

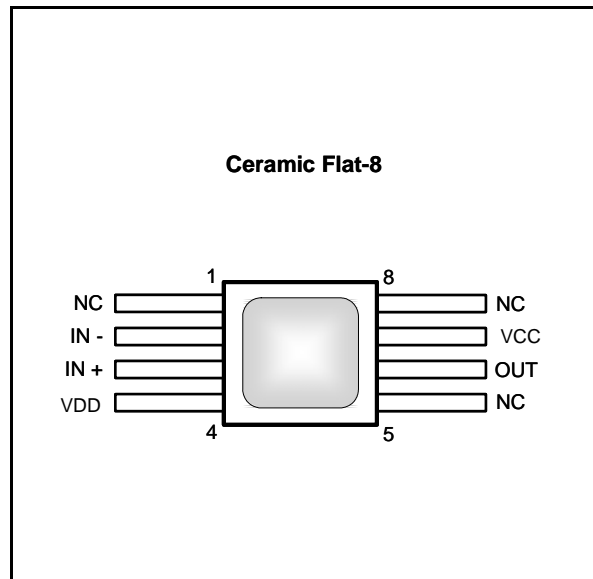


## RHF43B

RAD-hardened  
precision bipolar single operational amplifier

### Features

- High immunity to radiations, 300kRad TID; SEL immune at 68MeV/cm<sup>2</sup>/mg LET ions.
- Rail-to-rail input/output
- 8MHz gain bandwidth at 16V
- Stable for gain  $\geq 5$
- Low input offset voltage: 100 $\mu$ V typ
- Supply current: 2.2mA typ
- Operating from 3V to 16V
- Input bias current: 30nA typ
- ESD internal protection  $\geq 2$ kV
- Latch-up immunity: 200mA
- Soon RHA QML-V qualified with smd n° 5962-062xx



### Description

The RHF43B is a precision bipolar operational amplifier available in hermetic 8-pin flat package and in die form. In addition to its low offset voltage, rail-to-rail feature, wide supply voltage, the RHF43B is designed for increased tolerance to radiation. Its intrinsic ELDRS-free rad-hard design allows this product to be used in space environment and in applications operating in harsh environments.

### Applications

- Space probes and satellites
- Defense systems
- Scientific instrumentation
- Nuclear systems

# 1 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings (AMR)**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage <sup>(1)</sup>	18 ±9	V
$V_{id}$	Differential input voltage <sup>(2)</sup>	±1.2	V
$V_{in}$	Input voltage range <sup>(3)</sup>	$V_{DD}-0.3$ to 16	V
$I_{IN}$	Input current	45	mA
$T_{stg}$	Storage temperature	-65 to +150	°C
$R_{thja}$	Thermal resistance junction to ambient <sup>(4)(5)</sup>	125	°C/W
$R_{thjc}$	Thermal resistance junction to case <sup>(4)(5)</sup>	80	°C/W
$T_j$	Maximum junction temperature	150	°C
ESD	HBM: human body model <sup>(6)</sup>	2	kV
	Latch-up immunity	200	mA
	Lead temperature (soldering, 10 sec)	260	°C
<b>Radiation related parameters</b>			
	Low dose rate of 0.01 rad.sec <sup>-1</sup>	300	kRad
	High dose rate of 50-300 rad.sec <sup>-1</sup>	300	kRad
	Heavy ion latch-up (SEL) immune with heavy ions characterized by:	68	MeV.cm <sup>-2</sup> .mg
	Neutron immunity	2 <sup>+14</sup>	n.cm <sup>-2</sup>

1. All values, except differential voltage are with respect to network terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. The magnitude of input and output terminal must never exceed  $V_{CC}+0.3V$ .
4. Short-circuits can cause excessive heating and destructive dissipation.
5.  $R_{th}$  are typical values.
6. Human body model: 100pF discharged through a 1.5kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.

**Table 2. Operating conditions**

Symbol	Parameter	Value	Unit
$V_{CC}$	Supply voltage	3 to 16	V
$V_{icm}$	Common mode input voltage range	$V_{DD}$ to $V_{CC}$	V
$T_{oper}$	Operating free air temperature range	-55 to +125	°C

## 2 Electrical characteristics

**Table 3.**  $V_{CC} = +16V$ ,  $V_{DD} = 0V$ ,  $V_{icm} = V_{CC}/2$ ,  $T_{amb} = 25^{\circ}C$ ,  $R_L$  connected to  $V_{CC}/2$  (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
$V_{io}$	Offset voltage	$T = 25^{\circ}C$		100	300	$\mu V$
		$T_{min} < T_{op} < T_{max}$			500	
$DV_{io}$	Input offset voltage drift			1		$\mu V/^{\circ}C$
$I_{ib}$	Input bias current	$V_{icm} = V_{CC}/2$ , $T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$		30	60 100	nA
$DI_{ib}$	Input offset current temperature drift			100		$pA/^{\circ}C$
$I_{io}$	Input offset current ( $V_{out} = V_{CC}/2$ )	$V_{icm} = V_{CC}/2$ , $T = 25^{\circ}C$ $T_{min} < T_{op} < T_{max}$		1	15 35	nA
CMR	Common mode rejection ratio	$0 < V_{icm} < 16V$ $T_{min} < T_{op} < T_{max}$	72 72	110		dB
SVR	Supply rejection ratio	$3V < V_{CC} < 16V$ , $V_{icm} = V_{CC}/2$ $T_{min} < T_{op} < T_{max}$	90 80	120		dB
$A_{VD}$	Large signal voltage gain	$R_L = 10k\Omega$ , $V_{out} = 0.5V$ to $15.5V$ $T_{min} < T_{op} < T_{max}$	74 60	85		dB
$V_{OH}$	High level output voltage	$R_L = 1k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$	15.7 15.6	15.8		V
		$R_L = 10k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$	15.9 15.8	15.96		V
$V_{OL}$	Low level output voltage	$R_L = 1k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$		0.1	0.2 0.3	V
		$R_L = 10k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$		0.04	0.06 0.1	V
$I_{out}$	Output sink current	$V_{out} = V_{CC}$ $T_{min} < T_{op} < T_{max}$	20 15	30		mA
	Output source current	$V_{out} = V_{DD}$ $T_{min} < T_{op} < T_{max}$	15 10	25		
$I_{CC}$	Supply current	No load $T_{min} < T_{op} < T_{max}$		2.5	2.9	mA
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 1k\Omega$ , $C_L = 100pF$ , $f = 100kHz$ $T_{min} < T_{op} < T_{max}$	6 3.5	8		MHz
$F_u$	Unity gain frequency	$R_L = 1k\Omega$ , $C_L = 100pF$		5		MHz
$\phi_m$	Phase margin	$R_L = 1k\Omega$ , $C_L = 100pF$ , $G=5$		50		Degrees

**Table 3.**  $V_{CC} = +16V$ ,  $V_{DD} = 0V$ ,  $V_{icm} = V_{CC}/2$ ,  $T_{amb} = 25^{\circ}C$ ,  $R_L$  connected to  $V_{CC}/2$  (unless otherwise specified) (continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
SR	Slew rate	$R_L = 1k\Omega$ , $C_L = 100pF$ $T_{min} < T_{op} < T_{max}$	2 1.7	3		V/ $\mu s$
$e_n$	Equivalent input noise voltage	$f = 1kHz$		8		$\frac{nV}{\sqrt{Hz}}$
THD+ $e_n$	Total harmonic distortion	$V_{out} = (V_{CC}-1V)/5$ , $G = -5.1$ , $V_{icm} = V_{CC}/2$		0.01		%

**Table 4.**  $V_{CC} = +3V$ ,  $V_{DD} = 0V$ ,  $V_{icm} = V_{CC}/2$ ,  $T_{amb} = 25^{\circ}C$ ,  $R_L$  connected to  $V_{CC}/2$  (unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
<b>DC performance</b>						
$V_{io}$	Offset voltage	$T=25^{\circ}C$		100	300	$\mu V$
		$T_{min} < T_{op} < T_{max}$			500	
$DV_{io}$	Input offset voltage drift			1		$\mu V/^{\circ}C$
$I_{ib}$	Input bias current	$V_{CC}=4V$ , $V_{icm}=V_{CC}/2$ , $T=25^{\circ}C$ $T_{min} < T_{op} < T_{max}$		30	60 100	nA
$DI_{ib}$	Input offset current temperature drift	$V_{CC}=4V$ , $V_{icm}=V_{CC}/2$		100		$pA/^{\circ}C$
$I_{io}$	Input offset current ( $V_{out} = V_{CC}/2$ )	$V_{CC}=4V$ , $V_{icm}=V_{CC}/2$ , $T=25^{\circ}C$ $T_{min} < T_{op} < T_{max}$		1	15 35	nA
CMR	Common mode rejection ratio	$0 < V_{icm} < 3V$ $T_{min} < T_{op} < T_{max}$	72 72	90		dB
$A_{VD}$	Large signal voltage gain	$R_L = 10k\Omega$ , $V_{out}=0.5V$ to $2.5V$ $T_{min} < T_{op} < T_{max}$	74 60	85		dB
$V_{OH}$	High level output voltage	$R_L = 1k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$	2.9 2.8	2.95		V
		$R_L = 10k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$	2.94 2.9	2.98		V
$V_{OL}$	Low level output voltage	$R_L = 1k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$		0.05	0.1 0.2	V
		$R_L = 10k\Omega$ connected to $V_{CC}/2$ $T_{min} < T_{op} < T_{max}$		0.02	0.06 0.1	V
$I_{out}$	Output sink current	$V_{out} = V_{CC}$ $T_{min} < T_{op} < T_{max}$	20 15	30		mA
	Output source current	$V_{out} = V_{DD}$ $T_{min} < T_{op} < T_{max}$	15 10	25		
$I_{CC}$	Supply current per amplifier	No load $T_{min} < T_{op} < T_{max}$		2.2	2.6	mA
<b>AC performance</b>						
GBP	Gain bandwidth product	$R_L = 1k\Omega$ , $C_L = 100pF$ , $f = 100kHz$ $T_{min} < T_{op} < T_{max}$	6 3.5	7.5		MHz
$F_u$	Unity gain frequency	$R_L = 1k\Omega$ , $C_L = 100pF$		5		MHz
$\phi_m$	Phase margin	$R_L = 1k\Omega$ , $C_L = 100pF$ , $G=5$		50		Degrees
SR	Slew rate	$R_L = 1k\Omega$ , $C_L = 100pF$ $T_{min} < T_{op} < T_{max}$	2 1.7	2.7		V/ $\mu s$
$e_n$	Equivalent input noise voltage	$f = 1kHz$		8		$\frac{nV}{\sqrt{Hz}}$
THD+ $e_n$	Total harmonic distortion	$V_{out} = (V_{CC}-1V)/5$ , $G= -5.1$ , $V_{icm}=V_{CC}/2$		0.01		%

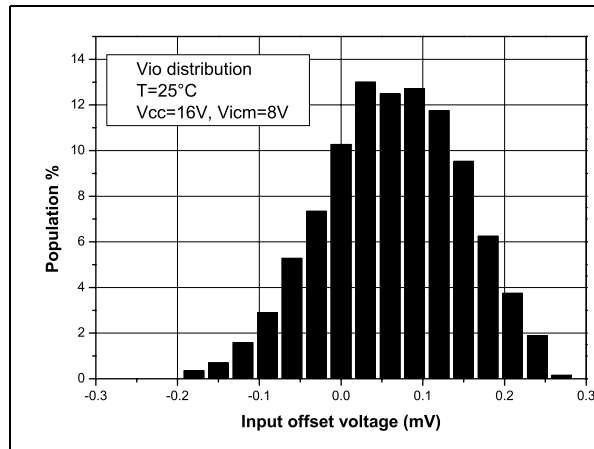
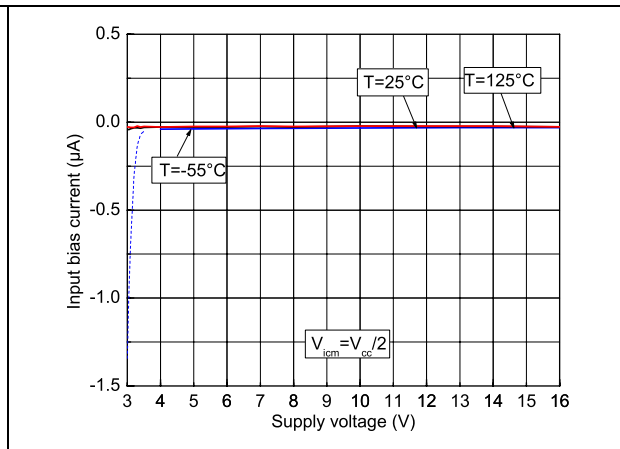
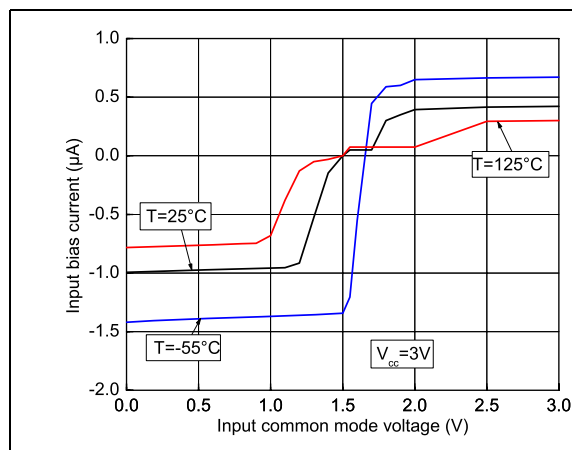
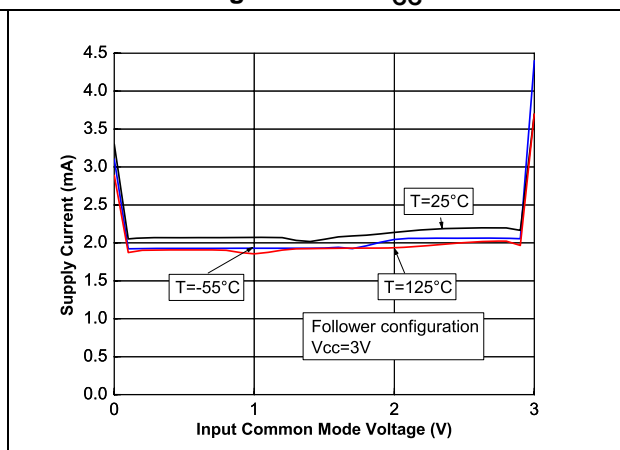
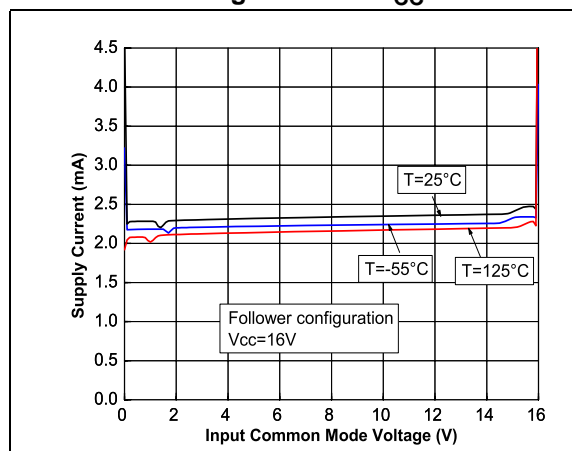
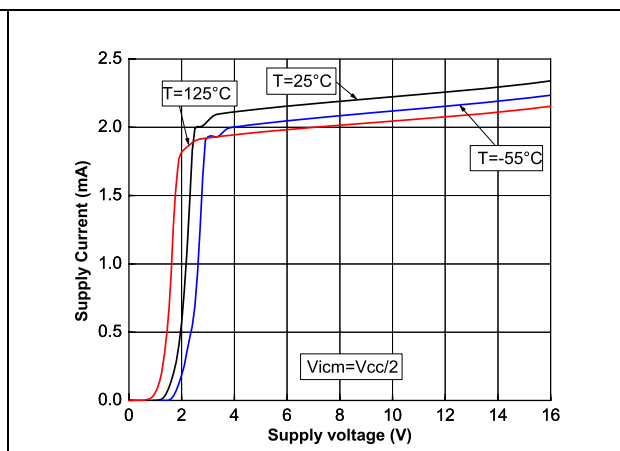
**Figure 1. Input offset voltage distribution at  $T = 25^{\circ}\text{C}$** **Figure 2. Input bias current vs. supply voltage****Figure 3. Input bias current vs. input common mode voltage at  $V_{CC} = 3\text{V}$** **Figure 4. Supply current vs. input common mode voltage in follower configuration at  $V_{CC} = 3\text{V}$** **Figure 5. Supply current vs. input common mode voltage in follower configuration at  $V_{CC} = 16\text{V}$** **Figure 6. Supply current vs. supply voltage at  $V_{icm} = V_{CC}/2$** 

Figure 7. Output current vs. supply voltage at  $V_{icm} = V_{CC}/2$

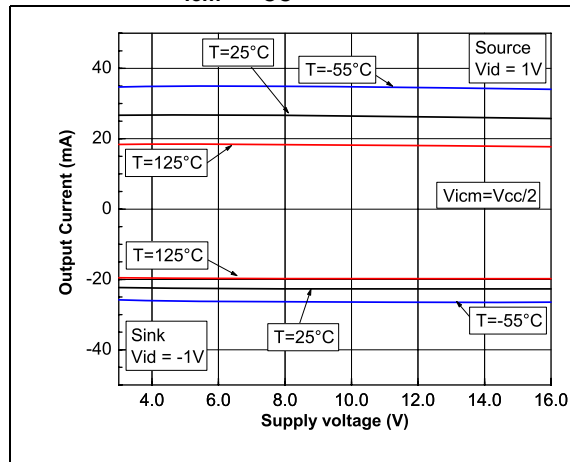


Figure 8. Output current vs. output voltage at  $V_{CC} = 3V$

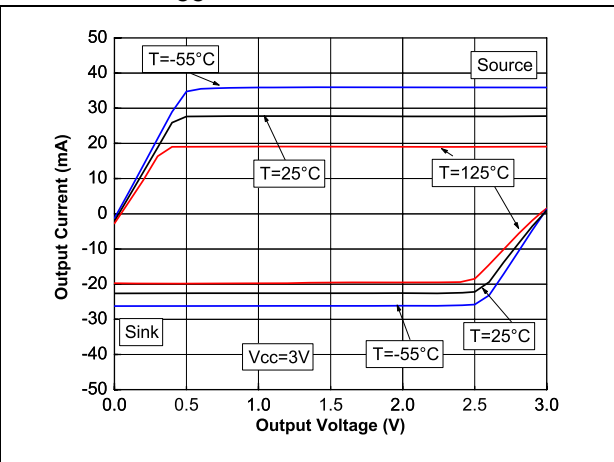


Figure 9. Output current vs. output voltage at  $V_{CC} = 16V$

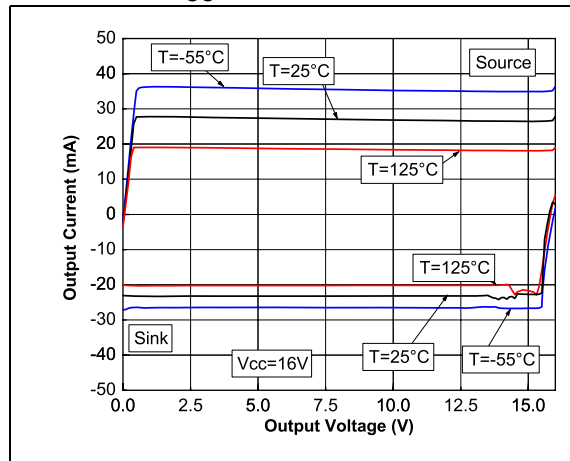


Figure 10. Differential input voltage vs. output voltage at  $V_{CC} = 3V$

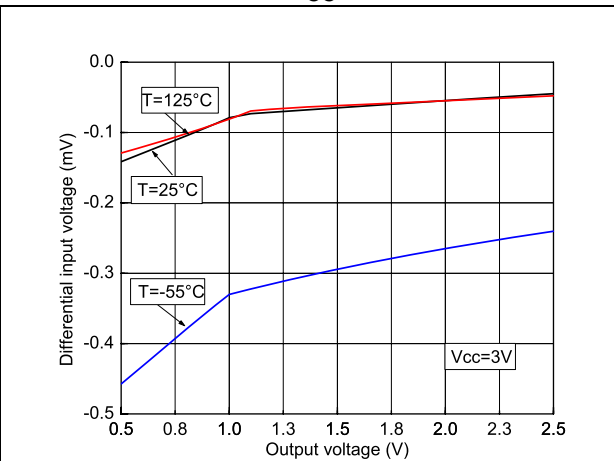


Figure 11. Differential input voltage vs. output voltage at  $V_{CC} = 16V$

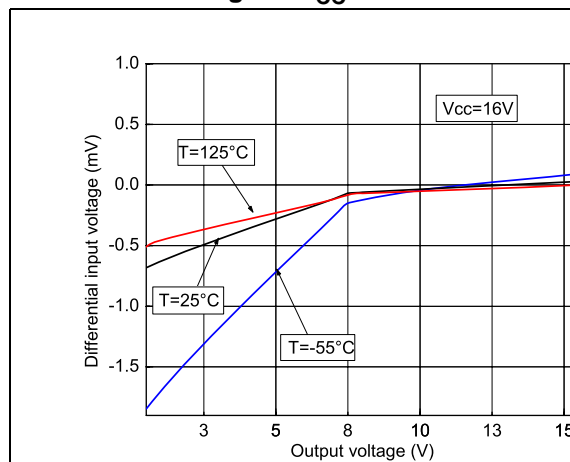
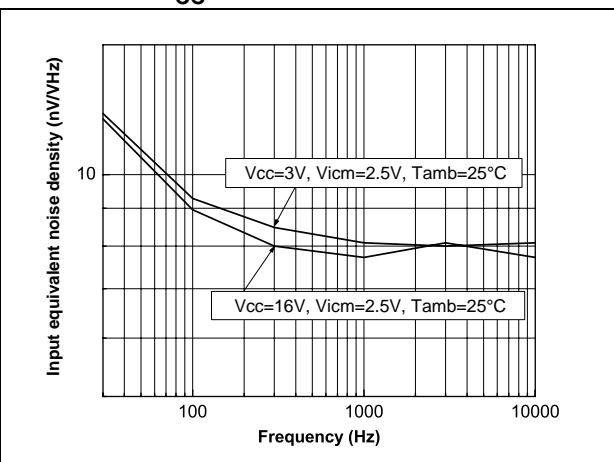
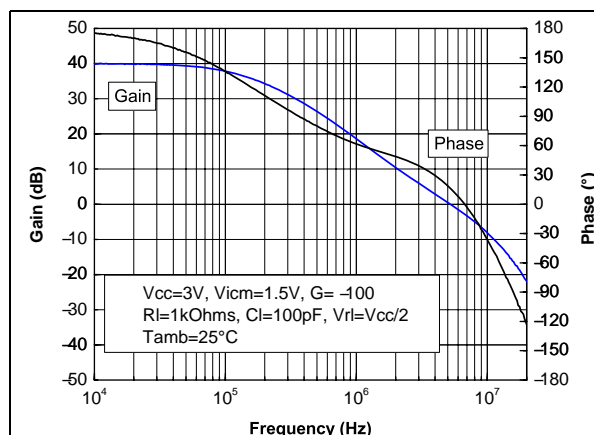


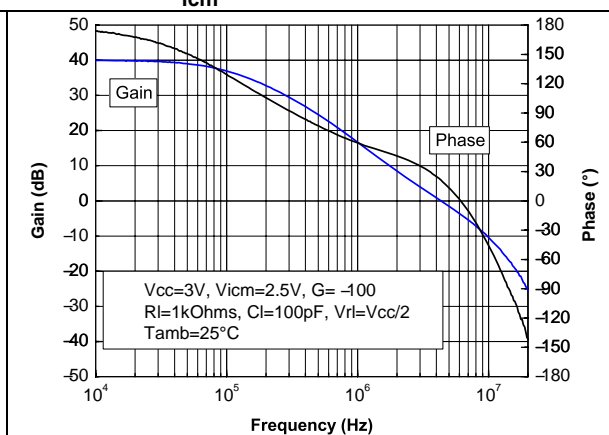
Figure 12. Noise vs. frequency at  $V_{CC} = 3V$  and  $V_{CC} = 16V$



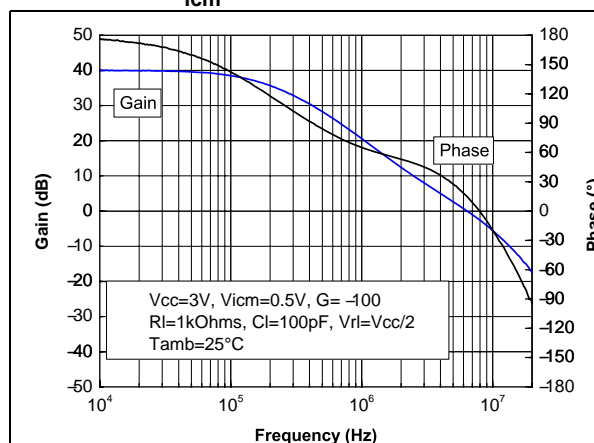
**Figure 13. Voltage gain and phase vs. frequency at  $V_{CC}=3V$ ,  $V_{icm}=1.5V$ , and  $T=25^{\circ}C$**



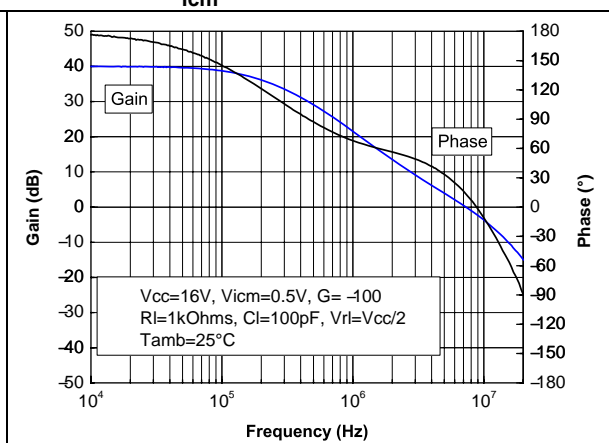
**Figure 14. Voltage gain and phase vs. frequency at  $V_{CC}=3V$  and  $V_{icm}=2.5V$  at  $T=25^{\circ}C$**



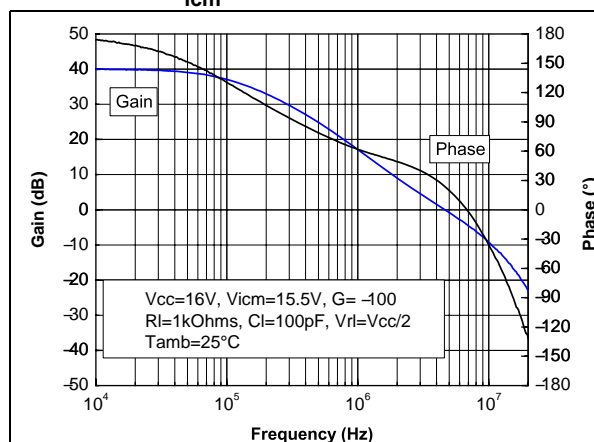
**Figure 15. Voltage gain and phase vs. frequency at  $V_{CC}=3V$  and  $V_{icm}=0.5V$  at  $T=25^{\circ}C$**



**Figure 16. Voltage gain and phase vs. frequency at  $V_{CC}=16V$  and  $V_{icm}=8V$  at  $T=25^{\circ}C$**



**Figure 17. Voltage gain and phase vs. frequency at  $V_{CC}=16V$  and  $V_{icm}=15.5V$  at  $T=25^{\circ}C$**



**Figure 18. Voltage gain and phase vs. frequency at  $V_{CC}=16V$  and  $V_{icm}=0.5V$  at  $T=25^{\circ}C$**

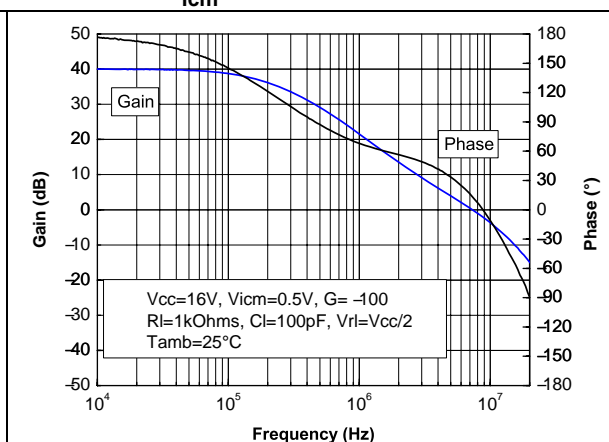




Figure 19. Inverting large signal pulse response at  $V_{CC}=3V$ ,  $T=25^{\circ}C$

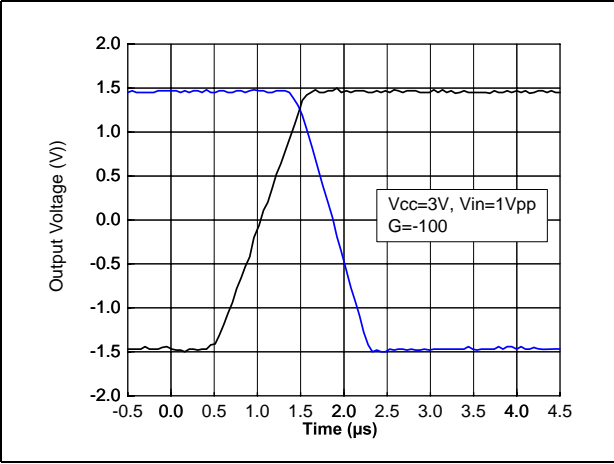
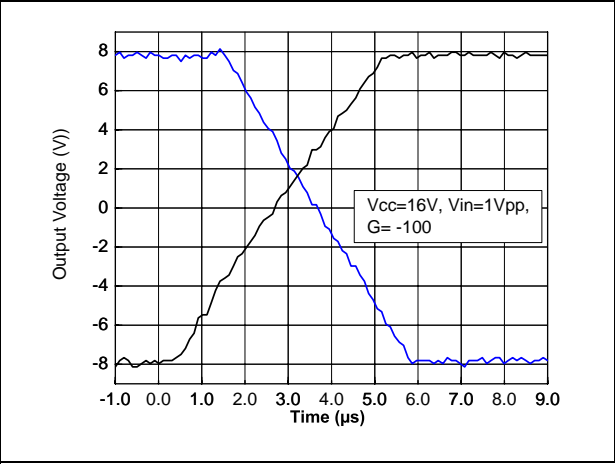
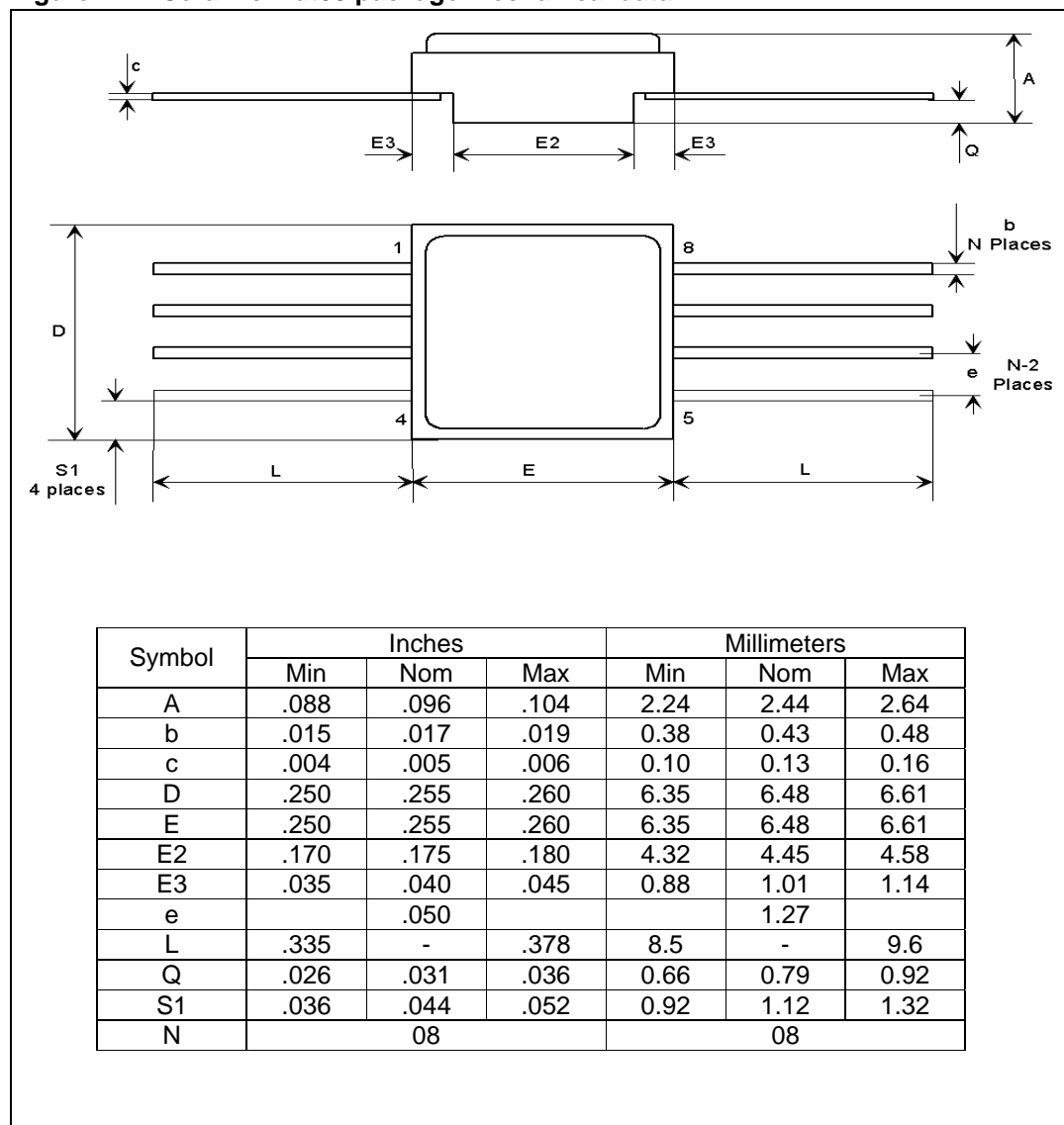


Figure 20. Inverting Large signal pulse response at  $V_{CC}=16V$ ,  $T=25^{\circ}C$



### 3 Package information

Figure 21. Ceramic Flat08 package mechanical data



## 4 Ordering information

Table 5. Order codes

Order code	Description	Temperature range	Package	Packing	Marking
RHF43BK-01V	Flight parts	-55°C, +125°C	Flat08	Individual cavity anti-static material trays	Marked against QML SMD
RHF43BK1	Engineering samples	-55°C, +125°C	Flat08	Individual cavity anti-static material trays	RHF43BK1
RHF43BK2	Engineering samples with 48h burn-in	-55°C, +125°C	Flat08	Individual cavity anti-static material trays	RHF43BK2
43BDIE2V	QMLV	-55°C, +125°C	Naked die	Waffle-pack	No die marking

## 5 Revision history

Table 6. Document revision history

Date	Revision	Changes
21-May-2007	1	First public release.
10-Dec-2007	2	Changed name of pins on pinout diagram on cover page. Modified supply current values over temperature range in electrical characteristics. Power dissipation removed from AMR table.
29-Jan-2008	3	Added ELRS-free rad-hard design in description on cover page. Modified description of heavy ion latch-up (SEL) immunity parameter in <a href="#">Table 1 on page 2</a> .

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