

# 43.1 Measurement loading, amplifier gain and detector response

Name: \_\_\_\_\_ Class: \_\_\_\_\_ Date: \_\_\_\_\_

Total: 10 marks

KEY WORDS dead time • input impedance

## Objective

Calculate measurement loading from finite meter and source impedances; Determine simple amplifier gain and first-order filter response; Interpret detector efficiency, resolution, dead time and calibration bias. Original public practice; not an ETS paper.

## 1 Key knowledge and worked examples

A meter forms a divider with the source:  $\text{reading} = V_{th} \cdot R_m / (R_m + R_{th}) \leq V_{th}$ . Quote both resistances.

Non-inverting gain is  $1 + R_2/R_1$ . A first-order low-pass has  $f_c = 1/(2\pi RC)$ , amplitude  $1/\sqrt{1 + (f/f_c)^2}$ , and passes  $1/\sqrt{2}$  at  $f_c$ .

Efficiency, FWHM/E resolution and dead time  $m = n/(1 + n\tau)$  are separate properties; invert to  $n = m/(1 - m\tau)$  with  $m\tau < 1$ .

Calibration removes constant offset or scale error, not noise or nonlinearity; report resolution and efficiency separately.

### ■ Worked method

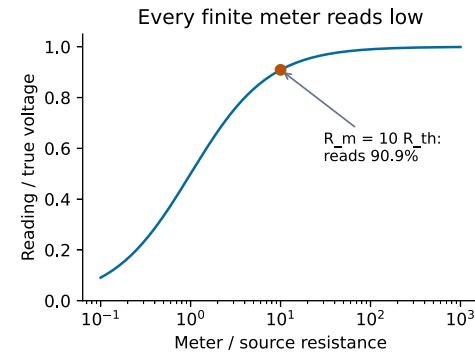
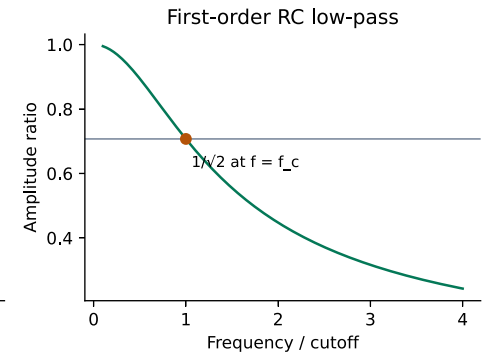
A voltmeter of finite input resistance forms a divider with the source resistance.

$$V_m = V_{th} \frac{R_m}{R_m + R_{th}} = (12 \text{ V}) \frac{1.0 \text{ M}\Omega}{1.0 \text{ M}\Omega + 0.20 \text{ M}\Omega} = 10.0 \text{ V}.$$

For a nonparalysable detector with observed rate  $m$  and dead time  $\tau$ ,

$$n = m / (1 - m\tau), \quad m\tau < 1.$$

Efficiency, dead time and spectral resolution are different corrections; one cannot replace the others.



## 2 Practice

2.1 Choose one answer. A 12 V source with internal resistance 200 k $\Omega$  is measured by a voltmeter with input resistance 1 M $\Omega$ . The meter reads: [1]

- A 12.0 V
- B 10.0 V
- C 9.6 V
- D 2.0 V
- E 11.0 V

2.2 Choose one answer. A first-order RC low-pass driven exactly at its cutoff frequency passes an amplitude fraction of: [1]

- A  $1/2$
- B  $1/\sqrt{2}$
- C  $1/e$
- D  $9/10$
- E 1

2.3 An ideal non-inverting op-amp stage with  $R_1 = 1 \text{ k}\Omega$  and  $R_2 = 9 \text{ k}\Omega$  has gain \_\_\_\_\_. Show your relation and units. [2]

[2]

[4]