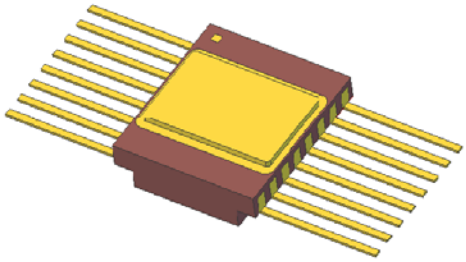
RHF200

Rad-hard, fully differential amplifier

Datasheet - production data



Ceramic Flat-16

The upper metallic lid is electronically connected to pin 16 (GND)

Features

- High input impedance
- 420 MHz bandwidth
- Single-ended input compatible
- Differential slew rate: 550 V/µs
- 4 gains selectable by 2 digital inputs
- Gain setting (V/V): 1, 1.33, 2, 4
- Output common-mode control
- Optimized output stage for short and long line driving
- 4.5 V to 5.5 V operating power supply range
- Settling time at 0.1 %, 200 Ω and 4 Vpp: 13 ns
- 300 krad MIL-STD-883 1019.9
- SEL immune
- SET characterized

Applications

- Space imaging and space data acquisition systems
- Aerospace instrumentation
- Harsh radiation environments
- ADC drivers

Description

The RHF200 is a very high-speed (420 MHz), pure, differential amplifier that operates with a power supply from 4.5 V to 5.5 V. Four gains can be set by two digital inputs.

It can be used as a differential-to-differential or single-differential amplifier, and it is able to drive either an ADC input or a 100 Ω differential line.

With its non-inverting architecture, the RHF200 features a high input impedance that is particularly intended to drive video signals from CCD sensors to an ADC.

The RHF200 is mounted in a hermetic ceramic Flat-16 package.

Table 1: Device summary

Parameter	RHF200K1	RHF200K01V
SMD [(1)]	—	5962F17210
Quality level	Engineering model	QML-V Flight
Package	Flat-16	Flat-16
Mass	0.65 g	0.65 g
Temperature range	-55 °C to 125 °C	-55 °C to 125 °C

Notes:

[(1)] SMD = standard microcircuit drawing

Contents

1 Functional description

Figure 1: Block diagram

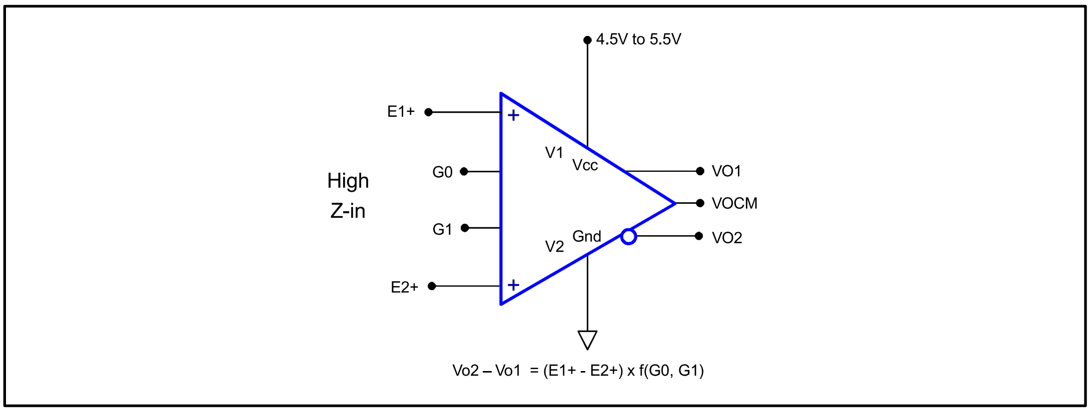
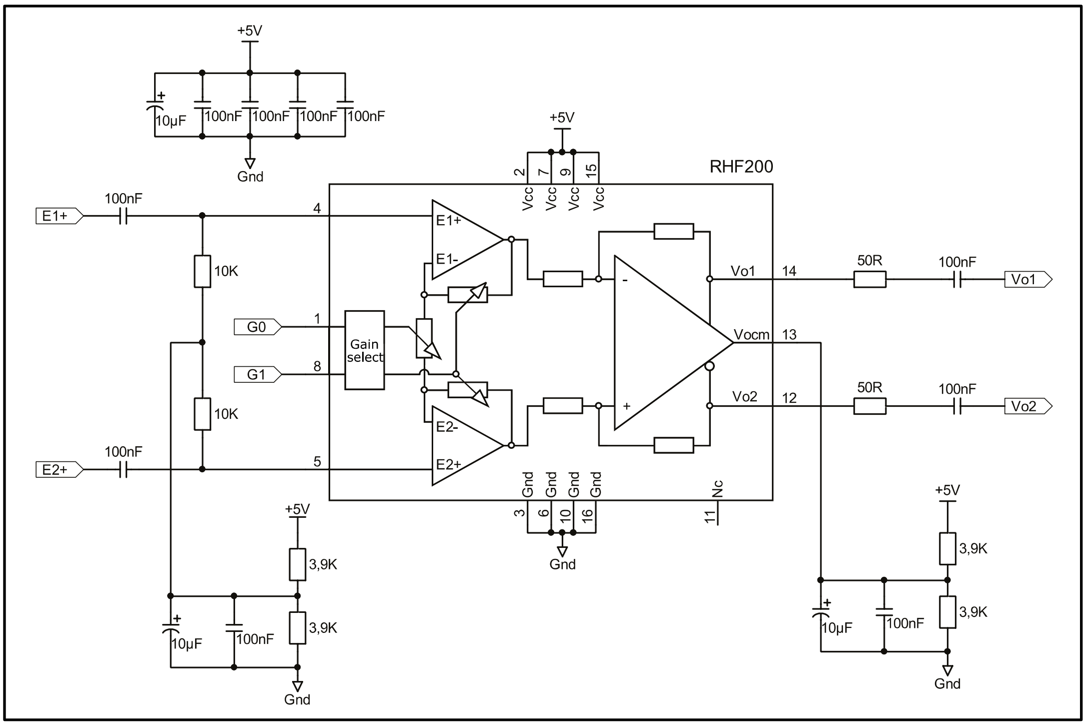
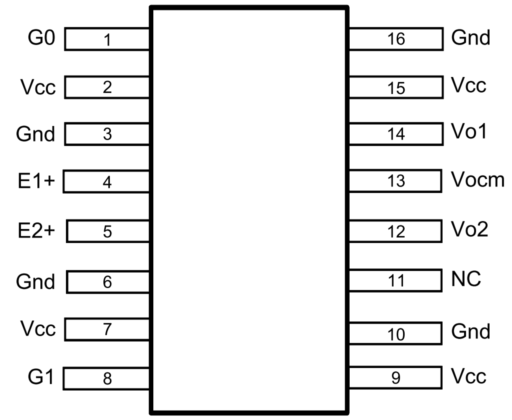


Figure 2: Typical application schematic



2 Pin description

Figure 3: Pin locations



1. Pins named Vcc **must be** externally connected together
2. Pins named Gnd **must be** externally connected together

Table 2: Pin description

Pin #	Name	Description
1	G0	Gain select
2	Vcc	Positive power supply
3	Gnd	Ground (reference level 0 V)
4	E1+	Positive input of amplifier 1
5	E2+	Positive input of amplifier 2
6	Gnd	Ground (reference level 0 V)
7	Vcc	Positive power supply
8	G1	Gain select
9	Vcc	Positive power supply
10	Gnd	Ground (reference level 0 V)
11	NC	Not connected
12	Vo2	Output 2 (in phase with E1+)
13	Vocm	Common-mode output voltage input pin
14	Vo1	Output 1 (in phase with E2+)
15	Vcc	Positive power supply
16	Gnd	Ground (reference level 0 V) - connected to upper metallic lid

Table 3: Truth table of RHF200

G1	G0	Gain (V/V)
0	0	1
0	1	1.33
1	0	2
1	1	4

3 Absolute maximum ratings and operating conditions

Table 4: Absolute maximum ratings

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage (1)	7	V
V_{in}	Input voltage range (2)	Gnd to Vcc	
V_{Gx}	Input voltage range on digital pin (3)	Gnd - 0.3 V to Vcc + 0.3 V	
T_{oper}	Operating free air temperature range	-55 to 125	°C
T_{stg}	Storage temperature	-65 to 150	
T_j	Maximum junction temperature (4)	150	
R_{thja}	thermal resistance junction to ambient	50	°C/W
R_{thjc}	thermal resistance junction to case	22	
ESD	HBM: human body model (5)	8	kV
	CDM: charged device model (6)	0.5	
IESD	ESD diode continuous current	10	mA
	Latch-up immunity	200	

Notes:

(1)All voltage values are measured with respect to the ground pin.

(2)The magnitude of input and output voltages must never exceed Gnd - 0.3 V and V_{CC} + 0.3 V.

(3)The magnitude of input and output voltages must never exceed Gnd - 0.3 V and V_{CC} + 0.3 V.

(4)Short-circuits can cause excessive heating. Destructive dissipation can result from short-circuits on all amplifiers.

(5)Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.

(6)Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to the ground through only one pin.

Table 5: Operating conditions

Symbol	Parameter	Value	Unit
V_{CC}	Supply voltage	4.5 to 5.5	V
V_{bias}	Input DC biasing range	1.6 to V_{CC} - 1.5	
V_{ocm}	Output common-mode range	0.8 to V_{CC} - 1.8	
V_{InAC}	Usable input signal range (1)	1.3 to V_{CC} - 1.3	
R_L	Minimum load impedance	190	Ω
C_L	Maximum load capacitance directly connected on outputs	3	pF

Notes:

(1)At any time, one of the inputs (E1+ or E2+) must be in the V_{bias} range.

4 Electrical characteristics

Table 6: Electrical characteristics beginning of life, Vcc = 4.5 V to 5.5 V, Gnd = 0 V (unless otherwise specified)

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
DC performance							
V_o	Output offset voltage	V_{ocm} = 0.8 V to Vcc - 1.8 V, V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C	-10		10	mV
			25 °C	-10		10	
			125 °C	-10		10	
ΔV_o	Output offset voltage drift $\Delta Vo = \frac{Vo(125°C) - Vo(-55°C)}{180°C} \times 10^6$	V_{ocm} = 0.8 V to Vcc - 1.8 V, V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C to 125 °C		±10		µV/°C
I_{CC}	Quiescent current	No load, V_{bias} = V_{ocm} = Vcc/2 (1)	-55 °C		20.5	26	mA
			25 °C		21	27	
			125 °C		21.5	28	
I_b	Input bias current	V_{ocm} = Vcc/2, V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C		0.02	1	µA
			25 °C		0.04	1	
			125 °C		0.15	1	
I_{ocm}	Input current on output common-mode range	V_{ocm} = 0.8 V to Vcc - 1.8 V	-55 °C to 125 °C	-25	-10		
C_{in}	Input capacitance		25 °C		2		pF
V_{bias}	Input DC biasing range	V_{ocm} = 0.8 V to Vcc - 1.8 V	-55 °C to 125 °C	1.6		Vcc - 1.5 V	V
V_{ocm}	Output common-mode range	V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C to 125 °C	0.8		Vcc - 1.8 V	
V_{InAC} (2)	Usable input signal range	V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C to 125 °C	1.3		Vcc - 1.3 V	
CMFBg	Common-mode feedback gain $CMFBg = \frac{\frac{Vo1 + Vo2}{2}}{Vocm}$	V_{ocm} = 0.8 V to Vcc - 1.8 V, V_{bias} = 1.6 V to Vcc - 1.5 V	-55 °C	0.985	1	1.015	V/V
			25 °C	0.985	1	1.015	
			125 °C	0.985	1	1.015	
V_{OH}	High output voltage	R_L = 200 Ω	-55 °C	Vcc - 0.45	Vcc - 0.39		V
			25 °C	Vcc - 0.58	Vcc - 0.49		
			125 °C	Vcc - 0.72	Vcc - 0.6		
		R_L = 1 kΩ	-55 °C	Vcc - 0.2	Vcc - 0.17		
			25 °C	Vcc - 0.26	Vcc - 0.22		

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
			125 °C	Vcc - 0.33	Vcc - 0.28		
V_{OL}	Low output voltage	R_L = 200 Ω	-55 °C		120	145	mV
			25 °C		160	195	
			125 °C		300	360	
		R_L = 1 kΩ	-55 °C		110	132	
			25 °C		160	195	
			125 °C		200	240	
I_{out}	Output short circuit (even if the amplifier has an output current limiter, this test is performed during a short period of time)	Output to GND, V_{ocm} = Vcc/2	-55 °C		100		mA
			25 °C		100		
			125 °C		100		
Dynamic performance							
Bw	Small signal -3 dB bandwidth	V_{ocm} = V_{bias} = Vcc/2, gain = 1, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω	-55 °C	360	460		MHz
			25 °C	330	420		
			125 °C	280	350		
		V_{ocm} = V_{bias} = Vcc/2, gain = 1.33, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω	-55 °C	270	340		
			25 °C	250	310		
			125 °C	210	270		
		V_{ocm} = V_{bias} = Vcc/2, gain = 2, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω	-55 °C		225		
			25 °C		220		
			125 °C		215		
		V_{ocm} = V_{bias} = Vcc/2, gain = 4, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω	-55 °C		60		
			25 °C		50		
			125 °C		45		
SR	Differential slew rate	V_{ocm} = V_{bias} = Vcc/2, gain = 1, V_{outdm} = 2 V_{pp}, 20 % to 80 %, R_L = 200 Ω	-55 °C		520		V/μs
			25 °C		500		
			125 °C		450		
		V_{ocm} = V_{bias} = Vcc/2, gain = 1.33, V_{outdm} = 2 V_{pp}, 20 % to 80 %, R_L = 200 Ω	-55 °C		540		
			25 °C		520		
			125 °C		470		
		V_{ocm} = V_{bias} = Vcc/2, gain = 2, V_{outdm} = 4 V_{pp}, 20 % to 80 %, R_L = 200 Ω	-55 °C	460	580		
			25 °C	440	550		
			125 °C	400	500		
		V_{ocm} = V_{bias} = Vcc/2,	-55 °C	450	570		

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
		gain = 4, V_{outdm} = 4 V_{pp}, 20 % to 80 %, R_L = 200 Ω	25 °C	420	530		
			125 °C	380	480		
St	Settling time 0.1 %	V_{outdm}= 4 Vpp-step, R_L = 200 Ω, gain = 2(3)	-55 °C		12		ns
			25 °C		13		
			125 °C		16		
tdio	Propagation delay input to output	All gains	-55 °C		0.9		
			25 °C		1		
			125 °C		1.3		
CMRR	Common-mode rejection ratio, 20 log ($\Delta V_{bias}/\Delta V_{outdm}$)	V_{bias} = Vcc/2 +/-0.5 V, all gains, F = 1 MHz	-55 °C	45	55		dB
			25 °C	45	55		
			125 °C	45	55		
CMRRo	Vocm CMRR, 20 log ($\Delta V_{ocm}/\Delta V_{outdm}$)	ΔV_{ocm} = 0.8 V to Vcc - 1.8 V, all gains	-55 °C	40	50		
			25 °C	40	50		
			125 °C	40	50		
Cu	Channel unbalanced, 20 log ($\Delta V_{outdm}/\Delta V_{outcm}$)	ΔV_{outdm} = 1 Vpp, F = 1 MHz, RL ≥ 200 Ω	- 55 °C to 125 °C	50	70		
PSRR	Power supply rejection ratio, 20 log ($\Delta V_{CC}/\Delta V_{outdm}$)	Vcc = 5 V ± 100 mV, F = 1 MHz, all gains	-55 °C to 125 °C		70		
Noise and distortion							
e_n	Differential output noise	F = 100 kHz, gain = 1	-55 °C		8.8		nV/√Hz
			25 °C		10		
			125 °C		12.5		
		F = 100 kHz, gain = 1.33	-55 °C		10		
			25 °C		12		
			125 °C		14.5		
		F = 100 kHz, gain = 2	-55 °C		13		
			25 °C		15		
			125 °C		18.5		
		F = 100 kHz, gain = 4	-55 °C		22.5		
			25 °C		28		
			125 °C		33.5		
H2/H3, SFDR	Distortion	V_{outdm} = 4 V_{pp}, V_{bias} = V_{ocm} = Vcc/2, gain = 2, R_L = 200 Ω, F = 1 MHz	25 °C		80		dBc

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
		V_{outdm} = 4 V_{pp}, V_{bias} = V_{ocm} = Vcc/2, gain = 2, R_L = 200 Ω, F = 10 MHz			54		
		V_{outdm} = 4 V_{pp}, V_{bias} = V_{ocm} = Vcc/2, gain = 2, R_L = 1 kΩ, F = 1 MHz			80		
		V_{outdm} = 4 V_{pp}, V_{bias} = V_{ocm} = Vcc/2, gain = 2, R_L = 1 kΩ, F = 10 MHz			68		
Gain select							
Thr max.	Max. threshold on pin G0, G1 for low level	Versus GND	-55 °C			0.4	V
			25 °C			0.4	
			125 °C			0.4	
Thr min.	Min. threshold on pin G0, G1 for high level		-55 °C	1.4			
			25 °C	1.4			
			125 °C	1.4			
IGL	Input current on gain pin	Gx = 0 V	-55 °C to 125 °C	-25	-10		µA
IGH	Input current on gain pin	Gx = Vcc	-55 °C to 125 °C		10	25	
Gain	Gain setting, no load, Fin = 1 MHz, V_{bias} = V_{ocm} = Vcc/2, V_{outdm} = 100 mVpp	G1, G0 = 0, 0	25 °C	0.99	1	1.01	V/V
		G1, G0 = 0, 1		1.31	1.33	1.35	
		G1, G0 = 1, 0		1.98	2	2.02	
		G1, G0 = 1, 1		3.96	4	4.04	
		G1, G0 = 0, 0		-0.87	0	0.86	dB

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
		G1, G0 = 0, 1		2.38	2.48	2.56	
		G1, G0 = 1, 0		5.94	6	6.1	
		G1, G0 = 1, 1		11.95	12	12.12	
Gain drift	Average gain drift, no load, Fin = 1 MHz, $V_{bias} = V_{ocm}$ = Vcc/2, V_{outdm} = 100 mVpp	Av = 1	-55 °C to 125 °C		5.9		(µV/V)/°C
		Av = 1.33			7.2		
		Av = 2			8.8		
		Av = 4			20		
	Standard deviation gain drift, no load, Fin = 1 MHz, $V_{bias} = V_{ocm}$ = Vcc/2, V_{outdm} = 100 mVpp	Av = 1			3.5		
		Av = 1.33			4.7		
		Av = 2			7.5		
		Av = 4			22		
tdgo	Propagation delay gain control to output	All gains	-55 °C to 125 °C		8		ns

Notes:

(1)When $V_{bias} \neq V_{ocm}$, an extra current consumption is added which depends on V_{bias} and V_{ocm} values.

(2)In AC mode, one of the two inputs, E1+ and E2+, must always be in V_{bias} range.

(3)$V_{OUT\ dm}$is the output differential amplitude

Table 7: Electrical characteristics after 300 krad high-dose rate (HDR), Vcc = 4.5 V to 5.5 V, Gnd = 0 V (unless otherwise specified)

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
DC performance							
V_o	Output offset voltage	V_{ocm} = 0.8 V to Vcc - 1.8 V, V_{bias} = 1.6 V to Vcc -1.5 V	25 °C	-10		30	mV
I_{CC}	Quiescent current	No load, V_{bias} = V_{ocm} = Vcc/2 [1]	25 °C		21	27	mA
I_b	Input bias current	V_{ocm} = Vcc/2, V_{bias} = 1.6 V to Vcc - 1.5 V	25 °C		0.04	1	µA
I_{ocm}	Input current on output common-mode range	V_{ocm} = 0.8 V to Vcc - 1.8 V	25 °C	-25	-10		µA
C_{in}	Input capacitance		25 °C		2		pF
V_{bias}	Input DC biasing range	V_{ocm} = 0.8 V to Vcc - 1.8 V	25 °C	1.6		Vcc - 1.5 V	V
V_{ocm}	Output common-mode range	V_{bias} = 1.6 V to Vcc - 1.5 V	25 °C	0.8		Vcc - 1.8 V	V
V_{InAC} [2]	Usable input signal range	V_{bias} = 1.6 V to Vcc - 1.5 V	25 °C	1.3		Vcc - 1.3 V	V
CMFBg	Common-mode feedback gain $CMFBg = \frac{\frac{Vo1 + Vo2}{2}}{Vocm}$	V_{ocm} = 0.8 V to Vcc - 1.8 V, V_{bias} = 1.6 V to Vcc - 1.5 V	25 °C	0.985	1	1.015	V/V
V_{OH}	High output voltage	R_L = 200 Ω	25 °C	Vcc - 0.58	Vcc - 0.49		V
		R_L = 1 kΩ		Vcc - 0.26	Vcc - 0.22		
V_{OL}	Low output voltage	R_L = 200 Ω	25 °C		160	195	mV
		R_L = 1 kΩ			160	195	
I_{out}	Output short circuit (even if the amplifier has an output current limiter, this test is performed during a short period of time)	Output to GND, V_{ocm} = Vcc/2	25 °C		100		mA
Dynamic performance							
Bw	Small signal -3 dB bandwidth	V_{ocm} = V_{bias} = Vcc/2, gain = 1, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω	25 °C	330	420		MHz
		V_{ocm} = V_{bias} = Vcc/2, gain = 1.33, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω		250	310		

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
		V_{ocm} = V_{bias} = Vcc/2, gain = 2, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω			220		
		V_{ocm} = V_{bias} = Vcc/2, gain = 4, V_{outdm} = 100 mV_{pp}, R_L = 200 Ω			50		
SR	Differential slew rate	V_{ocm} = V_{bias} = Vcc/2, gain = 1, V_{outdm} = 2 V_{pp}, 20 % to 80 %, R_L = 200 Ω	25 °C		500		V/µs
		V_{ocm} = V_{bias} = Vcc/2, gain = 1.33, V_{outdm} = 2 V_{pp}, 20 % to 80 %, R_L = 200 Ω			520		
		V_{ocm} = V_{bias} = Vcc/2, gain = 2, V_{outdm} = 4 V_{pp}, 20 % to 80 %, R_L = 200 Ω		440	550		
		V_{ocm} = V_{bias} = Vcc/2, gain = 4, V_{outdm} = 4 V_{pp}, 20 % to 80 %, R_L = 200 Ω		420	530		
CMRR	Common-mode rejection ratio, 20 log ($\Delta V_{bias}/\Delta V_{outdm}$)	V_{bias}= Vcc/2 ±0.5 V, all gains, F = 1 MHz	25 °C	45	55		dB
CMRRo	Vocm CMRR, 20 log ($\Delta V_{ocm}/\Delta V_{outdm}$)	ΔV_{ocm} = 0.8 V to Vcc - 1.8 V, all gains	25 °C	40	50		
Cu	Channel unbalanced, 20 log ($\Delta V_{outdm}/\Delta V_{outcm}$)	ΔV_{outdm} = 1 Vpp, F = 1 MHz, RL ≥ 200 Ω	25 °C	50	70		
Gain select							
Thr max.	Max. threshold on pin G0, G1 for low level	Versus GND	25 °C			0.4	V
Thr min.	Min. threshold on pin G0, G1 for high level		25 °C	1.4			
IGL	Input current on gain pin	Gx = 0 V	25 °C	-25	-10		µA
IGH	Input current on gain pin	Gx = Vcc	25 °C		10	25	
Gain	Gain setting, no load, Fin = 1 MHz, V_{bias} = V_{ocm} = Vcc/2, V_{outdm} = 100 mVpp	G1, G0 = 0, 0	25 °C	0.99	1	1.01	V/V

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
		G1, G0 = 0, 1		1.31	1.33	1.35	
		G1, G0 = 1, 0		1.9	2	2.02	
		G1, G0 = 1, 1		3.8	4	4.04	
		G1, G0 = 0, 0		-0.87	0	0.86	dB
		G1, G0 = 0, 1		2.38	2.48	2.56	
		G1, G0 = 1, 0		5.57	6	6.1	
		G1, G0 = 1, 1		11.6	12	12.12	

Notes:

(1)When $V_{bias} \neq V_{ocm}$, an extra current consumption is added which depends on V_{bias} and V_{ocm} values.

(2)In AC mode, one of the two inputs, E1+ and E2+, must always be in V_{bias} range.

4.1 Electrical characteristics curves

Figure 4: Gain vs. frequency, Av = 1

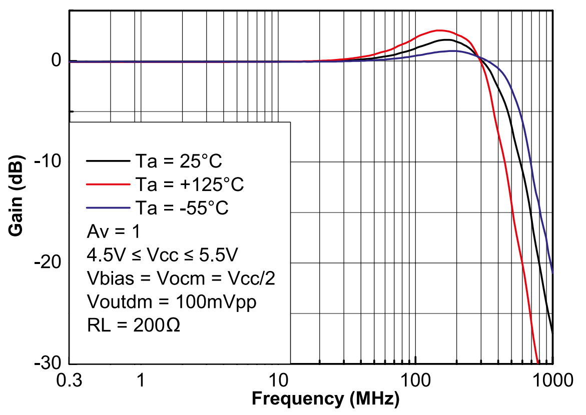


Figure 5: Gain vs. frequency, Av = 1, Vocm = 0.8 V

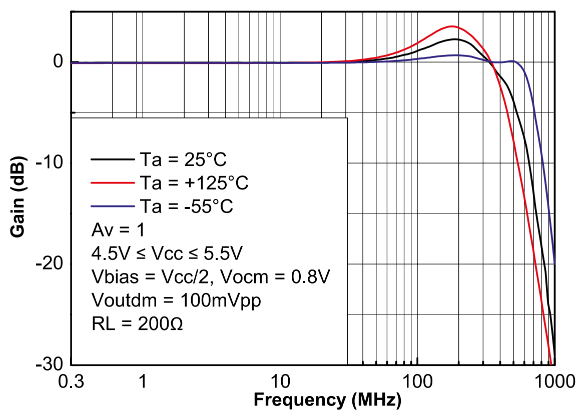


Figure 6: Gain vs. frequency, Av = 1.33

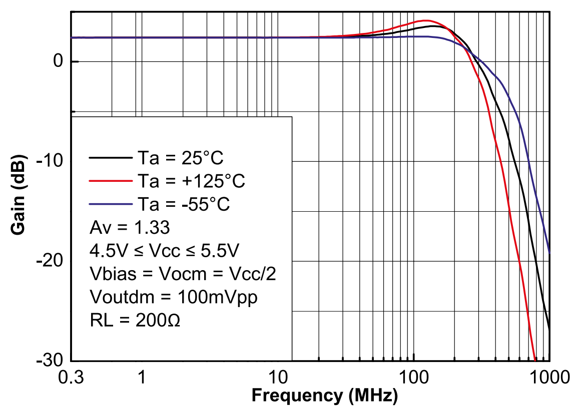


Figure 7: Gain vs. frequency, Av = 1.33, Vocm = 0.8 V

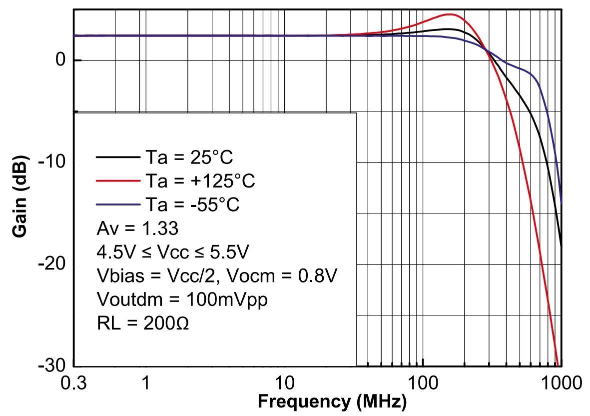


Figure 8: Gain vs. frequency, Av = 2

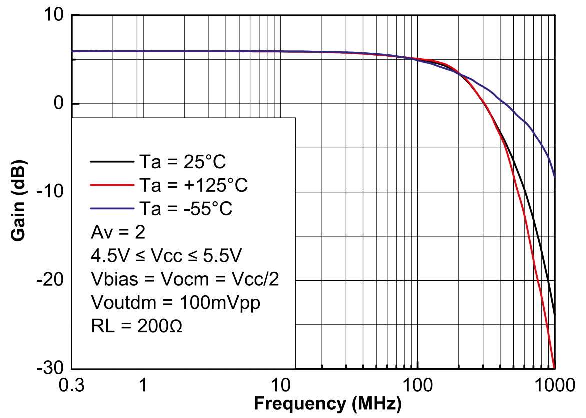


Figure 9: Gain vs. frequency, Av = 2, Vocm = 0.8 V

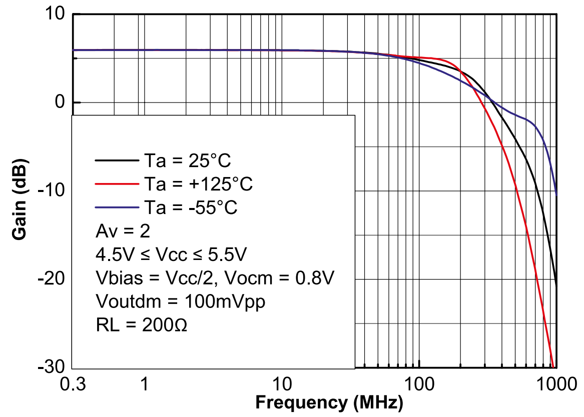


Figure 10: Gain vs. frequency, Av = 4

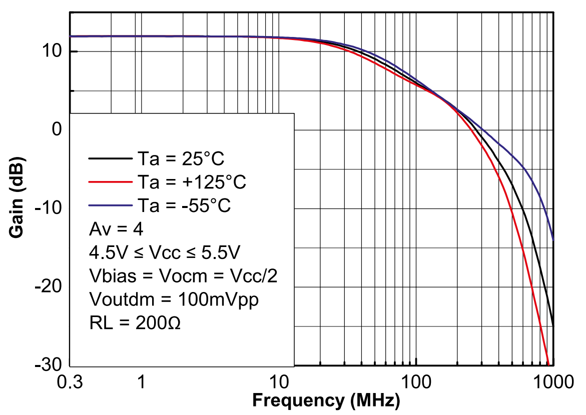


Figure 11: Gain vs. frequency, Av = 4, Vocm = 0.8 V

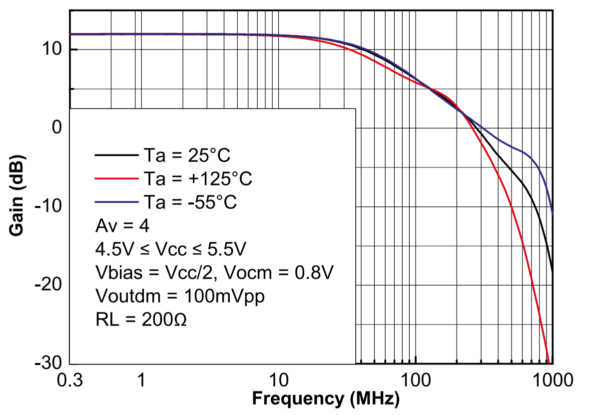


Figure 12: Gain vs. temperature, Av = 1

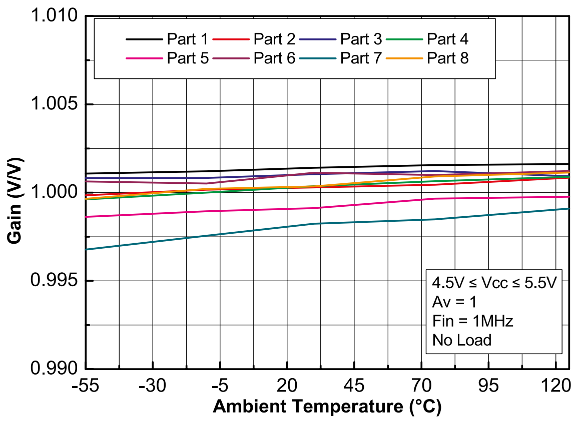


Figure 13: Gain drift, Av = 1

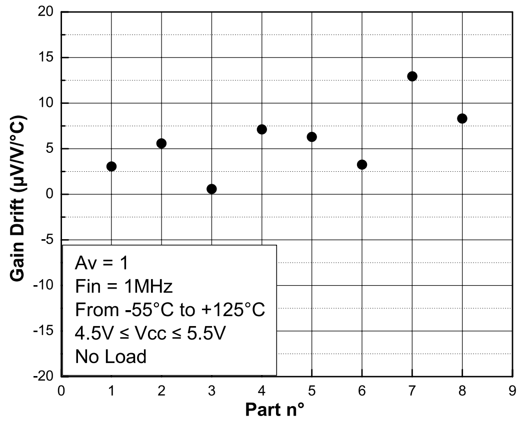


Figure 14: Gain vs. temperature, Av = 1.33

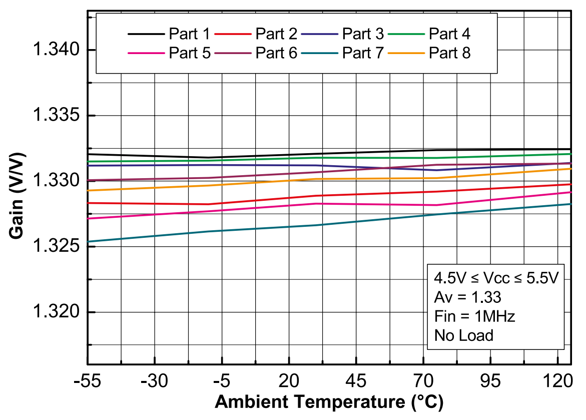


Figure 15: Gain drift, Av = 1.33

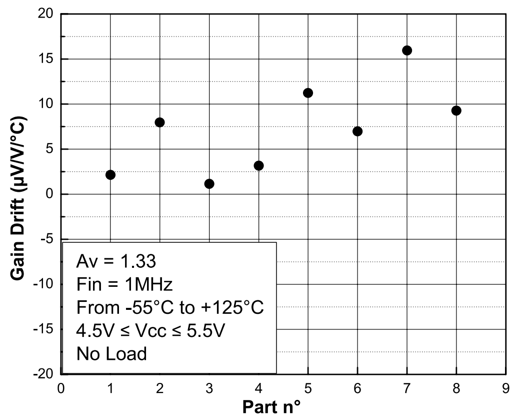


Figure 16: Gain vs. temperature, Av = 2

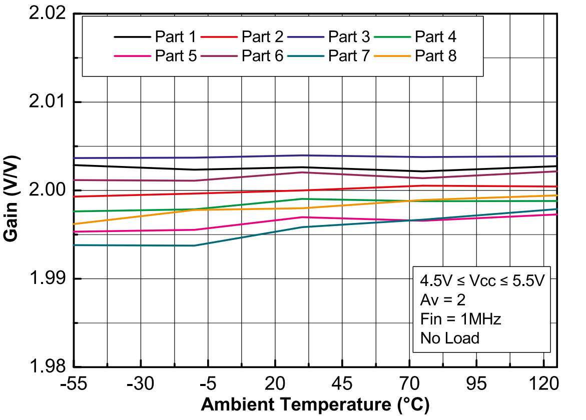


Figure 17: Gain drift, Av = 2

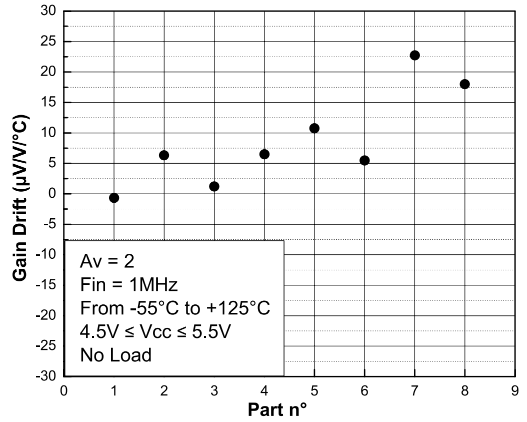


Figure 18: Gain vs. temperature, Av = 4

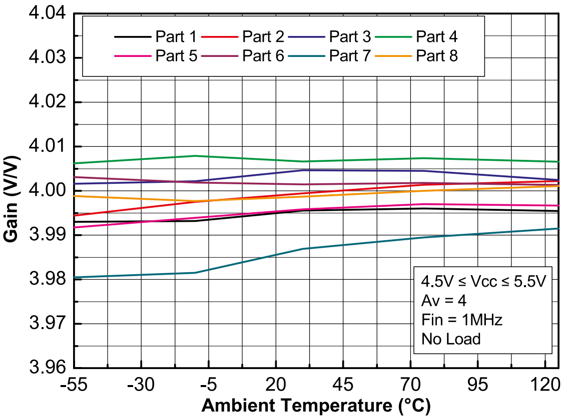


Figure 19: Gain drift, Av = 4

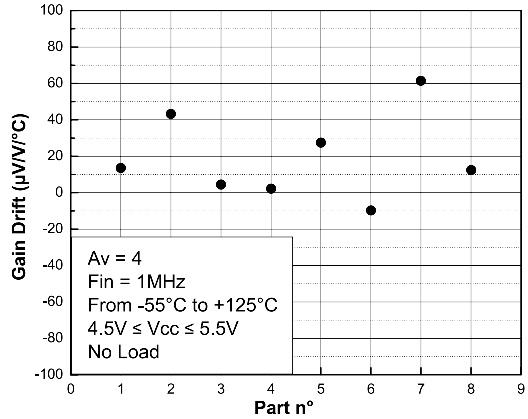


Figure 20: CMRR vs. frequency, Av = 1

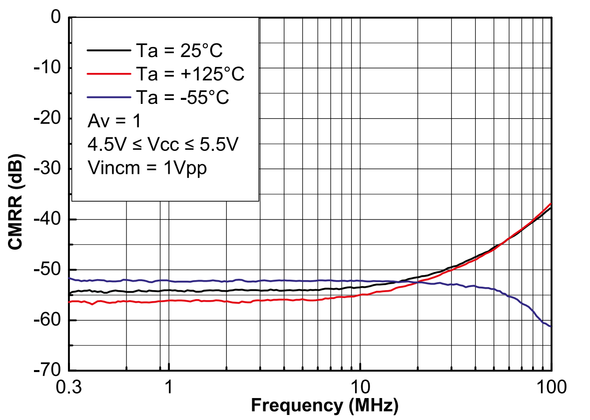


Figure 21: CMRR vs. frequency, Av = 1.33

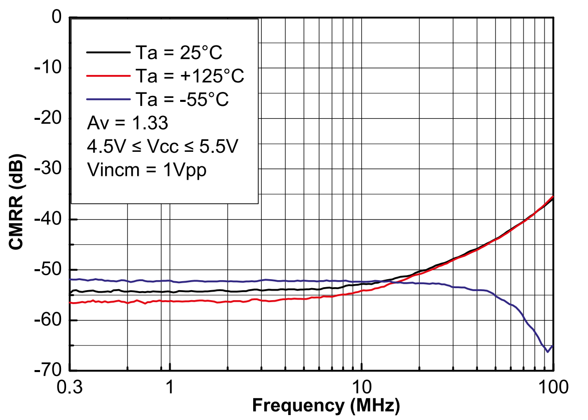


Figure 22: CMRR vs. frequency, Av = 2

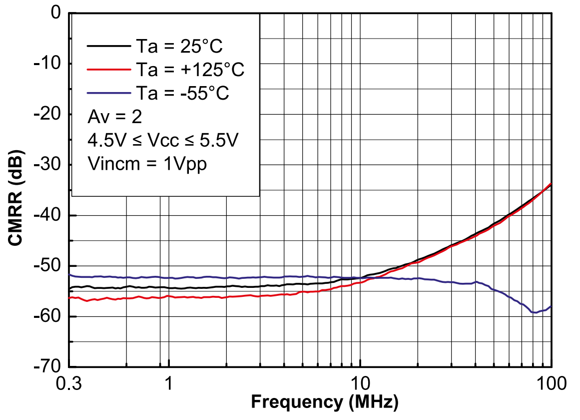


Figure 23: CMRR vs. frequency, Av = 4

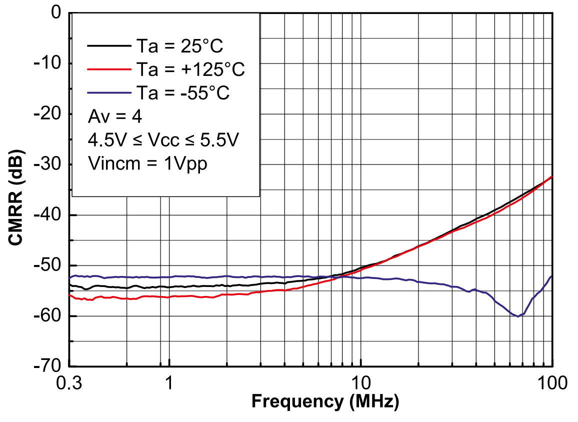


Figure 24: CMRRout vs. frequency

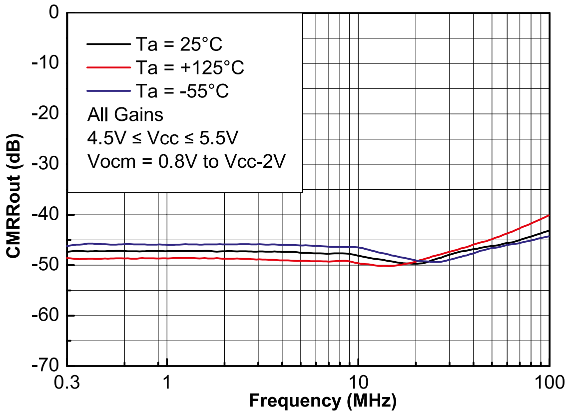


Figure 25: Channel unbalance vs. frequency

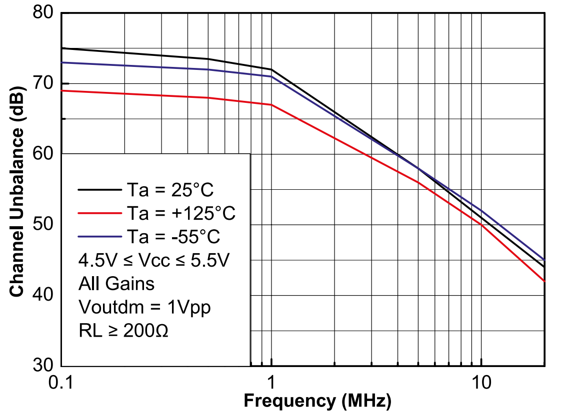


Figure 26: PSRR vs. frequency, Av = 1

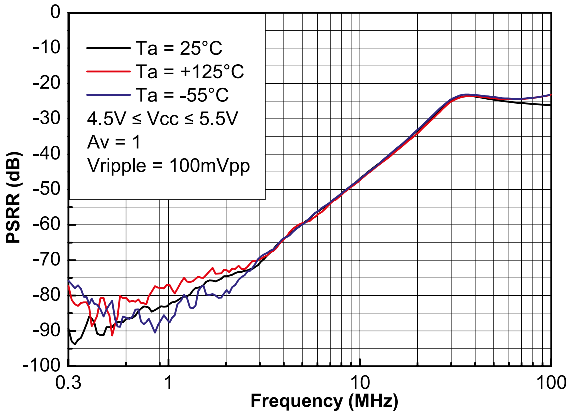


Figure 27: PSRR vs. frequency, Av = 1.33

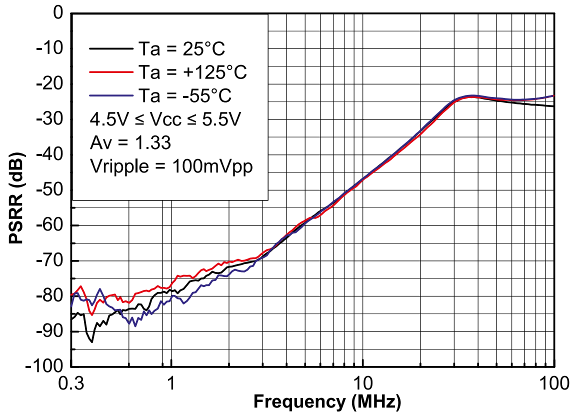


Figure 28: PSRR vs. frequency, Av = 2

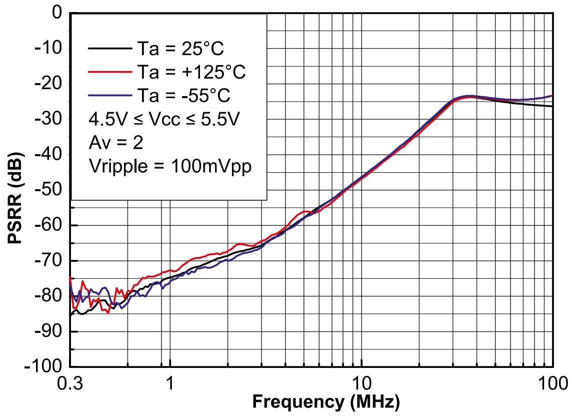


Figure 29: PSRR vs. frequency, Av = 4

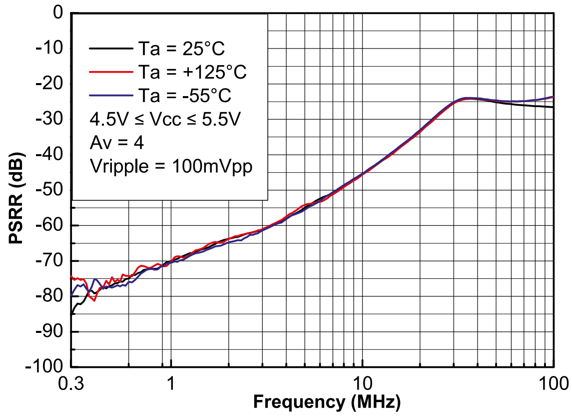
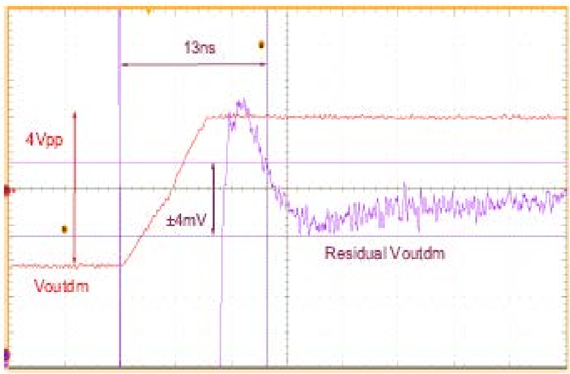
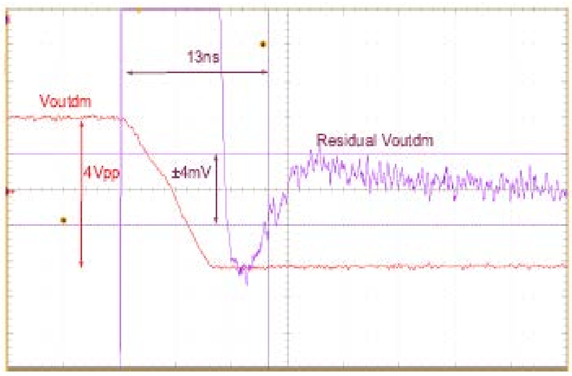


Figure 30: Settling time response, Av = 2, Ta = 25 °C, high side



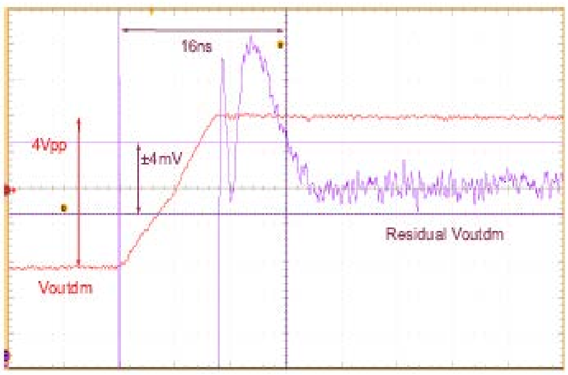
4.5V ≤ Vcc ≤ 5.5V, AV = 2, RL = 200Ω, 5ns/div, Ta = +25°C

Figure 31: Settling time response, Av = 2, Ta = 25 °C, low side



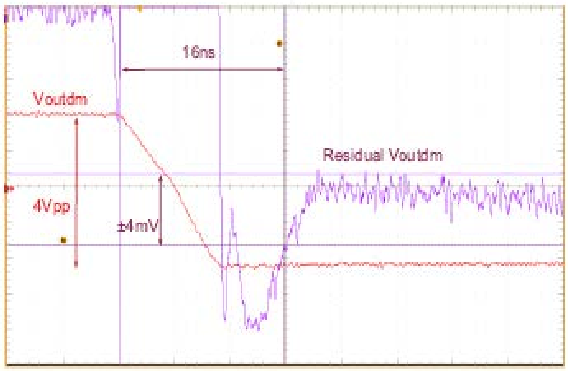
4.5V ≤ Vcc ≤ 5.5V, AV = 2, RL = 200Ω, 5ns/div, Ta = +25°C

Figure 32: Settling time response, Av = 2, Ta = 125 °C, high side



4.5V ≤ Vcc ≤ 5.5V, AV = 2, RL = 200Ω, 5ns/div, Ta = +125°C

Figure 33: Settling time response, Av = 2, Ta = 125 °C, low side



4.5V ≤ Vcc ≤ 5.5V, AV = 2, RL = 200Ω, 5ns/div, Ta = +125°C

Figure 34: Settling time response, Av = 2, Ta = -55 °C, high side

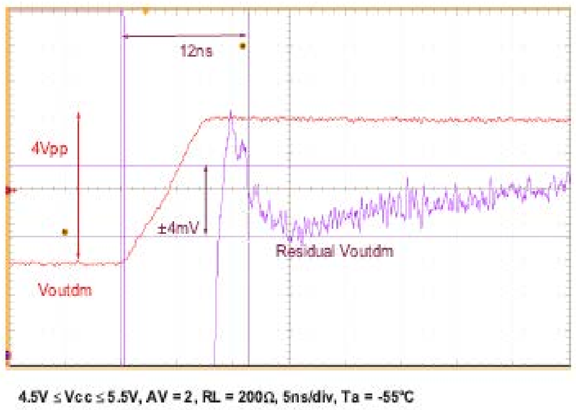


Figure 35: Settling time response, Av = 2, Ta = -55 °C, low side

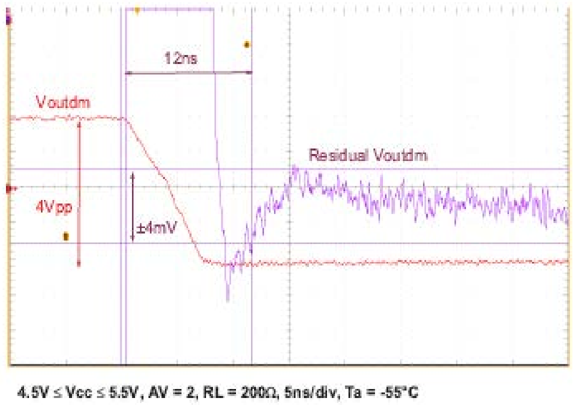


Figure 36: Harmonic level vs. frequency, RL = 200 Ω, Ta = 25 °C

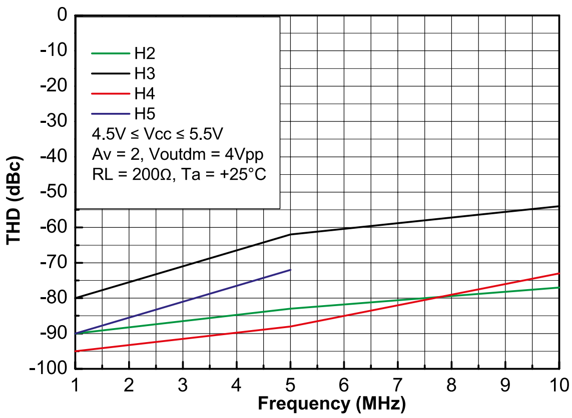


Figure 37: Harmonic level vs. frequency, RL = 1 kΩ, Ta = 25 °C

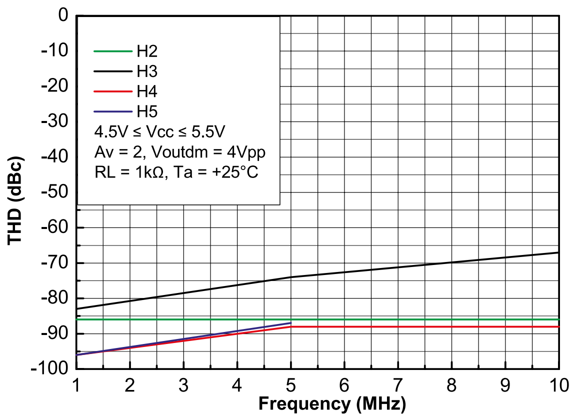


Figure 38: Harmonic level vs. frequency, RL = 200 Ω, Ta = 125 °C

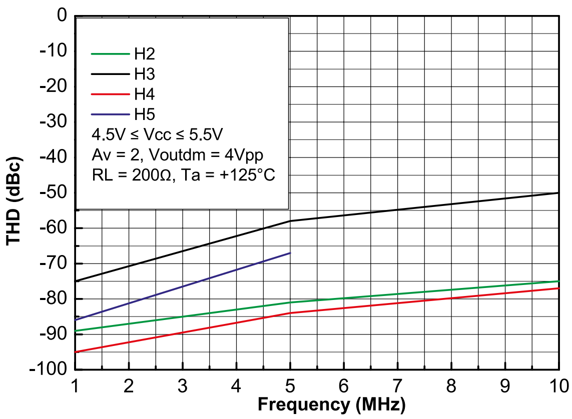


Figure 39: Harmonic level vs. frequency, RL = 1 kΩ, Ta = 125 °C

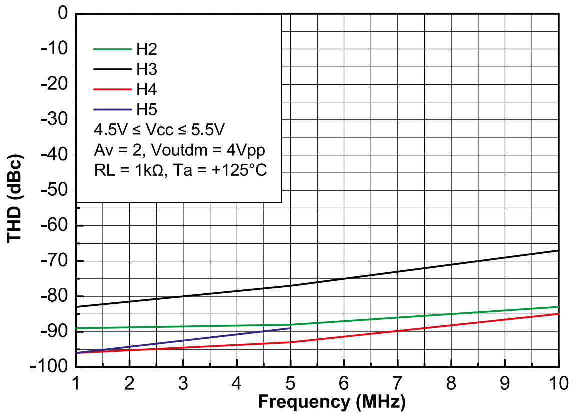


Figure 40: Harmonic level vs. frequency, RL = 200 Ω, Ta = -55 °C

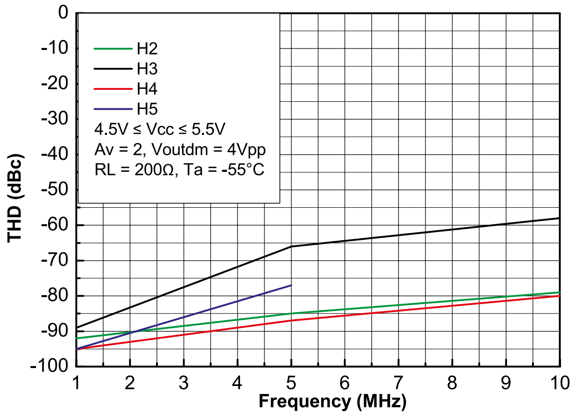


Figure 41: Harmonic level vs. frequency, RL = 1 kΩ, Ta = -55 °C

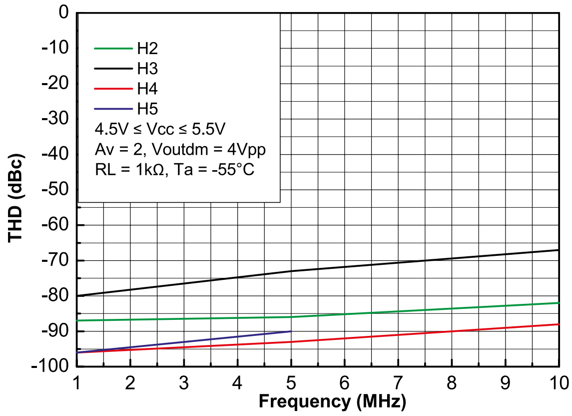
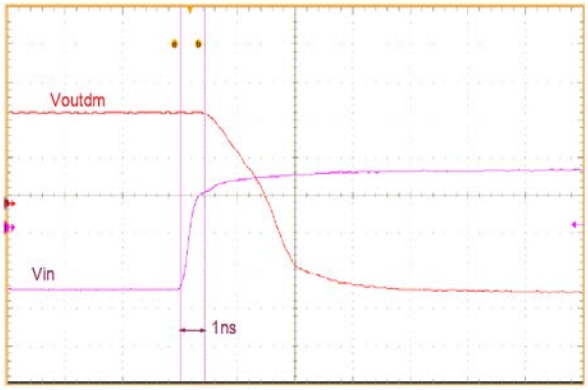
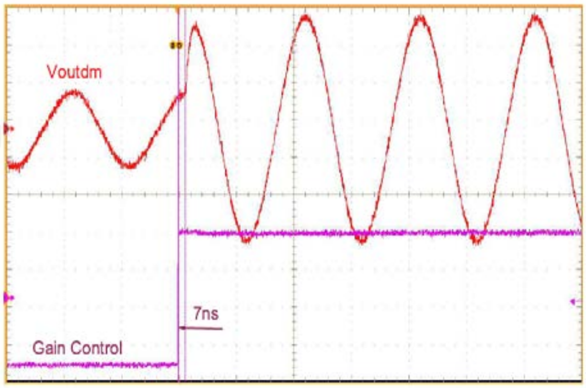


Figure 42: Propagation delay input to output



4.5V ≤ Vcc ≤ 5.5V, 2.5ns/div, Ta = +25°C

Figure 43: Propagation delay gain control to output



4.5V ≤ Vcc ≤ 5.5V, 50ns/div, Ta = +25°C

5 Radiations

5.1 Introduction

Table 8 summarizes the radiation performance of the RHF200.

Table 8: Radiations

Type	Features	Value	Unit
TID	180 krad/h high-dose rate (50 rad/s) up to:	300	krad (Si)
	ELDRS free up to:		
	36 rad/h low-dose rate (10 rad/s) up to:		
Heavy ions	SEL immunity (at 125 °C with a particle angle of 60 °) up to:	120	MeV.cm²/mg
	SEL immunity (at 125 °C with a particle angle of 0 °) up to:	60	
	SET (at 25 °C)	Characterized	

5.2 Total ionizing dose (TID)

The products guaranteed by radiation within the RHA QML-V system fully comply with the MIL-STD-883 test method 1019 specification.

The RHF200 is RHA QML-V tested and characterized in full compliance with the MIL-STD-883 specification both according to condition A (between 50 and 30 rad/s) and condition D (below 10 mrad/s).

- All tests are performed in accordance with MIL-PRF-38535 and the test method 1019 of the MIL-STD-883 for total ionizing dose (TID).
- The ELDRS characterization is performed in qualification only on both biased and unbiased parts, on a sample of 30 units from two different wafer lots.
- Each wafer lot is tested at high-dose rate only, in the worst bias case condition, based on the results obtained during the initial qualification.

5.3 Heavy ions

The behavior of the product when submitted to heavy ions is not tested in production. Heavy ion trials are performed on qualification lots only.

6 Application note

6.1 Description

The RHF200 is a fully differential amplifier featuring high impedance input. Input and output common-mode voltage can be set up independently in this device, giving a flexible design implementation. Thanks to the very low input DC bias current (less than 1 µA over the full temperature and input voltage biasing range), a high impedance resistor can be used to bias the input with a slight DC shift. This high impedance resistor allows the RHF200 to be used with low output current compliance sensors without adding an isolation buffer.

The RHF200 can work in full differential mode (differential input and differential output) or in single-to-differential mode (single-ended input and differential output). In single-to-differential mode, either the E1+ or the E2+ input can be used.

6.2 Input biasing

Input voltage biasing of the RHF200 can be achieved in several ways.

- In DC input coupling, the biasing must be provided by the source driver. Thanks to the low input biasing current, the output impedance (Rs) can be a few kilo ohms without degrading the output offset voltage (see *Figure 44: "DC input coupling"*).
- In AC input coupling, the biasing must be provided by an external source. The usual way to do this, although there are many ways, is to use two resistors (Rpol) as shown in *Figure 45: "AC input coupling"*. Thanks to a low input biasing current, these resistors can be as high as several kilo ohms.

Note that due to input current compensation techniques used in the RHF200, the polarity of the biasing current can be positive or negative over the full temperature and Vbias range.

Figure 44: DC input coupling

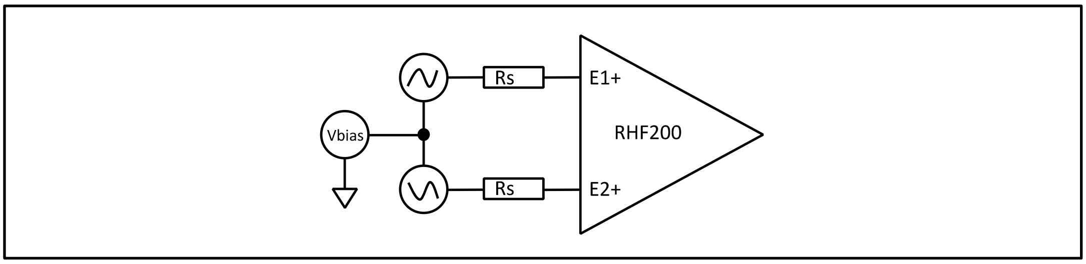
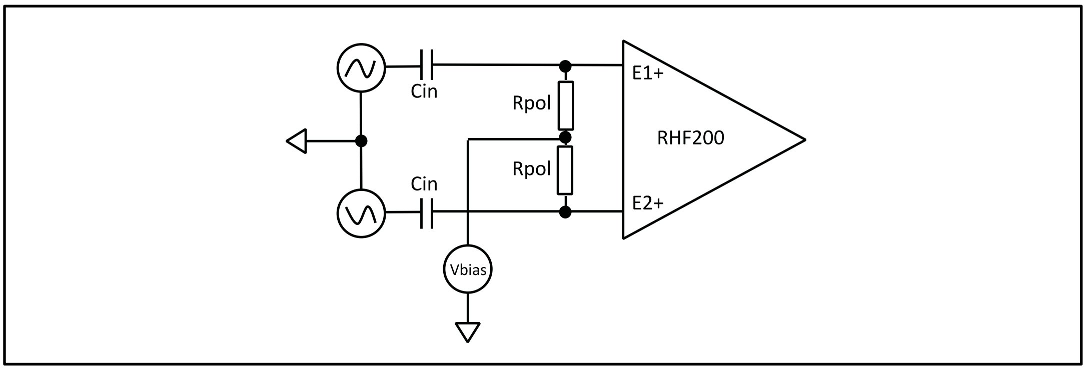


Figure 45: AC input coupling



6.3 Output biasing

The output voltage biasing of the RHF200 is achieved by applying the correct voltage on the Vocm pin. The voltage applied to Vocm sets the Vo1 and Vo2 bias voltage through the following equations: ((Vo1 + Vo2)/2)/CMFBg and Vo2 = Vo1 ± Vo. CMFBg is the common-mode feedback gain equal to 1 and Vo is the differential output offset voltage. The Vocm pin has a typical input bias current (Iocm) of -10 µA. The negative value means that this current flows from the RHF200. If a resistor bridge is used to create a Vocm voltage bias, this resistor bridge should have a low equivalent output resistance to minimize errors created by Iocm.

Please note that there is no internal biasing of the Vocm pin. If the Vocm pin is left floating, Vo1 and Vo2 will have an undetermined value.

Example: Vcc = 5 V and Vocm requested = 2.5 V. So, the resistor bridge has two equal resistors, R, and its internal resistance is R/2. With Iocm = -10 µA and a target error for Vocm vs. 2.5 V of approximately 20 mV maximum we have: R/2 ≤ 20 mV/10 µA = 2 kΩ. With a normalized value, R = 3.9 kΩ.

6.4 Current consumption

Table 6 gives the current consumption (Icc) of the RHF200 when Vbias and Vocm have equal voltage. If Vbias and Vocm are different, the current consumption rises with the following relationship: Total Icc ≈ Icc + |Vbias - Vocm| / R where R = 500 Ω ± 10 %. This current increase is due to the internal architecture of the RHF200. It is not gain dependent.

For example, when Vbias = 2.5 V and Vocm = 0.8 V, total Icc at 25 °C = 21 mA + 3.4 mA = 24.4 mA whatever the gain set.

Another source of additional current consumption is the output offset voltage (Vo). In conjunction with the load, the output offset voltage creates an added current equal to Vo/Rload. For example, if Vo = 5 mV and Rload = 200 Ω, the current added to Icc is 25 µA.

6.5 Usable input signal range in AC

The allowed DC biasing input voltage (Vbias) is in the range 1.6 V to Vcc - 1.5 V. Thanks to the input structure of the RHF200, the input AC signal can go beyond the Vbias range to: 1.3 V to Vcc - 1.3 V. However, this feature is only possible if one of the two inputs (E1+ or E2+) is always in the Vbias range at a given time. If this condition is not met, the usable AC input signal range must fit with the Vbias range. The following figures indicate correct and incorrect use of the input signal range.

Figure 46: Correct use of the input signal range

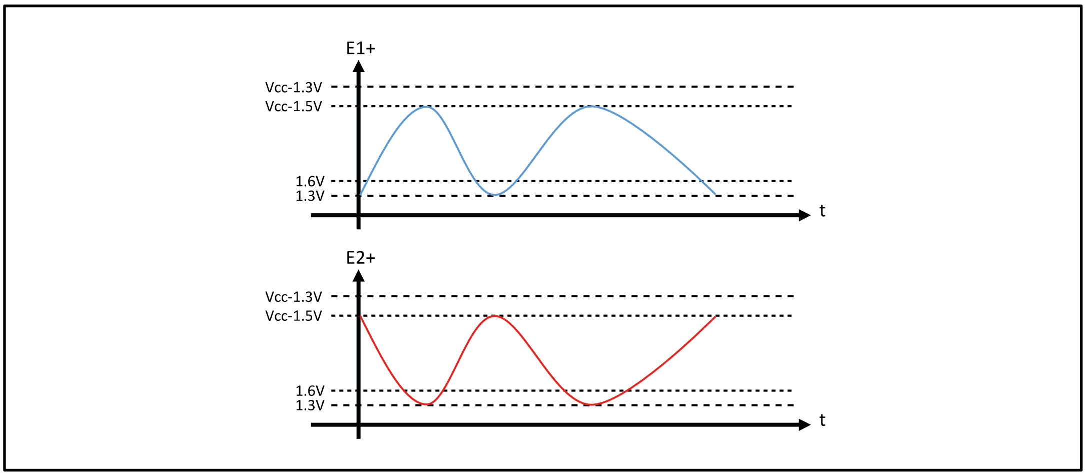


Figure 47: Second correct use of the input signal range

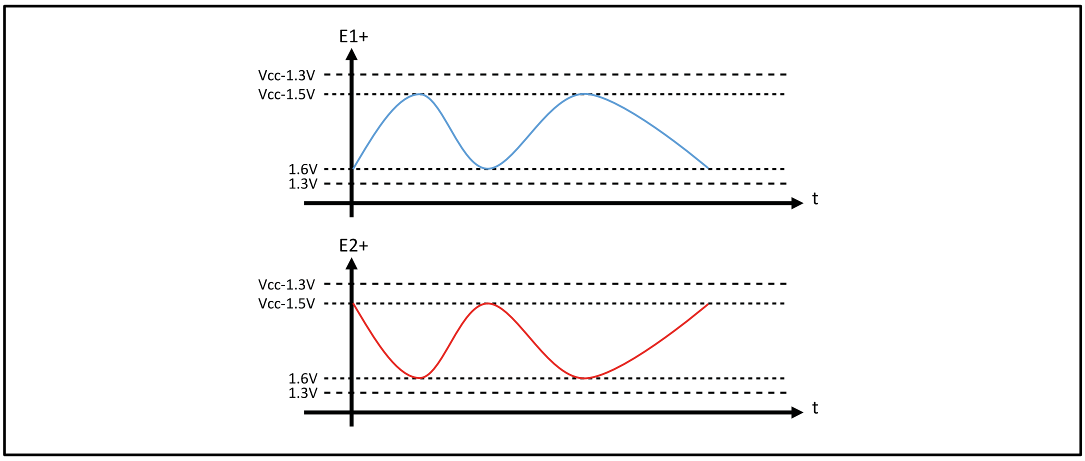
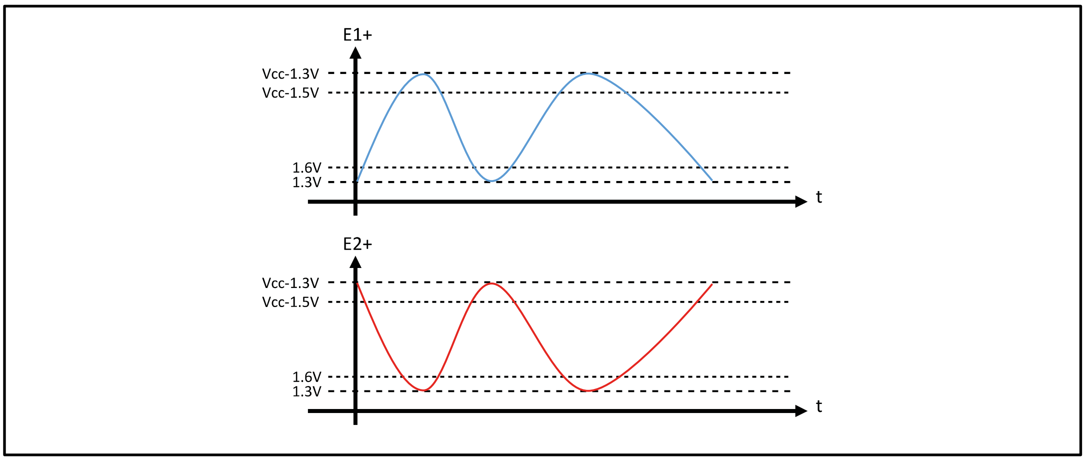


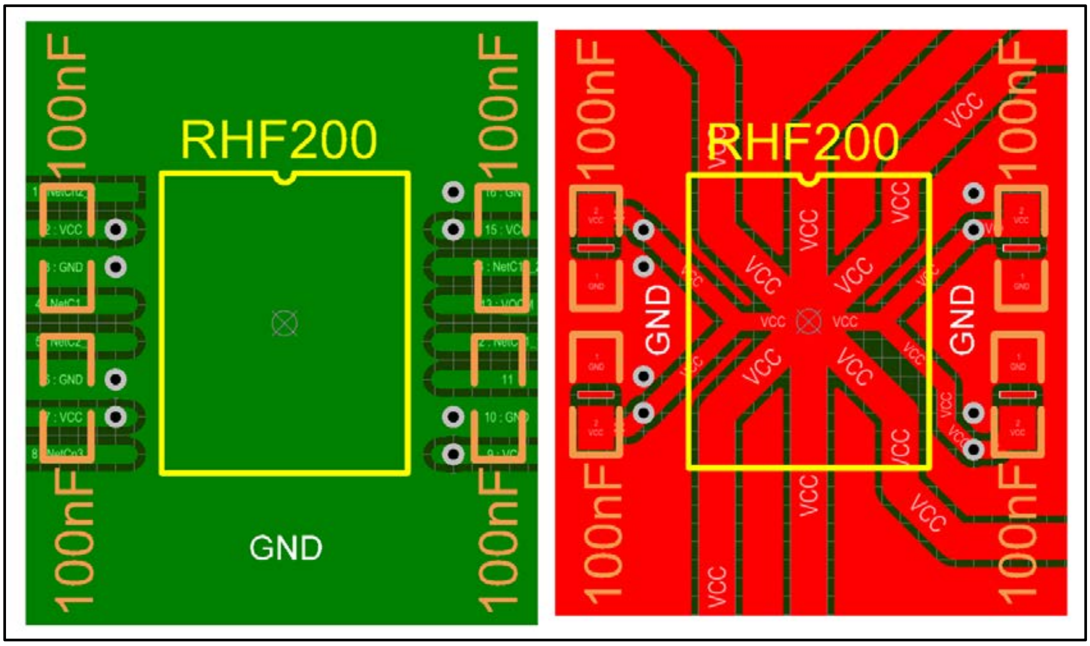
Figure 48: Incorrect use of the input signal range



6.6 Decoupling of RHF200

The RHF200 has four pairs of power supply pins (Vcc and Gnd). These pins must be connected together externally. The layout of each pair of pins is such that the placement of the capacitors can be as close as possible to the RHF200 package. Four 100 nF ceramic capacitors must be placed as close as possible to the RHF200 package and an additional 10 µF can also be placed close to the device. *Figure 49* shows a layout example of the RHF200 decoupling capacitors.

Figure 49: Layout example of the RHF200 decoupling capacitors (top and bottom layer respectively)



6.7 Single-to-differential use

The RHF200 is designed as a fully differential input/output amplifier. Thanks to its high input impedance, the device is able to convert a differential signal from a sensor which has no ability to drive a matched line, to a fully differential signal that is able to drive a matched line transmission down to 200 Ω.

However, the RHF200 can also be used as a converter from a single-ended input to a fully differential output. Thanks to a very good output balance error (70 dB typ), the symmetry of the RHF200 outputs (Vo1 and Vo2) are excellent.

Because the device also has a high CMRR value with a very good flatness-over-frequency (up to 10 MHz) and temperature, it can efficiently reject ground noise. The figures below show two possible single-to-differential implementations. E1+ and E2+ can be exchanged without any performance issues. However, the second configuration should not be used as it does not allow ground noise to be rejected.

Figure 50: Correct single-to-differential implementation

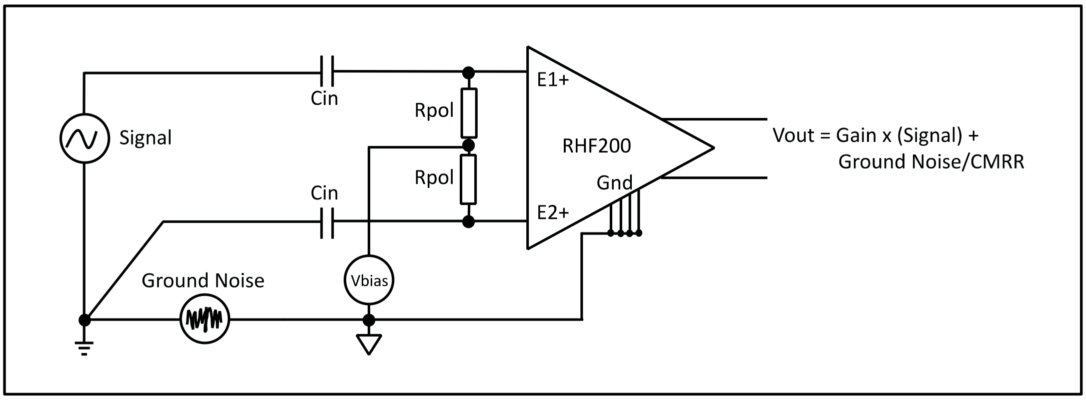
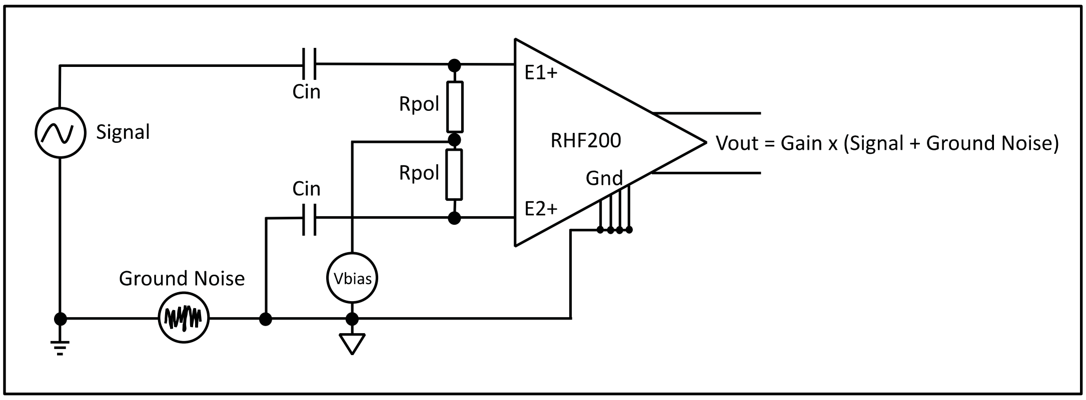


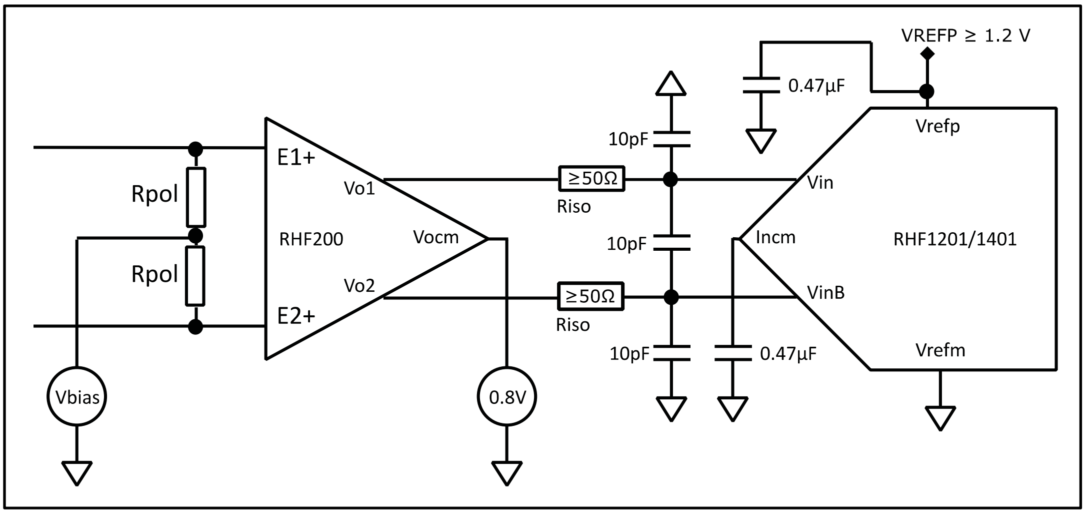
Figure 51: Incorrect single-to-differential implementation



6.8 RHF200 driving RHF1201 or RHF1401 ADC

The RHF200 has been designed to complement work with STMicroelectronic's rad-hard ADC: RHF1201 and RHF1401. Thanks to its 0.8 V output common-mode possibility, the RHF200 can drive RHF1x01 inputs without input coupling capacitors. *Figure 52* shows a possible design.

Figure 52: RHF200 in association with RHF1x01 in DC coupling



The DC output common-mode voltage of the RHF200 is set at 0.8 V through the Vocm pin. In DC, Vin = Vo1 and VinB = Vo2 so, Vin and VinB are also set at 0.8 V. The Incm pin can be left floating if the internal reference is used or externally set by the appropriate reference voltage (refer to the RHF1x01 datasheet). Note that Incm has no need to be at the same DC voltage as Vin and VinB. This is specific to the RHF1x01 (refer to the RHF1x01 datasheets for more information).

In addition, please note that Vrefp + Vrefm of the RHF1x01 must be higher than 1.2 V because the common-mode of the input is (Vin + VinB)/2 = 0.8 V. This condition is important and must respect these relationships (please refer to the RHF1x01 datasheet):

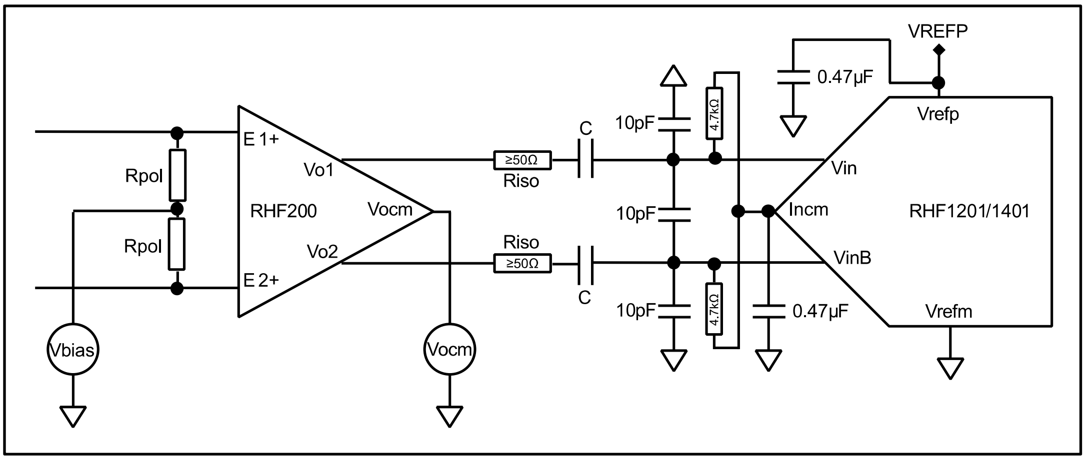
- CMinput = (Vin + VinB)/2
- CMref = (Vrefp + Vrefm)/2
- CMinput ≤ CMref + 0.2 V
- Full scale range = 2 x (Vrefp – Vrefm)
- So, CMinput = 0.8 V and fixed by the low limit of the RHF200 Vocm

- CMref ≥ 0.8 V - 0.2 V = 0.6 V gives Vrefp + Vrefm ≥ 1.2 V
- As Vrefm = Gnd = 0 V, Vrefp ≥ 1.2 V and full scale range = 2.4 Vpp

In the current configuration, we can drive the RHF1x01 inputs with a fully differential signal of 2.4 Vpp (Vin = VinB = 0.8 V ± 0.6 V -> 0.2 V to 1.4 V in line with Vin and VinB input range). The three 10 pF capacitors are there to limit the effect of the RHF1x01 sampling capacitor. The two resistors Riso (≥ 50 Ω) are used to "protect" the RHF200 from excessive capacitive load.

If the relationship CMinput ≤ CMref + 0.2 V cannot be achieved, the DC coupling of RHF200 with RHF1x01 has to be converted in AC coupling. *Figure 53* shows a possible design.

Figure 53: RHF200 in association with RHF1x01 in AC coupling

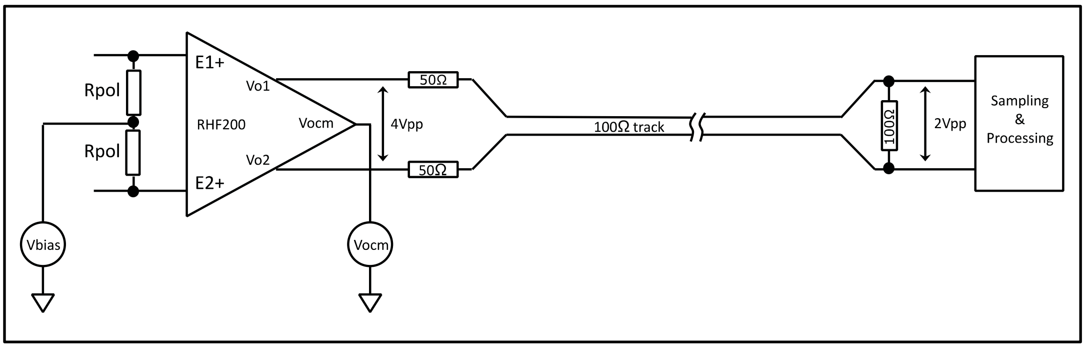


Thanks to the AC coupling, the DC output common-mode voltage of the RHF200 can be set at any value between 0.8 V to Vcc-1.8 V. Thanks also to the AC coupling, the DC biasing of Vin and VinB can be set to a different value of the RHF200 Vocm setting, but it must respect all conditions described in the RHF1x01 datasheet in the section: Driving the analog input: how to correctly bias the RHF1x01.

6.9 RHF200 driving a long track with impedance matching

Thanks to its ability to drive a 200 Ω load with low distortion and good settling time (13 ns at 0.1 %), the RHF200 can drive a long track with impedance matching if necessary.

Figure 54: RHF200 driving a long track with impedance matching



6.10 RHF200 in dual power supply mode

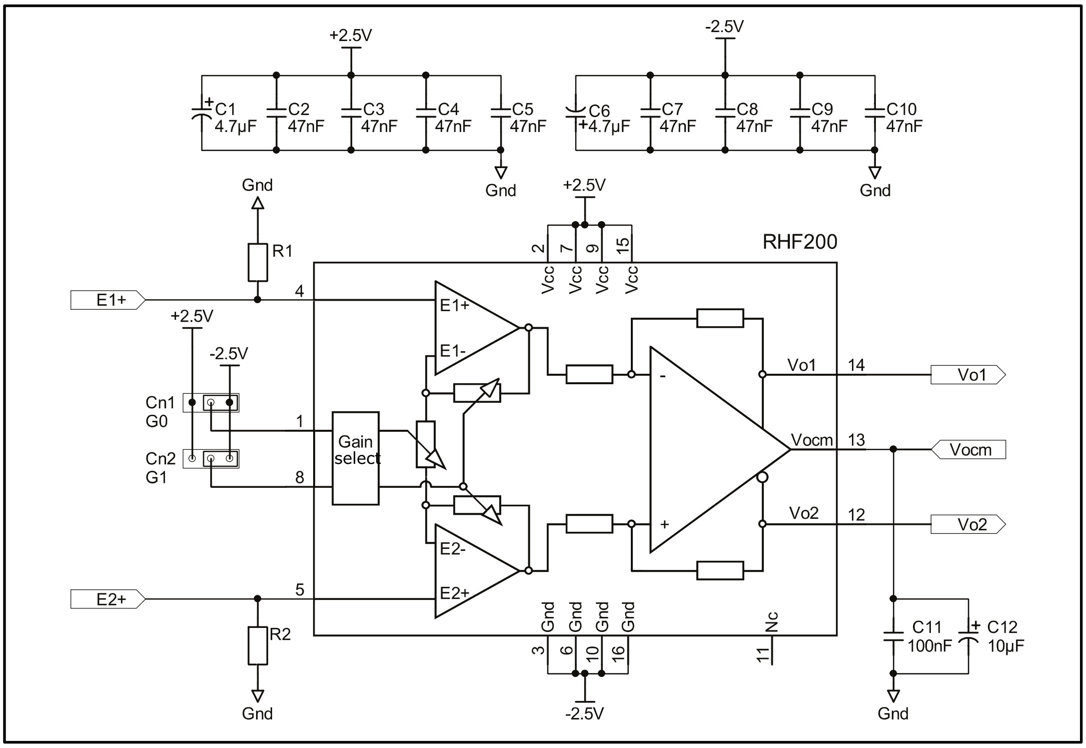
The RHF200 has been designed to be used with a single power supply voltage (5 V ± 10 %). However, it is also possible to use it with a dual power supply voltage (2.5 V ± 10 %) without any differences in performance.

In such a case, the Gnd pins become the negative power supply (-Vcc) and the positive power supply keeps the same function. In addition, the digital inputs (G0 and G1), Vocm input, and E1+ and E2+ become referenced at –Vcc. Overall, we have the following setup:

- Vbias range: from –Vcc + 1.6 V to Vcc – 1.5 V
- VinAC range: from –Vcc + 1.3 V to Vcc – 1.3 V
- Vocm range: from –Vcc + 0.8 V to Vcc – 1.8 V
- Max. threshold on G0 and G1 for low level: -Vcc + 0.4 V
- Min. threshold on G0 and G1) for high level: -Vcc + 14 V

Decoupling of the RHF200 is a little bit different in dual power supply mode than in single power supply mode. Instead of 4 x 100 nF located as close as possible, we need 8 x 47 nF as close as possible. We need 4 x 47 nF for each +Vcc and each –Vcc (previously Gnd). In addition, the 10 µF tank capacitor is now 2 x 4.7 µF. *Figure 55* shows a possible design in dual power supply mode.

Figure 55: Possible design of RHF200 in dual power supply mode

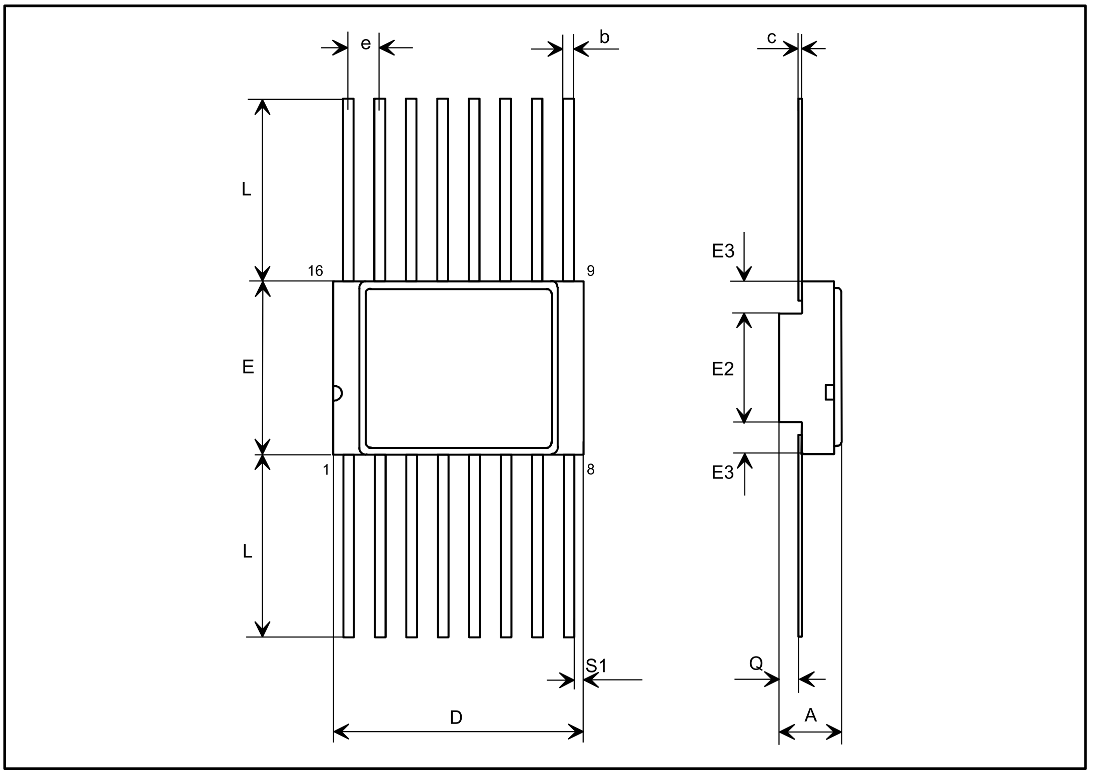


7 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK® specifications, grade definitions and product status are available at: ***www.st.com***. ECOPACK® is an ST trademark.

7.1 Ceramic Flat-16 package information

Figure 56: Ceramic Flat-16 package outline



1. The upper metallic lid is electrically connected to pin16.

Table 9: Ceramic Flat-16 mechanical data

Ref.	Dimensions					
	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	2.31		2.72	0.091		0.107
b	0.38		0.48	0.015		0.019
c	0.10		0.18	0.004		0.007
D	9.75		10.13	0.384		0.399
E	6.75		7.06	0.266		0.278
E2		4.32			0.170	
E3	0.76			0.030		
e		1.27			0.050	
L	6.35		7.36	0.250		0.290
Q	0.66		1.14	0.026		0.045
S1	0.13			0.005		

8 Ordering information

Table 10: Order codes

Order code	Description	Temp. range	Package	Marking	Packing
RHF200K1	Engineering model	-55 °C to 125 °C	Flat-16	RHF200K1	Conductive strip pack
RHF200K01V	QML-V Flight			5962F1721001VXC	

Contact your ST sales office for information regarding the specific conditions for products in die form and QML-Q versions.

9 Other information

9.1 Date code

The date code is structured as shown below:

- Engineering model: EM xyywwz
- QML flight model: FM yywwz

Where:

x (EM only): 3, assembly location Rennes (France)

yy: last two digits year

ww: week digits

z: lot index in the week

9.2 Documentation

Table 11: Documentation provided for QMLV flight

Quality level	Documentation
Engineering model	—
QML-V flight	• Certificate of conformance with Group C (reliability test) and group D (package qualification) reference • Precap report • PIND(1) test summary (test method conformance certificate) • SEM(2) report • X-ray report • Screening summary • Failed component list (list of components that have failed during screening) • Group A summary (QCI(3) electrical test) • Group B summary (QCI mechanical test) • Group E (QCI wafer lot radiation test)

Notes:

(1)PIND = particle impact noise detection

(2)SEM = scanning electron microscope

(3)QCI = quality conformance inspection

10 Revision history

Table 12: Document revision history

Date	Revision	Changes
09-Jan-2017	1	Initial release
06-Apr-2017	2	Datasheet status changed to "production data" Replaced *Figure 2: "Typical application schematic"* Added *Section 5: "Radiations"* *Section 6: "Application note"*: replaced content to finalize datasheet for the flight model.
18-Jul-2017	3	Added Flight model and SMD number.