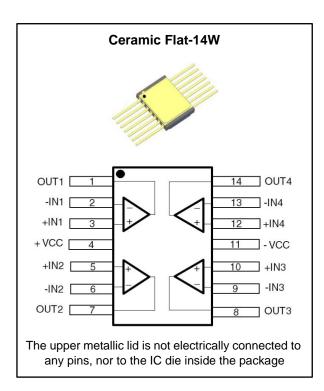


Rad-hard precision quad operational amplifier

Datasheet - production data



Features

- Bandwidth: 8 MHz gain bandwidth product
- Rail-to-rail input/output
- Low input offset voltage: 60 μV typ
- Supply current: 2.2 mA typ per amplifier
- Operating from 4 to 14 V
- Input bias current: 6 nA typ
- ELDRS free up to 100 krad
- SEL immune at LET = 120 MEV.cm²/mg at 125 °C
- SET characterized
- High radiation immunity: 300 krad TID at high-dose rate

Applications

- Space probes and satellites
- Harsh environments

Description

The RHF484 is a rail-to-rail, precision, bipolar, quad, operational amplifier featuring a low input offset voltage and a wide supply voltage. Designed to increase tolerance to radiation, the RHF484 is housed in a hermetic 14-pin flat package, making it an ideal product for space applications and harsh environments.

Table 1: Device summary

Parameter	RHF484K1	RHF484K-01V
SMD ⁽¹⁾	_	5962F08222
Quality level	Engineering model	QML-V flight
Package	Flat-14	W
Mass	0.7 g	1
EPPL (2)		Yes
Temp. range	-55 °C to 1	25 °C

Notes:

(1)SMD: standard microcircuit drawing

⁽²⁾ EPPL = ESA preferred part list



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

April 2016 DocID17351 Rev 3 1/19

Contents

1	Absolut	te maximum ratings and operating conditions	3
2	Electric	al characteristics	4
3	Electric	al characteristic curves	8
4	Radiation	ons	12
	4.1	Introduction	12
	4.2	Total ionizing dose (TID)	12
	4.3	Heavy ions	12
5	Achievi	ng good stability at low gain	13
6	Packag	e information	14
	6.1	Wide ceramic Flat-14W package information	15
7	Orderin	g information	16
8	Other in	nformation	17
	8.1	Date code	17
	8.2	Documentation	17
9	Revisio	n history	18

1 Absolute maximum ratings and operating conditions

Table 2: Absolute maximum ratings

Symbol	Parameter	Value	Unit
V _{CC}	Supply voltage (voltage difference between -V _{CC} and V _{CC} pins)	18	
V _{id}	Differential input voltage (1)	±1.2	V
V _{in}	Input voltage (2) (3)	-V _{CC} - 0.3 V to V _{CC} + 0.3 V	
I _{in}	Input current	45	mA
T _{stg}	Storage temperature	-65 to 150	ڻ
Tj	Maximum junction temperature	150	
R _{thja}	Thermal resistance junction to ambient area (4)	TBD	0000
R _{thjc}	Thermal resistance junction to case (4)	TBD	°C/W
ESD	HBM: human body model ⁽⁵⁾	2	kV
T _{Lead}	Lead temperature (soldering, 10 s)	260	°C

Notes:

Table 3: Operating conditions

Symbol	Parameter	Value	Unit
(V _{CC}) - (-V _{CC})	Supply voltage	4 to 14 ⁽¹⁾	V
V _{icm}	Common-mode input voltage	-V _{CC} to V _{CC}	V
T _{oper}	Operating free-air temperature range	-55 to 125	°C

Notes:

(1)SEL-free up to 120 MeV.cm²/mg

 $^{^{(1)}}$ The differential voltage is the voltage difference between the pins +IN and -IN of a channel.

⁽²⁾All voltage values except the differential voltage are with respect to the network ground terminal.

 $^{^{(3)}}$ The voltage on either input must never exceed V_{CC} + 0.3 V nor 16 V.

⁽⁴⁾Short circuits can cause excessive heating and destructive dissipation. Values are typical.

 $^{^{(5)}}$ 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.

Electrical characteristics RHF484

2 Electrical characteristics

Table 4: VCC = 7 V, -VCC = -7 V, Vicm = 0 V, Tamb = 25 °C, loads (RL, CL) connected to GND (unless otherwise specified)

Definition D	Symbol	Parameter	Test conditions		Min.	Тур.	Max.	Unit
Viore = 7 V 25 °C 500 700 700 755 °C 60 300 700 700 755 °C 600 300 700 700 700 755 °C 600 300 7	DC perfo	ormance						
Vio				-55 °C			700	
Vio			Vicm = 7 V	25 °C			500	
Vio				125 °C			700	
DVio Input offset voltage drift No load 1 DVio Input offset voltage drift No load 1 DVio Input offset voltage drift No load 1 DVio Input offset current No load Input offset current Input offset current No load Input offset current Input offset cu				-55 °C			500	
No load Supply current per amplifier Supply current per amplifier No load Supply current per amplifier Supply current per amplifier No load Supply current per amplifier Supply current per amplifier No load Supply current per amplifier Supply c	V_{io}	Offset voltage	Vicm = 0 V	25 °C		60	300	μV
No load 1				125 °C			500	
DV DV DV DV DV DV DV DV				-55 °C			700	
DV ₁₀ Input offset voltage drift No load -55 °C 100			Vicm = -7 V	25 °C			500	
Input bias current No load 25 °C 6 6 60				125 °C			700	
Input bias current No load 25 °C 6 6 60 nA	DV_{io}	Input offset voltage drift	No load			1		μV/°C
DII				-55 °C			100	
DII DIII DII D	I_{ib}	Input bias current	No load	25 °C		6	60	nA
Dilip drift				125 °C			100	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	DI_ib		No load			100		pA/°C
To be the component of the parameter of the pa		Input offset current		-55 °C			35	nA
C _{in} Differential input capacitance between IN and -IN Input capacitance between IN (or -IN) and GND 25°C 2 pF I _{cc} Supply current per amplifier No load -55 °C 2.2 2.9 mA CMR Common mode rejection ratio No load, -Vcc < Vicm < Vcc	I_{io}		No load, Vout = 0 V	25 °C		2	15	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				125 °C			35	
Input capacitance between IN (or -IN) and GND 2 2 2.9	C			25°C		8		5
	Cin			25 0		2		рг
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				-55 °C			2.9	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	I_{CC}	Supply current per amplifier	No load	25 °C		2.2	2.9	mA
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				125 °C			2.9	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$			No lood	-55 °C	72			
SVR Supply voltage rejection ratio	CMR	Common mode rejection ratio		25 °C	72	105		
SVR Supply voltage rejection ratio				125 °C	72			dВ
SVR Supply voltage rejection ratio				-55 °C	80			GD.
	SVR	Supply voltage rejection ratio		25 °C	90	120		
GBP Gain bandwidth product				125 °C	80			
GBP Gain bandwidth product	AC perfo	ormance						
$RL = 1 k\Omega$, $23 C 6 8 MHZ$				-55 °C	3.5			
	GBP	Gain bandwidth product		25 °C	6	8		MHz
				125 °C	3.5			

4/19 DocID17351 Rev 3



RHF484 Electrical characteristics

Symbol	Parameter	Test condition	Test conditions		Тур.	Max.	Unit
Fu	Unity gain frequency	RL = 1 kΩ, CL = 100 pF	25 °C		5		
φm	Phase margin	RL = 1 k Ω , CL = 100 pF, G = 5	25 °C		50		Degrees
			-55 °C	60			
A_{VD}	Large signal voltage gain	RL = 10 k Ω , Vout = -6.5 V to 6 V	25 °C	74	85		dB
		Vout = 0.0 V to 0 V	125 °C	60			
		RL = 1 kΩ, Vout =	-55 °C	1.7			
SR	Slew rate	-4.8 V to 4.8 V, Vout	25 °C	2	3.5		V/µs
		= 4.8 V to -4.8 V	125 °C	1.7			
en	Equivalent input noise voltage	No load, f = 1 kHz	25 °C		7		nV/√Hz
i _n	Equivalent input noise current	No load, f = 1 kHz	25 °C		0.8		pA/√Hz
THD+e _n	Total harmonic distortion + noise	Vout = 13 Vpp, RL = 1 k Ω , CL = 100 pF, G = -5.1	25 °C		0.01		%
	C	output characteristics					
		$Vcc = 14 \text{ V},$ $-Vcc = 0 \text{ V},$ $RL = 1 \text{ k}\Omega$	-55 °C	13.5			-
	High level output voltage		25 °C	13.6	13.8		
V_{OH}			125 °C	13.5			
VOH		Vcc = 14 V, -Vcc = 0 V, RL = 10 kΩ	-55 °C	13.6			
			25 °C	13.8	13.9		
			125 °C	13.6			V
		Vcc = 14 V,	-55 °C			0.3	V
		-Vcc = 0 V,	25 °C		0.12	0.2	
V_{OL}	Low lovel output voltage	RL = 1 kΩ	125 °C			0.3	
VOL	Low level output voltage	Vcc = 14 V,	-55 °C			0.2	
		-Vcc = 0 V,	25 °C		0.04	0.08	
		RL = 10 kΩ	125 °C			0.2	
			-55 °C	15			
	Output sink current	Vout = Vcc, no load, Vid = -1 V	25 °C	20	35		mA
(1)		1.4 - 1.4	125 °C	15			
l _{out} ⁽¹⁾			-55 °C	10			
	Output source current	Vout = -Vcc, no load, Vid = 1 V	25 °C	15	30		
		, , v	125 °C	10			

Notes:

 $^{^{(1)}}$ These tests are performed during a very short period of time. Excessive heating can damage the device. In the application, the junction temperature must never exceed 150 °C.

Electrical characteristics RHF484

Table 5: VCC = 2 V, -VCC = -2 V, Vicm = 0 V, Tamb = 25 °C, loads (RL, CL) connected to GND (unless otherwise specified)

Symbol	Parameter	Test conditions		Min.	Тур.	Max.	Unit
DC perfo	rmance						
			-55 °C			700	
		Vicm = 2 V	25 °C			500	
			125 °C			700	
			-55 °C			500	
V_{io}	Offset voltage	Vicm = 0 V	25 °C		60	300	μV
			125 °C			500	
			-55 °C			700	
		Vicm = -2 V	25 °C			500	
			125 °C			700	
DV_io	Input offset voltage drift	No load			1		μV/°C
			-55 °C			100	
I_{ib}	Input bias current	No load	25 °C		11	60	nA
			125 °C			100	
DI_ib	Input offset current temperature drift	No load			100		pA/°C
			-55 °C			35	nA
I_{io}	Input offset current	No load, Vout = 0 V	25 °C		2	15	
			125 °C			35	
0	Differential input capacitance between IN and -IN				8		5.
C _{in}	Input capacitance between IN (or -IN) and GND		- 25°C		2		pF
		No load	-55 °C			2.6	
Icc	Supply current per amplifier		25 °C		2	2.6	mA
			125 °C			2.6	
			-55 °C	72			
CMR	Common mode rejection ratio	No load, -Vcc < Vicm < Vcc	25 °C	72	95		dB
		125		72			
AC perfo	rmance						
		Vout = 200 mVpp,	-55 °C	3.5			
GBP	Gain bandwidth product	f = 100 kHz, RL = 1 k Ω ,	25 °C	6	8		1
		CL = 100 pF	125 °C	3.5			MHz
Fu	Unity gain frequency	RL = 1 k Ω , CL = 100 pF	25 °C		5		
φm	Phase margin	RL = 1 k Ω , CL = 100 pF, G = 5	25 °C		50		Degrees
٨	Lorgo pignol voltogo goig	RL = 10 kΩ, Vout =	-55 °C	60			dB
A_{VD}	Large signal voltage gain	-1.5 V to 0.5 V	25 °C	70	80		

6/19 DocID17351 Rev 3



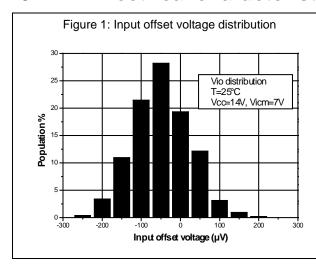
RHF484 Electrical characteristics

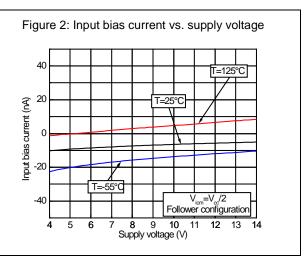
Symbol	Parameter	Test condition	ns	Min.	Тур.	Max.	Unit
A _{VD}	Large signal voltage gain	RL = 10 kΩ, Vout = -1.5 V to 0.5 V	125 °C	60			dB
		RL = 1 kΩ, Vout =	-55 °C	1.7			
SR	Slew rate	-1.28 V to 1.28 V, Vout = 1.28 V to	25 °C	2	3.1		V/µs
		-1.28 V	125 °C	1.7			
en	Equivalent input noise voltage	No load, f = 1 kHz	25 °C		7.5		nV/√Hz
i _n	Equivalent input noise current	No load, f = 1 kHz	25 °C		0.8		pA/√Hz
THD+e _n	Total harmonic distortion + noise	Vout = 3 Vpp, RL = 1 k Ω , CL = 100 pF, G = -5.1	25 °C		0.01		%
	0	utput characteristics					
		Vcc = 4 V,	-55 °C	3.75			
	High level output voltage	$-Vcc = 0 V,$ $RL = 1 k\Omega$	25 °C	3.8	3.9		
V _{OH}			125 °C	3.75			
VOH		Vcc = 4 V,	-55 °C	3.75			
		-Vcc = 0 V,	25 °C	3.85	3.95		
		RL = 10 kΩ	125 °C	3.75			V
		Vcc = 4 V,	-55 °C			0.2	v
		-Vcc = 0 V,	25 °C		0.05	0.1	
V _{OL}	Low level output voltage	RL = 1 kΩ	125 °C			0.2	
100	Low love, output vertage	Vcc = 4 V,	-55 °C			0.1	
		-Vcc = 0 V,	25 °C		0.03	0.07	
		RL = 10 kΩ	125 °C			0.1	
		Vout Voe no load	-55 °C	15			
	Output sink current	Vout = Vcc, no load, Vid = -1 V	25 °C	20	35		- mA
I _{out} ⁽¹⁾			125 °C	15			
·out		Vout = -Vcc, no load, Vid = 1 V	-55 °C	10			1117
	Output source current		25 °C	15	30		
			125 °C	10			

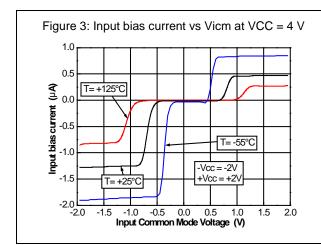
Notes:

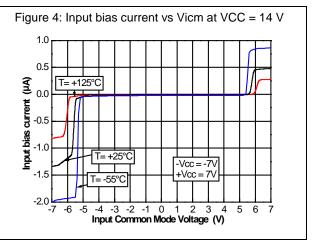
 $^{^{(1)}}$ These tests are performed during a very short period of time. Excessive heating can damage the device. In the application, the junction temperature must never exceed 150 °C.

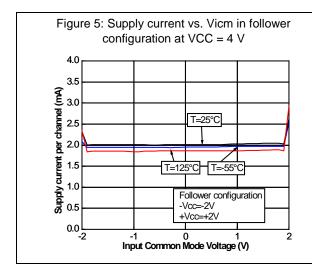
3 Electrical characteristic curves

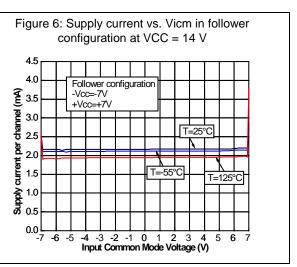












DocID17351 Rev 3

8/19

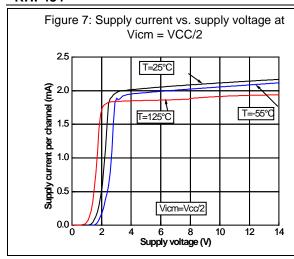
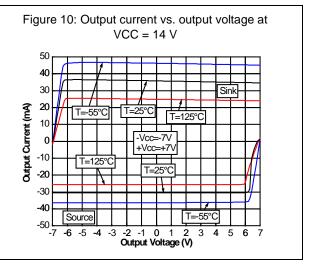
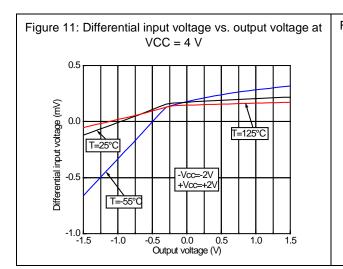
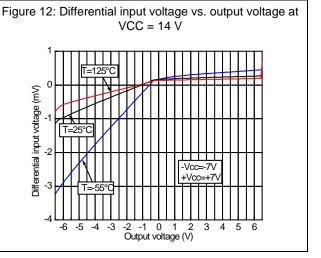


Figure 8: Output current vs. supply voltage at Vicm = VCC/2Output Current (mA) Sink Vid = -1V T=125°C T=-55°C Vicm=Vcc/2 T=125°C Source Vid = 1V T=25°C T=-55°C 6.0 8.0 14.0 Supply voltage (V)

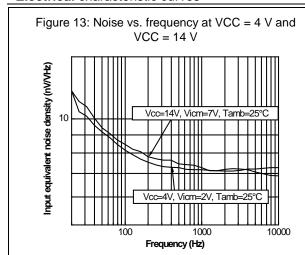
Figure 9: Output current vs. output voltage at VCC = 4 V50 40 30 20 Output Current (mA) T=25°C 10 T=-55°C T=125°C +Vcc=2V -Vcc=-2V -10 -20 -30 -40 Source T=25°C -50 -2.0 -0.5 0.0 0.5 Output Voltage (V) -1.5 -1.0 1.0 1.5







57/



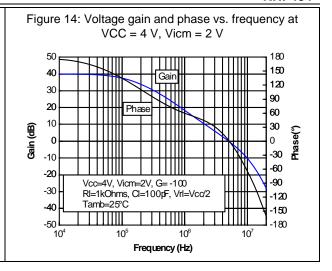
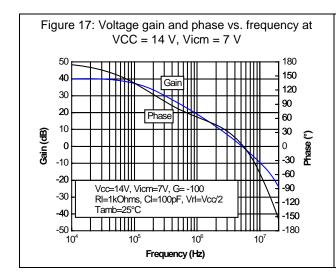
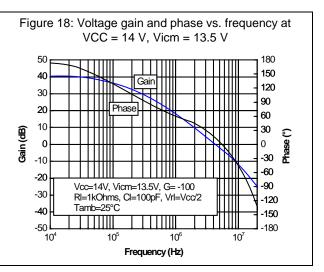


Figure 15: Voltage gain and phase vs. frequency at VCC = 4 V, Vicm = 3.5 V 180 150 40 Gain 120 30 90 20 60 10 30 O 0 Gain -30 -10 -60 -20 Vcc=4V, Vicm=3.5V, G= -100 -90 -30 RI=1kOhms, CI=100pF, VrI=Vcc/2 -120 Tamb=25°C -40 -150 l₋₁₈₀ 10⁴ 10⁵ 10⁶ 10 Frequency (Hz)

Figure 16: Voltage gain and phase vs. frequency at VCC = 4 V, Vicm = 0.5 V 180 150 40 Gain 120 30 90 20 60 10 30 9 \mathbb{S} 0 0 Gain -30 -10 -60 -20 -90 Vcc=14V, Vicm=0.5V, G= -100 -30 RI=1kOhms, CI=100pF, VrI=Vcc/2 -120 Tamb=25°C -40 -150 l ₋₁₈₀ 10⁴ 10 10⁶ 10⁷ Frequency (Hz)





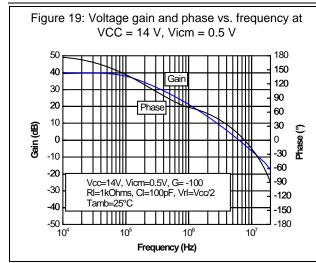
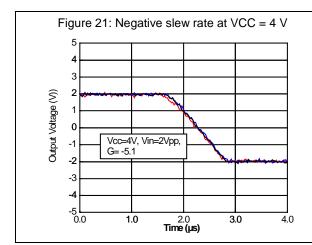
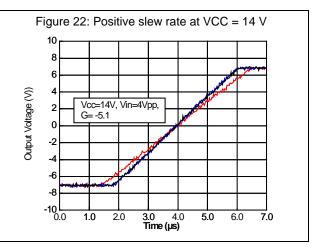
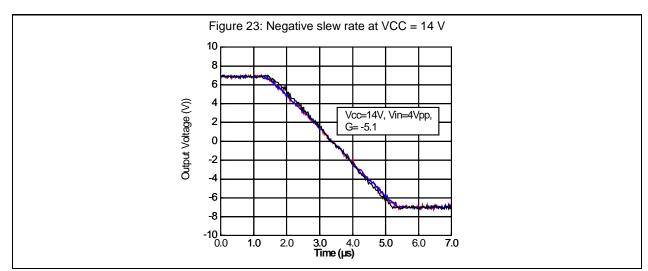


Figure 20: Positive slew rate at VCC = 4 V







47/

Radiations RHF484

4 Radiations

4.1 Introduction

Table 6 summarizes the radiation performance of the RHF484.

Table 6: Radiations

Туре	Features		Value	Unit
	High-dose rate	High-dose rate		
TID	Low-dose rate		300	krad
	ELDRS		300	
	SEL immunity (at 125 °C) up to:		110	MeV.cm²/mg
	SET characterized	Inverting	LET _{th} = 1	MeV.cm²/mg
		inverting	σ = 3.10E-03	cm²/device
Heavy ions		Non-inverting	LET _{th} = 1	MeV.cm²/mg
		Non-inverting	σ = 3.20E-03	cm²/device
		Subtracting	LET _{th} = 1	MeV.cm²/mg
		Subtracting	σ = 2.80E-03	cm²/device

4.2 Total ionizing dose (TID)

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

The RHF484 is RHA QML-V qualified, and is tested and characterized in full compliance with the MIL-STD-883 specification. It using a mixed bipolar and CMOS technology and is tested both below 10 mrad/s (low dose rate) and between 50 and 300 rad/s (high dose rate).

- The ELDRS characterization is performed in qualification only on both biased and unbiased parts, on a sample of ten 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.

4.3 Heavy ions

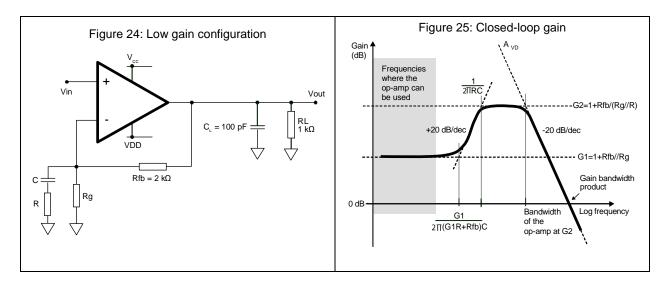


The heavy ion trials are performed on qualification lots only. No additional test is performed.

Downloaded from Arrow.com.

5 Achieving good stability at low gain

At low frequencies, the RHF484 can be used in a low gain configuration as shown in *Figure 24*. At lower frequencies, the stability is not affected by the value of the gain, which can be set close to 1 V/V (0 dB), and is reduced to its simplest expression G1 = 1+Rfb/Rg. Therefore, an R-C cell is added in the gain network so that the gain is increased (up to 5) at higher frequencies (where the stability of the amplifier could be affected). At higher frequencies, the gain becomes G2 = 1+Rfb/(Rg//R).



Rg becomes a complex impedance. The closed-loop gain features a variation in frequency and can be expressed as *Equation 1*.

Equation 1

$$Gain = G1 \frac{1 + jC\omega x \left(\frac{G1R + Rfb}{G1}\right)}{1 + jCR\omega}$$

Where a pole appears at $1/2\pi RC$ and a zero at $G1/2\pi (G1R+Rfb)C$. The frequency can be plotted as shown in *Figure 25*.

Table 7: External components versus low-frequency gain

G1 (v/V)	R (Ω)	C (nF)	Rg (Ω)	Rfb (Ω)
1.1			20 k	
2	510	4	2 k	2 k
3	510	1	1 k	
4			750	2.4 k
5	Not connected	Not connected	820	3.3 k



Package information RHF484

6 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.



RHF484 Package information

6.1 Wide ceramic Flat-14W package information

 $\begin{array}{c} & & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & \\ & & & \\ & & & \\ & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & &$

Figure 26: Wide ceramic Flat-14W package outline



The upper metallic lid is not electrically connected to any pins, nor to the IC die inside the package. Connecting unused pins or metal lid to ground or VCC will not affect the electrical characteristics.

Dimensions Ref. **Millimeters** Inches Min. Min. Тур. Max. Тур. Max. 2.29 0.076 0.083 Α 1.93 2.11 0.090 b 0.38 0.43 0.48 0.015 0.017 0.019 0.10 0.13 0.18 0.004 0.005 0.007 С D 9.71 9.91 10.11 0.382 0.390 0.398 7.57 0.292 Ε 7.27 7.42 0.286 0.298 E2 5.4 0.213 E3 0.76 0.030 1.27 0.050 е L 6.3 6.6 0.248 0.260 Q 0.20 0.28 0.008 0.011 S1 0.13 0.005

Table 8: Wide ceramic Flat-14W mechanical data



Ordering information RHF484

Ordering information 7

Table 9: Ordering information

Order code	SMD pin	EPPL (1)	Quality level	Package	Lead finish	Marking ⁽²⁾	Packing
RHF484K1	-	-	Engineering model	Flat-14W	Gold	RHF484K1	Strip
RHF484K-01V	5962F0822201VXC	Yes	QML-V flight			5962F0822201VXC	pack

Notes:

⁻ QML logo (Q or V) - Country of origin (FR = France).



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

⁽¹⁾EPPL = ESA preferred part list

 $[\]ensuremath{^{(2)}}\mbox{Specific marking only.}$ Complete marking includes the following:

⁻ SMD pin (as indicated in above table)
- ST logo

⁻ Date code (date the package was sealed) in YYWWA (year, week, and lot index of week)

RHF484 Other information

8 Other information

8.1 Date code

The date code is structured as shown below:

- EM xyywwz
- QML-V yywwz where:
 - x (EM only) = 3 and the assembly location is Rennes, France
 - yy = last two digits of the year
 - ww = week digits
 - z = lot index in the week

8.2 Documentation

Table 10: Documentation provided for each type of product

Quality level	Documentation
Engineering model	_
	Certificate of conformance
	QCI (groups A, B, C, D, and E) (1)
	Screening electrical data
QML-V flight	Precap report
	PIND test (2)
	SEM inspection report (3)
	X-ray report

Notes:

⁽¹⁾QCI = quality conformance inspection

 $^{^{(2)}}$ PIND = particle impact noise detection

⁽³⁾SEM = scanning electron microscope

Revision history RHF484

9 Revision history

Table 11: Document revision history

Date	Revision	Changes
26-Apr-2011	1	Initial release
06-Feb-2015	2	Replaced package silhouette and added marker to show position of pin 1 on the silhouette, pinout, and package drawing. Updated Features Updated Table 1: Device summary Table 2: Absolute maximum ratings: transferred radiation information to Section 3. Added Section 3: Radiations Section 5.1: Wide ceramic Flat14W package information: added "W" to package information.
		Updated Section 6: Ordering information Added Section 7: Other information
06-Apr-2016	3	Updated document layout Table 1: "Device summary": updated footnote 1, SMD = standard microcircuit drawing.

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