Noise in OAs

[SLYT-051 + SLVA043 + AN-104 + AN-358]

- Noise factor

$$F = \frac{SNR_I}{SNR_O}.$$

- Noise figure

$$(F): NF\,(dB) = 10\log(F).$$

$$F = \frac{SNR_I}{SNR_O} = \left[\frac{\frac{S_I}{N_I}}{\frac{G \times S_I}{G(N_I + N_A)}}\right] = 1 + \frac{N_A}{N_I}.$$

Note: these are powers, not intensities; *G* is the *power gain*

Figure 1. Non-inverting noise analysis diagram

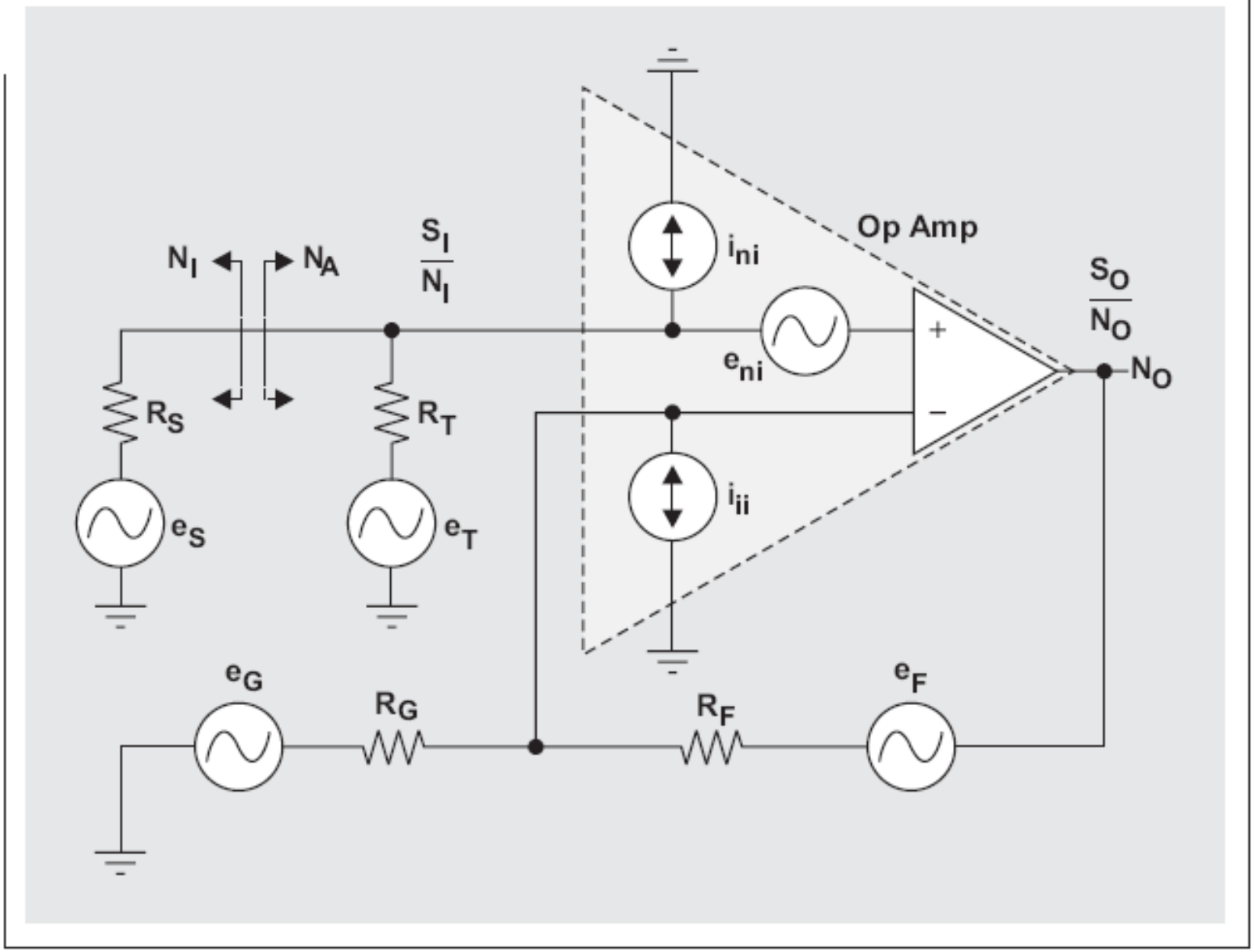
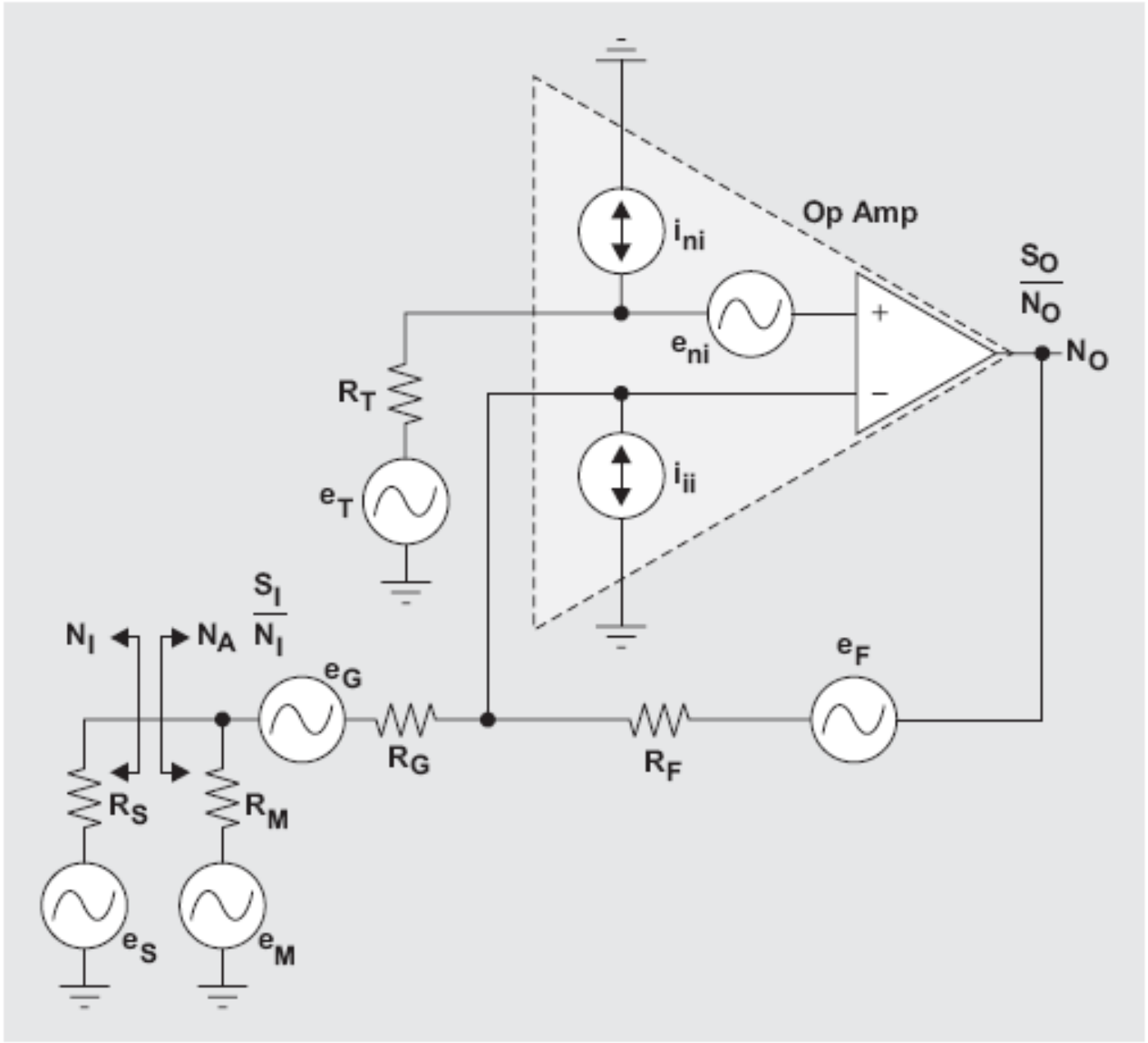


Figure 2. Inverting noise analysis diagram



Signal input noise (N_I) terms

AMPLIFIER CONFIGURATION	NOISE SOURCE	NOISE CONTRIBUTION
Non-inverting	Source thermal noise	$4kTR_S\left(\frac{R_T}{R_S+R_T}\right)^2$
Inverting	Source thermal noise	$N_I = 4kTR_S\left[\frac{R_M R_S}{R_S(R_M+R_G)+(R_M R_G)}\right]^2$ (1)

(1) no, the numerator is $R_M R_G$

it comes out from the voltage divider $(R_M // R_G) / (R_M // R_G + R_S)$

Device input noise (N_A) terms

AMPLIFIER CONFIGURATION	NOISE SOURCE	NOISE CONTRIBUTION
Non-inverting	Op amp input-referred voltage noise	e_{ni}^2
	Op amp non-inverting input-referred current noise	$i_{ni}^2\left(\frac{R_S R_T}{R_S + R_T}\right)^2$
	Op amp inverting input-referred current noise	$i_{ii}^2\left(\frac{R_F R_G}{R_F + R_G}\right)^2$ (1)
	Termination resistor thermal noise voltage	$4kTR_T\left(\frac{R_S}{R_S + R_T}\right)^2$
	Gain resistor thermal noise voltage	$4kTR_G\left(\frac{R_F}{R_F + R_G}\right)^2$ (1)
	Feedback resistor thermal noise voltage	$4kTR_F\left(\frac{R_G}{R_F + R_G}\right)^2$ (1)

(1) from SLVA043A

Inverting	Op amp input-referred voltage noise	$e_{ni}^2\left(\frac{R_G}{R_F}+\frac{R_G}{R_G+\frac{R_S R_M}{R_S+R_M}}\right)^2$
	Op amp non-inverting input-referred current noise	$i_{ni}^2\left(\frac{R_T R_G}{R_F}+\frac{R_T R_G}{R_G+\frac{R_S R_M}{R_S+R_M}}\right)^2$
	Op amp inverting input-referred current noise	$i_{ii}^2(R_G)^2$
	Non-inverting bias matching resistor thermal noise voltage	$4kTR_T\left(\frac{R_G}{R_F}+\frac{R_G}{R_G+\frac{R_S R_M}{R_S+R_M}}\right)^2$
	Gain resistor thermal noise voltage	$4kTR_G\left(\frac{R_G}{R_G+\frac{R_S R_M}{R_S+R_M}}\right)^2$
	Feedback resistor thermal noise voltage	$4kTR_F\left(\frac{R_G}{R_F}\right)^2$
	Inverting termination matching resistor thermal noise voltage	$4kTR_M\left[\frac{R_S R_G}{R_M(R_S+R_G)+R_S R_G}\right]^2$

For the configuration as differential amp. See SLVA043A
For the fully differential opamp see SLYT051