

# CHT-RUBY DATASHEET

## High-Temperature, Triple Operational Amplifier and Voltage Reference

### General Description

The CHT-RUBY is a general-purpose triple operational amplifier combined with a bandgap voltage reference for applications with an operating temperature range of -55 to 225°C.

The three operational amplifiers can be configured in an instrumentation amplifier with external resistors, while the built-in voltage reference provides complete bridge excitation for sensor applications.

The total precision (absolute plus temperature drift) of the voltage reference is better than 2%. It exhibits a quiescent current consumption of 700µA, and an output current capability of up to 25mA into an external load at 225°C.

The operational amplifiers can operate with either single or symmetrical power supplies. The supply voltages range goes from 6 to 20V. This circuit is designed and fabricated with specific CISSOID techniques that enable best-in-class reliability and lifetime operation.

### Features

- Operating temperature: Junction temperature from -55°C to 225°C (other temperature range: contact marketing)
- Single or symmetrical supply operation (Operational Amplifier)
- Validated at 225°C for 1000 hours (and still on-going)
- Package: CSOIC16

### Voltage Reference:

- Fixed Reference Voltage: 5V
- Output voltage initial accuracy: ±2%
- Min dropout voltage: 2V @ 25mA
- Max. output current: 25mA @225°C
- Load capacitance: 100nF to 10 µF
- Stand-by current: 700µA typical

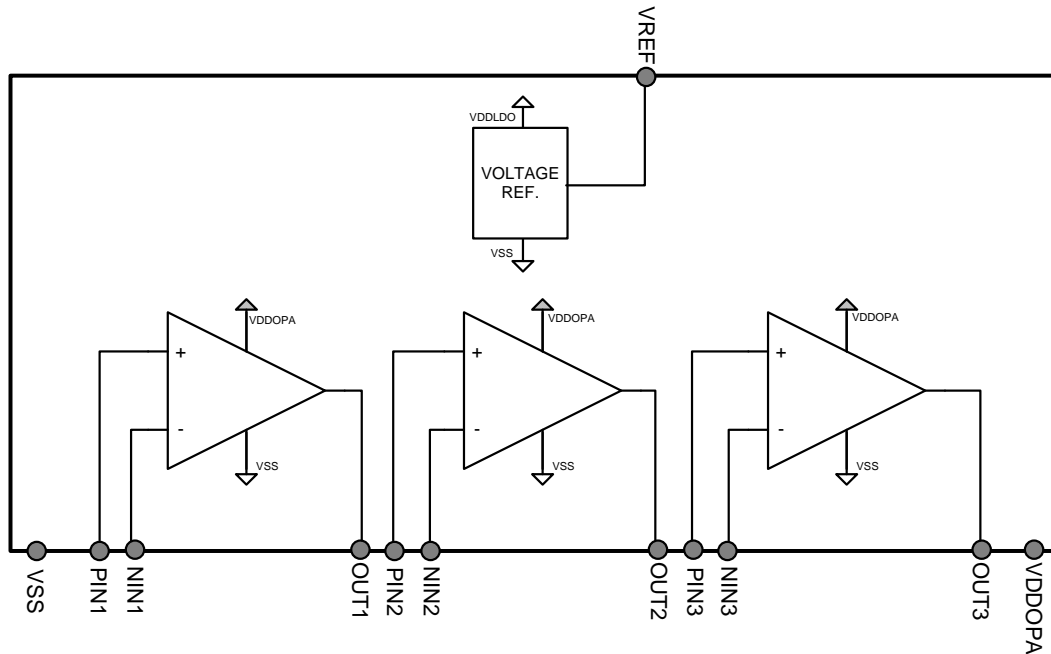
### Triple Operational Amplifier:

- Supply voltage VDDOPA-VSS: 5V to 20V
- Supply current: 550µA max / OPA (@VDDOPA = 10V)
- Gain-bandwidth product: 1.3MHz Typ.
- Input offset voltage: ±2.5mV Typ

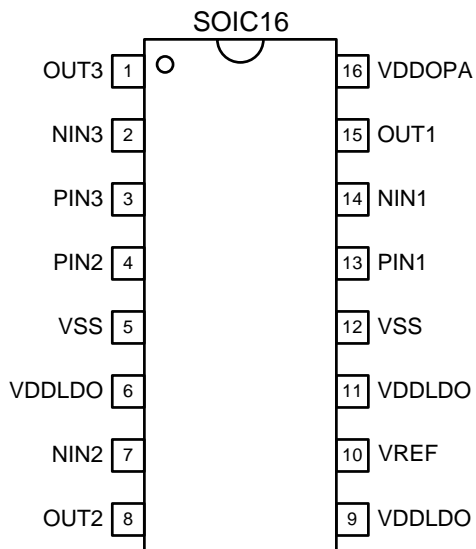
### Applications

Signal conditioning and voltage control applications, switched-mode power supplies

## Block Diagram



## Package Configurations and Pin Description:



Pin #	Pin Name	Pin Description
1	OUT3	OPA3 output
2	NIN3	OPA3 negative input
3	PIN3	OPA3 positive input
4	PIN2	OPA2 positive input
5	VSS	Negative power supply
6	VDDLDO	Voltage Reference Positive power supply
7	NIN2	OPA2 negative input
8	OUT2	OPA2 output
9	VDDLDO	Voltage Reference Positive power supply
10	VREF	Voltage reference
11	VDDLDO <sup>1</sup>	Voltage Reference Positive power supply
12	VSS	Negative power supply
13	PIN1	OPA1 positive input
14	NIN1	OPA1 negative input
15	OUT1	OPA1 output
16	VDDOPA	OPAs Positive power supply

<sup>1</sup> Please read carefully paragraph "Modes of operation" at page 7 for details about possible scenario of power supplies connections

## Absolute Maximum Ratings

Supply Voltage VDDLDO-VSS	-0.5V...25V
Supply Voltage VDDOPA-VSS	-0.5V...25V
Junction Temperature (Tj)	-55°C to +250°C
Voltage on any pin to VSS	-0.5 to VDDOPA+0.5V

## Operating Conditions

Supply Voltage VDDLDO-VSS	6V to 20V
Supply Voltage VDDOPA-VSS	4.5V to 20V
VREF Dropout Voltage	1.0V to 15V
Junction temperature	-55°C to +225°C

## ESD Rating

Human Body Model	>1.5kV
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**CAUTION:** Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Frequent or extended exposure to absolute maximum rating conditions or above may affect device reliability.

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## Voltage Reference:

### Electrical Characteristics

Unless otherwise stated: VDDLDO=10V, VSS=0V,  $T_j=25^{\circ}\text{C}$ . **Bold underlined** values indicate values over the whole temperature range ( $-55^{\circ}\text{C} < T_j < +225^{\circ}\text{C}$ ).

Parameter	Condition	Min	Typ	Max	Units
Supply voltage VDDLDO-VSS		6		20	V
Dropout (VDDLDO-VREF)	$I_L=25\text{mA}$	2			V
Output voltage Initial Accuracy	$I_L=2.5\text{mA}$ ; DO=VREF+2V, $T_j = 25^{\circ}\text{C}$		0	+/-2	%
Drift with temperature	$I_L=2.5\text{mA}$ ; DO=VREF+2V	<b><u>0</u></b>		<b><u>0.5</u></b>	mV/ $^{\circ}\text{C}$
Line regulation	$I_L=2.5\text{mA}$ VDDL- DO=[VREF+2V..VREF+15V ]			<b><u>+/-1</u></b>	mV/V
Load regulation Rout	$I_L=0\text{mA}$ to 25mA VDDLDO=VREF+2V			<b><u>-1.5</u></b>	mV/mA
Quiescent Ground Pin current	$0 < I_L < 25\text{mA}$ ; VDDLDO=10V		700		$\mu\text{A}$
Power supply rejection ratio	f=0Hz ..100Hz VDDLDO=VREF+2V; $I_L=2.5\text{mA}$		60		dB
Output noise	10Hz-10kHz VDDLDO=VREF+2V; $I_L=2.5\text{mA}$		TBD		$\mu\text{VRMS}$

## Triple Operational Amplifier:

Unless otherwise stated: VDDOPA=10V, VSS=0V,  $T_j=25^\circ\text{C}$ . **Bold underlined** values indicate values over the whole temperature range ( $-55^\circ\text{C} < T_j < +225^\circ\text{C}$ ).

### DC Electrical Characteristics

Parameter	Condition	Min	Typ	Max	Units
Supply voltage VDDOPA-VSS		4.5		20	V
Supply current (3 OPAs) I <sub>DD</sub>	$T_j=25^\circ\text{C}$		1.3		mA
	$T_j=-55$ to $225^\circ\text{C}$			<b><u>1.6</u></b>	
Output voltage swing V <sub>o</sub>	RL=2k $\Omega$ , THD <sup>2</sup> =1%	0.15		VDDOPA-0.25	V
	RL= $\infty$ , THD=0.1%	0.04		VDDOPA-0.1	
Output current <sup>3,4</sup> I <sub>o</sub>	$T_j=-55$ to $225^\circ\text{C}$			<b><u><math>\pm 15</math></u></b>	mA
Common mode input range V <sub>CM</sub>	$T_j=225^\circ\text{C}$	2.0		VDDOPA-0.1	V
	$T_j=-55^\circ\text{C}$	1.5		VDDOPA-0.2	
Input offset voltage <sup>5</sup> V <sub>IOFF</sub>	$T_j=25^\circ\text{C}$		< $\pm 2.5$	$\pm 8$	mV
Input offset drift <sup>3</sup> TC <sub>VIOFF</sub>	$T_j=25^\circ\text{C}$		< $\pm 30$	$\pm 70$	$\mu\text{V}/^\circ\text{C}$
Input bias current <sup>6</sup> I <sub>B</sub>	$T_j=-55$ to $225^\circ\text{C}$			<b><u><math>\pm 160</math></u></b>	nA
Input offset current <sup>4</sup> I <sub>OFF</sub>	$T_j=25^\circ\text{C}$			$\pm 0.6$	nA
	$T_j=225^\circ\text{C}$			$\pm 5$	

### AC Electrical Characteristics

Parameter	Condition	Min	Typ	Max	Units
DC gain A <sub>o</sub>	RL=2k $\Omega$ , $T_j=25^\circ\text{C}$	90	100		dB
	RL=2k $\Omega$ , $T_j=225^\circ\text{C}$	85	95		
Gain-bandwidth product GBW	RL=2k $\Omega$ , CL=30pF	<b><u>0.95</u></b>	1.25		MHz
Common mode rejection ratio CMRR	DC to 1kHz	<b><u>60</u></b>			dB
Power supply rejection ratio PSRR	Positive or negative. DC to 100Hz	<b><u>70</u></b>			dB
Slew rate SR	RL=2k $\Omega$ , CL=30pF $T_j=25^\circ\text{C}$	1.25	1.55		V/ $\mu\text{sec}$
	RL=2k $\Omega$ , CL=30pF $T_j=225^\circ\text{C}$	2.45	2.7		
Phase margin $\Phi_M$	RL=2k $\Omega$ , CL=30pF	<b><u>32</u></b>	>40		Degree
Input noise spectral density	F=1Hz		11.0		$\mu\text{V}/\sqrt{\text{Hz}}$
	F=100Hz		1.2		
	F=1kHz		0.43		
	F=10kHz		0.19		
Integrated input noise e <sub>n</sub>	DC to 10Hz, $T_j=-55$ to $225^\circ\text{C}$		25		$\mu\text{V}_{\text{RMS}}$

<sup>2</sup> Total Harmonic Distortion.

<sup>3</sup> Source or sink.

<sup>4</sup> Output current is not internally limited. Value given indicate the maximum recommended operating conditions.

<sup>5</sup> The absolute value of the input offset voltage, |V<sub>IOFF</sub>|, decreases as temperature increases. TC<sub>VIOFF</sub> must be used so that |V<sub>IOFF</sub>| decreases with temperature, i.e. TC<sub>VIOFF</sub> has opposite sign than V<sub>IOFF</sub>.

<sup>6</sup> Due to ESD structures. Under full characterization.

### Typical Performance Characteristics

Unless otherwise stated: VDDLDO/VDDOPA=10V, VSS=0V, Tj=25°C.

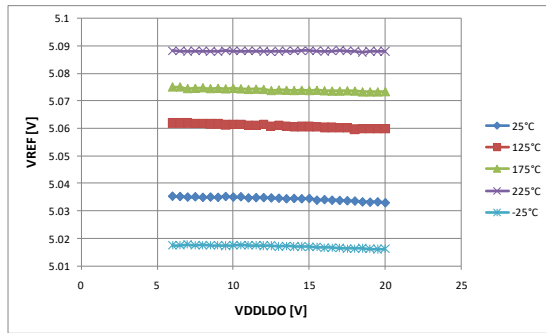


Figure 1: VREF line regulation from -55°C to 175°C (IL = 2.5 mA)

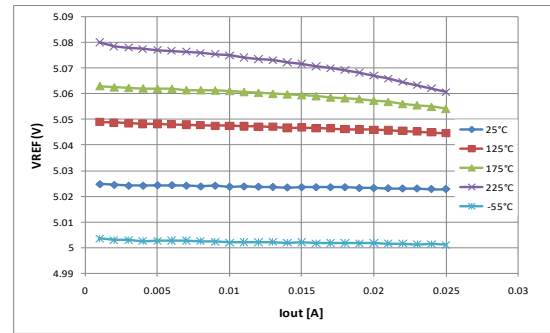


Figure 2: VREF load regulation from -25°C to 225°C

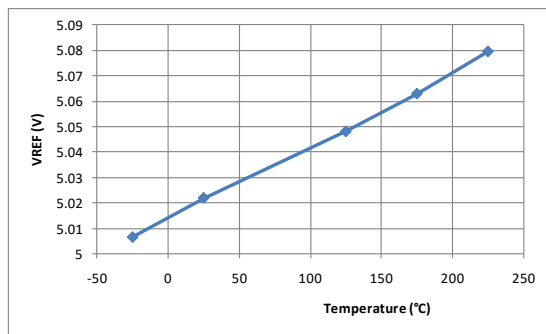


Figure 3: VREF temperature drift (IL = 2.5 mA; VDDLDO = 7V)

TBD

Figure 4: VREF Input ripple rejection @ 25°C (VDDLDO=7V; IL=0 mA)

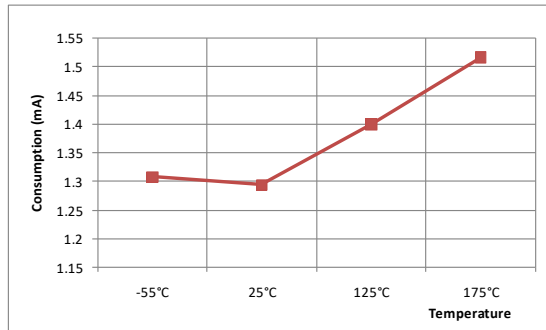


Figure 5: Current consumption (3 OPA + LDO quiescent) vs. Temperature

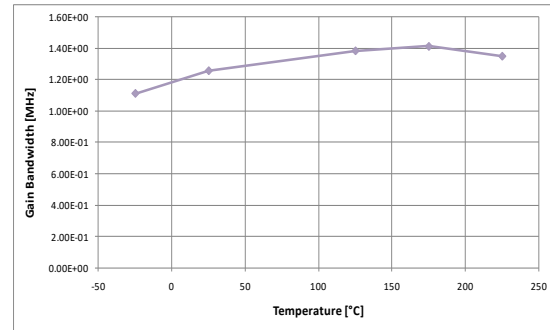


Figure 6: GBW vs. Temperature

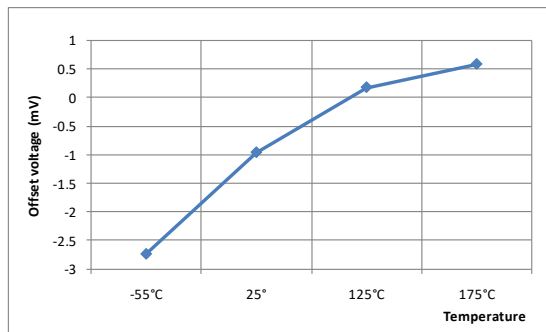


Figure 7: Offset voltage vs. Temperature

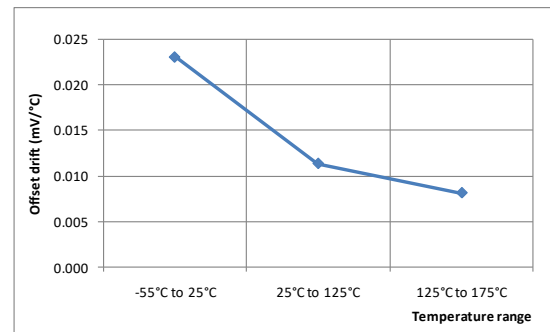


Figure 8: Offset drift vs Temperature

## Circuit Functionality – Operational Amplifiers

### Operating conditions

The CHT-RUBY has been conceived to operate in closed loop configuration under linear regime. When operating with supply voltages above 6V, it is mandatory to ensure that voltage between positive and negative inputs of the OPA does not exceed 5.5V. Continuous or repetitive operation outside linear regime could permanently damage the part.

### Specific Operating Conditions

The CHT-RUBY presents slightly different positive and negative slewing values. This makes that when a square wave is used as input signal, the output presents an additional DC offset due to the slight change of the output duty cycle.

Additionally, for square input signals with frequencies above 10kHz, the circuit presents an output DC offset which increases with the input frequency. At 30kHz, the input referred offset increases by about 20mV.

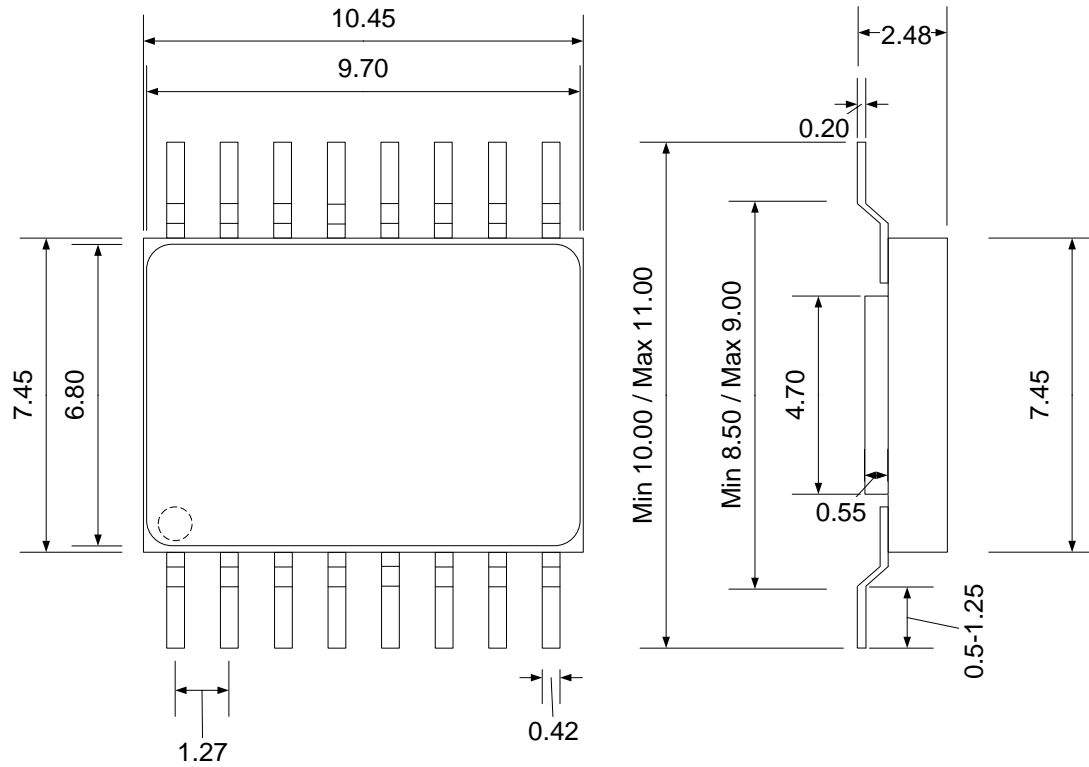
### Modes of operation

CHT-RUBY consists of 2 functions: a Voltage Reference and 3 Operational Amplifiers.

The table below describes the possible use of CHT-RUBY and the implications on the power supply connections:

CHT-RUBY use	Power supply connections
Only Voltage Reference used	VDDOPA and PINx/NINx must be connected to VSS
Only OPAs used	VDDLDO must be connected to VDDOPA
Both OPAs and Voltage Reference with separate power supplies	VDDLDO voltage must be higher than or equal to VDDOPA voltage
Both OPAs and Voltage Reference with same power supply	VDDLDO and VDDOPA connected together
OPAs fed by VREF output	VDDOPA must be connected to VREF

### Package Dimensions



CSOIC 16 Drawing (mm +/- 10%)

### Ordering Information

Ordering Reference	Package	Temperature Range	Marking
CHT-GEM9813C-CSOIC16-T	Ceramic CSOIC16	-55°C to +225°C	CHT-GEM9813C



## Contact & Ordering

### CISSOID S.A.

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