# 11.4 Noise and SNR

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

**KEY WORDS** noise figure

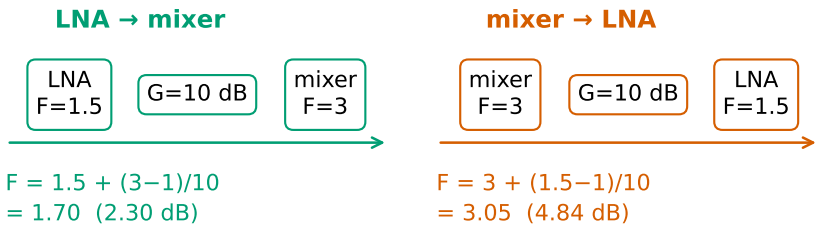
## Objective

Model noise density and figure in a receiver chain, compute output SNR for AM and FM, and do dB arithmetic without hesitation.

## 1 Key knowledge and worked examples

### ■ The cascade law

$F = F_1 + (F_2 - 1)/G_1$ (linear ratios!): the first stage decides everything. Thermal floor $-174 dBm/Hz + 10 log_{10} B$.




*Same blocks, swapped order, 2.5 dB different – the front-end gain IS the protection.*

### ■ Worked example: the front end is the receiver

LNA $F_1 = 1.5$ (1.76 dB), $G_1 = 10$ dB ahead of a mixer $F_2 = 3$ (4.77 dB): $F = 1.5 + 2/10 = 1.70 = 2.3$ dB. Reversed: `3 + 0.5/10 = 3.05` = 4.84 dB – gain before lossy stages IS noise protection.

### ■ FM's dividend

Wideband FM post-detection SNR gain $\approx 3\beta^2/2$ over the input: $\beta = 5$ gives $10 log_{10} 37.5 = 15.7 dB$ – lost below threshold, where clicks and capture take over.

## 2 Practice

**2.1** A chain has $F_1 = 2$ dB, $G_1 = 20$ dB, then $F_2 = 6$ dB. Compute the total noise figure in dB. [3]

**2.2** Compute the thermal noise power in a 1 MHz bandwidth. [3]

**2.3** A signal of −90 dBm passes a 20 dB amplifier. Give the output level. [3]

## 3 Exam-style questions

**3.1** A receiver for a 200 kHz-wide FM channel needs an output SNR of 10 dB at minimum signal. The chain: LNA (F = 1.76 dB, G = 10 dB), then mixer+IF (F = 4.77 dB).

Compute the chain's total noise figure. Compute the thermal noise power in the 200 kHz channel. Compute the minimum detectable signal level (dBm) at the antenna for 10 dB SNR. State, with the cascade law, what happens if the LNA gain drops to 0 dB. [8]

**3.2** The same FM link runs $\beta = 5$; the input SNR at the detector is 20 dB.

Compute the post-detection SNR improvement for wideband FM and the resulting output SNR. State what happens below the FM threshold. Compare with an AM envelope detector at the same 20 dB input SNR, which passes the SNR through roughly unchanged (degraded further at small m) – and explain why FM is called a wideband trade. [7]