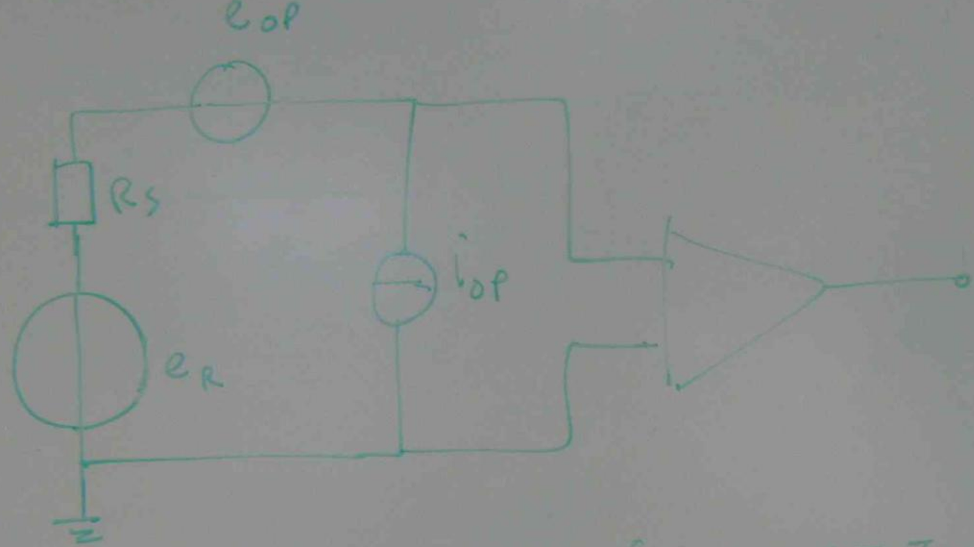
NOISE MODEL FOR OPERATIONAL AMPLIFIER



R_S = SOURCE NOISE RESISTANCE (EQUIVALENT TO ALL EXTERNALLY CONNECTED RESISTORS IN THE CIRCUIT)

e_R = THERMAL NOISE VOLTAGE SOURCE DUE TO R_S

e_{op} = EQUIVALENT INPUT NOISE VOLTAGE DUE TO OP-AMP

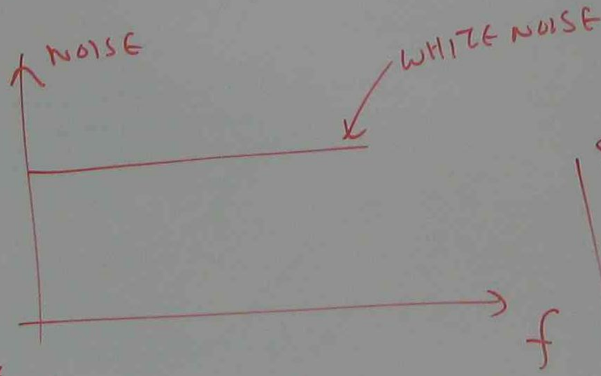
i_{op} = EQUIVALENT INPUT NOISE CURRENT DUE TO OP-AMP

DESCRIPTION AND CALCULATION OF NOISE

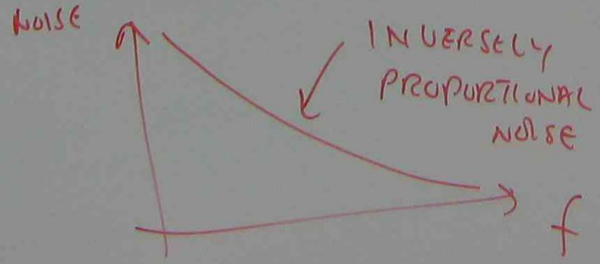
NOISE VOLTAGE / CURRENT IN RMS VALUE

$\sqrt{2}$ CONVERSION CAN NOT BE USED FOR NOISE

NOISE POWER DENSITY IN GRAPH



SPECIFIC AT CERTAIN FREQUENCY



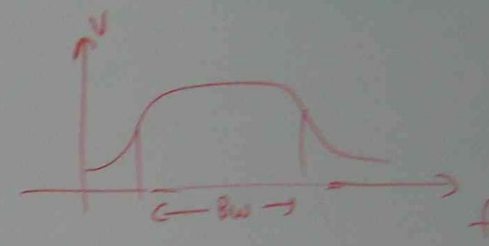
IF NOISE IS CONSTANT OVER FREQUENCY, IT IS CALLED WHITE NOISE. SOME NOISES ARE INVERSELY PROPORTIONAL TO FREQUENCY.

SOME NOISE CAN HAPPEN ONLY AT SPECIFIC FREQUENCY.

WHITE NOISE — THERMAL NOISE / SHORT NOISE

NOISE $\propto$ BANDWIDTH

NOISE VOLTAGE DEPENDS ON BANDWIDTH (B.W)



$$\left(\frac{\text{NOISE DENSITY RMS VOLTAGE}}{\sqrt{\text{HZ}}}\right) = \text{NOISE VOLTAGE}$$

$$\text{TOTAL NOISE VOLTAGE OVER BANDWIDTH} = \sqrt{\left(\frac{\text{NOISE DENSITY VOLTAGE}}{\text{HZ}}\right)^2 \times \text{BANDWIDTH}}$$

IF NOISE IS CONSTANT OVER FREQUENCY, BY SELECTING R | C VALUES FOR FILTER, BANDWIDTH THAT INFLUENCES ON NOISE CAN BE CONTROLLED AND AS AN EFFECT, THE NOISE CAN BE CONTROLLED.

pb ① IF AN OP-AMP IS STATED TO HAVE A NOISE VOLTAGE DENSITY OF

$\frac{15\,nV}{\sqrt{Hz}}$). FIND RMS NOISE VOLTAGE OVER BANDWIDTH 30 KHZ

$15\,nV/\sqrt{Hz}$

pb ② THE NOISE CURRENT DENSITY OF 741 OP-AMP IS $3\times10^{-25}\ A^2/Hz$

FIND RMS NOISE CURRENT OVER 25 KHZ BANDWIDTH

pb ③ THE NOISE VOLTAGE OF AN AMPLIFIER IS 6.5 μV OVER 40 KHZ

BANDWIDTH. IF BANDWIDTH IS CHANGED TO 15 KHZ, CALCULATE

THE NOISE VOLTAGE.

pb ①

Rms noise voltage over bandwidth $= \sqrt{\frac{\text{Noise density voltage}^2}{\text{Hz}} \times \text{Band width}} = \frac{\text{Noise density voltage}}{\sqrt{\text{Hz}}} \times \sqrt{\text{Bandwidth}} = 15\,\text{nV} \times \sqrt{30 \times 10^3}$

$= 2.6\,\mu V$

pb ②

Rms noise current over bandwidth $= \sqrt{\frac{\text{Noise density current}^2}{\text{Hz}} \times \text{Band width}} = \sqrt{3 \times 10^{-25} \times 25 \times 10^3} = 87 \times 10^{-12}\,\text{Amp}$

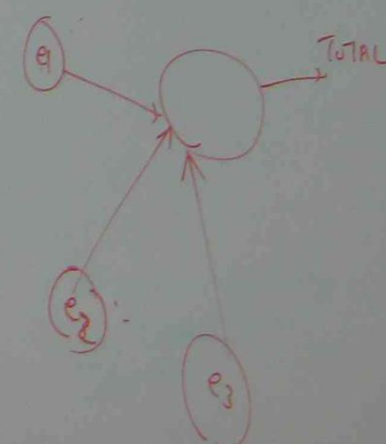
$= 87\,\text{pA rms}$

pb ③

$$\boxed{\text{Noise voltage } ② = \text{Noise voltage } ① \times \sqrt{\frac{f_2}{f_1}}}$$

$$\text{Noise voltage } ② = 6.5\,\mu V \times \sqrt{\frac{15}{40}} = 4\,\mu V_{rms}$$

Addition of noise voltages/currents



$$e_{TOTAL} = \sqrt{e_1^2 + e_2^2 + e_3^2 + ---}$$

pb (4) IN AN OPERATIONAL AMPLIFIER, THE SOURCE NOISE RESISTANCE = 30 kΩ. THERMAL NOISE DUE TO SOURCE RESISTANCE = 2.8 μV. INTERNAL NOISE CURRENT = 60 pA, INTERNAL NOISE VOLTAGE = 4.1 μV.

(a) WHAT IS EQUIVALENT INPUT NOISE VOLTAGE $e_n = ?$

(b) WHAT WILL BE NEW VALUE OF NOISE AT TRIPPLED BANDWIDTH

THERMAL NOISE $e_1 = 2.8\,\mu V$

INTERNAL RESISTANCE NOISE $e_2 = IR = 60 \times 10^{-12} \times 30 \times 10^{3}$

INTERNAL NOISE VOLTAGE $e_3 = 4.1\,\mu V$

$$e_n = \sqrt{e_1^2 + e_2^2 + e_3^2}$$

$$= \sqrt{(2.8 \times 10^{-6})^2 + (60 \times 10^{-12} \times 30 \times 10^{3})^2 + (4.1 \times 10^{-6})^2}$$

$$\simeq 5.3 \times 10^{-6}\,V = 5.3\,\mu V$$

$$e_{n_2} = e_{n_1} \times \sqrt{\frac{f_2}{f_1}} = 5.3 \times \sqrt{\frac{3f_1}{f_1}} = 5.3 \times \sqrt{3}$$

$$= 9.2\,\mu V$$

DESCRIPTION

NOISE VOLTAGE

$\sqrt{2}$ CONVERSION

NOISE POWER DE

NOISE