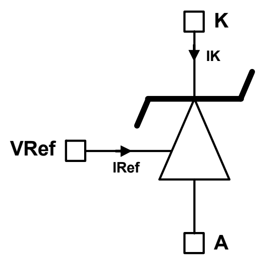
RHF1009A

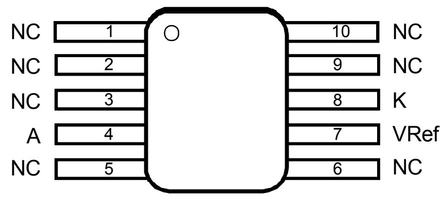
Rad-hard adjustable 2.5 V/5.5 V precision shunt V-ref

Datasheet - production data



Pin connections - top view

10-lead ceramic Flat-10 package



The upper metallic lid is not electrically connected to any pins, nor to the IC die inside the package.

Features

- Adjustable shunt, 2.5 V to 5.5 V
- High precision ±0.2 % at 2.5 V at 25 °C
- Wide operating current: 60 µA to 12 mA
- 30 ppm/°C maximum temperature range at 2.5 V
- Stable on capacitive load
- ELDRS-free up to 300 krad
- 300krad high/low dose rate
- SEL-free up to 120MeV.cm²/mg
- SET characterized

Applications

- Space systems
- Space data acquisition systems
- Aerospace instrumentation
- ADC references

Description

The RHF1009A is a low-power adjustable 2.5 V voltage reference dedicated to space applications.

Mounted in a Flat-10 ceramic package, the RHF1009A uses dedicated architecture and design rules to provide the best immunity against radiation.

A very low operating current and very good stability over a wide temperature range of -55°C to +125°C make the RHF1009A particularly suitable for precision and power saving.

Table 1. Device summary

Reference	SMD pin	Quality level	Package	Lead finish	Mass	EPPL (1)	Temp. range
RHF1009AK1		Engineering model	Flat-10	Gold	0.50 g		-55 °C to 125 °C
RHF1009AK01V (2)	TBD	QML-V flight				Target	

1. EPPL = ESA preferred part list
2. Not yet in full production

This is information on a product in full production. www.st.com

Contents

1 Absolute maximum ratings and operating conditions

Table 2. Absolute maximum ratings

Symbol	Parameter	Value	Unit
I_K	Reverse breakdown current	15	mA
I_F	forward current	20	mA
V_{KA}	Reverse breakdown voltage in standby mode ($V_{Ref} = V_A$)	6	V
T_{stg}	Storage temperature	-65 to +150	°C
T_j	Maximum junction temperature	150	°C
R_{thja}	Thermal resistance junction (T_j) to ambient (T_{amb})	140	°C/W
R_{thjc}	Thermal resistance junction to case	40	°C/W
ESD	HBM: human body model (1)	2	kV
	MM: machine model (2)	200	V
	CDM: charged device model (3)	1.5	kV

1. 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.
2. This is a minimum value. Machine model: a 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
3. Charged device model: all pins and package are charged together to the specified voltage and then discharged directly to ground through only one pin.

Table 3. Operating conditions

Symbol	Parameter	Value	Unit
I_{Kmin}	Minimum operating current [$V_K \geq V_K$ (I_K = 100 µA, Ta = 25°C) - 100 µV] $V_K = V_{Ref}$	60	µA
V_{KA}	Reverse breakdown voltage in operating mode: in standby mode ($V_{Ref} = V_A$):	 2.5 to 5.5 2.5 to 5.5	V
I_{Kmax}	Maximum operating current [$V_K \geq V_K$ (I_K = 100 µA, Ta = 25°C) + 2 mV] $V_K = V_{Ref}$	12	mA
T_{oper}	Operating ambient temperature range	-55 to +125	°C

2 Electrical characteristics

Parameters tested before radiation are shown in *Table 4*.

Table 4. Anode is connected to Gnd (0 V), V_K is in reference to anode voltage. C_K (between anode and cathode) = 100 nF, R_1 = 0 and R_2 not connected unless otherwise specified

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
DC performance							
V_{Ref}	Reference input voltage	I_K = 100 µA $V_K = V_{Ref}$	+25°C		2.5		V
ΔV_{Ref}	Reference input voltage tolerance	I_K = 100 µA $V_K = V_{Ref}$	+25°C	-5		+5	mV
I_{Kmin}	Minimum operating current	[$V_K \geq V_K$ (I_K = 100 µA, Ta = 25°C) - 100 µV] $V_K = V_{Ref}$	-55°C +25°C +125°C			60 60 60	µA
I_{Koff}	Off state cathode current	$V_{Ref} = V_A$ V_{KA} = 2.5V	-55°C +25°C +125°C			1 1 1	µA
I_{Ref}	Reference input current	I_K = 100 µA to 10 mA $V_K = V_{Ref}$ on R_1 = 10 kΩ	-55°C +25°C +125°C			1 1 1	µA
$\Delta V_{Ref}/\Delta T$	Average temperature coefficient $\frac{VRefmax - VRefmin}{180°C \times VRef(25°C)} \times 10^6$	I_K = 100 µA $V_K = V_{Ref}$	-55°C to +125°C			30	ppm/°C
		I_K = 10 mA $V_K = V_{Ref}$	-55°C to +125°C			30	
$\Delta V_{Ref}/\Delta V_{KA}$	Reference voltage versus cathode voltage variation	I_K = 100 µA V_{KA} = 2.5 V to 5.5 V R_1 = 10 kΩ, R_2Variable	-55°C to +125°C		1.5	2.5	mV/V
		I_K = 10 mA V_{KA} = 2.5 V to 5.5 V R_1 = 10 kΩ, R_2Variable	-55°C to +125°C		1.5	2.5	
$\Delta V_{Ref}/\Delta I_K$	Reference voltage versus cathode current variation	$I_{Kmin} \leq I_K \leq$ 1 mA $V_K = V_{Ref}$	-55°C +25°C +125°C		0.075 0.08 0.15	0.15 0.16 0.3	mV
		1 mA $\leq I_K \leq$ 12 mA $V_K = V_{Ref}$	-55°C +25°C +125°C		0.65 0.7 1	1.3 1.4 2	
R_{KA}	Reverse static impedance	$\Delta I_K = I_{Kmin}$ to 10 mA $V_K = V_{Ref}$	-55°C +25°C +125°C		0.05 0.06 0.1	0.1 0.12 0.2	Ω
Z_{KA}	Reverse dynamic impedance	I_K = 1mA to 1.1mA $V_K = V_{Ref}$, F ≤ 1 kHz No capacitive load	-55°C +25°C +125°C		0.4 0.4 0.5		Ω

Table 4. Anode is connected to Gnd (0 V), V_K is in reference to anode voltage. C_K (between anode and cathode) = 100 nF, R_1 = 0 and R_2 not connected unless otherwise specified (continued)

Symbol	Parameter	Test conditions	Temp.	Min.	Typ.	Max.	Unit
Kvh(1)	Long-term stability $\frac{\lvert Vk(0hr) - Vk(1000hrs) \rvert}{Vk(0hr)} \times 10^6$	I_K = 100 µA $V_K = V_{Ref}$ t = 1000 hrs	-55°C +25°C +125°C		100 100 100		ppm
Kvhd	Stability in radiation $\frac{\lvert Vk(0rad) - Vk(300krad) \rvert}{Vk(0rad)} \times 10^6$	I_K = 100 µA $V_K = V_{Ref}$ Total dose = 300krad Dose rate = 0.01rad/s	-55°C +25°C +125°C		1000 1000 1000		ppm
en	Voltage noise	I_K = 100 µA $V_K = V_{Ref}$ F= 1 kHz	-55°C +25°C +125°C		760 880 980		nV/ √Hz

1. Reliability verified with a cathode current setting I_K = 10 mA

3 Radiation

Total ionizing dose (MIL-STD-883 TM 1019)

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

The RHF1009A is RHA QML-V, tested and characterized in full compliance with the MIL-STD-883 specification, both below 10 mrad/s and between 50 and 300 rad/s, as follows:

- All tests are performed in accordance with MIL-PRF-38535 and the test method 1019 of 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 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.

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.

Table 5. Radiation

Type	Characteristics	Value	Unit
TID	180 krad/h high-dose rate (50 rad/sec) up to:	300	krad
	ELDRS-free up to:	300	
	36 Rad/h low-dose rate (0.01 rad/sec) up to:	300	
Heavy ions	SEL immunity up to: (at 125 °C, with a particle angle of 60 °)	120	MeV.cm²/mg
	SEL immunity up to: (at 125 °C, with a particle angle of 0 °)	60	
	SET (at 25 °C)	Characterized	

Note: In Figure 1 to 24, temp. = temperature, freq. = frequency, and resp. = response.

Figure 1. Reverse breakdown voltage characteristics vs. cathode current

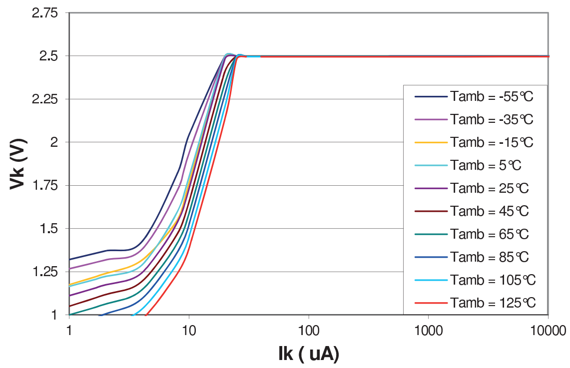


Figure 2. Zoom of reverse breakdown voltage characteristics vs. cathode current

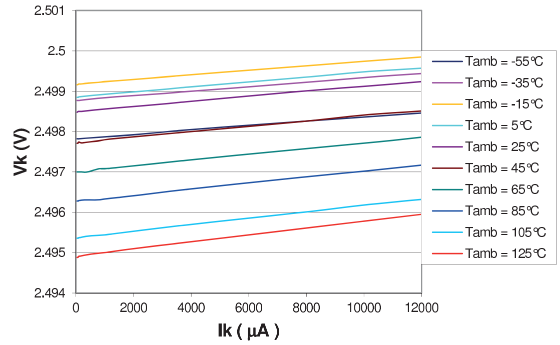


Figure 3. Reverse breakdown voltage characteristics vs. ambient temp.

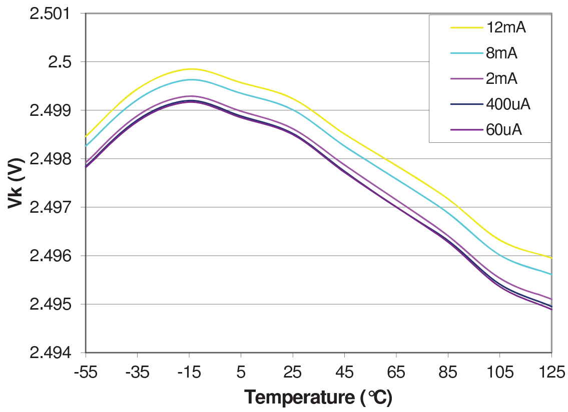


Figure 4. Average temp. coefficient vs. cathode current

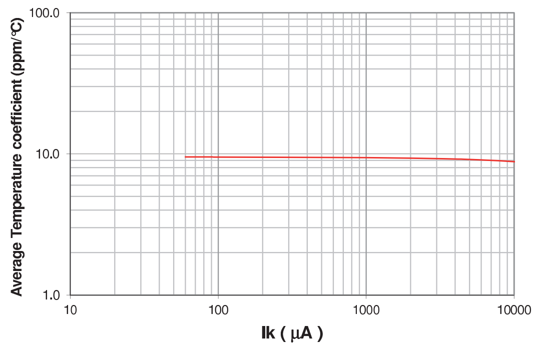


Figure 5. Output impedance vs. freq. at +125 ° C, C_k = 47nF

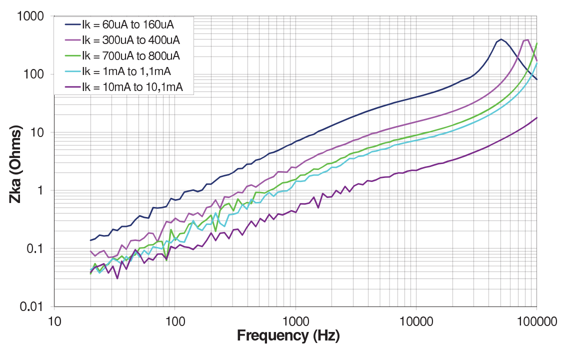


Figure 6. Output impedance vs. freq. at 125 ° C, C_k = 100 nF

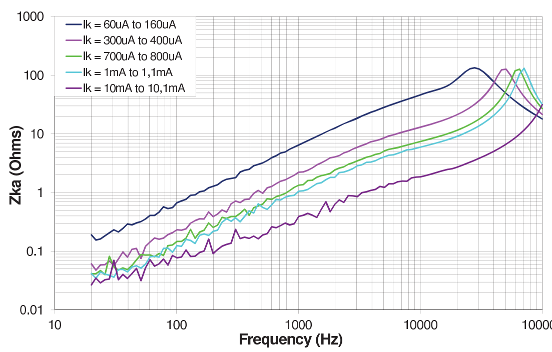


Figure 7. Output impedance vs. freq. at +25 °C, C_k = 47nF

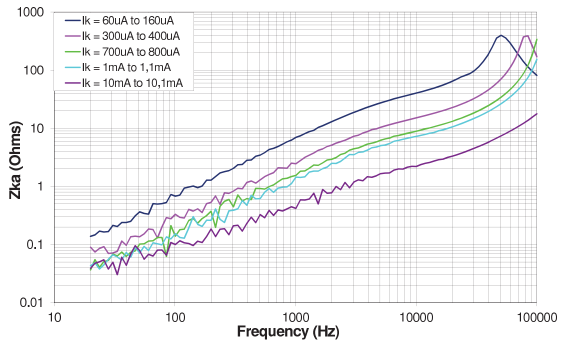


Figure 8. Output impedance vs. freq. at 25 °C, C_k = 100 nF

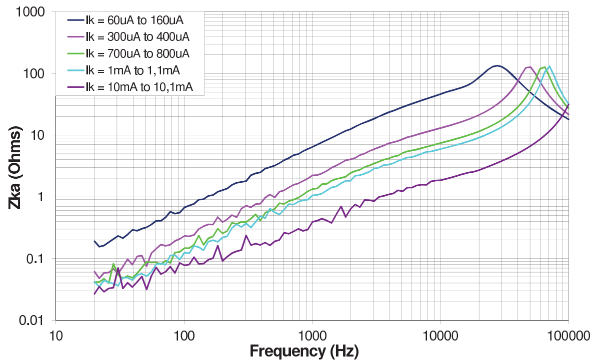


Figure 9. Output impedance vs. freq. at -55 °C, C_k = 47 nF

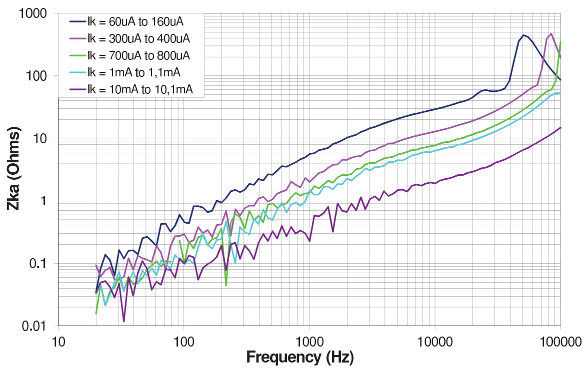


Figure 10. Output impedance vs. freq. at -55 °C, C_k = 100 nF

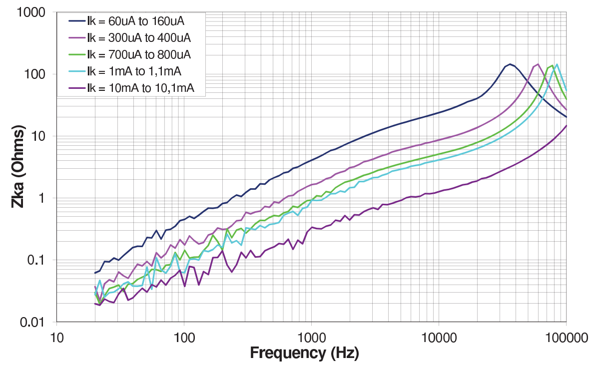


Figure 11. Output impedance vs. freq. at +125 °C, C_k = 470 nF

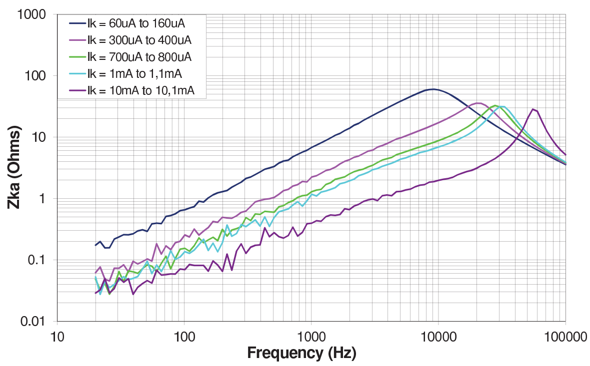


Figure 12. Output impedance vs. freq. at +125 °C, C_k = 1 µF

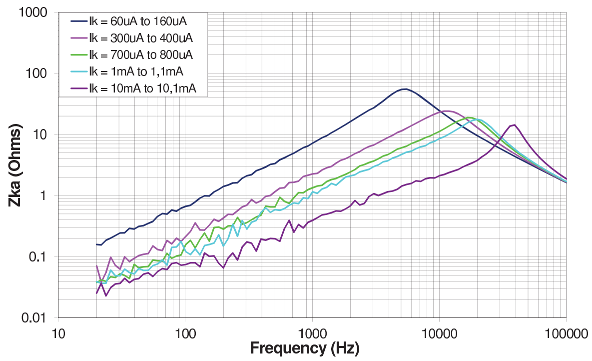


Figure 13. Output impedance vs. freq. at +25 ° C, C_k = 470 nF

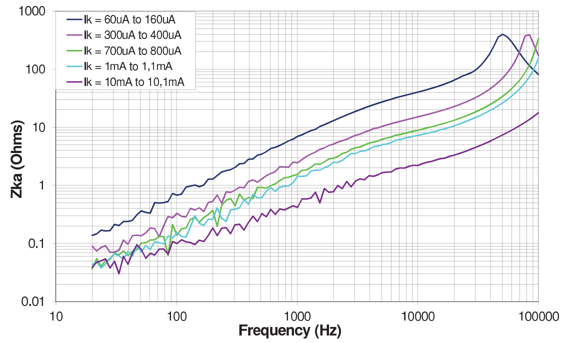


Figure 14. Output impedance vs. freq. at +25 ° C, C_k = 1 µF

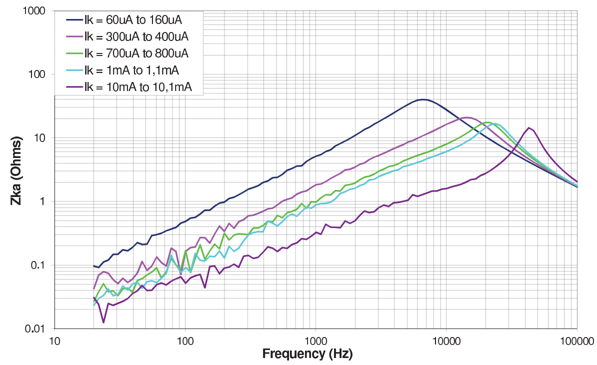


Figure 15. Output impedance vs. freq. at -55 ° C, C_k = 470 nF

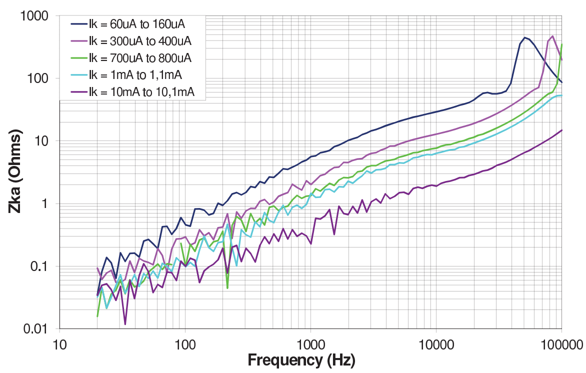


Figure 16. Output impedance vs. freq. at -55 ° C, C_k = 1 µF

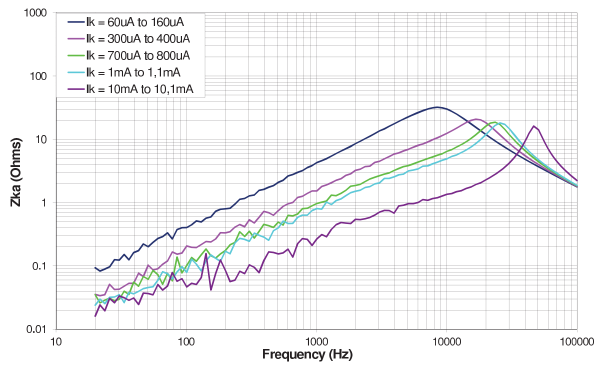


Figure 17. Spectral noise density vs. freq. at +125 ° C, C_k = 100 nF

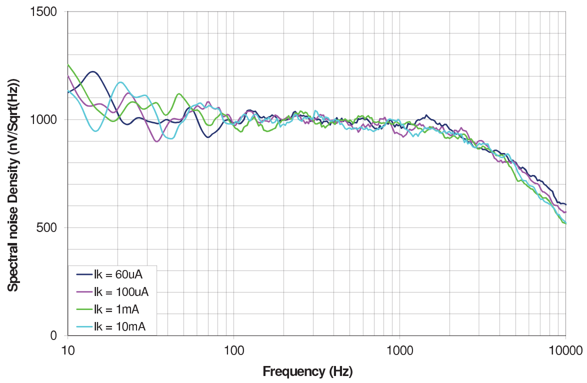


Figure 18. Spectral noise density vs. freq. at +125 ° C, C_k = 1 µF

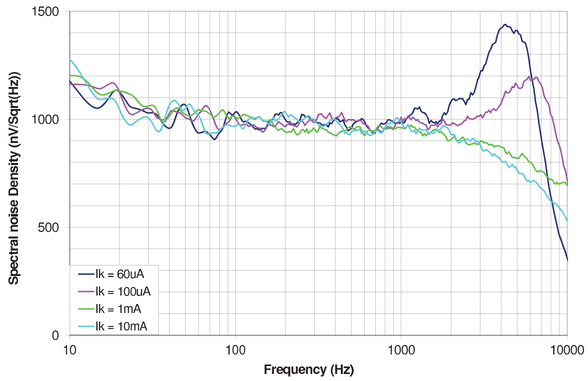


Figure 19. Spectral noise density vs. freq. at +25 °C, C_k = 100 nF

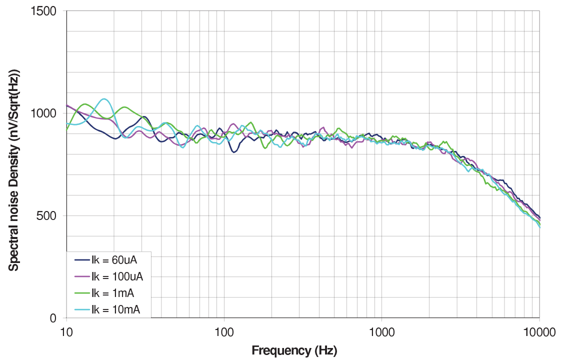


Figure 20. Spectral noise density vs. freq. at +25 °C, C_k = 1 µF

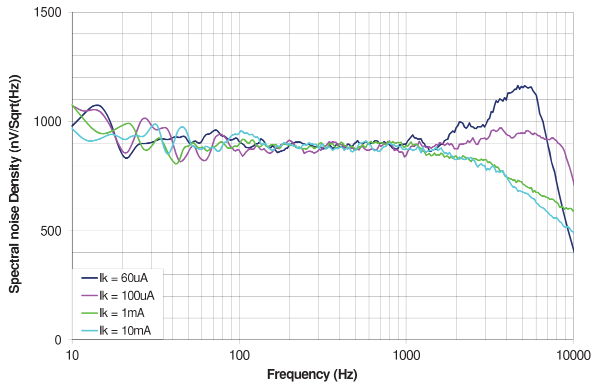


Figure 21. Spectral noise density vs. freq. at -55 °C, C_k = 100 nF

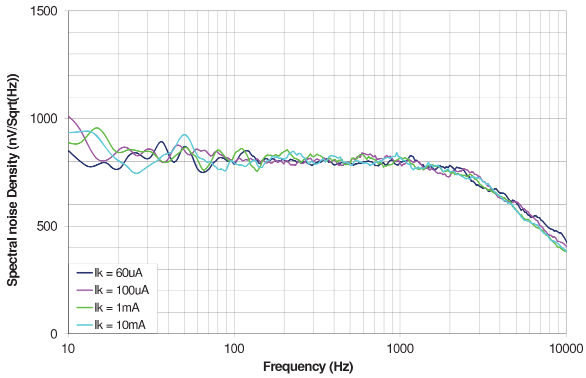


Figure 22. Spectral noise density vs. freq. at -55 °C, C_k = 1 µF

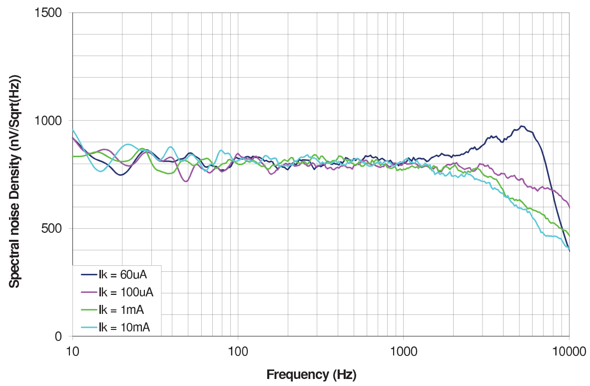


Figure 23. Low freq. spectral noise density vs. freq. C_k = 100 nF to 1µF, Ik = 60µA to 10mA

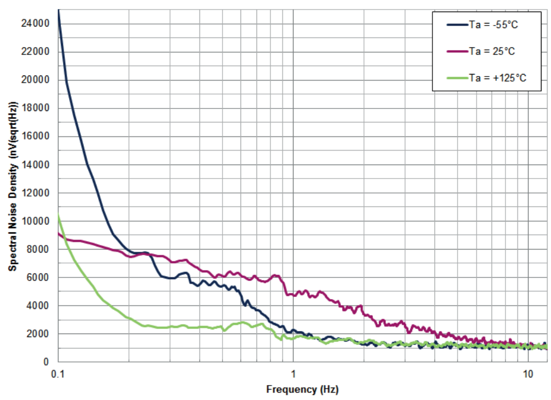
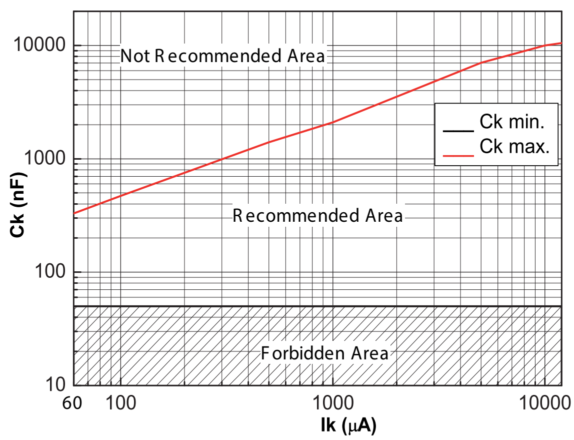


Figure 24. Recommended operating area



4 Design information

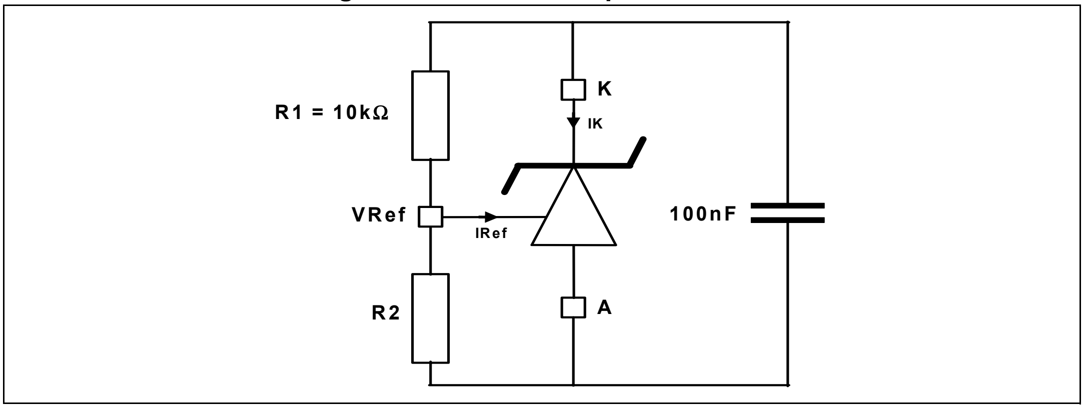
4.1 Introduction

The RHF1009A is a programmable voltage reference. It can be set from 2.5 V to 5.5 V by a bridge of 2 resistors (see *Figure 25*).

From -55°C to +125°C, the cathode current capability of the RHF1009A ranges from 60 µA up to 12 mA.

Internal double bonding allows the RHF1009A to have an equivalent output resistance as low as 110 mΩ. Consequently, the RHF1009A has very good load regulation.

Figure 25. Electrical implementation



$$V_{KA} = V_{Ref} \times \left(1 + \frac{R_1}{R_2}\right) + R_1 \times I_{Ref}$$

4.2 Average temperature coefficient

The RHF1009A is designed with a second order compensation in temperature. This gives an S-shaped curve for the V_k variation over the temperature range.

For the RHF1009A, the average temperature coefficient is calculated as shown in *Equation 1*.

Equation 1

$$\text{Average temperature coefficient} = \frac{V_{kmax} - V_{kmin}}{(T_{max} - T_{min}) \times v_k(25°C)} \times 10^6$$

where T_{max} = +125 °C and T_{min} = -55 °C.

For each sample, use *Equation 1* and the procedure below:

- Set a cathode current (I_k)
- Measure V_k at I_k with an ambient temperature of 25 °C
- Measure V_k at I_k with the following ambient temperatures: -55 °C, -15 °C, +75 °C, and +125°C.
- For the above five temperature measurements, find the V_k maximum and minimum
- Apply *Equation 1*

The average temperature coefficient is evaluated during product qualification on the above five temperature measurements and is guaranteed on production tests with three temperature measurements: -55 °C, +25 °C, and +125 °C.

4.3 Minimum and maximum cathode current

4.3.1 Minimum operating cathode current

The minimum operating cathode current ($I_{kmin.}$) is a combination of parameters (such as reference voltage, stability, noise, and process drift) that are taken over the ambient temperature range. For the RHF1009A, $I_{kmin.}$ is 60 µA.

$I_{kmin.}$ is guaranteed over the ambient temperature range by *Equation 2*.

Equation 2: $V_k(I_k = 60\ \mu A) \geq V_k(I_k = 100\ \mu A, 25\ °C) - 100\ \mu V$

4.3.2 Maximum operating cathode current ($I_{kmax.}$)

The maximum operating cathode current ($I_{kmax.}$) is limited by the output ballast current capabilities and process drift. For the RHF1009A, $I_{kmax.}$ is 12 mA.

$I_{kmax.}$ is guaranteed by the ΔV_k vs. ΔI_k parameter (see *Table 4*) and by *Equation 3* (at T_{amb} = 25 °C).

Equation 3: $V_k(I_k = 12\ mA) \leq V_k(I_k = 100\ \mu A, 25\ °C) + 3\ mV$

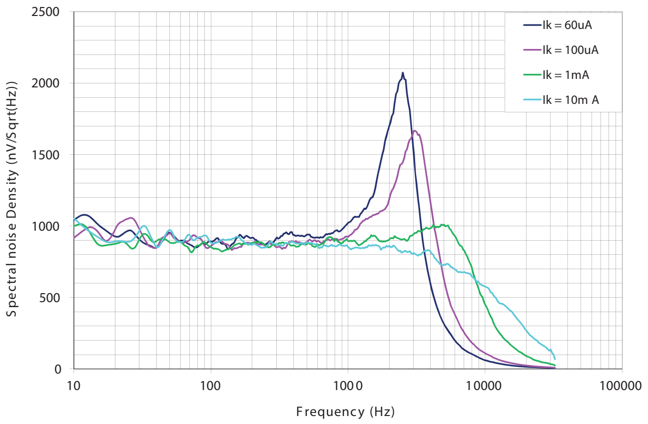
4.4 Capacitive load considerations

The RHF1009A can oscillate for a small I_k and no C_k. This is why we recommend a minimum capacitive load of 47 nF. The RHF1009A is designed to be stable with a capacitive load (C_k) over the cathode current range (60 µA to 12 mA) and ambient temperature range (-55 °C to +125 °C).

If an oscillation amplitude less than 2 mVrms is acceptable, this device can be considered usable with any capacitive load given in *Figure 24: Recommended operating area*.

Figure 26: Spectral noise density vs. frequency shows the spectral noise density measurements vs. frequency. For example, with a capacitive load of 4.7 µF and I_k = 60 µA, there is a noise peak at about 2500 Hz. For the reverse breakdown voltage (V_k), this peaking corresponds to a micro-oscillation, with jitter, centered at 2500 Hz.

Figure 26. Spectral noise density vs. frequency



5 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.

5.1 Ceramic Flat-10 package information

Figure 27. Ceramic Flat-10 package outline

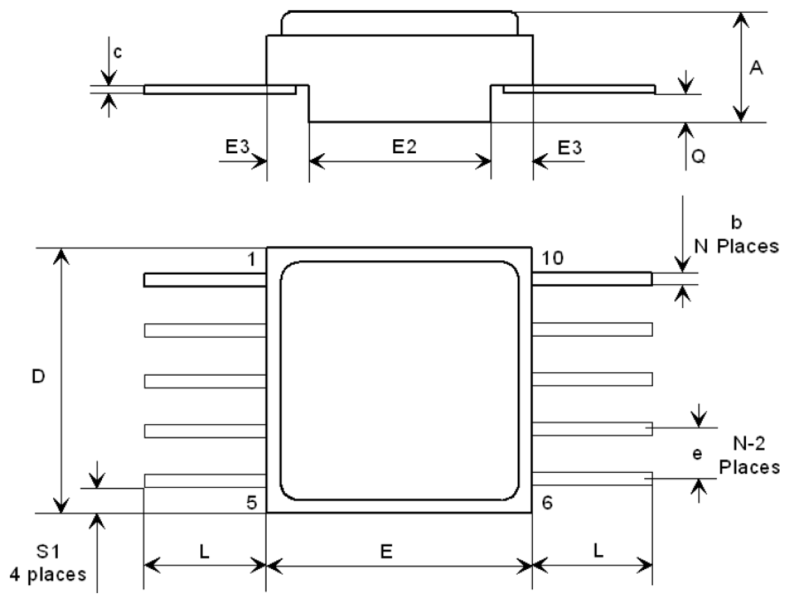


Table 6. Ceramic Flat-10 mechanical data

Ref	Dimensions					
	Millimeters			Inches		
	Min	Typ	Max	Min	Typ	Max
A	2.26	2.44	2.62	0.089	0.096	0.103
b	0.38	0.43	0.48	0.015	0.017	0.019
c	0.102	0.127	0.152	0.004	0.005	0.006
D	6.35	6.48	6.60	0.250	0.255	0.260
E	6.35	6.48	6.60	0.250	0.255	0.260
E2	4.32	4.45	4.58	0.170	0.175	0.180
E3	0.88	1.01	1.14	0.035	0.040	0.045
e		1.27			0.050	
L	6.35		9.40	0.250		0.370
Q	0.66	0.79	0.92	0.026	0.031	0.036
S1	0.16	0.485	0.81	0.006	0.019	0.032
N		10			10	

Note: The upper metallic lid is not electrically connected to any pins, nor to the IC die inside the package.

6 Ordering information

Table 7. Order codes

Order code	Description	Temp. range	Package	Marking [(1)]	Packing
RHF1009AK1	Engineering model	-55 °C to 125 °C	Flat-10	RHF1009AK1	Strip pack
RHF1009AK01V [(2)]	QML-V flight			TBD	

1. Specific marking only. Complete marking includes the following:
   - SMD pin (for QML flight only)
   - ST logo
   - Date code (date the package was sealed) in YYWWA (year, week, and lot index of week)
   - QML logo (Q or V)
   - Country of origin (FR = France)
2. Not yet in full production

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

7 Other information

7.1 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

7.2 Documentation

Table 8. Documentation provided for QML-V 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(3) mechanical test) – Group E (QCI(3) wafer lot radiation test)

1. PIND = particle impact noise detection
2. SEM = scanning electron microscope
3. QCI = quality conformance inspection

8 Revision history

Table 9. Document revision history

Date	Revision	Changes
18-Jun-2014	1	Initial release
08-Jul-2015	2	*Features*: updated Vref. accuracy *Table 3: Operating conditions*: modified V_{KA} Corrected *Figure 20: Spectral noise density vs. freq. at +25 °C, C_k = 1 µF* and *Figure 21: Spectral noise density vs. freq. at -55 °C, C_k = 100 nF*. Added *Figure 23: Low freq. spectral noise density vs. freq. C_k = 100 nF to 1µF, Ik = 60µA to 10mA*. Changed layout of *Figure 24: Recommended operating area*