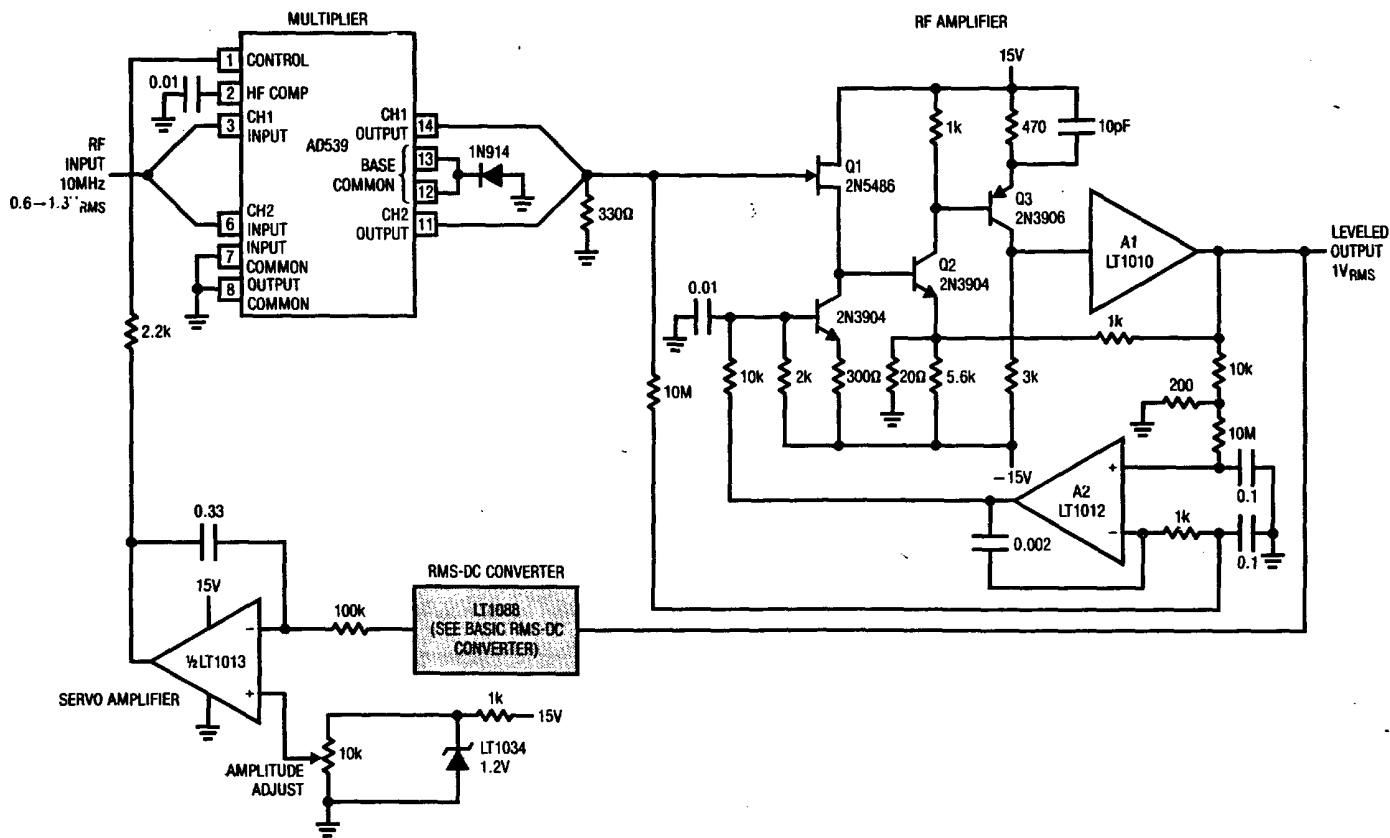
† See Summary of Buffer Characteristics table for buffer speed.

# APPLICATIONS

Summary of Buffer Characteristics

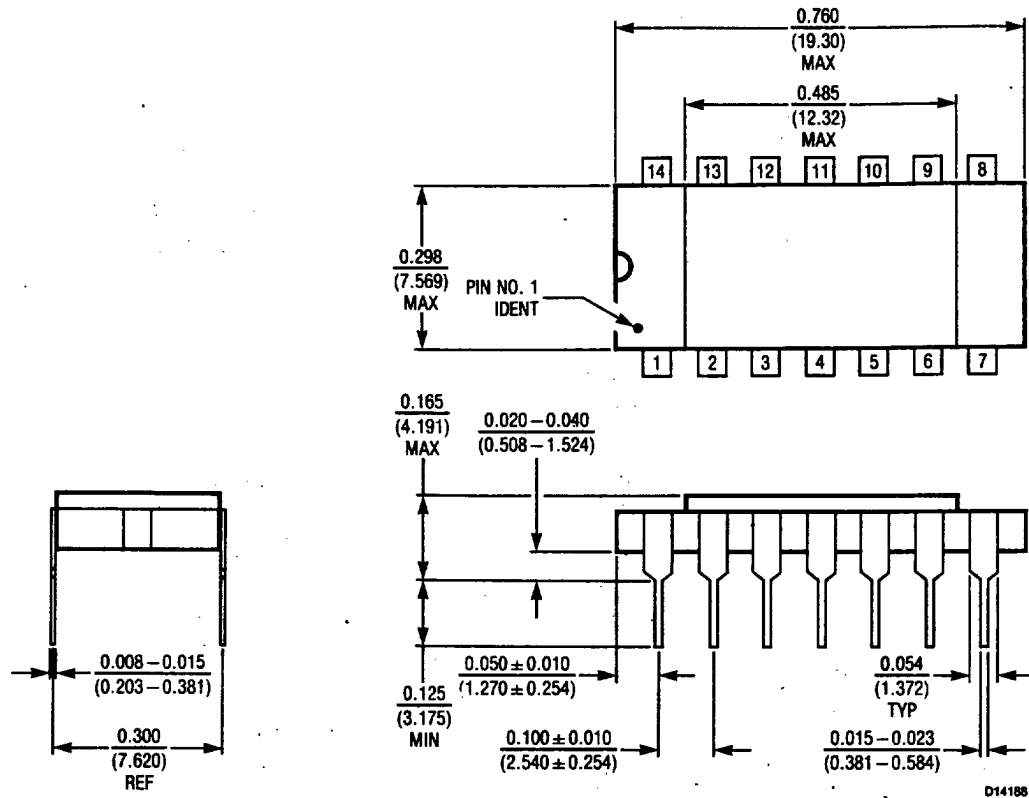
Type of Buffer	Slew Rate	1% Error Bandwidth	
		250Ω Load (± 10V <sub>OUT</sub> )	50Ω Load (± 5V <sub>OUT</sub> )
Discrete—A = 10	3000V/μs	25MHz	32MHz
LT1010 Based—A = 10	100V/μs	0.75MHz	2MHz
Discrete—A = 1	2000V/μs	15MHz	25MHz
LT1010 Based—A = 1	100V/μs	0.75MHz	2MHz

RF Leveling Loop



**PACKAGE DESCRIPTION** Dimensions in inches (millimeters) unless otherwise noted.

**D Package**  
14-Lead Sidebraced Ceramic DIP



**N Package**  
14-Lead Plastic DIP

