Lista 1 - Instrumentação de Controle

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1a) Histograma na Figura 1. Dados gerados ao final do relatório (Apêndice).

b) $\hat{\mu} = 227{,}271$ $\hat{\sigma} = 3{,}043$

Os valores obtidos de $\hat{\mu}$ e $\hat{\sigma}$ diferiram de μ e σ, pois foi tomada uma amostra finita da variável aleatória. Espera-se que $\hat{\mu}$ e $\hat{\sigma}$ convirjam para μ e σ quando o número de amostras tender ao infinito.

c) O valor de $\sigma = 3V$ se explica também pela própria variância da tensão RMS da rede, para além daquela do voltímetro. Nesse sentido, pode-se inferir que o comportamento probabilístico da rede introduz mais variância ao sistema que o instrumento de medição

2.

a)

$$f(x) = \begin{cases} \frac{1}{10}, & \text{se } 0 \leq x \leq 10 \\ 0, & \text{caso contrário} \end{cases}$$

Podemos verificar o resultado para a função distribuição acumulada $F(x) = \int_{-\infty}^{x} f(x)\,dx$ para a qual esperamos

$$F(\infty) = \lim_{x \to \infty} F(x) = 1$$

$$F(\infty) = \int_{-\infty}^{\infty} f(x)\,dx = \int_{0}^{10} \frac{1}{10}\,dx = \left[\frac{1}{10} \cdot x\right]_{0}^{10} = 1$$

b) Histograma na Figura 2b.

Não, a forma do histograma não é idêntica à função do item "a". Para que isso ocorresse, a frequência relativa de cada intervalo do histograma deveria ser igual. Como foram tomados 1000 amostras, espera-se que haja, de fato, um discrepância em relação à função do item "a".

c) Observa-se, no histograma, que os valores se limitaram ao intervalo [4,56 , 5,59]. Isto é natural, uma vez que se tomou o valor médio de uma variável aleatória contínua uniformemente distribuída no intervalo [0, 10], cujo valor intermediário é 5.

3.

a) 0,5 mm. A incerteza na medição não pode ser maior, já que a resolução corresponde à menor mensuração que se pode fazer.

b) $\overline{X} = 162,25 \pm 0,25$ mm

Incerteza: 0,25 mm. Resolução: 0,5 mm

A diferença entre a resolução e à incerteza se deve ao fato de que o instrumento de medição último (régua) é analógico. Com isso,

c) O paquímetro indicaria uma medida entre 1,60 mm e 1,65 mm, pois ele tem menor divisão em décimo de milímetro.

Resolução = 0,1 mm Incerteza = 0,05 mm

O motivo é o mesmo do item b).

d) A resolução e a incerteza permanecem inalteradas

e) A lente altera o valor medido. O paquímetro, a resolução

4. $O(I) = KI + a + N(I)$

Da definição de sensibilidade:

$$\frac{dO}{dI} = K + \frac{dN}{dI}(I)$$

Pela condição imposta:

$$\frac{dO}{dI} = K \quad (II)$$

Igualando (I) e (II), temos:

$$\frac{dN}{dI} + K = K \Rightarrow \frac{dN}{dI} = 0 \quad (III)$$

De (III) concluímos que N(I) assume um valor de máximo

5. $\bar{K} = 3{,}1 \cdot 10^{6}\ \Omega$; $\bar{\beta} = -2254{,}473\ K$; $\sigma_K = 1{,}2 \cdot 10^{5}\ \Omega$; $\sigma_\beta = 11{,}94\ K$

$R(\theta) = K \exp\left(\frac{\beta}{\theta}\right)$; $I_{min} = -55^{\circ}C = 218\ K$; $I_{max} = 120^{\circ}C = 393\ K$; $O_{min} = 100\ \Omega$; $O_{máx} = 10\ K\Omega$

a)

$$K = (O_{max} - O_{min})/(I_{max} - I_{min}) = 56{,}57\ \Omega K^{-1}$$

$$a = O_{min} - K \cdot I_{min} = -1{,}22\ 10^{4}\ \Omega$$

$$\Rightarrow O(I) = 56{,}57 \cdot I - 1{,}22 \cdot 10^{4}$$

b)

$$R_{Ideal}(\theta) = 56{,}57\,\theta - 1{,}22 \cdot 10^{4}$$

$$N(\theta) = R(\theta) - R_{Ideal}(\theta) = K \exp(\beta/\theta) - 56{,}57\,\theta + 1{,}22 \cdot 10^{4}$$

Note que:

$$\frac{dN}{d\theta}(\theta) = -\frac{K\beta}{\theta^2} \exp(\beta/\theta) - 56{,}57 = \frac{6{,}99 \cdot 10^{9}}{\theta^2} \cdot \exp\left(\frac{-2254}{\theta}\right) - 56{,}57$$

$$\frac{d^2N}{d\theta^2} = \frac{1{,}58 \cdot 10^{13}}{\theta^4} \cdot \exp(-2254/\theta) - \frac{1{,}39 \cdot}{\theta^2} \exp(-2254/\theta)$$

Observe que $\frac{d^2N}{d\theta^2} > 0 \ \forall \ \theta \in [218, 393\ K]$

Com isso, verifica-se que a função é monotônica, portanto o valor máximo absoluto é único.

c) Resolvendo $\frac{dN(\theta)}{d\theta} = 0$, temos:

$$\theta_{\hat{N}} = 316{,}9\ K \qquad \hat{N} = -3173\ \Omega$$

$$\hat{N}_{\%\,fsd} = \frac{\hat{N}}{R_{max} - R_{min}} \cdot 100\,\% = -31{,}73\,\%$$

d) $R = K \cdot \exp(\beta/\theta) = 3{,}1 \cdot 10^{6} \cdot \exp(-2254/\theta)$

$$\dot{R}(\theta) = \frac{dR(\theta)}{d\theta} = \frac{6{,}989}{\theta^2} \cdot \exp(-2254/\theta)$$

$$\dot{R}(\hat{\theta}_N) = \dot{R}(316{,}9) = 56{,}57 \;\Omega\, K^{-1}$$

Este é, com efeito, o valor calculado no item a), como esperávamos pela questão 4.

e)
$$\sigma_R = \sqrt{\frac{\partial R}{\partial \beta}^2 \cdot \sigma_\beta^2 + \frac{\partial R}{\partial K}^2 \sigma_K^2}$$

$\sigma_K = 1{,}2 \cdot 10^{5}\ \Omega$ $\qquad \sigma_\beta = 11{,}94\ K$

$$\frac{\partial R}{\partial \beta} = \frac{1}{\bar{\theta}} \cdot \exp(\bar{\beta}/\bar{\theta}) \qquad \frac{\partial R}{\partial K} = \exp(\bar{\beta}/\bar{\theta})$$

Para $\bar{\theta} = 100\,°C = 373\ K$: $\frac{\partial R}{\partial \beta} = 19{,}71$ $\qquad \frac{\partial R}{\partial K} = 0{,}0024$

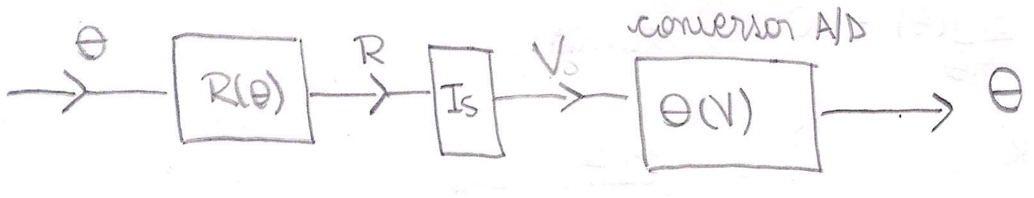
$\therefore \quad \sigma_R = 369{,}30\ \Omega$

Para $\bar{\theta} = \hat{\theta}_N = 316{,}9\ K$: $\frac{\partial R}{\partial \beta} = 7{,}951$ $\qquad \frac{\partial R}{\partial K} = 8{,}13 \cdot 10^{-4}$

$\therefore \quad \sigma_R = 136{,}09\ \Omega$

f) Ver Figura 5 f na seção de figuras.

g) O conversor AD pode funcionar como elemento compensador de não linearidade.



$$\Theta(V) = \frac{V}{I_S} \cdot R^{-1}(\Theta)$$

Note que $R(\Theta) \cdot R^{-1}(\Theta) = \Theta$

h) Introduz-se uma nova fonte de variância ao sistema. Observe que $R(373) = 7352\ \Omega$ Para $I_S = 0{,}1$ mA, temos:

$$V = R \cdot I_S = 7{,}352\ k\Omega \cdot 0{,}1\,mA = 0{,}7352V.$$

No entanto, a resolução do conversor é 0,7352V e a aproximação para 0,7V (perda de informação) levará a uma discrepância na temperatura medida.

6. $R_T = R_0(1+\alpha T)$

$\bar{R_0} = 100$, $\bar{\alpha} = 3{,}91 \cdot 10^{-3}$, $\bar{T} = 37°C$, $\sigma_{R_0} = 0{,}29$, $\sigma_a = 2{,}94 \cdot 10^{-5}$

$$\bar{R_T} = \bar{R_0}(1+\bar{\alpha}\bar{T}) = 114{,}5\ \Omega$$

$$\frac{\partial R_T}{\partial R_0} = 1+\bar{\alpha}\bar{T} = 1{,}145 \qquad \frac{\partial R}{\partial \alpha} = \bar{R}\bar{T} = 3700$$

$$\Rightarrow \sigma_{R_T} = \sqrt{\frac{\partial R_T}{\partial R_0}^2 \cdot \sigma_{R_T}^2 + \frac{\partial R_T}{\partial a}^2 \cdot \sigma_a^2} = 0{,}3493$$

$$V = V_S \cdot r\left(\frac{R_T}{R_1} - 1\right) \text{ com: } \begin{cases} \bar{V_S} = 10 & \bar{R_1} = 100 & \bar{r} = 0{,}01 \\ \sigma_{VS} = 0 & \sigma_{R_1} = 0{,}89 & \sigma_r = 1{,}94 \cdot 10^{-4} \end{cases}$$

$$\bar{V} = \bar{V_S}\bar{r}\left(\frac{\bar{R_T}}{\bar{R_1}} - 1\right) = 0{,}0145$$

$$\frac{\partial V}{\partial R_1} = -\frac{\bar{V_S}\bar{r}\bar{R_T}}{(\bar{R_1})^2} = -0{,}0011 \quad \frac{\partial V}{\partial r} = \bar{V_S}\left(\frac{\bar{R_T}}{\bar{R_1}} - 1\right) = 1{,}447 \quad \frac{\partial V}{\partial R_T} = \frac{\bar{V_S}\bar{r}}{\bar{R_1}} = 0{,}001$$

$$\sigma_V = \sqrt{\frac{\partial V}{\partial R_1}^2 \cdot \sigma_{R_1}^2 + \frac{\partial V}{\partial r}^2 \sigma_r^2 + \frac{\partial V}{\partial R_T}^2 \cdot \sigma_{R_T}^2} = 0{,}0011$$

$n = K_1 V + b_1 \quad \bar{K_1} = 6522 \quad \sigma_{K_1} = 0 \quad \bar{b_1} = 0 \quad h_{b_1} = 0{,}5$

$\sigma_{b_1} = h_{b_1}/\sqrt{3} = 0{,}289$

$$\bar{n}_b = [\bar{K}_1 \bar{V} + \bar{b}_1] = 94 \quad \text{(com arredondamento)}$$

$$\frac{\partial n}{\partial b_1} = 1 \qquad \frac{\partial n}{\partial V} = 6522$$

$$\sigma_n = \sqrt{\frac{\partial n}{\partial b_1}^2 \cdot \sigma_{b_1}^2 + \frac{\partial n}{\partial V}^2 \cdot \sigma_V^2}$$

$$\Rightarrow \sigma_n = 7,264$$

$$T_m = K_2 n + b_2 \qquad \bar{K}_2 = 0,391 \, ; \; \bar{b}_2 = 0 \, ; \; \sigma_{K_2} = \sigma_{b_2} = 0$$

$$\bar{T}_m = \bar{K}_2 \bar{n} + \bar{b}_2 = 36,75$$

$$\frac{\partial T_m}{\partial n} = \bar{K}_2 \qquad \sigma_{T_m} = \sqrt{\frac{\partial T_m}{\partial n}^2 \cdot \sigma_n^2} = 2,840$$

$$\varepsilon = T - \bar{T}_m = 36,75 - 37 = -0,25\,°C$$

$$\sigma_\varepsilon = \sigma_{T_m} = 2,840\,°C$$

b) $[\bar{T}_m - 3\sigma, \bar{T}_m + 3\sigma] = [28,23°C, 45,28°C]$

Sim, o valor verdadeiro está neste intervalo. No entanto, o sistema de medição não é adequado. Basta olhar o intervalo de confiança ($\approx 99,7\%$) acima para concluir que ele é longo demais para a aplicação.

c) σ_V na fórmula simplificada ($V = V_S r \alpha T$)

$$\sigma_V = \sqrt{\frac{\partial V}{\partial V_S}^2 \cdot \sigma_{V_S}^2 + \frac{\partial V}{\partial r}^2 \cdot \sigma_r^2 + \frac{\partial V}{\partial \alpha}^2 \cdot \sigma_\alpha^2}$$

σ_V na fórmula original:

$$\sigma_V = \sqrt{\frac{\partial V}{\partial V_S}^2 \cdot \sigma_{V_S}^2 + \frac{\partial V}{\partial r} \cdot \sigma_r^2 + \frac{\partial V}{\partial R_T}^2 \cdot \sigma_{R_T}^2 + \frac{\partial V}{\partial R_1}^2 \cdot \sigma_{R_1}^2}$$

Observa-se que a primeira expressão não leva em conta os desvios-padrão de R_0 e R_1. A segunda leva, pois V é função de R_1 e R_T é função de R_0.

d) Entrada de interferência

7. a) Graficamente, podemos obter:

$$T_p = 1{,}05\ s \qquad M_p = 38{,}4\% = 0{,}384$$

Com isso, calculamos ξ e ω_n

$$\xi = \frac{-\ln(M_p)}{\sqrt{\pi^2 + (\ln(M_p))^2}} = 0{,}2916$$

$$\omega_d = \frac{\pi}{T_p} = 2{,}992\ rad/s$$

$$\omega_n = \frac{\omega_d}{\sqrt{1-\xi^2}} = 3{,}128\ rad/s$$

$$G(s) = \frac{\omega_n^2}{s^2 + 2\xi\omega_n + \omega_n^2} = \frac{9{,}784}{s^2 + 1{,}824s + 9{,}784}$$

b) A Figura 7b mostra o gráfico da função estimada. Observa-se que ela se ajusta bem aos dados originais.

8.

a) $G_C(s) = K \qquad G(s) = \frac{1}{\tau s + 1} \qquad H(s) = \frac{1}{\tau_F s + 1}$

Por meio da álgebra de blocos, escrevemos C/R:

$$\frac{C(s)}{R(s)} = \frac{G_C(s) \cdot G(s)}{1 + G_C(s) \cdot G(s) H(s)} = \frac{K\tau_F s + K}{\tau \cdot \tau_F s^2 + (\tau + \tau_F)s + K + 1}$$

$$E(s) = R(s) - C(s) = R(s)\left[1 - \frac{K\tau_F s + K}{\tau \cdot \tau_F s^2 + (\tau + \tau_F)s + K + 1}\right]$$

b) Pelo Teo do Valor final:

$$e(\infty) := \lim_{t \to \infty} e(\infty) = \lim_{s \to 0} \left(s E(s)\right)$$

$$\lim_{s \to 0} sE(s) = \lim_{s \to 0} s \cdot \frac{\tau \tau_F s^2 + (\tau + \tau_F - K\tau_F)s + 1}{\tau \cdot \tau_F \cdot s^3 + (\tau + \tau_F)s^2 + (K+1)s}$$

$$= \frac{1}{K+1} = 0{,}01 \Rightarrow K = 99$$

c) $$\frac{C(s)}{R(s)} = \frac{K\tau_F s + K}{\tau \tau_F s^2 + (\tau + \tau_F)s + K + 1}$$

Para R(s) degrau unitário:

$$C(s) = \frac{1}{s} \cdot \frac{K\tau_F s + K}{\tau \tau_F s^2 + (\tau + \tau_F)s + K + 1}$$

Ganho em regime permanente (A):

$$A = \lim_{s \to 0} s\,C(s) = \frac{K}{K+1}$$

Da expressão $Y(s)/R(s)$ podemos encontrar ζ e ω_n:

$$\omega_n^2 = \frac{K+1}{\tau \tau_F} \qquad \zeta = \frac{1}{2\omega_n} \cdot \frac{\tau + \tau_F}{\tau \tau_F}$$

Para $\tau = 10\ s\,rad^{-1}$, $\tau_F = 2\ s \cdot rad^{-1}$ e $K = 99$, temos:

$\omega_n = 2{,}236\ rad/s \qquad \zeta = 0{,}1342$

d) $$C(s) = \frac{1}{s} \cdot \frac{\frac{K}{\tau}s + \frac{K}{\tau\tau_F}}{s^2 + 2\zeta\omega_n + \omega_n^2} = \frac{1}{s}\left[\frac{\omega_n^2}{s^2 + 2\zeta\omega_n + \omega_n^2} + \frac{\frac{K}{\tau}s - \frac{1}{\tau\tau_F}}{s^2 + 2\zeta\omega_n + \omega_n^2}\right]$$

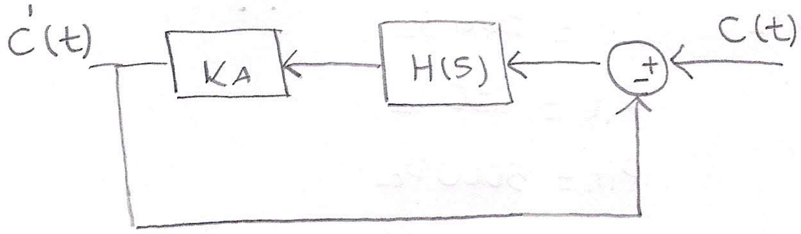
$$c(t) = \mathcal{L}^{-1}\{C(s)\} = 1 - \frac{1}{\sqrt{1-\zeta^2}} \cdot e^{-\zeta\omega_n t} \cdot \sin(\omega_n\sqrt{1-\zeta^2}\,t + \phi_1) +$$

$$+ \frac{1}{\tau\tau_F\omega_n^2} + \frac{1}{\omega_n\sqrt{1-\zeta^2}} \cdot \sqrt{\frac{\left(\frac{1}{K\tau_F} - \zeta\omega_n\right)^2 + \omega_n^2(1-\zeta^2)}{\omega_n^2}}\; e^{-\zeta\omega_n t} \sin(\omega_n\sqrt{1-\zeta^2}\,t + \phi_2)$$

Graficamente podemos encontrar M_p e T_p da resposta $c(t)$:

$M_p = 3{,}5 \qquad T_p = 0{,}72$

e) Abaixo, o recorte do sistema de medição



$$\frac{C'(s)}{C(s)} = H_2(s) = \frac{K_A\,H(s)}{1+K_A H(s)} = \frac{K_A}{\tau_F s + K_A + 1}$$

$$\frac{C(s)}{R(s)} = \frac{G_C(s)G(s)}{1+G_C(s)G(s)H_2(s)} = \frac{K\tau_F s + K + K K_A}{\tau\tau_F s^2 + (\tau+\tau_F+K_A\tau)s + K_A + K\cdot K_A + 1}$$

Nova constante de tempo:

$$H_2(s) = \frac{K_A}{\tau_F s + K_A + 1} = \frac{\frac{K_A}{K_A+1}}{\frac{\tau_F}{K_A+1}s + 1} \Rightarrow \tau_{F\,NOVO} = \frac{\tau_F}{K_A+1}$$

Nova sensibilidade:

$$\lim_{s\to 0} H_2(s) = \lim_{s\to 0}\left[\frac{K_A}{\tau_F s + K_A + 1}\right] = \frac{K_A}{K_A+1}$$

f) $\tau_{F\,NOVO} = \frac{\tau_F}{K_A+1} = \frac{2}{K_A+1} = 0{,}2 \Rightarrow K_A = 9$

Com isso, a resposta transitória fica mais rápida, como vemos:

	ξ	ω_n	$M_p\%$	T_p
Sistema antigo	0,134	2,24	353%	0,703
Sistema novo	0,380	6,71	59,9%	0,307

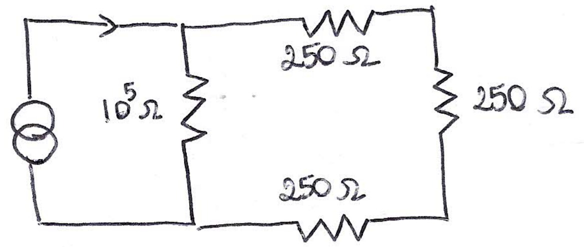
Erro em regime permanente:

$$e(\infty) = \lim_{s\to 0} s\,E(s) = \lim_{s\to 0} s\left[\frac{1}{s} - \frac{K\tau_F s + K + K K_A}{\tau\cdot\tau_F s^2 + (\tau+\tau_F+K_A\tau)s + K_A + K K_A + 1}\right]$$

$$= 1 - \frac{K + K\cdot K_A}{K_A + K\cdot K_A + 1} = -0{,}0988$$

g) Pode-se projetar um compensador em avanço-atraso.

9.



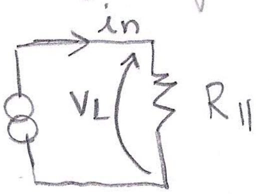
$R_N = 10^5\ \Omega$

$R_C = 500\ \Omega$

$R_R = 250\ \Omega$

$P_{in} = 5000\ Pa$

Circuito equivalente



$$R_{\parallel} = (R_C + R_R) \parallel R_N$$

$$\Rightarrow R_{\parallel} = \frac{R_N\ (R_C + R_R)}{R_N + R_C + R_R}$$

Divisor de tensão:

$$V_R = \frac{R_R}{R_C + R_R} \cdot V_L = \frac{R_R}{R_C + R_R} \cdot R_{\parallel} \cdot i_n = \frac{R_N}{R_N + R_C + R_R} \cdot R_R\, i_n$$

Substituindo os valores: $V_R = 0{,}9926 \cdot \overline{V}$, onde $\overline{V} = R_R\, i_n$

Equação do transmissor:

$K_1 = (20\,mA - 4\,mA) / 10^4\ Pa = 1{,}6 \cdot 10^{-3}\ mA/Pa$

$a_1 = 4\,ma$

$i = K_1 \cdot P_{IN} + a_1 = 1{,}6 \cdot 10^{-6} \cdot 5 \cdot 10^{3} + 4 \cdot 10^{-3} = 0{,}012A$

Equação indicador

$K_2 = 10^4/(5-1) = 2500\ Pa/V$

$a_2 = -2500 \cdot 1 = -2500\ Pa$

Tensão verdadeira:

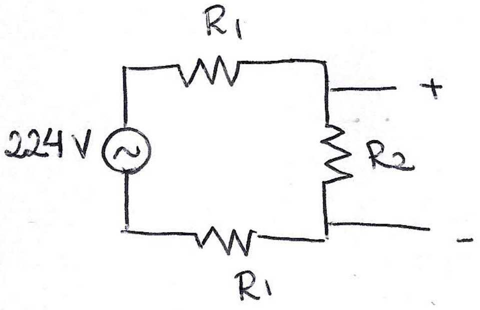
$\overline{V} = R_R \cdot i = 250 \cdot 0{,}012 = 3V \Rightarrow \overline{P} = K_2 \overline{V} + a_2 = 2500 \cdot 3 - 2500$
$= 5000\ Pa$

Tensão medida:

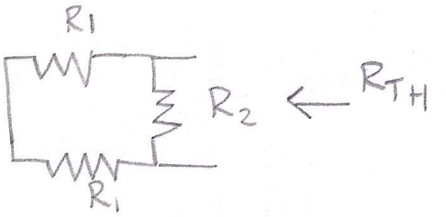
$V_R = 0{,}9926\ \overline{V} = 2{,}978\ V \Rightarrow P_m = K_2 V_R + a_2 = 4{,}944 \cdot 10^{3}\ Pa$

$\varepsilon = P_m - \overline{P} = 4{,}944 \cdot 10^{3} - 5 \cdot 10^{3} = -56\ Pa$

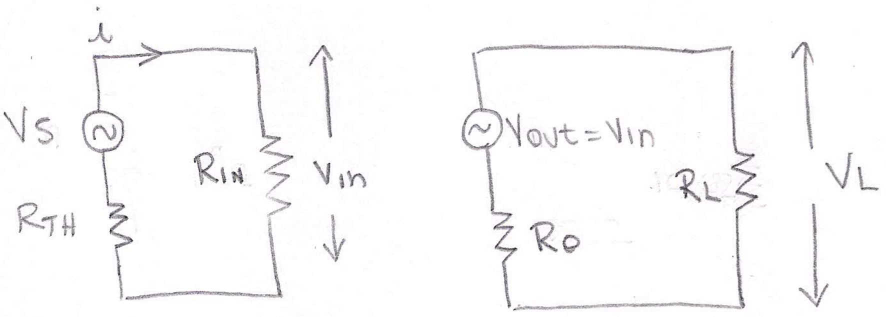
10.



a)



$R_{TH} = 2R_1 \parallel R_2 = \frac{2R_1R_2}{2R_1+R_2}$



$V_{in} = \frac{R_{IN}}{R_{TH}+R_{IN}} \cdot V_s \qquad V_L = \frac{R_L}{R_o+R_L} \cdot V_{in}$

$\Rightarrow V_L = \frac{R_{IN}}{R_{TH}+R_{IN}} \cdot \frac{R_L}{R_o+R_L} \cdot V_{in}$

b) $\frac{10^9}{R_{TH}+10^9} \cdot \frac{10^4}{100+10^4} \cdot 224 = 2,5 \Rightarrow R_{TH} = 8,77 \cdot 10^{10}$

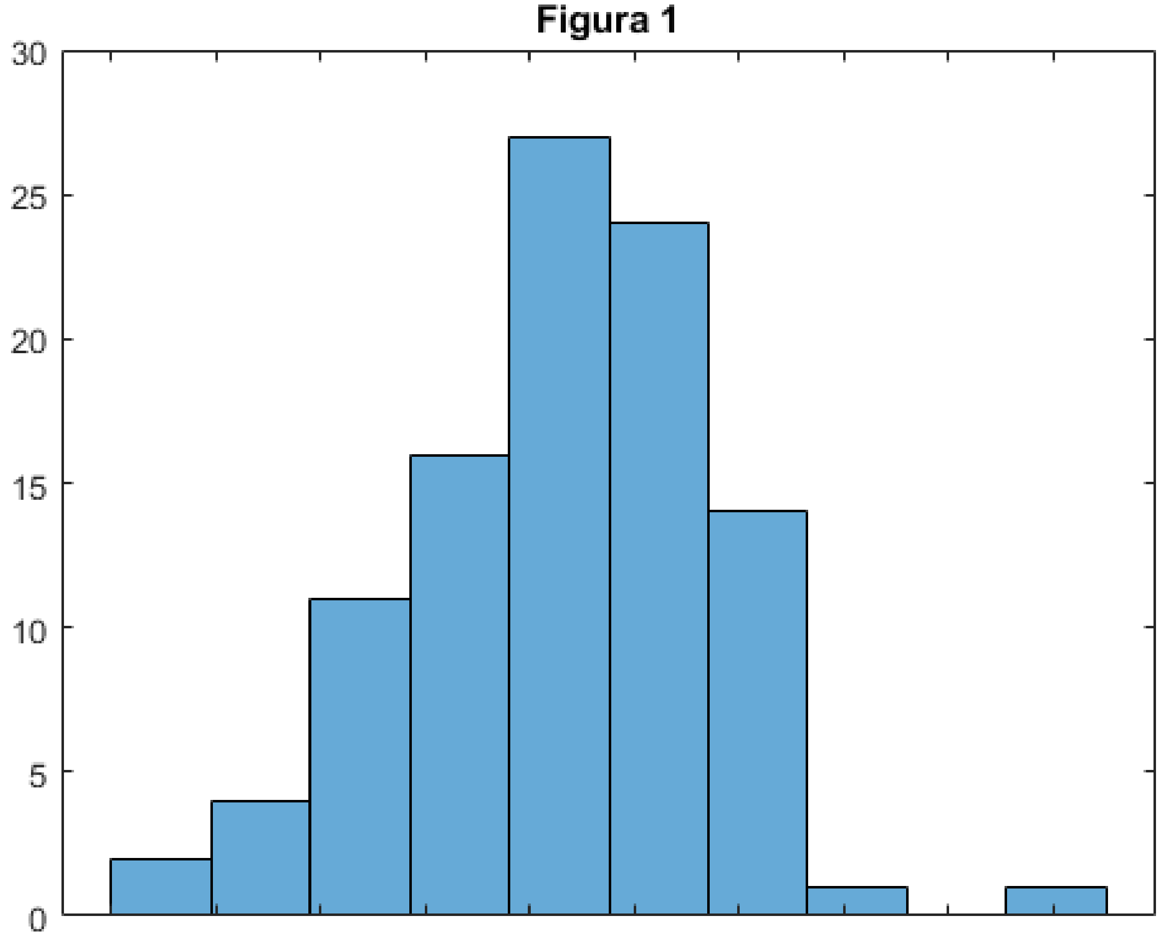
Corrente no transmissor: $i = V_s/R_{TH} = 5,17 \cdot 10^{-9}$ A

Escolhendo $P_{R2} = 5W \Rightarrow R_1 = 5/i^2 = 1,87 \cdot 10^{17}\ \Omega$

$R_{TH} = 8,77 \cdot 10^{10} = \frac{2 \cdot R_1R_2}{2R_1+R_2} \Rightarrow R_2 = 4,34 \cdot 10^{10}\ \Omega$

$P_{R2} = 1,157 \cdot 10^{-6}$ W $< 1/8$ W

Figuras



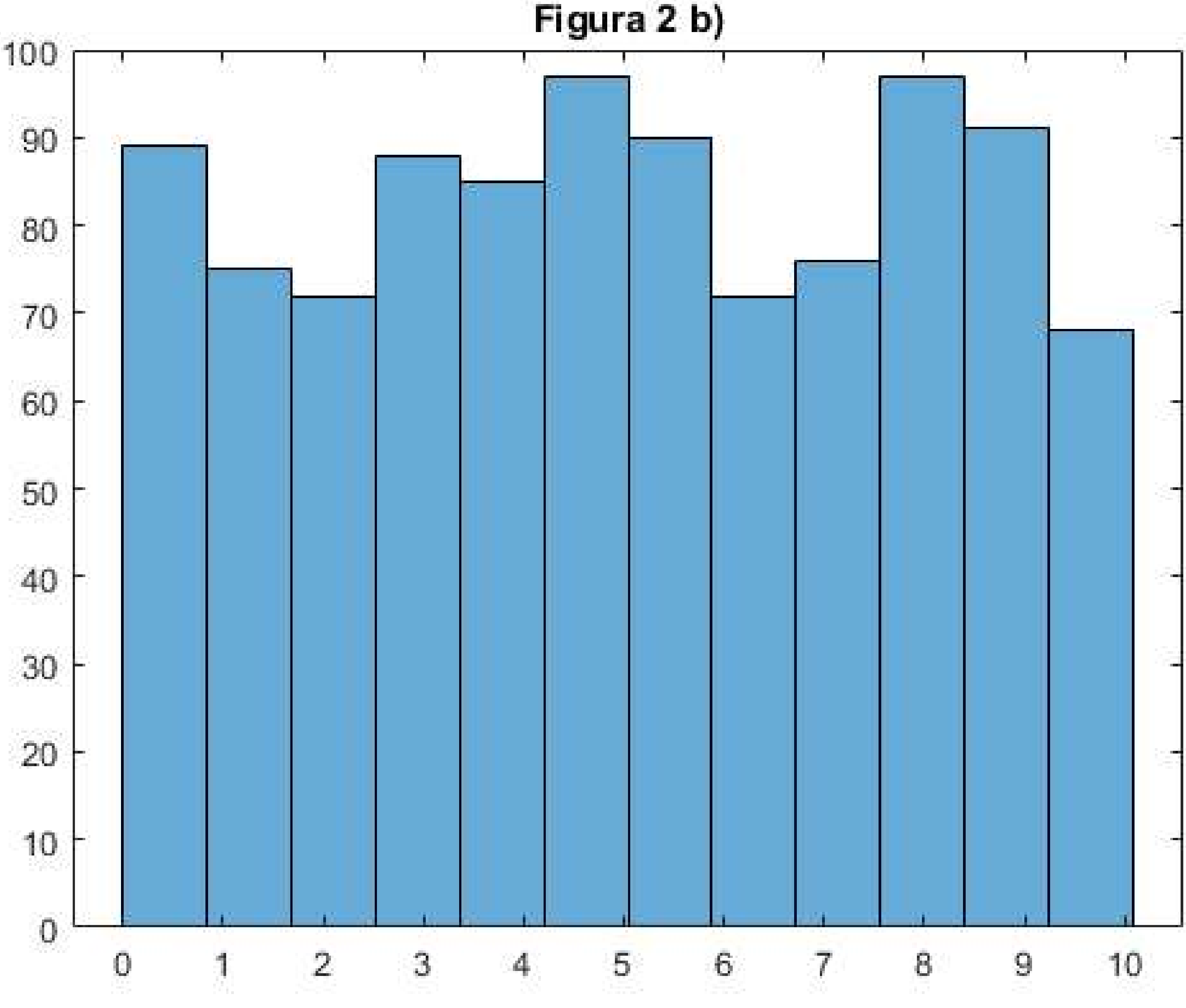


Figura 2 b)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10

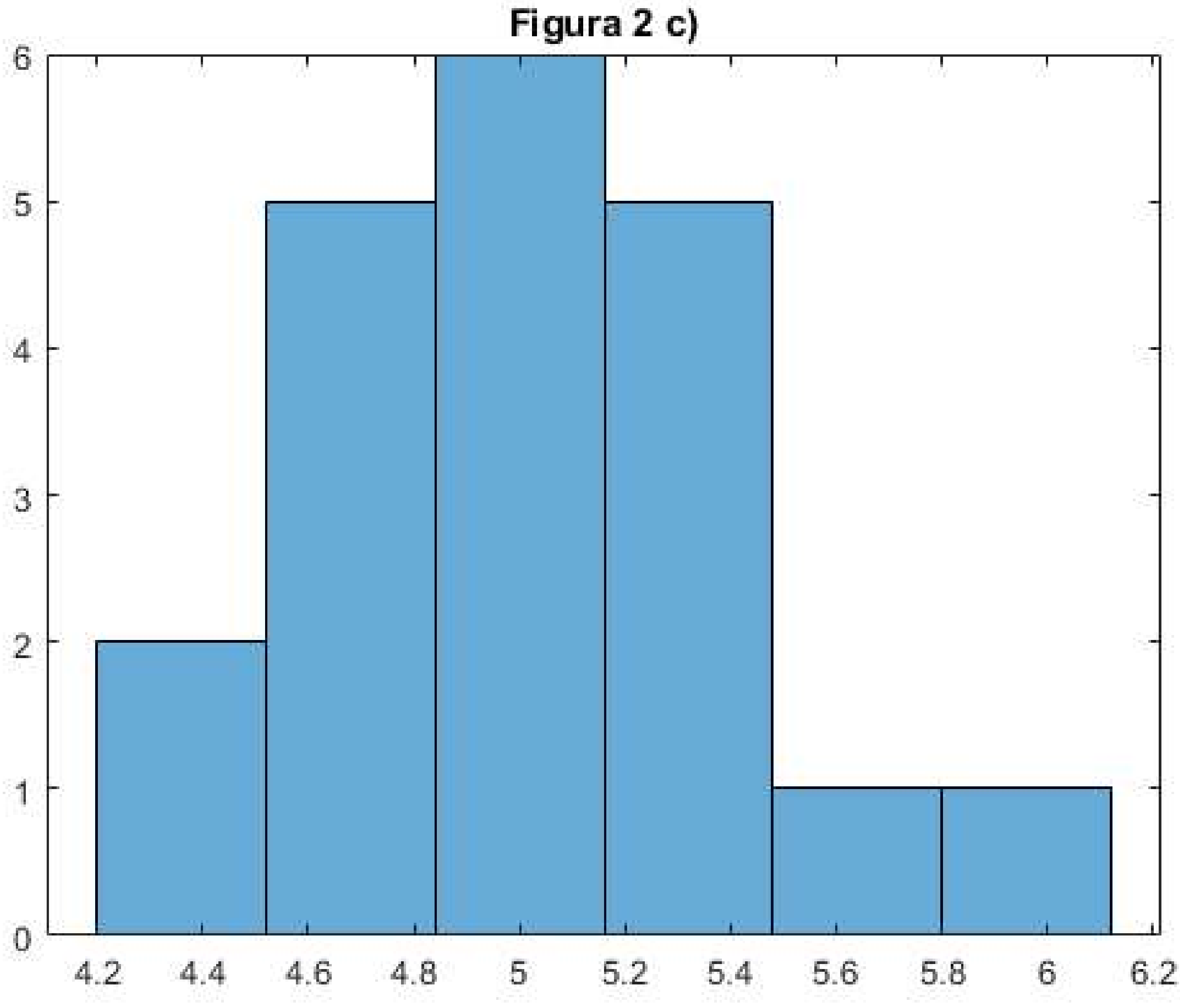


Figura 2 c)
0
1
2
3
4
5
6
4.2
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
6
6.2

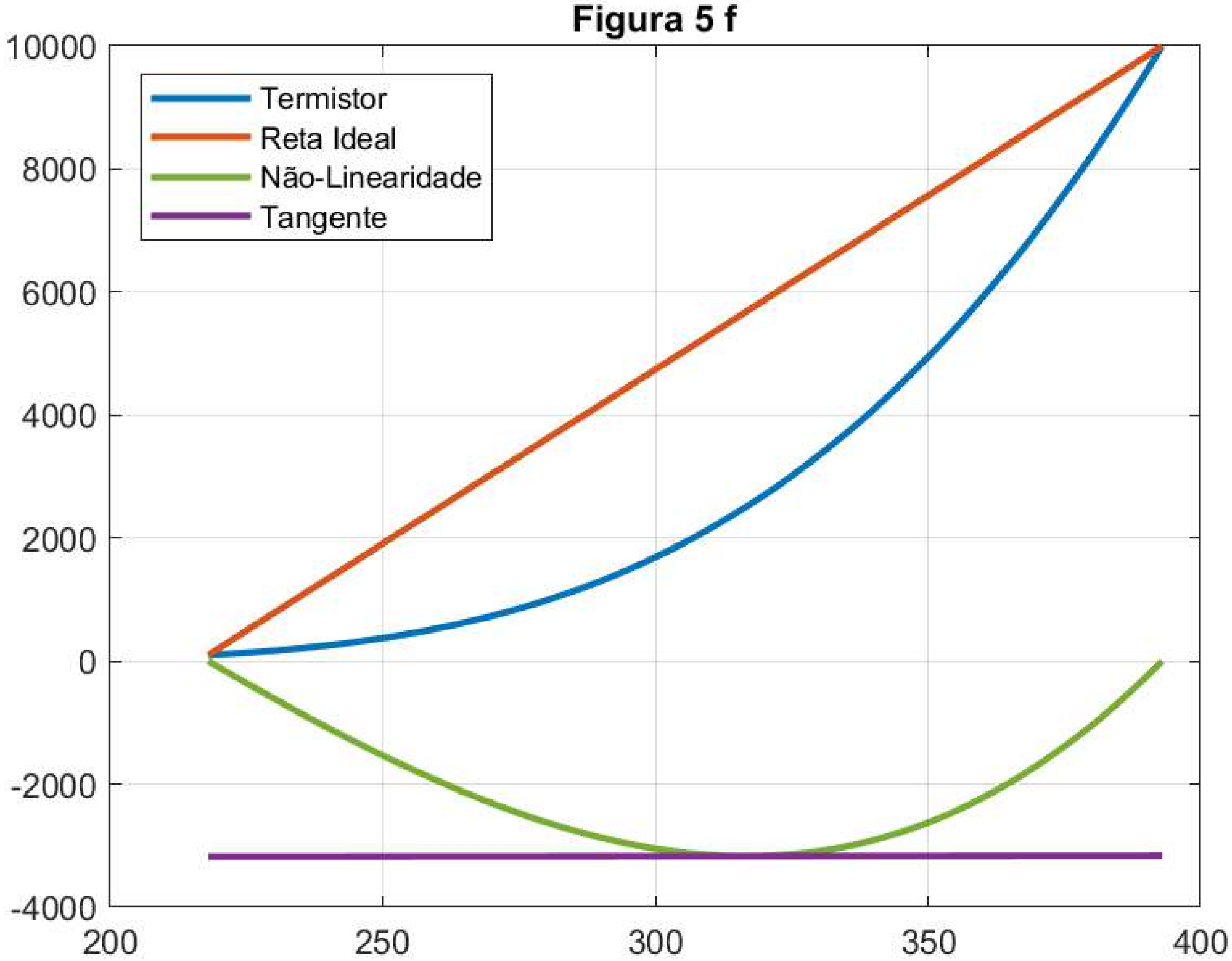


Figura 5 f
Termistor
Reta Ideal
Não-Linearidade
Tangente
10000
8000
6000
4000
2000
0
-2000
-4000
200
250
300
350
400

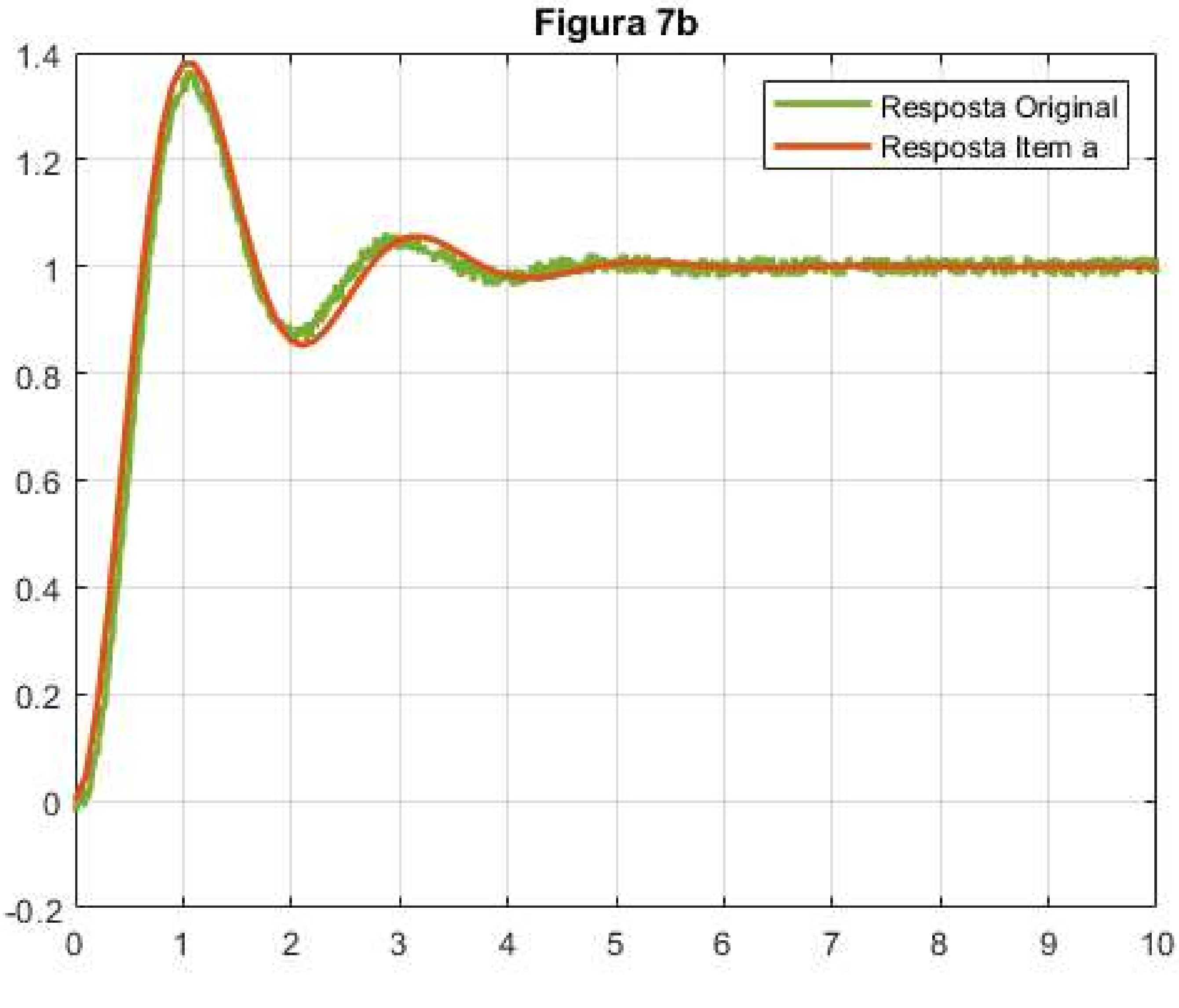


Figura 7b
Resposta Original
Resposta Item a
1.4
1.2
1
0.8
0.6
0.4
0.2
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0
1
2
3
4
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9
10

APÊNDICE

Dados do Item 1 a)

Número	Tensão (em Volts)
1	221,3646
2	225,728
3	229,3317
4	224,8582
5	231,7539
6	224,3351
7	233,4225
8	224,9235
9	227,2979
10	231,3049
11	230,7002
12	224,7271
13	229,2157
14	223,6569
15	221,8824
16	228,9835
17	221,8111
18	220,5858
19	226,8199
20	231,1571
21	230,6534
22	222,5148

23	227,1118
24	229,4086
25	229,9216
26	231,6822
27	231,7587
28	229,5689
29	222,7266
30	227,1191
31	222,8603
32	230,6992
33	232,2262
34	220,9955
35	229,5065
36	225,9715
37	225,5661
38	224,3327
39	230,7903
40	228,1496
41	226,6434
42	228,2517
43	230,0397
44	224,3914
45	224,616
46	229,0655
47	231,757
48	230,7505
49	226,6532

50	223,0047
51	219,9716
52	224,2203
53	230,3887
54	225,3526
55	227,8512
56	227,6383
57	220,3917
58	230,7532
59	233,0741
60	226,8833
61	229,9958
62	224,728
63	228,7884
64	233,3697
65	230,9352
66	224,9002
67	223,9412
68	227,1593
69	226,2889
70	226,8118
71	230,8133
72	227,6634
73	231,9921
74	226,8711
75	226,6003
76	229,3796

77	228,2788
78	226,3703
79	222,2355
80	223,6509
81	228,8506
82	228,6304
83	222,5963
84	227,3597
85	228,5881
86	223,4743
87	224,0054
88	230,5821
89	221,7389
90	228,3396
91	229,9342
92	221,6262
93	226,6094
94	223,4743
95	227,2699
96	225,7335
97	222,0472
98	228,8539
99	228,7885
100	225,1447

Dados do Item 2

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17	9,49903572251659
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179	4,99700655035464
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192	1,15821311515106 9,09118925919542
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194	4,95548839147225 4,60786812518747
195	5,26166447205296 3,75337513399287
196	7,87379398857163 4,69875755894587
197	8,18246746657067 4,66095358849819
198	4,28294289368832 8,96545783222087
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