LINEAR TECHNOLOGY

DESIGN NOTES

Number 3 in a series from Linear Technology Corporation *October, 1987*

Operational Amplifier Selection Guide for Optimum Noise Performance

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The LT1028 is the lowest noise op amp available today. Its voltage noise is less than that of a 50Ω resistor. In other words, if the LT1028 is operated with source resistors in excess of 50Ω, resistor noise will dominate. If the application requires large source resistors, the LT1028's relatively high current noise will limit performance, and other op amps will provide lower overall noise.

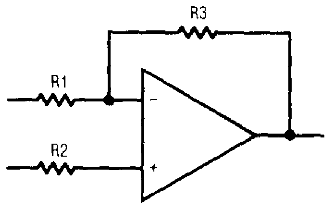
In general, the total noise of any op amp (referred to the input) is given by:

$$\text{total noise} = \sqrt{(\text{voltage noise})^2 + (\text{resistor noise})^2 + (\text{current noise} \times R_{eq})^2}$$

where,

resistor noise $= 0.13\sqrt{R_{eq}}$ in $nV/\sqrt{Hz}$

and R_{eq} = equivalent source resistance $= R2 + R1//R3$



Several conclusions can be reached by inspection of the equation:

(a) To minimize noise, resistor values should be minimized to make the contribution of the second and third terms of the equation negligible. Don't forget, however, that feedback resistor R3 is a load on the output.

(b) Total noise is dominated by:
(i) voltage noise at low R_{eq},
(ii) resistor noise at mid R_{eq},
(iii) current noise at high R_{eq}, because resistor noise is proportional to $\sqrt{R_{eq}}$, while the current noise contribution to total noise is proportional to R_{eq}.

The table below lists which op amp gives minimum total noise for a specified equivalènt source resistance. A two step prcoedure should be followed to optimize noise:

(1) Reduce equivalent source resistance to a minimum allowed by the specific application.

(2) Enter the table to find the optimum op amp.

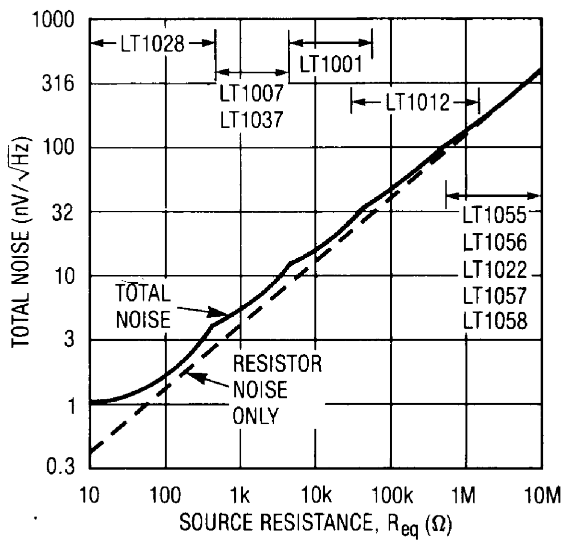
The table actually has two sets of devices: one for low frequency (instrumentation), one for wideband applications. The slight differences between the two columns occur because voltage and current noise increase at low frequencies (below the so-called 1/f corner) while resistor noise is flat with frequency.

Best Op Amp for Lowest Noise vs Source Resistance

SOURCE R (R_{eq})	BEST OP AMP @ LOW FREQ. (10Hz)	BEST OP AMP @ WIDEBAND (1kHz)
0Ω to 400Ω	LT1028	LT1028
400Ω to 1k	LT1007/37	LT1028
1k to 4k	LT1007/37	LT1028, LT1007/37
4k to 15k	LT1001	LT1007/37
15k to 30k	LT1001	LT1001, LT1007/37
30k to 70k	LT1001, LT1012	LT1001
70k to 150k	LT1012	LT1001, LT1012 LT1055/56/22, LT1057/58
150k to 600k	LT1012, LT1006/13/14	LT1012, LT1006/13/14 LT1055/56/22, LT1057/58
600k to 2M	LT1012 LT1055/56/22, LT1057/58	LT1012, LT1006/13/14 LT1055/56/22, LT1057/58
2M to 10M	LT1055/56/22, LT1057/58	LT1012 LT1055/56/22, LT1057/58
>10M	LT1055/56/22, LT1057/58	LT1055/56/22, LT1057/58

The actual achievable total noise is plotted at 10Hz and 1kHz. The striking feature of these plots is that with the proper selection of op amps total noise is dominated by equivalent source resistor noise over a five decade (100Ω to 10MΩ) range.

10Hz Total Noise vs Equivalent Source Resistance



1kHz Total Noise vs Equivalent Source Resistance