Amplificador de Instrumentación real

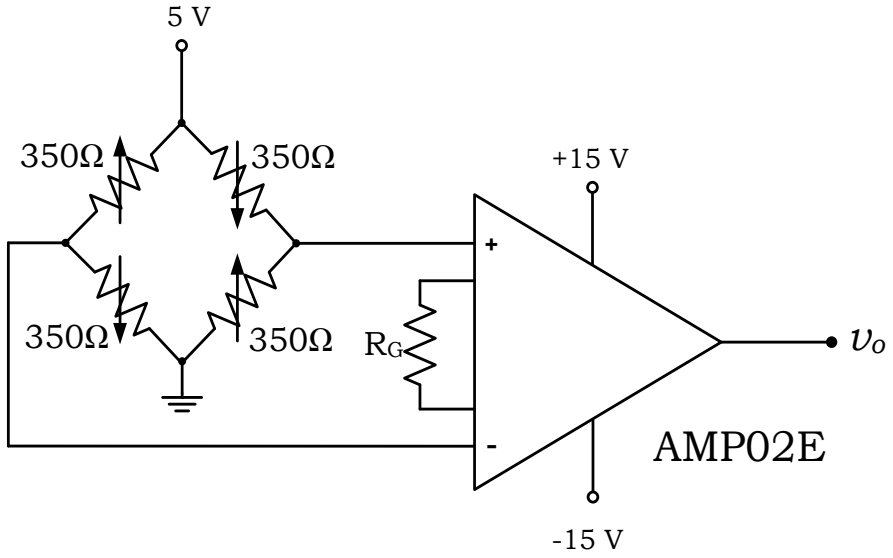
ANÁLISIS DE ERRORES

Ejercicio E5. Circuito acondicionador: cálculo de errores

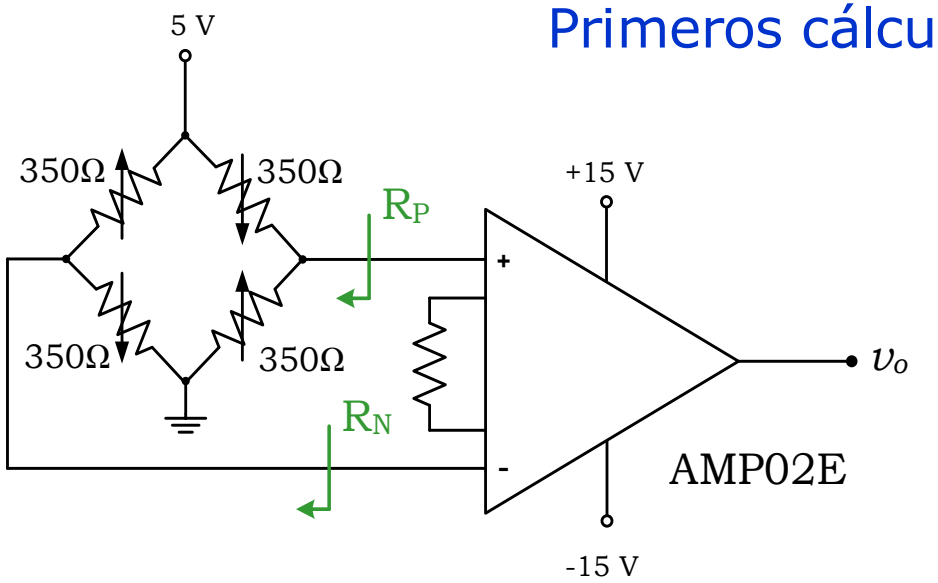
Pregunta: En el acondicionador de la figura, calcular el máximo error que introduce el amplificador de instrumentación en la medida

DATOS:

- FSR_I = 20 mV
- $V_D(FS)$ = 20 mV
- -40°C ≤ T ≤ 85°C
- R_G = 86,6 Ω
- R_G: 0,1% TOL y TC = 15 ppm/°C



Primeros cálculos

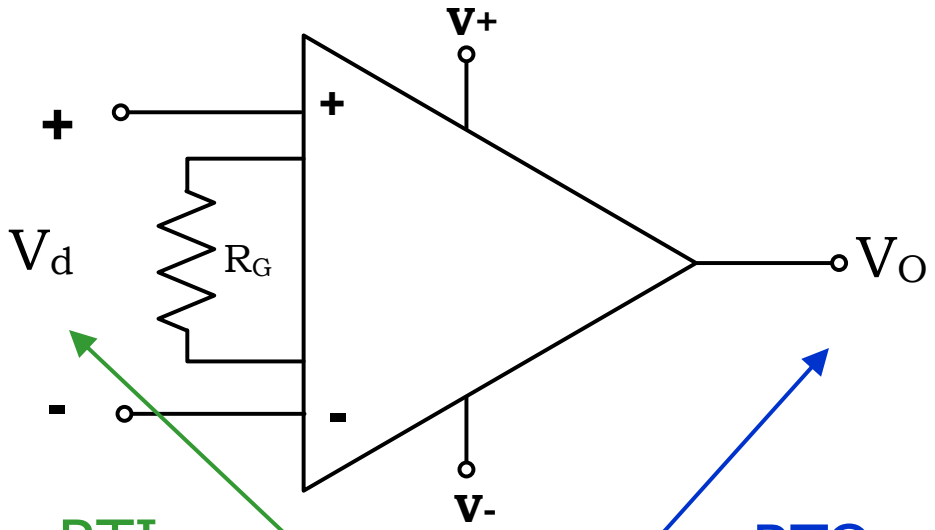


Ganancia del AI.

Cálculo de R_P y R_N.

V_D y V_C de salida del puente.

Conceptos previos



V_d + ?

$V_O = A_d \cdot V_d$ + ?

Referred To Input

RTI

?

RTO

Referred To Output

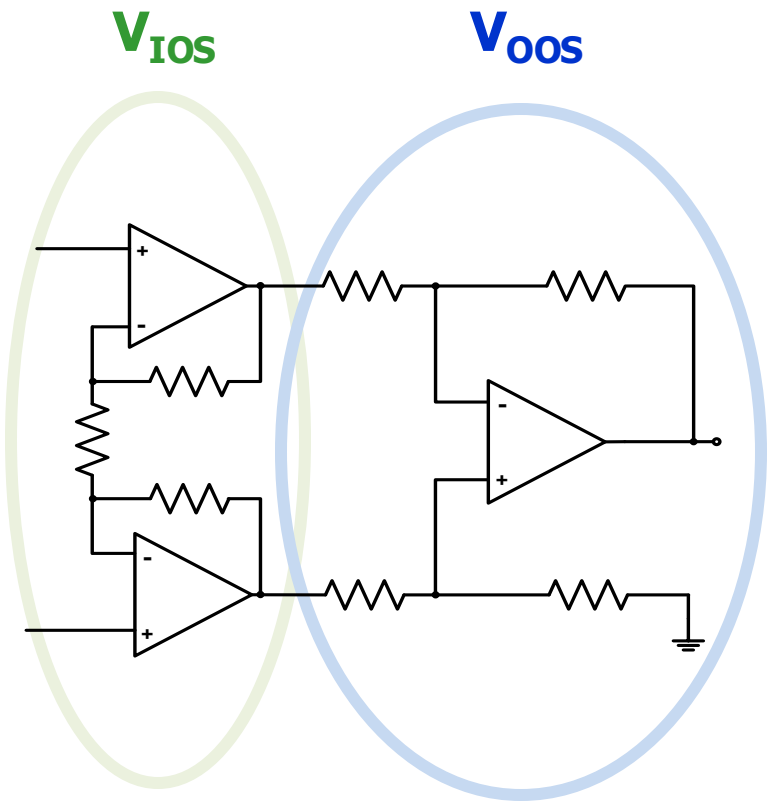
$$E_{(RTI)} = \frac{E_{(RTO)}}{A_d}$$

$$E_{(RTO)} = V_{O\,(REAL)} - V_{O\,(IDEAL)}$$

Estimación pormenorizada del error: Fuentes de Error

- V_{IOS}, V_{OOS}
- TC[V_{IOS}], TC[V_{OOS}]
- I_B, I_{OS}
- TC[I_B], TC[I_{OS}]
- CMR
- PSR
- e_n
- NL
- EG
- TC[A_d]
- Tolerancia R → **EG**
- TC[R] → **EG**

Efecto de la tensión de offset



RTI

V_{IOS} ⇨ $\pm V_{IOS}$

V_{OOS} ⇨ $\pm \frac{V_{OOS}}{A_d}$

Efecto de la tensión de offset

AMP02–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OFFSET VOLTAGE						
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	100	µV
		–40°C ≤ T_A ≤ +85°C		50	200	µV
Input Offset Voltage Drift	TCV_{IOS}	–40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		–40°C ≤ T_A ≤ +85°C		4	10	mV
Output Offset Voltage Drift	TCV_{OOS}	–40°C ≤ T_A ≤ +85°C		50	100	µV/°C
Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				
		G = 100, 1000	115	125		dB
		G = 10	100	110		dB
		G = 1	80	90		dB
		V_S = ±4.8 V to ±18 V				
		–40°C ≤ T_A ≤ +85°C				
		G = 1000, 100	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB

Efecto de la tensión de offset

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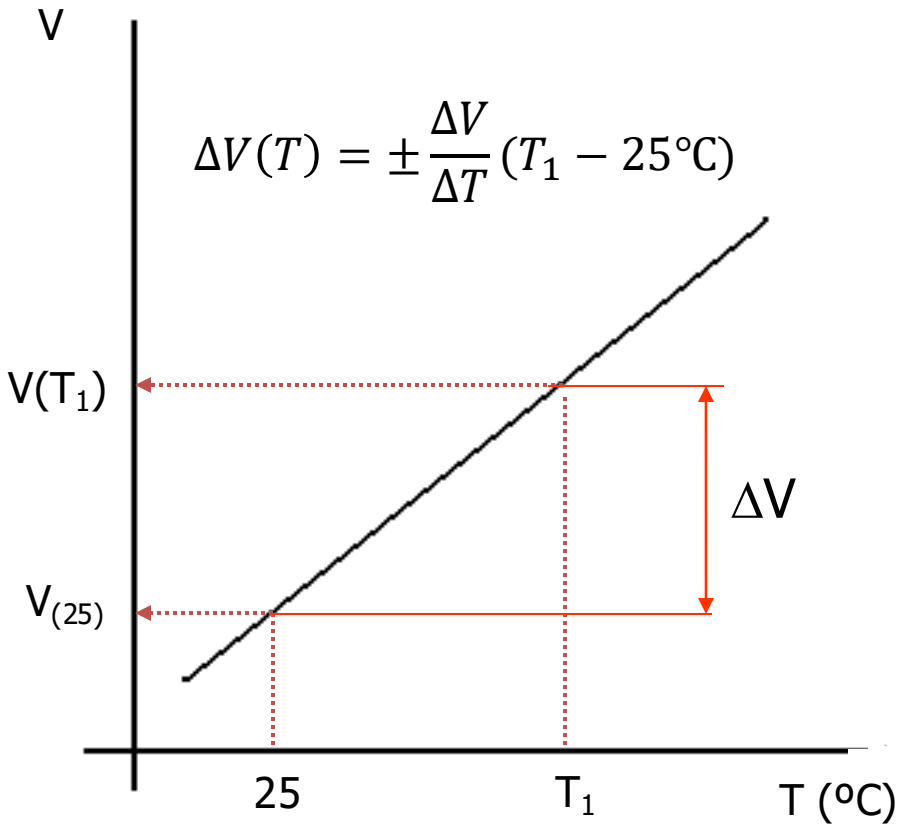
Input Offset Voltage Drift	TCV_{IOS}	−40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		−40°C ≤ T_A ≤ +85°C		4	10	mV

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
V_{IOS} = 100 uV				
V_{OOS} = 4 mV				

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25ºC)
V_{IOS}=100 μV	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
V_{OOS}=4mV	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}] = 2\,\mu V/ºC = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}] = 100\,\mu V/ºC = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
I_B=10nA; I_{OS}=5nA	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B] = 150\,pA/ºC = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}] = 9\,pA/ºC = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
CMR =110 dB	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
PSR =110 dB	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{n\,p\text{-}p}$=0,4 μVpp	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) NL_{real}=0,006·[26/(20·10^{-3}·578,36)]=0,0134%FSR	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G] = 50\,ppm/ºC = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ (G=577,79 / G=578,94)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G] = 15\,ppm/ºC = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ (G=577,84 / G=578,92)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de la temperatura en las tensiones de *offset*



RTI

$$TC_{V_{IOS}} = \frac{\Delta V_{IOS}}{\Delta T}$$

$$\Delta V_{IOS_{(RTI)}} = \pm\left[TC_{V_{IOS}} \times (T - 25°C)\right]$$

$$TC_{V_{OOS}} = \frac{\Delta V_{OOS}}{\Delta T}$$

$$\Delta V_{OOS_{(RTI)}} = \pm\frac{1}{A_d}\left[TC_{V_{OOS}} \times (T - 25°C)\right]$$

Efecto de T en las tensiones de *offset*

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ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

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Input Offset Voltage Drift	TCV_{IOS}	−40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		−40°C ≤ T_A ≤ +85°C		4	10	mV
Output Offset Voltage Drift	TCV_{OOS}	−40°C ≤ T_A ≤ +85°C		50	100	µV/°C
Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				
		G = 100, 1000	115	125		dB
		G = 10	100	110		dB
		G = 1	80	90		dB
		V_S = ±4.8 V to ±18 V				
		−40°C ≤ T_A ≤ +85°C				
		G = 1000, 100	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
INPUT CURRENT						
Input Bias Current	I_B	T_A = +25°C		2	10	nA
Input Bias Current Drift	TCI_B	−40°C ≤ T_A ≤ +85°C		150		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		1.2	5	nA
Input Offset Current Drift	TCI_{OS}	−40°C ≤ T_A ≤ +85°C		9		pA/°C

Efecto de T en las tensiones de *offset*

AMP02–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

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Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$TC[V_{IOS}] = \frac{\Delta V_{IOS}}{\Delta T} = 2\,\mu V/^{\circ}C$				
$TC[V_{OOS}] = \frac{\Delta V_{OOS}}{\Delta T} = 100\,\mu V/^{\circ}C$				

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
V_{IOS}=100 μV	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
V_{OOS}=4mV	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}] = 2\,\mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}] = 100\,\mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
I_B=10nA; I_{OS}=5nA	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B] = 150\,pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}] = 9\,pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
CMR =110 dB	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
PSR =110 dB	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\text{-}p}$=0,4 μVpp	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) NL_{real}=0,006·[26/(20·10^{-3}·578,36)]=0,0134%FSR	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G] = 50\,ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ (G=577,79 G=578,94)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
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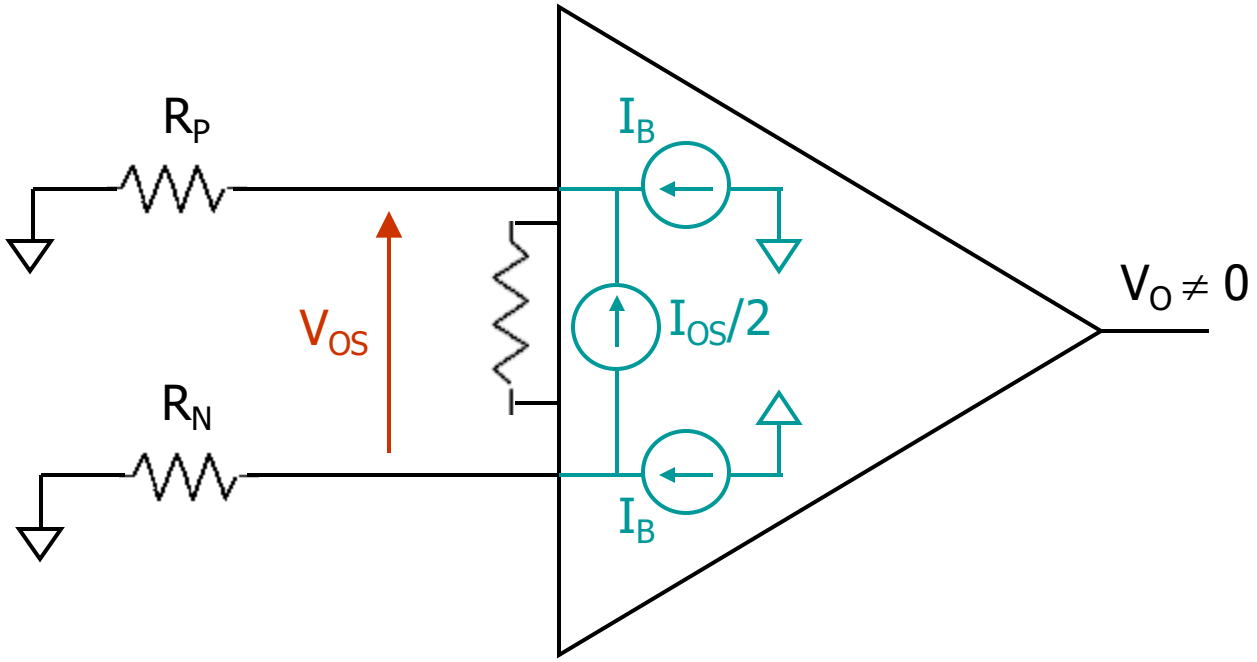
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de las corrientes de polarización y de offset: I_B e I_{OS}

$$R_P = R_N \approx 175 \ \ \Omega$$



Como, generalmente, desconocemos el signo de I_B e I_{OS}, calcularemos:

$$V_{OS(RTI)} = \pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2}(R_P + R_N)\right]$$

Efecto I_B e I_{OS}

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		G = 1000, 100	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
INPUT CURRENT						
Input Bias Current	I_B	T_A = +25°C		2	10	nA
Input Bias Current Drift	TCI_B	–40°C ≤ T_A ≤ +85°C		150		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		1.2	5	nA
Input Offset Current Drift	TCI_{OS}	–40°C ≤ T_A ≤ +85°C		9		pA/°C

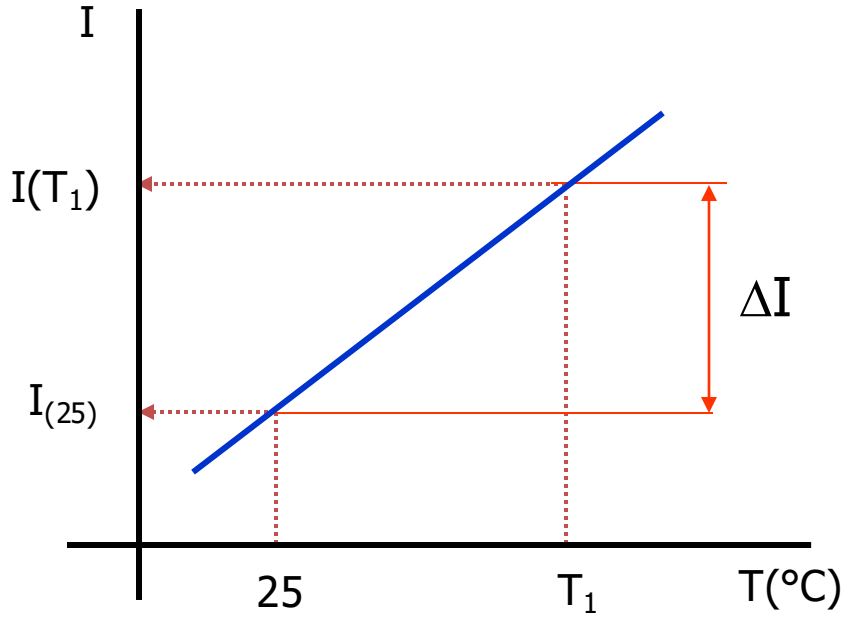
Efecto de I_B e I_{OS}

	$E_{(RTI)}$ (V)		$E_{(RTI)}(\%) = 100 \cdot E_{(RTI)}(V) / FSR_i(V)$	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$I_B = 10nA$ $I_{OS} = 5nA$				

INPUT CURRENT					
Input Bias Current	I_B	$T_A = +25°C$	2	10	nA
Input Bias Current Drift	TCI_B	$-40°C \le T_A \le +85°C$	150		pA/°C
Input Offset Current	I_{OS}	$T_A = +25°C$	1.2	5	nA
Input Offset Current Drift	TCI_{OS}	$-40°C \le T_A \le +85°C$	9		pA/°C

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C=\frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C=\frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C=\frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C=\frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{n\,p\text{-}p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)]=0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C=\frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C=\frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de la temperatura en I_B e I_{OS}



$$\Delta I(T) = \pm \frac{\Delta I}{\Delta T}(T_1 - 25°C)$$

Como, generalmente, desconocemos el signo de I_B e I_{OS} calcularemos:

$$\Delta V_{OS\,(RTI)} = \pm \left[TC_{I_B}(T-25)(R_P - R_N) + TC_{I_{OS}}(T-25)\frac{(R_P + R_N)}{2} \right]$$

Efecto de la temperatura en I_B e I_{OS}

AMP02–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OFFSET VOLTAGE						
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	100	µV
		–40°C ≤ T_A ≤ +85°C		50	200	µV
Input Offset Voltage Drift	TCV_{IOS}	–40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		–40°C ≤ T_A ≤ +85°C		4	10	mV
Output Offset Voltage Drift	TCV_{OOS}	–40°C ≤ T_A ≤ +85°C		50	100	µV/°C
Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				
		G = 100, 1000	115	125		dB
		G = 10	100	110		dB
		G = 1	80	90		dB
		V_S = ±4.8 V to ±18 V				
		–40°C ≤ T_A ≤ +85°C				
		G = 1000, 100	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
INPUT CURRENT						
Input Bias Current	I_B	T_A = +25°C		2	10	nA
Input Bias Current Drift	TCI_B	–40°C ≤ T_A ≤ +85°C		150		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		1.2	5	nA
Input Offset Current Drift	TCI_{OS}	–40°C ≤ T_A ≤ +85°C		9		pA/°C

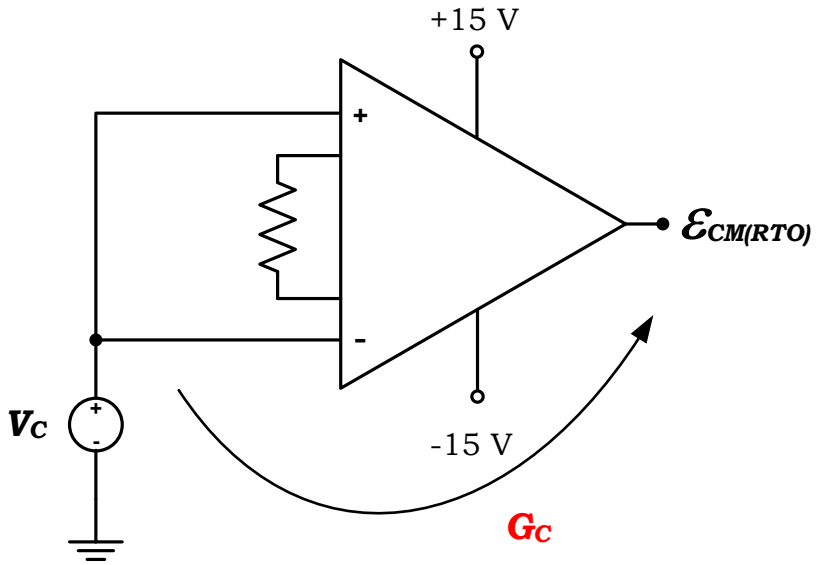
Efecto de la temperatura en I_B e I_{OS}

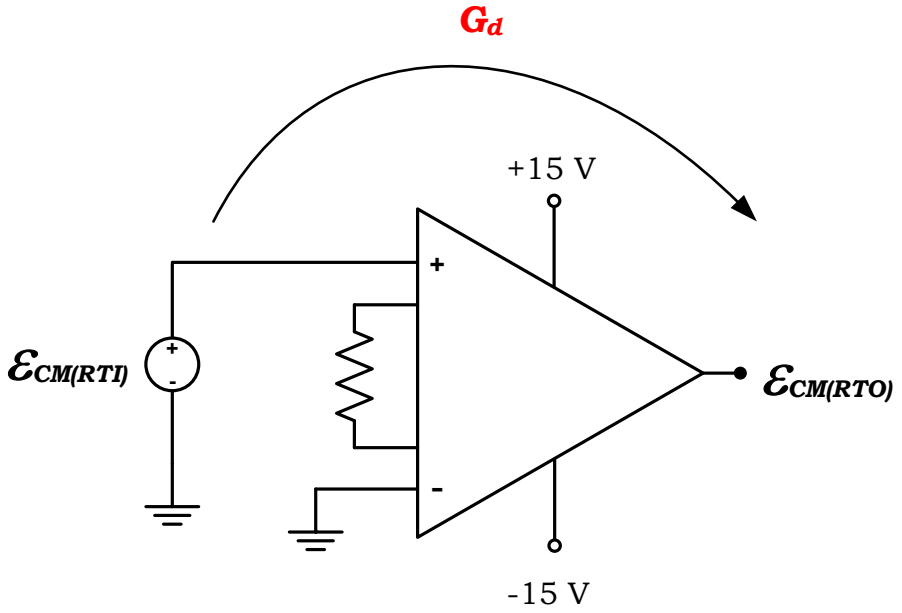
	$E_{(RTI)}$ (V)		$E_{(RTI)}(\%) = 100 \cdot E_{(RTI)}(V) / FSR_i(V)$	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$TC[I_B] = \frac{\Delta I_B}{\Delta T} = 150\ pA/^oC$				
$TC[I_{OS}] = \frac{\Delta I_{OS}}{\Delta T} = 9\ pA/^oC$				

INPUT CURRENT					
Input Bias Current	I_B	$T_A = +25°C$	2	10	nA
Input Bias Current Drift	TCI_B	$-40°C \le T_A \le +85°C$	150		pA/°C
Input Offset Current	I_{OS}	$T_A = +25°C$	1.2	5	nA
Input Offset Current Drift	TCI_{OS}	$-40°C \le T_A \le +85°C$	9		pA/°C

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C=\frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C=\frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C=\frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C=\frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{n\,p\text{-}p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)]=0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C=\frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C=\frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G' = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$ $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de la Tensión en Modo Común





$$E_{CM(RTO)} = A_C \times V_C \quad CMR_{AI} = \frac{A_d}{A_C}$$

$$E_{CM(RTO)} = \frac{A_d}{CMR_{AI}} \times V_C = \frac{A_d}{10^{\frac{CMRR_{AI}}{20}}} \times V_C$$

$$E_{CM(RTI)} = \frac{E_{CM(RTO)}}{A_d} = \frac{V_C}{CMR_{AI}} = \frac{V_C}{10^{\frac{CMRR_{AI}}{20}}}$$

¡ Igual que hacíamos con el AO !

Efecto de la Tensión en Modo Común

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
INPUT						
Input Resistance	R_{IN}	Differential, G ≤ 1000		10		GΩ
		Common-Mode, G = 1000		16.5		GΩ
Input Voltage Range	IVR	T_A = +25°C (Note 1)	±11			V
Common-Mode Rejection	CMR	V_{CM} = ±11 V				
		G = 1000, 100	115	120		dB
		G = 10	100	115		dB
		G = 1	80	95		dB
		V_{CM} = ±11 V				
		−40°C ≤ T_A ≤ +85°C				
		G = 100, 1000	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

No hay TC, así que elegimos el caso peor en T

Efecto de la Tensión en Modo Común

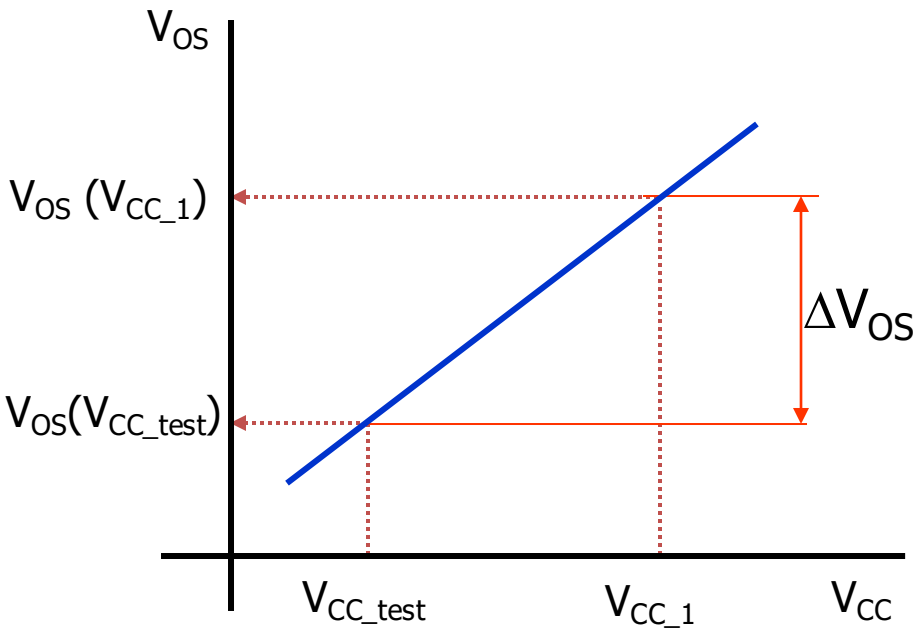
ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
INPUT						
Input Resistance	R_{IN}	Differential, G ≤ 1000		10		GΩ
		Common-Mode, G = 1000		16.5		GΩ
Input Voltage Range	IVR	T_A = +25°C (Note 1)	±11			V
Common-Mode Rejection	CMR	V_{CM} = ±11 V				
		G = 1000, 100	115	120		dB
		G = 10	100	115		dB
		G = 1	80	95		dB
		V_{CM} = ±11 V, −40°C ≤ T_A ≤ +85°C				
		G = 100, 1000	110	120		dB

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
CMRR = 110 dB				

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\text{-}p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)] = 0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ (G=577,79 / G=578,94)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ (G=577,84 / G=578,92)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

PSR: rechazo a las variaciones de la alimentación (V_{CC})



$$\Delta V_{OS(RTI)}(V_{CC_1}) = \pm \frac{\Delta V_{OS}}{\Delta V_{CC}} \, (V_{CC\_1} - V_{CC\_test})$$

Como:

$$PSRR = 20 \log\left(\frac{\Delta V_{CC}}{\Delta V_{OS}}\right)$$

$$\Delta V_{OS(RTI)} = \pm \frac{\Delta V_{CC}}{10^{\frac{PSRR}{20}}}$$

¡ Igual que hacíamos con el AO !

PSR: rechazo a las variaciones de Vcc

AMP02–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OFFSET VOLTAGE						
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	100	µV
		–40°C ≤ T_A ≤ +85°C		50	200	µV
Input Offset Voltage Drift	TCV_{IOS}	–40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		–40°C ≤ T_A ≤ +85°C		4	10	mV
Output Offset Voltage Drift	TCV_{OOS}	–40°C ≤ T_A ≤ +85°C		50	100	µV/°C
Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				
		G = 100, 1000	115	125		dB
		G = 10	100	110		dB
		G = 1	80	90		dB
		V_S = ±4.8 V to ±18 V				
		–40°C ≤ T_A ≤ +85°C				
		G = 1000, 100	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
INPUT CURRENT						
Input Bias Current	I_B	T_A = +25°C		2	10	nA
Input Bias Current Drift	TCI_B	–40°C ≤ T_A ≤ +85°C		150		pA/°C
Input Offset Current	I_{OS}	T_A = +25°C		1.2	5	nA
Input Offset Current Drift	TCI_{OS}	–40°C ≤ T_A ≤ +85°C		9		pA/°C

No hay TC, así que elegimos el caso peor en T

PSR: rechazo a las variaciones de Vcc

AMP02–SPECIFICATIONS

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OFFSET VOLTAGE						
Input Offset Voltage	V_{IOS}	T_A = +25°C		20	100	µV
		−40°C ≤ T_A ≤ +85°C		50	200	µV
Input Offset Voltage Drift	TCV_{IOS}	−40°C ≤ T_A ≤ +85°C		0.5	2	µV/°C
Output Offset Voltage	V_{OOS}	T_A = +25°C		1	4	mV
		−40°C ≤ T_A ≤ +85°C		4	10	mV
Output Offset Voltage Drift	TCV_{OOS}	−40°C ≤ T_A ≤ +85°C		50	100	µV/°C
Power Supply Rejection	PSR	V_S = ±4.8 V to ±18 V				
		G = 100, 1000	115	125		dB
		G = 10	100	110		dB
		G = 1	80	90		dB
		V_S = ±4.8 V to ±18 V				
		−40°C ≤ T_A ≤ +85°C				
		G = 1000, 100	110	120		dB

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
PSR=110dB				

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G} \frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm \left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N) \right]$	$\pm \left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175) \right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\ p-p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)] = 0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto del ruido

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OUTPUT RATING						
Output Voltage Swing	V_{OUT}	T_A = +25°C, R_L = 1 kΩ	±12	±13		V
		R_L = 1 kΩ, –40°C ≤ T_A ≤ +85°C	±11	±12		V
Positive Current Limit		Output-to-Ground Short		22		mA
Negative Current Limit		Output-to-Ground Short		32		mA
NOISE						
Voltage Density, RTI	e_n	f_O = 1 kHz				
		G = 1000		9		nV/√Hz
		G = 100		10		nV/√Hz
		G = 10		18		nV/√Hz
		G = 1		120		nV/√Hz
Noise Current Density, RTI	i_n	f_O = 1 kHz, G = 1000		0.4		pA/√Hz
Input Noise Voltage	e_n p-p	0.1 Hz to 10 Hz				
		G = 1000		0.4		µV p-p
		G = 100		0.5		µV p-p
		G = 10		1.2		µV p-p

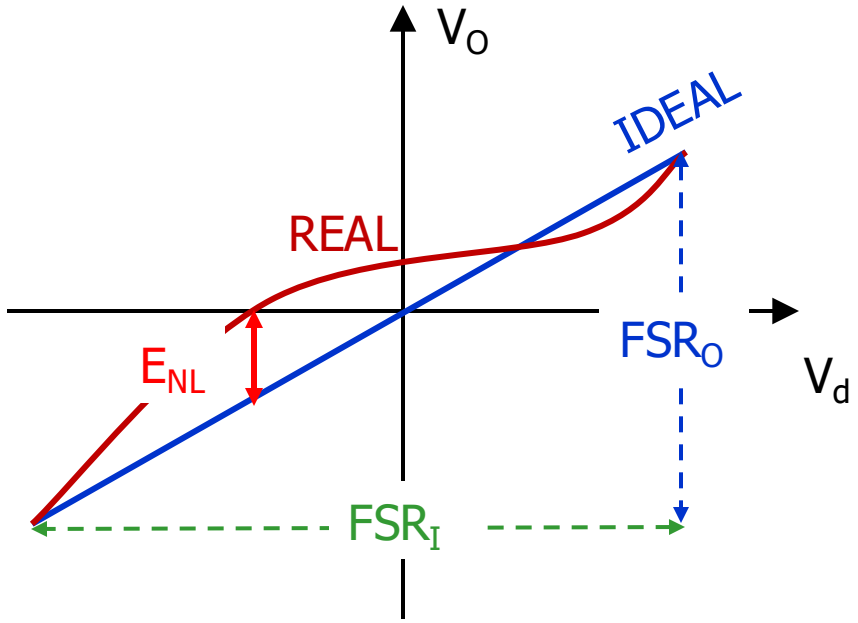
Efecto del ruido

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$e_{n\,p-p} = 0{,}4\,\mu V_{p-p}$				

Noise Current Density, RTI	i_n	f_O = 1 kHz, G = 1000	0.4	pA/√Hz
Input Noise Voltage	e_n p-p	0.1 Hz to 10 Hz		
		G = 1000	0.4	µV p-p
		G = 100	0.5	µV p-p
		G = 10	1.2	µV p-p

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C=\frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C=\frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C=\frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C=\frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR=110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR=110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\text{-}p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)] = 0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C=\frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ (G=577,79 / G=578,94)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$; $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C=\frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ (G=577,84 / G=578,92)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$; $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de la NL



$$NL\,(V) = \left(V_{o\,(REAL)} - V_{o\,(IDEAL)}\right)_{max}$$

$$NL\,(\%FSR_O) = \frac{\left(V_{o\,(REAL)} - V_{o\,(IDEAL)}\right)_{max}}{FSR_O} \times 100$$

En el catálogo se da en módulo

Con ello la tensión de error se calcula:

$$E_{NL\,(RTO)}(V) = \pm\frac{NL}{100}FSR_O$$

$$E_{NL\,(RTI)}(V) = \frac{E_{NL\,(RTO)}(V)}{A_d} = \pm\frac{NL}{100}\frac{FSR_O}{A_d} = \pm\frac{NL}{100}FSR_I$$

Detalle para el cálculo del error por NL

- El fabricante expresa la NL (%) de forma relativa al $FSR_{O\,(AI)}$(V) del AI que viene determinado por el parámetro *Output Voltage Swing*
- P.ej., si el *Output Voltage Swing = ± 13 V* $\rightarrow$ $FSR_{O\,(AI)}$(V) = 26 V
- Hay que determinar la NL_{real} (%) para el rango de fondo de escala del circuito, que no tiene que ser el mismo que el del AI.
- P.ej., si el FSR_O (V) = 10 V, la no linealidad relativa del circuito es:

$$NL_{real}(\%) = NL_{AI}(\%)\frac{FSR_{O(AI)}(V)}{FSR_O(V)} = NL_{AI}(\%)\frac{26V}{10V}$$

- El error de NL en tensión puede obtenerse referido a la entrada o a la salida:

$$\varepsilon_{NL\_RTI}(V) = \frac{NL_{real}(\%)}{100}\cdot FSR_I(V) \qquad \varepsilon_{NL\_RTO}(V) = \frac{NL_{real}(\%)}{100}\cdot FSR_O(V)$$

con $FSR_O(V) = A_d \cdot FSR_I(V)$

Efecto de la NL

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
OUTPUT RATING						
Output Voltage Swing	V_{OUT}	T_A = +25°C, R_L = 1 kΩ	±12	±13		V
		R_L = 1 kΩ, –40°C ≤ T_A ≤ +85°C	±11	±12		V
Positive Current Limit		Output-to-Ground Short		22		mA
Negative Current Limit		Output-to-Ground Short		32		mA

NL para ±13v en la salida→NL para un *FSR_o=26V*

GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

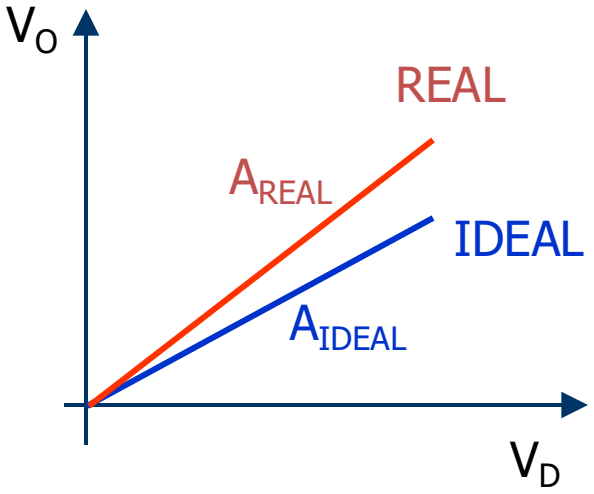
Efecto de la NL

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
NL=0,006% ***para*** *FSR (±13V)*				

GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
$V_{IOS}=100\ \mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\ \mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\ \mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G} \frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm \left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N) \right]$	$\pm \left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175) \right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\ pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\ pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\text{-}p}=0,4\ \mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)]=0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G]=50\ ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ (G=577,79 / G=578,94)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/°C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ (G=577,84 / G=578,92)	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$ / $\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto del error de Ganancia



$$E_{RTO}(V) = V_{O_{real}} - V_{O_{ideal}} = \underbrace{\left(A_{d_{real}} - A_{d_{ideal}}\right)}_{EG} \cdot V_D$$

$$EG(\%) = \frac{\left(A_{d_{real}} - A_{d_{ideal}}\right)}{A_{d_{ideal}}} \cdot 100$$

En el catálogo se da en módulo

Con ello la tensión de error se calcula:

$$E_{RTO}(V) = \pm \frac{EG(\%)}{100} \cdot A_{d_{ideal}} \cdot V_D \Rightarrow E_{RTO_{max}}(V) = \pm \frac{EG(\%)}{100} \cdot \overbrace{A_{d_{ideal}} \cdot FS_I}^{FS_O}$$

$$E_{RTI_{max}}(V) = \pm \frac{E_{RTO_{max}}(V)}{A_{d_{ideal}}} = \pm \frac{EG(\%)}{100} \cdot FS_I \Rightarrow E_{RTI_{max}}(\%FSR_I) = \pm \frac{E_{RTI_{max}}(V)}{FSR_I} \cdot 100$$

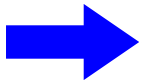
Efecto del error de Ganancia

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
INPUT						
Input Resistance	R_{IN}	Differential, G ≤ 1000		10		GΩ
		Common-Mode, G = 1000		16.5		GΩ
Input Voltage Range	IVR	T_A = +25°C (Note 1)	±11			V
Common-Mode Rejection	CMR	V_{CM} = ±11 V				
		G = 1000, 100	115	120		dB
		G = 10	100	115		dB
		G = 1	80	95		dB
		V_{CM} = ±11 V, −40°C ≤ T_A ≤ +85°C				
		G = 100, 1000	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

Efecto del error de Ganancia

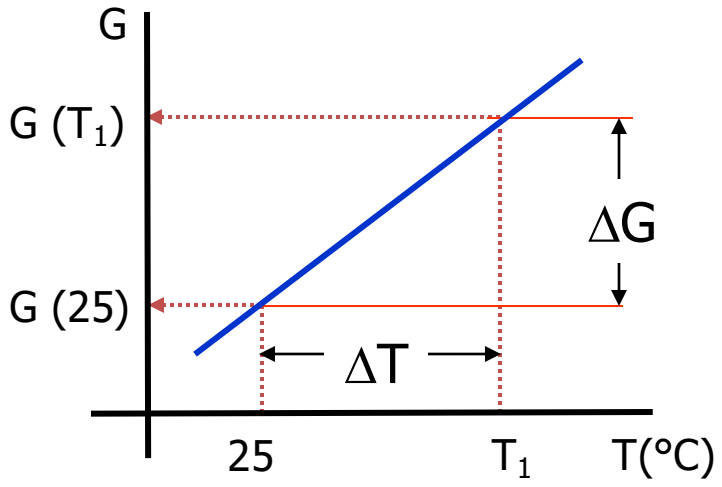
	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$EG = \frac{\Delta G}{G} \cdot 100 = 0{,}5\%$				



GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25°C)
V_{IOS}=100 µV	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
V_{OOS}=4mV	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}] = 2\,\mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}] = 100\,\mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
I_B=10nA; I_{OS}=5nA	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B] = 150\,pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}] = 9\,pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
CMR =110 dB	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
PSR =110 dB	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{np\text{-}p}$=0,4 µVpp	$e_{np} = \frac{e_{np\text{-}p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) NL_{real}=0,006·[26/(20·10^{-3}·578,36)]=0,0134%FSR	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G] = 50\,ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86.6 \pm \frac{0,1}{100} \cdot 86.6\Omega$ G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G] = 15\,ppm/°C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL			-2,26387<Error<2,31387	-1,22687<Error<1,23787

Efecto de la T en la ganancia



$$TC_G(\%) = \frac{\frac{\Delta A_d}{A_{d_{ideal}}}}{\Delta T} \cdot 100$$

Un incremento en T, llevará a un incremento en la ganancia que es equivalente a un error de ganancia (EG)

$$\Delta G = \frac{TC_G(\%)}{100} \cdot \Delta T \cdot A_{d_{ideal}} \equiv EG$$

Con ello la tensión de error se calcula:

$$E_{RTO_{max}}(V) = \pm\Delta A_d \cdot V_{d_{max}} = \pm\Delta A_d \cdot FS_I = \pm\frac{TC_G(\%)}{100} \cdot \Delta T \cdot \overbrace{A_{d_{ideal}} \cdot FS_I}^{FS_O}$$

$$E_{RTI_{max}}(V) = \frac{E_{RTO_{max}}(V)}{A_{d_{ideal}}} = \pm\frac{TC_G(\%)}{100} \cdot \Delta T \cdot FS_I$$

$$E_{RTI_{max}}(\%FSR_I) = \pm\frac{E_{RTI_{max}}(V)}{FSR_I} \cdot 100$$

Efecto de T en la ganancia

ELECTRICAL CHARACTERISTICS (@ V_S = ±15 V, V_{CM} = 0 V, T_A = +25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	AMP02E Min	AMP02E Typ	AMP02E Max	Units
INPUT						
Input Resistance	R_{IN}	Differential, G ≤ 1000		10		GΩ
		Common-Mode, G = 1000		16.5		GΩ
Input Voltage Range	IVR	T_A = +25°C (Note 1)	±11			V
Common-Mode Rejection	CMR	V_{CM} = ±11 V				
		G = 1000, 100	115	120		dB
		G = 10	100	115		dB
		G = 1	80	95		dB
		V_{CM} = ±11 V, −40°C ≤ T_A ≤ +85°C				
		G = 100, 1000	110	120		dB
		G = 10	95	110		dB
		G = 1	75	90		dB
GAIN						
Gain Equation Accuracy	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

Efecto del error de Ganancia

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$TC[G] = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6 =$ $= 50\ ppm/^oC$				

GAIN						
Gain Equation	$G = \frac{50\ k\Omega}{R_G} + 1$	G = 1000			0.50	%
Accuracy		G = 100			0.30	%
		G = 10			0.25	%
		G = 1			0.02	%
Gain Range	G		1		10k	V/V
Nonlinearity		G = 1 to 1000		0.006		%
Temperature Coefficient	G_{TC}	1 ≤ G ≤ 1000 (Notes 2, 3)		20	50	ppm/°C

	$Error_{(RTI)}(V)$		$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_i} \cdot 100$	
	Expresión del error (V)	Error (V)	OS, G NO Corregidos	OS, G SI Corregidos 25ºC)
$V_{IOS}=100\,\mu V$	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$	±0,5	0
$V_{OOS}=4mV$	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$	±0,033	0
$TC[V_{IOS}]=2\,\mu V/^{\circ}C=\frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$	±0,65	±0,65
$TC[V_{OOS}]=100\,\mu V/^{\circ}C=\frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$	±0,05	±0,05
$I_B=10nA;\ I_{OS}=5nA$	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$	±0,004	0
$TC[I_B]=150\,pA/^{\circ}C=\frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0	0	0
$TC[I_{OS}]=9\,pA/^{\circ}C=\frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$	±0,00047	±0,00047
$CMR = 110\ dB$	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$	0,039	0
$PSR = 110\ dB$	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$	0	0
$e_{n\,p\text{-}p}=0,4\,\mu Vpp$	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$	±0,001	±0,001
1. NL=0,006% 2. NL=0,006% **se supone para** FSR (±13V) $NL_{real}=0,006 \cdot [26/(20 \cdot 10^{-3} \cdot 578,36)]=0,0134\%FSR$	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$	±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$	±0,5	0
$TC[G] = 50\ ppm/^{\circ}C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$	±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$ G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G]=15\ ppm/^{\circ}C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$ G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACIÓN DEL ERROR MÁXIMO TOTAL				-2,26387<Error<2,31387	-1,22687<Error<1,23787

Ahora nos fijamos en R_G:

¿Qué error produce su Tolerancia?

¿Qué error produce su Coeficiente de Temperatura?

Como R_G forma parte de la ganancia del AI: $A_d = \left(1 + \frac{2R_3}{R_G}\right)$, cambios en el valor de R_G llevarán a cambios en la Ganancia.

Así, tanto la Tolerancia como el Coeficiente de Temperatura de R_G, llevarán a un error de ganancia.

Error de ganancia debido a la Tolerancia de R_G

$$A_{d_{ideal}} = 1 + \frac{2R_3}{R_G} \quad \text{y} \quad A_{d_{real}} = 1 + \frac{2R_3}{R_G(1 \pm Tol)}$$

$$EG_{R_G} = A_{d_{real}} - A_{d_{ideal}} = \frac{2R_3}{R_G(1 \pm Tol)} - \frac{2R_3}{R_G} = \pm \frac{2R_3 \cdot Tol}{R_G(1 \pm Tol)}$$

Normalmente Tol << 1, con ello: $\boxed{EG_{R_G} \cong \pm \frac{2R_3 \cdot Tol}{R_G}}$

Que expresado en %:

$$EG_{R_G}(\%) = \frac{A_{d_{real}} - A_{d_{ideal}}}{A_{d_{ideal}}} 100 = \pm \frac{\frac{2R_3 \cdot Tol}{R_G}}{1 + \frac{2R_3}{R_G}} 100 = \pm \frac{2R_3 \cdot Tol(\%)}{R_G + 2R_3}$$

… pero como es habitual que:

$$A_{d_{ideal}} = \left(1 + \frac{2R_3}{R_G}\right) \gg 1 \rightarrow R_G \ll 2R_3 \rightarrow \boxed{EG_{R_G}(\%) \cong \pm Tol(\%)}$$

Efecto del Error de ganancia debido a la Tolerancia de R_G

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$R_G = 86{,}6 \pm \frac{0{,}1}{100} \cdot 86{,}6\Omega$				

Error de ganancia debido al Coef. de Temp. de R_G

Definición de TC:

$$TC(\%) = \frac{\frac{\Delta R_G}{R_G}}{\Delta T} \times 100 = \frac{Tol(\%)}{\Delta T}$$

Por tanto, los resultados de EG debidos a la Tolerancia de R_G son válidos ahora, sin más que sustituir:

$$Tol(\%) = TC(\%) \cdot \Delta T$$

Con ello:

$$EG_{R_G}(\%) \cong \pm \frac{2R_3 \cdot TC(\%) \cdot \Delta T}{R_G + 2R_3}$$

$$EG_{R_G}(\%) \cong \pm TC(\%) \cdot \Delta T$$

Efecto del Error de ganancia debido al Coeficiente de Temperatura de R_G

	$E_{(RTI)}$ (V)		$E_{(RTI)}$(%) = 100 · $E_{(RTI)}$(V) / FSR_i(V)	
	Expresión error (V)	Error (V)	OS, G no corregido	OS, G corregido
$TC[R_G] = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $= 15\, ppm/ºC$				

	$Error_{(RTI)}(V)$			$\%FSR = \frac{Error_{(RTI)}(V)}{FSR_I} \cdot 100$	
	Expresión del error (V)	Error (V)		OS, G NO Corregidos	OS, G SI Corregidos 25°C)
V_{IOS}=100 μV	$\pm V_{IOS}$	$\pm 100 \cdot 10^{-6}$		±0,5	0
V_{OOS}=4mV	$\frac{\pm V_{OOS}}{G}$	$\pm \frac{4 \cdot 10^{-3}}{578,36} = \pm 6,9 \cdot 10^{-6}$		±0,033	0
$TC[V_{IOS}] = 2\,\mu V/°C = \frac{\Delta V_{IOS}}{\Delta T}$	$\pm \frac{\Delta V_{IOS}}{\Delta T}(T-25)$	$\pm 2 \cdot 10^{-6} \cdot (-40-25) = \pm 130 \cdot 10^{-6}$		±0,65	±0,65
$TC[V_{OOS}] = 100\,\mu V/°C = \frac{\Delta V_{OOS}}{\Delta T}$	$\pm \frac{1}{G}\frac{\Delta V_{OOS}}{\Delta T}(T-25)$	$\pm \frac{1}{578,36} \cdot 100 \cdot 10^{-6} \cdot (-40-25) = \pm 11,2 \cdot 10^{-6}$		±0,05	±0,05
I_B=10nA; I_{OS}=5nA	$\pm\left[I_B \cdot (R_P - R_N) + \frac{I_{OS}}{2} \cdot (R_P + R_N)\right]$	$\pm\left[0 + \frac{5 \cdot 10^{-9}}{2} \cdot (175+175)\right] = \pm 8,75 \cdot 10^{-7}$		±0,004	0
$TC[I_B] = 150\,pA/°C = \frac{\Delta I_B}{\Delta T}$	$\pm \frac{\Delta I_B}{\Delta T} \cdot (T-25) \cdot (R_P - R_N)$	0		0	0
$TC[I_{OS}] = 9\,pA/°C = \frac{\Delta I_{OS}}{\Delta T}$	$\pm \frac{1}{2} \cdot \frac{\Delta I_{OS}}{\Delta T} \cdot (T-25) \cdot (R_P + R_N)$	$\pm \frac{1}{2} \cdot 9 \cdot 10^{-12} \cdot (-40-25) \cdot (175+175) = \pm 1,02 \cdot 10^{-7}$		±0,00047	±0,00047
CMR =110 dB	$V_{MC(RTI)} = V_C \cdot 10^{\frac{-CMR}{20}}$	$2,5 \cdot 10^{\frac{-110}{20}} = 7,9 \cdot 10^{-6}$		0,039	0
PSR =110 dB	$\pm 10^{\frac{-PSR}{20}} \cdot (V_{CC1} - 15)$	$\pm 10^{\frac{-110}{20}} \cdot (15-15) = 0$		0	0
$e_{n\,p\text{-}p}$=0,4 μVpp	$e_{np} = \frac{e_{np-p}}{2}$	$e_{np} = \frac{0,4 \cdot 10^{-6}}{2} = 0,2 \cdot 10^{-6}$		±0,001	±0,001
1. NL=0,006% 2. NL=0,006% se supone para FSR (±13V) NL_{real}=0,006·[26/(20·10⁻³·578,36)]=0,0134%FSR	$\pm V_D \cdot \frac{NL_{real}(\%)}{100}$	$\pm \frac{20 \cdot 10^{-3} \cdot 0,0134}{100} = \pm 2,68 \cdot 10^{-6}$		±0,0134	±0,0134
$EG = 0,5\% = \frac{\Delta G}{G} \cdot 100$	$\frac{\pm V_D}{G} \cdot \Delta G$	$\pm \frac{20 \cdot 10^{-3}}{578,36} \cdot \frac{0,5}{100} \cdot 578,36 = \pm 100 \cdot 10^{-6}$		±0,5	0
$TC[G] = 50\,ppm/°C = \frac{\Delta G}{\Delta T} \cdot \frac{1}{G} \cdot 10^6$	$\pm \frac{V_D}{G} \cdot \frac{\Delta G}{\Delta T} \cdot (T-25)$	$\pm 20 \cdot 10^{-3} \cdot 50 \cdot 10^{-6} (-40-25) = \pm 65 \cdot 10^{-6}$		±0,325	±0,325
$R_G = 86,6 \pm \frac{0,1}{100} \cdot 86,6\Omega$	G=577,79 G=578,94	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,57) = -19,71 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,58 = 20,06 \cdot 10^{-6}$	-0,098<Error < 0,1	-0,098<Error < 0,1
$TC[R_G] = 15\,ppm/°C = \frac{\Delta R}{\Delta T} \cdot \frac{1}{R} \cdot 10^6$ $R_G = R_g \pm \Delta R = R_G \pm \frac{\Delta R_G}{\Delta T} \cdot (T-25)$	G=577,84 G=578,92	$\frac{V_D}{G} \cdot (G_R - G)$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot (-0,52) = -17,98 \cdot 10^{-6}$	$\frac{20 \cdot 10^{-3}}{578,36} \cdot 0,56 = 19,36 \cdot 10^{-6}$	-0,089<Error<0,098	-0,089<Error < 0,098
ESTIMACION DEL ERROR MAXIMO TOTAL					-2,26387<Error<2,31387	-1,22687<Error<1,23787

Conclusiones: Ajustes

- Los errores que provoquen un offset (constante) en la salida pueden corregirse con un ajuste.

- V_{IOS}, V_{OOS}
- I_B, I_{OS}
- CMR
- EG

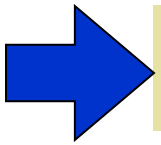
} Se podrían corregir

- TC[V_{IOS}], TC[V_{OOS}]
- TC[I_B], TC[I_{OS}]
- PSR
- NL
- en, in
- TC[G]

} No se pueden corregir

Conclusiones

V_{IOS}	100 µV	0,5 %
V_{OOS}	4 mV	0,033 %
I_{OS}	5 nA	0,004 %
CMR	110 dB	0,039 %
EG	0,5%	0,5 %
R_G	0,1%	0,1 %
e_{npp}	0,4 µVpp	0,001 %
TC V_{IOS}	2 µV/ºC	0,65 %
TC V_{OOS}	100 µV/ºC	0,05 %
TC I_{OS}	9 pA/ºC	0,00047 %
TC G	50 ppm/ºC	0,325 %
TC R_G	15 ppm/ºC	0,1 %
NL	0,006%	0,0134 %



2,3 %

Conclusiones

V_{IOS}	100 µV	0,5 %
V_{OOS}	4 mV	0,033 %
I_{OS}	5 nA	0,004 %
CMR	110 dB	0,039 %
EG	0,5%	0,5 %
R_G	0,1%	0,1 %
e_{npp}	0,4 µVpp	0,001 %
TC V_{IOS}	2 µV/ºC	0,65 %
TC V_{OOS}	100 µV/ºC	0,05 %
TC I_{OS}	9 pA/ºC	0,00047 %
TC G	50 ppm/ºC	0,325 %
TC R_G	15 ppm/ºC	0,1 %
NL	0,006%	0,0134 %

2,3 %

V_{IOS}	1 µV	%
V_{OOS}		%
I_{OS}	5	004 %
CMR	1	039 %
EG		
R_G		%
e_{npp}	0,4 µVpp	0,001 %
TC V_{IOS}	2 µV/ºC	0,65 %
TC V_{OOS}	100 µV/ºC	0,05 %
TC I_{OS}	9 pA/ºC	0,00047 %
TC G	50 ppm/ºC	0,325 %
TC R_G	15 ppm/ºC	0,1 %
NL	0,006%	0,0134 %

1,1%

Conclusiones: Simplificaciones

1. El error de ganancia (***EG***) está dado en un ***%G*** y está relacionado con el con el ***%FSR*** que se pretende calcular, según estas fórmulas:

FSR unipolar	FSR Bipolar y simétrico	FSR Bipolar y no simétrico
%FSR = %G	%FSR = %G/2	$\%FSR=100\cdot\lvert V_{Dmax}\rvert\cdot\Delta G/FSR_{RTO}$

2. En la mayoría de los casos el ***% de tolerancia de la R_G*** coincide con el ***% G***, y por tanto con el ***%FSR*** que se pretende calcular.
3. La variación con la temperatura de la ***R_G*** puede calcularse como un ***% de la R_G***, que coincide con la variación en ***%G,*** y este, coincide con el ***%FSR*** que se pretende calcular.
4. Aunque los errores tienen signo, en la mayoría de ellos se desconoce cual es, por lo que se cuantificaría como ***"±error"***, por este motivo para calcular el ***"error total"*** *se suman los valores absolutos de todos los errores máximos* y el resultado del error sería ***"± error total".***
5. Con ***impedancias bajas***, el efecto de las corrientes de offset, polarización y ruido es ***despreciable***.
6. Con ***ganancias elevadas*** el efecto de la tensión de offset de la etapa de salida es ***despreciable***.

Conclusiones: Simplificaciones

	V_{IOS}	100 µV	0,5 %
	V_{OOS}	4 mV	0,033 %
(5)	~~I_{OS}~~	~~5 nA~~	~~0,004 %~~
	CMR	110 dB	0,039 %
(1)	EG	0,5%	0,5 %
(2)	R_G	0,1%	0,1 %
(muy bajo)	e_{npp}	~~0,4 µVpp~~	~~0,001 %~~
	TC V_{IOS}	2 µV/ºC	0,65 %
	TC V_{OOS}	100 µV/ºC	0,05 %
(5)	~~TC I_{OS}~~	~~9 pA/ºC~~	~~0,00047 %~~
	TC G	50 ppm/ºC	0,325 %
(3)	TC R_G	15 ppm/ºC (tol=0,0975%)	0,1 %
	NL	0,006%	0,0134 %

2,3 %

Conclusiones: Simplificaciones

	V_{IOS}	100 µV	0,5 %
	V_{OOS}	4 mV	0,033 %
(5)	~~I_{OS}~~	~~5 nA~~	~~0,004 %~~
	CMR	110 dB	0,039 %
(1)	EG	0,5%	0,5 %
(2)	R_G	0,1%	0,1 %
(muy bajo)	e_{npp}	0,4 µVpp	0,001 %
	TC V_{IOS}	2 µV/ºC	0,65 %
	TC V_{OOS}	100 µV/ºC	0,05 %
(5)	~~TC I_{OS}~~	~~9 pA/ºC~~	~~0,00047 %~~
	TC G	50 ppm/ºC	0,325 %
(3)	TC R_G	15 ppm/ºC (tol=0,0975%)	0,1 %
	NL	0,006%	0,0134 %

2,3 %

	V_{IOS}	[illegible] µV	0,5 %
	V_{OOS}	[illegible]	[illegible]33 %
(5)	~~I_{OS}~~	[illegible]	~~0,004 %~~
	CMR	[illegible]	0,039 %
(1)	EG	[illegible]	[illegible]%
(2)	R_G	[illegible]%	0,1 %
(muy bajo)	e_{npp}	0,4 µVpp	0,001 %
	TC V_{IOS}	2 µV/ºC	0,65 %
	TC V_{OOS}	100 µV/ºC	0,05 %
(5)	~~TC I_{OS}~~	~~9 pA/ºC~~	~~0,00047 %~~
	TC G	50 ppm/ºC	0,325 %
(3)	TC R_G	15 ppm/ºC (tol=0,0975%)	0,1 %
	NL	0,006%	0,0134 %

1,1%