i Forside (Norsk)

See next page for English version

i Front page (English)

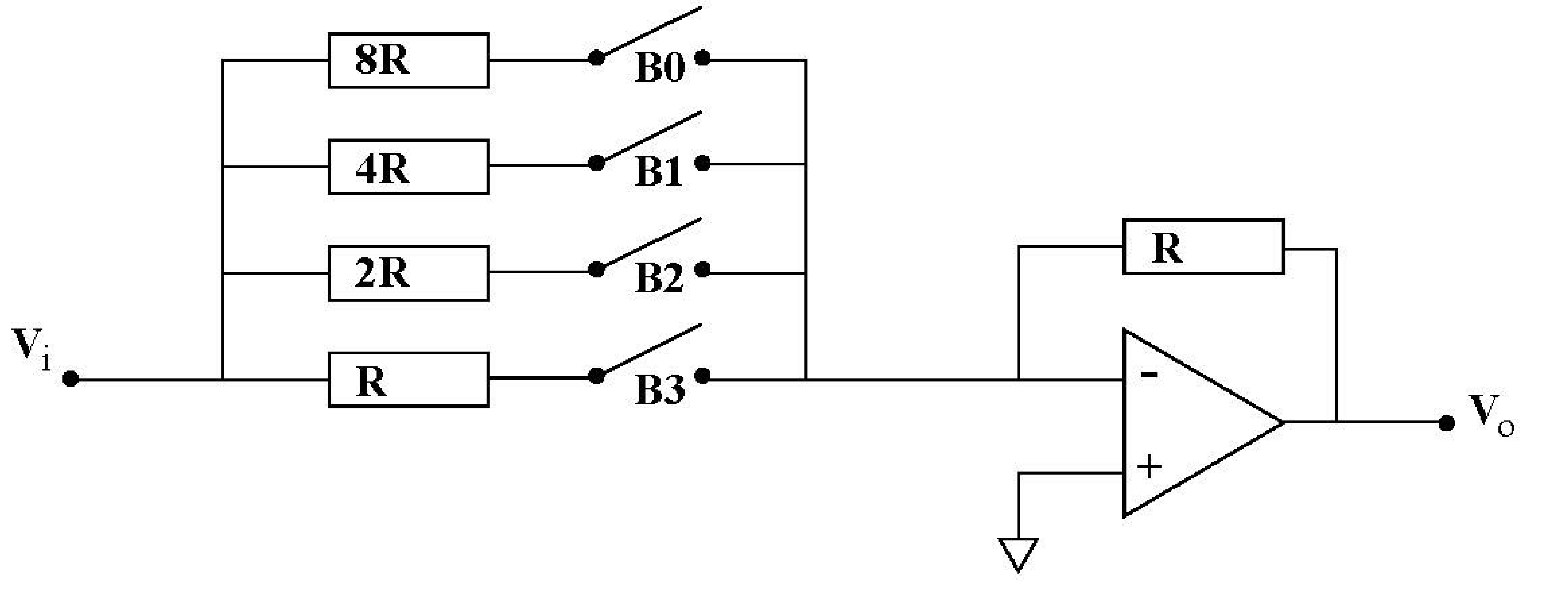
1 p1v1-2020TFY4190

What is the binary 2-complement representation of the decimal number -44?
Select one alternative:

- 1011011
- 010011
- 1010100
- 010100
- 1010011

Maximum marks: 1

2 p2v3-2020TFY4190



The figure above shows a circuit consisting of an ideal operational amplifier, resistors and switches B0 to B3. V_i = 8V and V_o are the input and output voltages, respectively, and the value of R = 100Ω.

What is the output voltage V_o when switches B2 and B3 are closed and switches B0 and B1 are open?

Enter the answer here:

What is the binary equivalent of the output voltage V_o when switches B2 and B3 are closed and switches B0 and B1 are open?

Enter the answer here:

Maximum marks: 2

3

p3v1-2020TFY4190

A double-precision binary number is given by the hexadecimal number C01B 0000 0000 0000. The MSB gives the sign, the next 11 bits give the exponent, whereas the remaining 52 bits give the fraction. A bias of 1023 for the exponent is used. What is the decimal value of the number?

Enter the number here:

Maximum marks: 1

4

p4v2-2020TFY4190

A single precision binary number consists of 32 bits. The MSB gives the sign, the next 8 bits the exponent, and the 23 remaining bits give the fraction. A bias of 127 is used for the exponent.
The number 0 is represented by all zeros in the exponent. Infinite is represented by all ones in the exponent.

What is the smallest positive number that can be represented ? (not including zero)

Enter $\log_{10}$ of the number here:

Maximum marks: 1

5

p5v3-2020TFY4190

Convert decimal 49.22 to binary format.

Enter the answer here:

Maximum marks: 1

6

p6v3-2020TFY4190

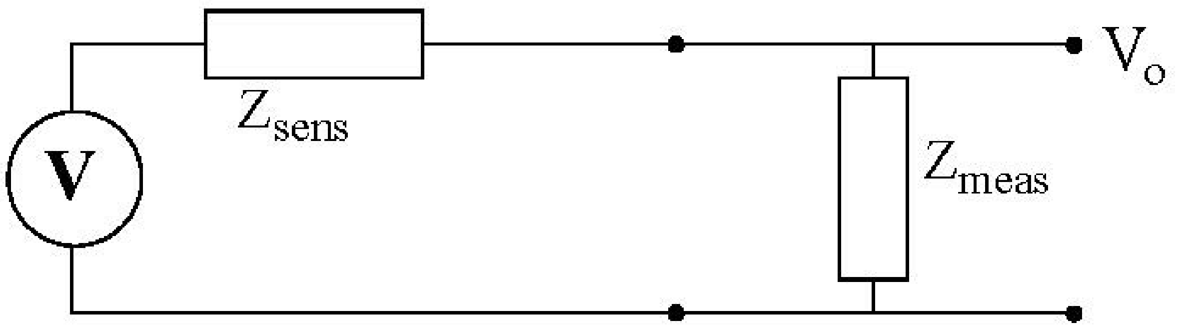
A current $I = 1.0A$ flows through a resistor $R = 100\Omega$. The uncertainty in both the current and the resistor is $\pm 1\%$. Use Gauss' law of error propagation to estimate the error in the dissipated power in the resistor.

Enter the answer here: $\pm$ W

Maximum marks: 1

7

p7v3-2020TFY4190



The figure above show an equivalent circuit for a voltage source and a measurement circuit. The impedance for the source $Z_{sens} = 50\Omega$.

What should the impedance Z_{meas} be for transfer of maximum power from the source to the measurement circuit?

Enter the answer here: [ ] Ω

Will the impedance $Z_{meas} = 50\Omega$ be a good choice for high accuracy of the output signal V_o?

Select one alternative

- Yes
- No

Maximum marks: 2

8

p8v3-2020TFY4190

A 12 bit ADC has working range from 0 to 5V. The digital output is given in 2 complement form.

What is the resolution?

Enter the answer here: [ ] V.

What is the analogue input for output 7AC?

Enter the answer here: [ ] V.

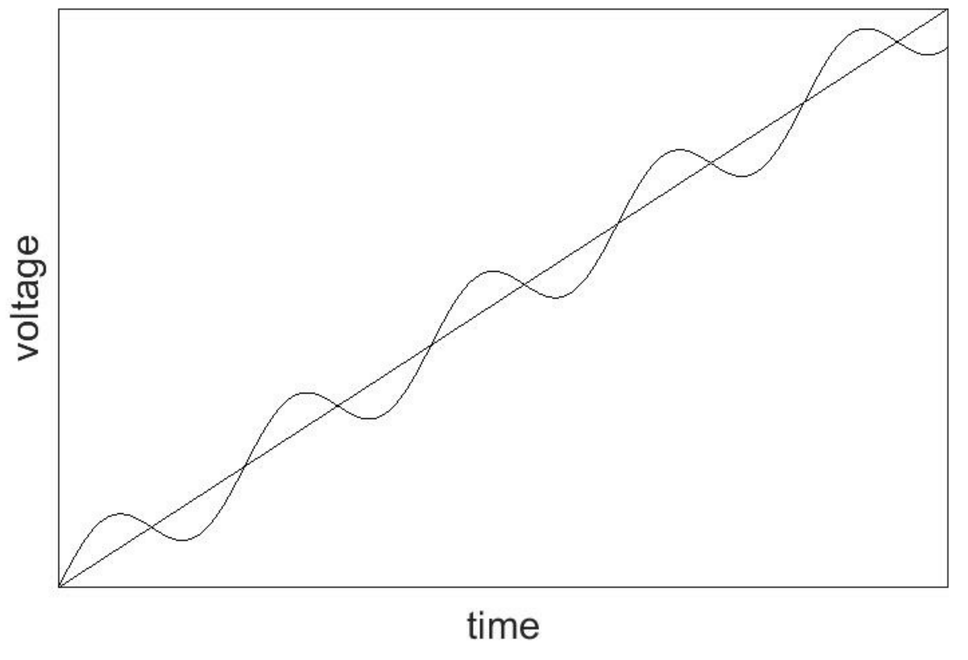
How many decimals should be used in the answer?

Select one alternative

- 2 decimals
- 3 decimals
- 4 decimals
- 5 decimals

Maximum marks: 3

9 p9v3-2020TFY4190



A linear voltage signal has superimposed a noise signal that may be approximated by a sinusoidal function.
The total voltage becomes $V(t) = \alpha t + Asin(\omega t)$.
Estimate the quantization noise of the signal when $A = 4V$.

Enter the answer here: [ ] .

Maximum marks: 1

10 p10v3-2020TFY4190

A signal has bandwidth from 5 to 15000Hz. Only frequencies up to 8000Hz are of interest for a particular application. Assume that a digital sampling is to be done of the signal.
What should the minimum sampling frequencey be to avoid aliasing?

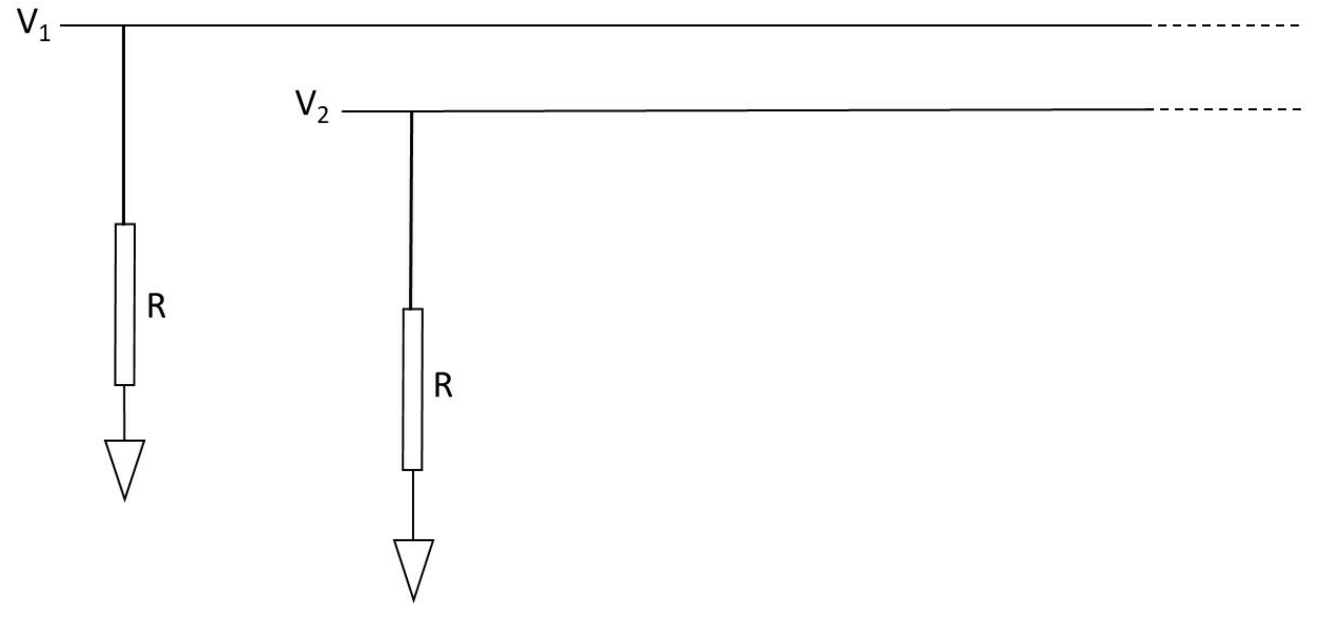
Enter the answer here: [ ] Hz

What should the cut-off frequencey be for the low-pass filter?

Enter the answer here: [ ] Hz

Maximum marks: 2

11 p11v3-2020TFY4190



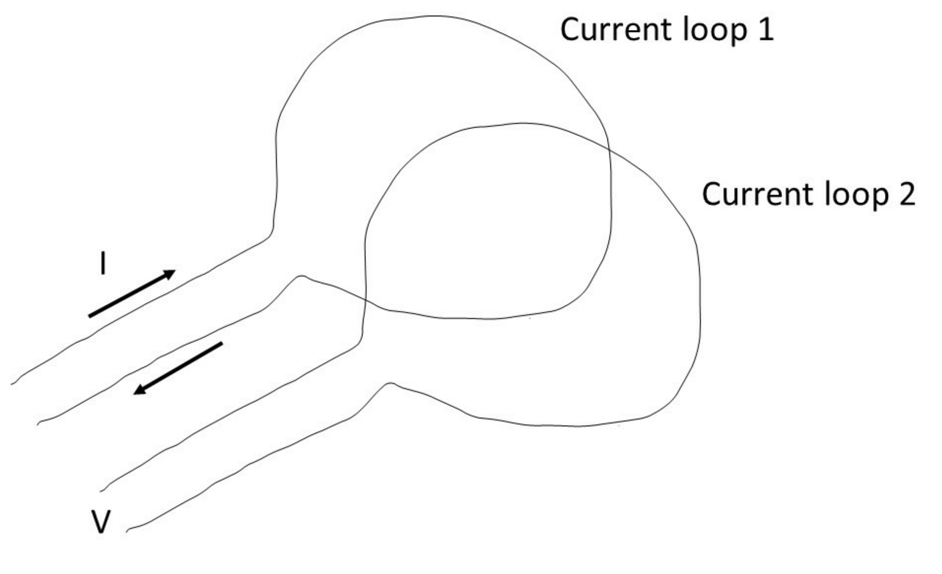
Two long signal cables are placed next to each other as shown in the figure. Both cables have a finite resistance to ground. There is a stray capacitance between the two cables.
A high frequency voltage signal V_1 induces a noise signal V_2 in the other cable.

Find an estimate of the magnitude of V_2/V_1 when $\omega = 15000s^{-1}$, $R = 5000\Omega$, and the stray capacitance is $30pF$.

Enter the answer here: [ ].

Maximum marks: 1

12 p12v1-2020TFY4190



A harmonic time varying current in **loop 1** induces a voltage in the nearby current **loop 2**. The amplitude of the current $I = 1A$ and the mutual inductance of the current loops is $M = 1\mu H$. The angular frequency of the current is $\omega = 1000s^{-1}$.
Estimate the magnitude of the induced voltage V in current **loop 2**.

Enter the answer here: [ ] V.

Maximum marks: 1

13 p13v1-2020TFY4190

We want to sample a harmonic voltage signal that is described by $V(t) = Asin(2\pi ft)$.
We require that the signal should change by less then 25% of the resolution between samplings. Assume a 16 bit ADC and that $f = 10kHz$.
Find the maximum sampling time that can be used.

Enter answer here: [ ] ns.

Maximum marks: 1

14 p14v2-2020TFY4190

A DAC is designed to output voltages in the range 0 - 10V. The voltage reference source has an accuracy of $1.0mV$. How many bits are needed in the DAC for maximum accuracy?

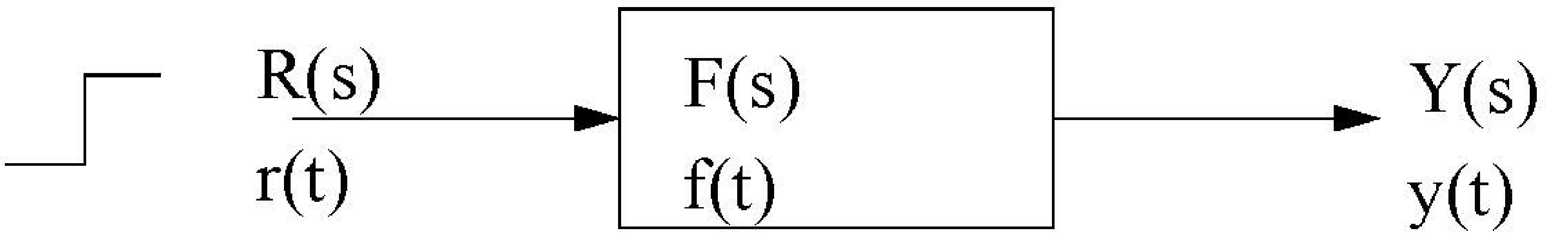
Select one alternative:

- 12 bits
- 13 bits
- 14 bits
- 15 bits
- 16 bits
- 17 bits

Maximum marks: 1

15

p15v1-2020TFY4190



A thermocouple sensor which is at initial temperature 20 ^{o}C is immersed rapidly into a bowl of water of temperature 30 ^{o}C. The voltage output from the sensor is measured in mV.
The transfer function of the sensor is given by $F(s) = \frac{4}{(s+2)(s+3)}$.
What is the value of the output signal y(t) after time t=1s?
Select one alternative:

- 1.65 mV
- 2.85 mV
- 3.74 mV
- 4.03 mV
- 4.62 mV
- 5.25 mV

Maximum marks: 1

16

p16v2-2020TFY4190

A system is disturbed by a unit impulse. The transfer function is given by $F(s) = \frac{1}{(2+4s)}$.
How large is the effect of the disturbance after time t = 1s?
Give the answer in percent of the maximum disturbance.
Select one alternative:

- 37 %
- 47 %
- 51 %
- 61 %
- 63 %

Maximum marks: 1

17

p17v3-2020TFY4190

The transfer function of a regulated system is given by $F(s) = \frac{20}{0.01s^3+s^2+s}$.

Consider proportional control and harmonic frequency response and find the frequency ω_0 where the phase shift is 180 ^{o}.

Select one alternative:

- $3s^{-1}$
- $10s^{-1}$
- $30s^{-1}$
- $100s^{-1}$
- $200s^{-1}$

Find the amplitude of the transfer function at frequency ω_0.

Select one alternative

- 0.25
- 0.32
- 0.5
- 1.0
- 2.0

What is the proportional control parameter where the system starts to oscillate?

Select one alternative

- 0.24
- 0.5
- 1.0
- 1.46
- 2.0

Maximum marks: 3

18

p18v2-2020TFY4190

We want to measure small currents using a precise electrometer having an internal resistance of $R = 250M\Omega$. The bandwidth is $4kHz$.

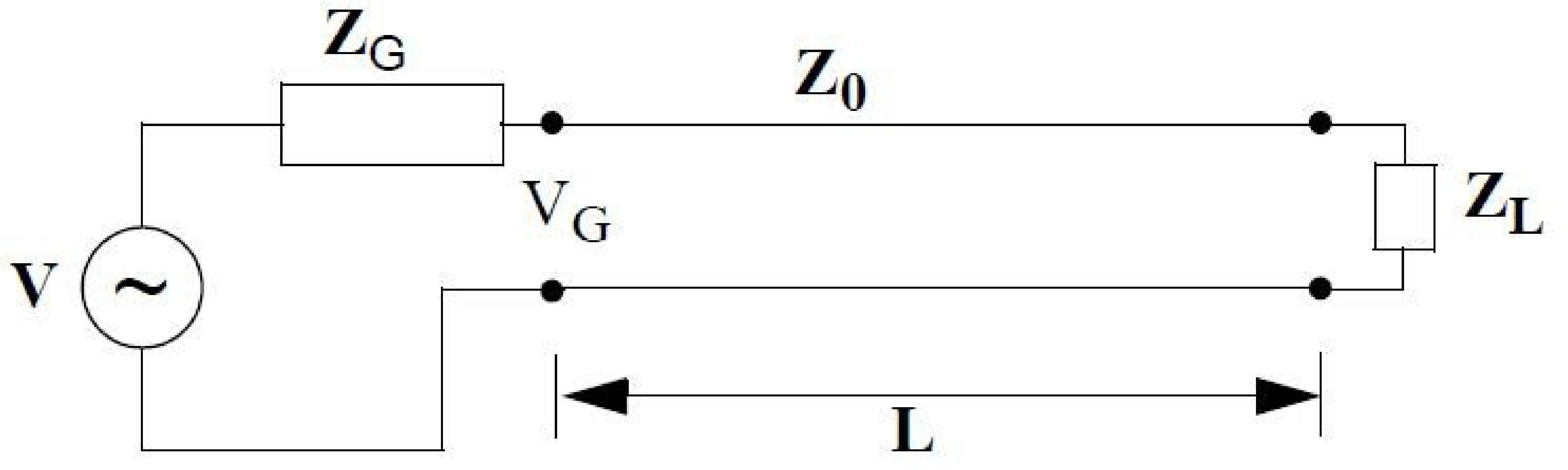
Estimate the thermal noise current. Enter the answer here: [ ] pA.

Estimate the shot noise for a current of $0.5nA$. Enter the answer here: [ ] pA.

Maximum marks: 2

19

p19v3-2020TFY4190



A high frequency voltage signal is transmitted to a transmission line of length L as shown in the figure. Z_G and Z_L are the impedances of the generator and load; respectively. Z_0 is the characteristic impedance of the transmission line. The inductance and capacitance per length of the transmission line are $L = 350nH/m$ and $C = 80pF/m$. The transmission line may be assumed to be loss-less.

Find the characteristic line impedance of the transmission line.

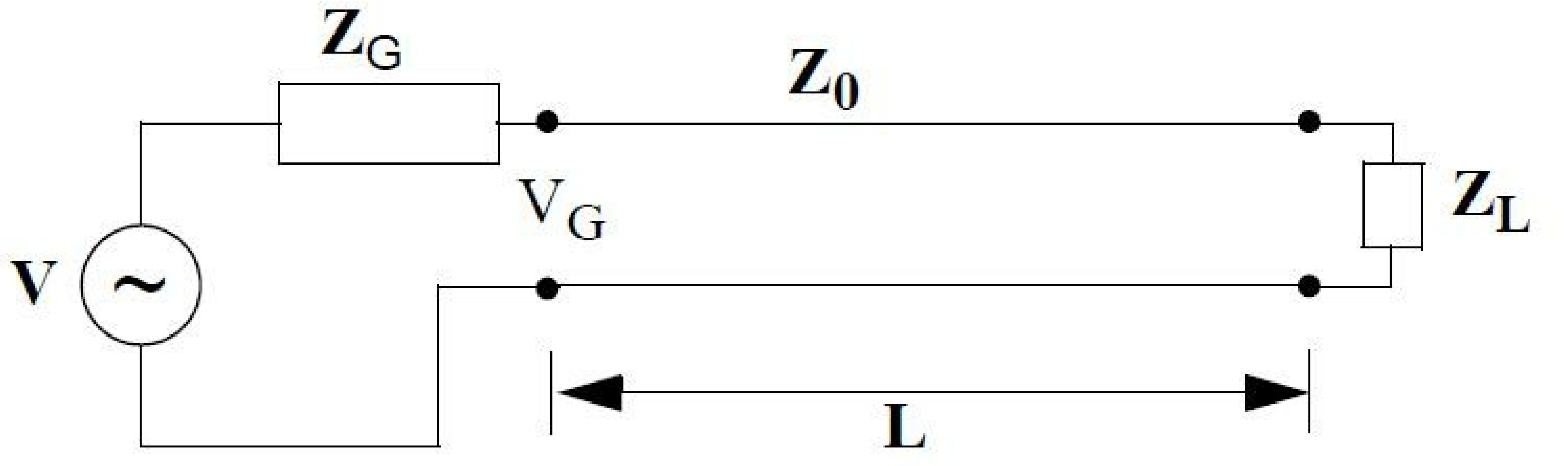
Enter the answer here: ____ Ω.

The reflection coefficient at the load is 0.5. What is the value of the load impedance?

Enter the answer here: ____ Ω.

Maximum marks: 2

20 p20v3-2020TFY4190



(same figure as in the previous problem)

A high frequency voltage signal of angular frequency $\omega = 1 \cdot 10^9 s^{-1}$ is sent from a source to a transmission line of length L, as shown in the figure above. The characteristic impedance of the transmission line is 50Ω. The inductance and capacitance per length of the transmission line are $L = 250nH/m$ and $C = 100pF/m$. The transmission line may be assumed to be loss-less. The load impedance is 150Ω.

The line impedance at distance d from the load may be found by $Z(d) = \frac{V(d)}{I(d)}$.

Find the magnitude of the ratio $|\frac{Z(d)}{Z_0}|$ at distance $d = 5cm$ from the load.

Enter the answer here: [ ] Ω.

Maximum marks: 1

Problem 1

v1: 1010100 → 0101100 (2-comp) = -(32+8+4) = -44

v2: 1010011 → 0101101 (2-comp) = -(32+8+4+1) = -45

v3: 1011011 → 0100101 (2-comp) = -(32+4+1) = -37

Problem 2

$$V_o = \frac{-8VR}{\frac{R_a \cdot R_b}{R_a + R_b}}$$

v1: *R_a = 8R, R_b = 4R => V = -3V -> corresponds to 0011*

v2: *R_a = 4R, R_b = R => V = -10V -> corresponds to 1010*

v3: *R_a = 2R, R_b = R => V = -12V -> corresponds to 1100*

Problem 3

Double precision numbers

v1: C01B = 1100 0000 0001 1011 = - $2^{1025-1023}$ (1+0.5+0.125+0.0625) = -2^2x1.6875 = -6.75

v2: C01C = 1100 0000 0001 1100 = - $2^{1025-1023}$ (1+0.5+0.25) = -2^2x1.75 = -7.00

v3: C11C = 1100 0001 0001 1100 = - $2^{1041-1023}$ (1+0.5+0.25) = -2^{18}x1.75 = -4.59x10^5

Problem 4

Single precision number

v1: Largest positive number = 0(111 1111 0) 11111111…… = $2^{254-127}$x1.999999 = 3.403x10^{38}

log10 -> +38.53

Largest exponent is 1111 1110 since 1111 1111 defines infinity

v2: Smallest positive number = 0(000 0000 1) 00000000…… = 2^{1-127}x1.0 = 1.1755x10^{-38}

Smallest exponent is 0000 0001 since 0000 0000 defines zero

Log10 -> -37.93

Problem 5

v1: 56.43 -> 111000.0110111	.43x2 = 0.86 + 0	
v2: 43.56 -> 101011.10001111	.86x2 = 0.72 + 1	↓ 0110111
v3: 49.22 -> 110001.00111	.72x2 = 0.44 + 1	
	.44x2 = 0.88 + 0	
	.88x2 = 0.76 + 1	
	.76x2 = 0.52 + 1	
	.52x2 = 0.04 + 0	

Problem 6

$$\mathrm{P} = \mathrm{RI}^2 \text{ and } \frac{\Delta P}{P} = \sqrt{\left(\frac{\Delta R}{R}\right)^2 + 4\left(\frac{\Delta I}{I}\right)^2} \text{ } gives \text{ } \Delta P = \pm RI^2\sqrt{\left(\frac{\Delta R}{R}\right)^2 + 4\left(\frac{\Delta I}{I}\right)^2}$$

v1: R=100Ω, I=1A, Δ=2% -> ΔP = 4.47W

v2: R=50Ω, I=2A, Δ=2% -> ΔP = 8.94W

v3: R=100Ω, I=1A, Δ=1% -> ΔP = 2.24W

Problem 7

Impedance matching. Max power transfer: $Z_{meas} = Z_{sens} = 100\Omega$

v1: $Z_{meas} = 100\Omega$, $Z_{meas} = 1\Omega$ is <u>not</u> a good choice

v2: $Z_{meas} = 10\Omega$, $Z_{meas} = 1000\Omega$ is a good choice

v3: $Z_{meas} = 50\Omega$, $Z_{meas} = 50\Omega$ is <u>not</u> a good choice

Problem 8

v1: 14-bit ADC, 0-5V -> resolution = 0.00031V

Output A7C = 1010 0111 1100 -> - 10110000100 = -1412 -> -1412x0.00031V = -0.4377V (4 decimals)

v2: 16-bit ADC, 0-5V -> resolution = 0.000076V

Output A7C = 1010 0111 1100 -> - 10110000100 = -1412 -> -1412x0.000076V = -0.1077V (4 decimals)

v3: 12-bit ADC, 0-5V -> resolution = 0.0012V

Output 7AC = 0111 1010 1100 -> 1964 -> 1964x0.0012V = 2.398V (3 decimals)

Problem 9

$$V(t) = \alpha t + A sin(\omega t) = \alpha t + v(t)$$

$$\Delta q = \sqrt{\overline{v^2}} = \sqrt{\frac{1}{T}\int_0^T v(t)^2 dt} = \sqrt{\frac{1}{T}\int_0^T A^2 sin^2(at) dt} = \sqrt{\frac{A^2}{Ta}\int_0^{aT} sin^2(x) dx} = \frac{A}{\sqrt{2}}$$

v1: A = 5mV -> Δq = 3.54mV. v2: A = 2mV -> Δq = 1.41mV. v3: A = 4mV -> Δq = 2.83mV.

Problem 10

Nyquist sampling. Use $2f_{max}$ for sampling frequency.

v1: f_s = 20kHz, $f_{cut\text{-}off}$ = 5kHz. v2: f_s = 60kHz, $f_{cut\text{-}off}$ = 20kHz. v3: f_s = 30kHz, $f_{cut\text{-}off}$ = 8kHz.

Problem 11

Voltage divider. $\frac{\mathrm{V}_1 - V_2}{\frac{1}{\mathrm{j\omega C}}} = \frac{\mathrm{V}_2}{\mathrm{R}} \Rightarrow \frac{V_2}{V_1} \approx j\omega CR \Rightarrow \left|\frac{V_2}{V_1}\right| = \omega CR$

v1: $\omega = 20ks^{-1}$, R=2kΩ, C= 50pF -> 0.002

v2: $\omega = 15ks^{-1}$, R=500kΩ, C= 100pF -> 0.00075

v3: $\omega = 15ks^{-1}$, R=5000kΩ, C= 30pF -> 0.00225

Problem 12

Faraday's law of induction. $V = j\omega MI \Rightarrow |V| = \omega MI$

v1: ω=1000s^{-1}, M=1μH, I=1A -> |V|= 0.001V

v2: ω=3000s^{-1}, M=2μH, I=1A -> |V|= 0.006V

v3: ω=2000s^{-1}, M=5μH, I=1A -> |V|= 0.01V

Problem 13

Sampling $\left(\frac{\Delta V}{\Delta t}\right)_{max} = 2\pi Af = \frac{\Delta V}{4\tau} \Rightarrow \tau = \frac{\Delta V}{8\pi fA} = \frac{\frac{2A}{2^{16}-1}}{8\pi fA}$

v1: 16-bit ADC, f = 10kHz -> τ = 0.12 ns.

v2: 14-bit ADC, f = 10kHz -> τ = 0.49 ns.

v3: 14-bit ADC, f = 4kHz -> τ = 1.2 ns.

Problem 14

Voltage source accuracy.

v1: accuracy 0.1mV = 0.0001V. Resolution = 10V/(2^{17}-1) = 0.000076V -> 17-bit

v2: accuracy 1.0mV = 0.001V. Resolution = 10V/(2^{14}-1) = 0.00061V -> 14-bit

v3: accuracy 0.5mV = 0.0005V. Resolution = 10V/(2^{15}-1) = 0.00031V -> 15-bit

Problem 15

Transfer function. $F(s) = \frac{A}{(s+\alpha)(s+\beta)}, Y(s) = \frac{10}{s}F(s), y(t) = \frac{10A}{\alpha\beta} + \frac{10Ae^{-\alpha t}}{\alpha(\alpha-\beta)} + \frac{10Ae^{-\beta t}}{\beta(\beta-\alpha)}$

v1: α = 2, β = 3, A = 4 -> y(1s) = 4.62mV

v2: α = 2, β = 4, A = 4 -> y(1s) = 3.74mV

v3: α = 3, β = 3, A = 4 -> y(1s) = 2.85mV

Problem 16

System disturbed by unit pulse.

$$F(s) = \frac{1}{\alpha + \beta s} = \frac{\frac{1}{\beta}}{s + \frac{\alpha}{\beta}} \quad \Rightarrow \quad y(t) = f(t) = \frac{1}{\beta} e^{-\alpha t/\beta}$$

v1: α=2, β=3 -> y(1s) = 51.3%

v2: α=2, β=4 -> y(1s) = 60.7%

v3: α=3, β=4 -> y(1s) = 47.2%

Problem 17

$$\boldsymbol{F(s) = \frac{A}{0.01s^3 + 0.1s^2 + s} \xrightarrow{s=j\omega} F(\omega) = \frac{A}{-0.1\omega^2 + j(\omega - 0.01\omega^3)}}$$

$$|\boldsymbol{F(\omega)}| = \frac{\boldsymbol{A}}{\sqrt{\boldsymbol{10^{-2}\omega^4 + (\omega - 10^{-2}\omega^3)^2}}}$$

$< F(\omega) = tan^{-1}\left(\frac{\omega - 0.01\omega^3}{0.1\omega^2}\right)$ noting that $tan(180^o) = 0$ -> $\omega_{180} = 10s^{-1}$

Proportional control and phase shift 180° -> $K_0 \cdot F(\omega_{180^0}) = 1$

v1: A=10. $|F(\omega_{180})| = 1.0$ -> $K_0 = 1.0$

v2: A=5. $|F(\omega_{180})| = 0.5$ -> $K_0 = 2.0$

v3: A=20. $|F(\omega_{180})| = 2.0$ -> $K_0 = 0.5$

Problem 18

Thermal noise $I_{thermal} = \sqrt{\frac{4k_B T\Delta f}{R}}$

Shot noise $I_{shot} = \sqrt{2eI\Delta f}$

v1: R=150MΩ, Δf=5kHz, I=1.0nA -> I_{th}=0.74pA and I_{sh}=1.26pA

v2: R=250MΩ, Δf=4kHz, I=0.5nA -> I_{th}=0.51pA and I_{sh}=0.80pA

v3: R=90MΩ, Δf=6kHz, I=2.1nA -> I_{th}=1.05pA and I_{sh}=2.00pA

Problem 19

Characteristic line impedance $Z_0 = \sqrt{\frac{L}{C}}, L = 250nH/m, C = 100pF/m$

Reflection coefficient at load $\Gamma_R = \frac{Z_L - Z_0}{Z_L + Z_0} = 0.5 \Rightarrow Z_L = 3Z_0$

v1: L=200nH, C=100pF -> Z_0=44.72Ω, Z_L=134.2Ω.

v2: L=300nH, C=100pF -> Z_0=54.77Ω, Z_L=164.3Ω.

v3: L=350nH, C=80pF -> Z_0=66.14Ω, Z_L=198.4Ω.

Problem 20

HiFreqSignalTrans.

$$\gamma = \alpha + j\beta \xrightarrow{loss-less, \alpha=0} j\beta = j\omega\sqrt{LC} = j1 \cdot 10^9 \sqrt{250 \cdot 10^{-9}\, 100 \cdot 10^{-12}} m^{-1} = j5\, m^{-1}$$

$$\frac{Z(d)}{Z_0} = \frac{1 + \Gamma_R e^{-2\gamma d}}{1 - \Gamma_R e^{-2\gamma d}} = \frac{1 + \Gamma_R cos(2\beta d) - j\Gamma_R sin(2\beta d)}{1 - \Gamma_R cos(2\beta d) + j\Gamma_R sin(2\beta d)}$$

$$A = \left|\frac{Z(d)}{Z_0}\right| = \sqrt{\frac{\left(1 + \Gamma_R cos(2\beta d)\right)^2 + \left(\Gamma_R sin(2\beta d)\right)^2}{\left(1 - \Gamma_R cos(2\beta d)\right)^2 + \left(\Gamma_R sin(2\beta d)\right)^2}}, \qquad \Gamma_R = \frac{Z_L - Z_0}{Z_L + Z_0} = 0.5$$

v1: d=0.1m -> 2βd=1.0 -> A=1.588

v2: d=0.2m -> 2βd=2.0 -> A=0.707

v3: d=0.05m -> 2βd=0.5 -> A=1.855