Amplifier

1. A voltage divider consists of the resistors R_1 = 2 kΩ and R_2 = 20 kΩ.
   a) What is the output voltage taken away from the R_1 resistor if the input voltage is 230 V?
   b) What is the voltage gain?
   c) What is the power gain? (Neglect the difference between R_{in} and R_{out}.)
   d) What is the power gain level in decibel units?

2. How many kiloohms should be the R_2 resistor of the voltage divider, if we want to take away 25% of the input voltage from the R_1 = 1200 Ω resistor?

3. The power gain level of a voltage divider is -23 dB. (Neglect the difference between R_{in} and R_{out}.)
   a) What is the power gain?
   b) What is the voltage gain?
   c) How many ohms should be the R_2 resistor if the output voltage is taken away from R_1 = 1 kΩ?

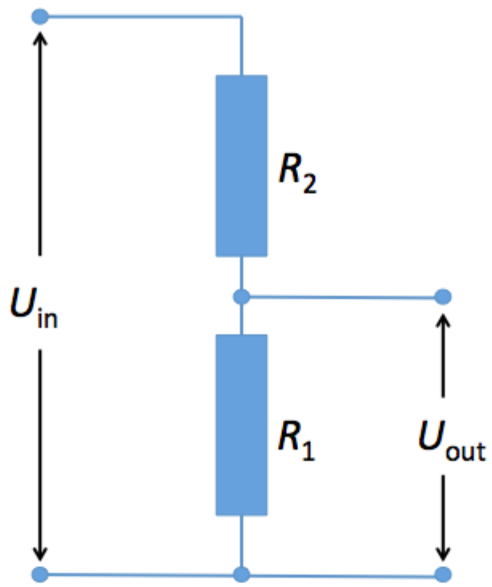

***Fig.* 1**

4. For the voltage divider shown in *Fig*. 1
   U_{in} = 100 V, R_1 = 1700 Ω, R_2 = 300 Ω. Find U_{out} and A_U.

5. For the voltage divider shown in *Fig*. 1
   U_{out} = 100 V, R_1 = 1700 Ω, R_2 = 300 Ω. Find U_{in} and A_U.

6. For the voltage divider shown in *Fig*. 1

   U_{in} = 250 V, R_1 = 800 Ω, U_{out} = 75 V. Find R_2.

7. For the voltage divider shown in *Fig*. 1
   U_{in} = 250 V, R_2 = 800 Ω, U_{out} = 75 V. Find R_1.

8. For the voltage divider shown in *Fig*. 1
   A_U = 0.05 and R_2 = 2 kΩ. Find R_1.

9. For the voltage divider shown in *Fig*. 1
   A_U = 0.08 and R_1 = 4 kΩ. Find R_2.

10. The input voltage of the potentiometer shown in *Fig*. 2 is 200 V. To what % should the wiper be adjusted so that the output voltage becomes
    a) 40 V
    b) 100 V
    c) 0 V
    d) 200 V?

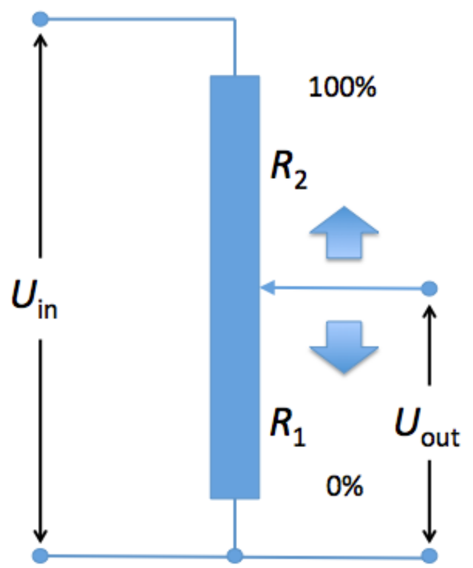

***Fig.* 2**

11. The input voltage of the potentiometer shown in *Fig*. 2 is 10 V. What is the output voltage if the wiper stands at 20%?

12. An amplifier amplifies the amplitude of the input signal voltage by one thousand fold. Find the power gain level. (Suppose $R_{in} = R_{out}$.)

13. An amplifier amplifies the signal power by a factor of one thousand. Find
a) the voltage gain (suppose $R_{in} = R_{out}$) and
b) the power gain level.

14. By how many times does an amplifier of 43 dB amplify the signal power? ($R_{in} = R_{out}$)

15. How many dB change does the halving of the signal voltage correspond to? ($R_{in} = R_{out}$)

16. We double the voltage of a signal with an amplifier. What is the change in signal power expressed on the decibel scale? ($R_{in} = R_{out}$)

17. How many decibels is the power gain level if the output power belonging to the 2 W input power is
a) 2000 W
b) 100 W
c) 4 W
d) 2 W
e) 1 W
f) 0.2 W
g) 0 W?

18. To what power does an amplifier amplify the 5 W input signal power if the power gain level for this signal is
a) 50 dB
b) 3.7 B
c) 10 dB
d) 1 dB
e) 0 dB
f) -1 dB
g) $-\infty$ dB?

19. Two harmonic (i.e. sinusoidal) signals of equal power but different frequencies (f_1 and f_2) are amplified with an amplifier the power gain level of which is 30 dB at the f_1 and 27 dB at the f_2 frequency. What is the power ratio of the amplified signals?

20. Two harmonic signals of equal power but different frequencies (f_1 and f_2) are amplified with an amplifier the power gain level of which is 50 dB at the f_1 and 33 dB at the f_2 frequency. What is the power ratio of the amplified signals?

21. The power gain level of an amplifier without feedback is 50 dB. What will be the power gain level if 1% of the output signal voltage is fed back in opposite phase? The difference between R_{in} and R_{out} can be neglected.

22. The power gain level of an amplifier is 13 dB. It decreases to 10 dB as a result of negative feedback. What part of the output voltage is fed back? The difference between R_{in} and R_{out} is to be neglected.

23. The power gain level of an amplifier is 26 dB. It decreases to 20 dB as a result of negative feedback. What percentage of the output voltage is fed back? The difference between R_{in} and R_{out} is negligible.

24. The voltage gain of an amplifier is 100. 3% of the output voltage is fed back in opposite phase with a feedback loop. R_{in} and R_{out} can be considered equal.
a) What is the power gain level without feedback?
b) To what value does the voltage gain change as a result of the feedback?
c) What will be the power gain level as a result of the negative feedback?

Formulæ

$$R = \frac{U}{I}$$ (Ohm's law)

$$P = U \cdot I = \frac{U^2}{R} = I^2 \cdot R$$ (electric power)

$$\frac{U_1}{U_{source}} = \frac{R_1}{R_1 + R_2}$$ (voltage divider)

$$A_U = \frac{U_{out}}{U_{in}}$$ (definition of voltage gain)

$$A_P = \frac{P_{out}}{P_{in}} = \frac{\left(\frac{U_{out}^2}{R_{out}}\right)}{\left(\frac{U_{in}^2}{R_{in}}\right)} = \frac{U_{out}^2}{R_{out}} \cdot \frac{R_{in}}{U_{in}^2} = \frac{U_{out}^2}{U_{in}^2} \cdot \frac{R_{in}}{R_{out}} = \left(\frac{U_{out}}{U_{in}}\right)^2 \cdot \frac{R_{in}}{R_{out}} = \underbrace{A_U^2 \cdot \frac{R_{in}}{R_{out}} \approx A_U^2}_{R_{in} \approx R_{out}}$$ (definition of power gain)

$$n_{dB} = 10 n_B = \underbrace{10 \log A_P \approx 20 \log A_U}_{R_{in} \approx R_{out}}$$ (definition of power gain level)

$$A_{U,NFB} = \frac{A_U}{1 + A_U \cdot \beta}$$ (voltage gain of amplifier with negative feedback)

Solutions

1. a) $U_1 = U_{source} \cdot \frac{R_1}{R_1 + R_2} = 230V \cdot \frac{2k\Omega}{2k\Omega + 20k\Omega} = 20.9V$

   b) $A_U = \frac{U_{out}}{U_{in}} = \frac{20.9V}{230V} = 0.0909 = 9.09\%$

   c) $A_P \approx A_U{}^2 = 0.0909^2 = 0.00826 = 0.826\%$

   d) $n_{dB} = 10\log A_P = 10\log 0.00826 = -20.83dB = -2.083B$

2. $\frac{U_1}{U_{source}} = \frac{R_1}{R_1 + R_2} \Rightarrow R_2 = R_1 \cdot \frac{U_{source}}{U_1} - R_1 = 1200\Omega \cdot \frac{1}{0.25} - 1200\Omega = 3600\Omega$

3. a) $n_{dB} = 10\log A_P \Rightarrow A_P = 10^{\frac{n_{dB}}{10}} = 10^{\frac{-23}{10}} = 0.005 = 0.5\%$

   b) $A_P \approx A_U{}^2 \Rightarrow A_U \approx \sqrt{A_P} = \sqrt{0.005} = 0.0707 = 7.07\%$

   c) $A_U = \frac{U_1}{U_{source}} = \frac{R_1}{R_1 + R_2} \Rightarrow R_2 = \frac{R_1}{A_U} - R_1 = \frac{1k\Omega}{0.0707} - 1k\Omega = 13.142k\Omega = 13142\Omega$

4. U_{out} = 85 V; A_U = 0.85

5. U_{in} = 117.65 V; A_U = 0.85

6. R_2 = 1867 Ω

7. R_1 = 343 Ω

8. R_1 = 105.3 Ω

9. R_2 = 46 kΩ

10. a) 20%
    b) 50%
    c) 0%
    d) 100%

11. U_{out} = 2 V

12. $n_{dB} \approx 20\log A_U = 20\log\frac{U_{out}}{U_{in}} = 20\log 1000 = 60dB$

13. a) $A_U \approx \sqrt{A_P} = \sqrt{1000} = 31.62$

    b) $n_{dB} = 10\log A_P = 10\log 1000 = 30dB$

14. $n_{dB} = 10\log A_P \Rightarrow A_P = 10^{\frac{n_{dB}}{10}} = 10^{\frac{43}{10}} \approx 20000$

15. $n_{dB} \approx 20\log A_U = 20\log 0.5 = -6.02dB$

16. $n_{dB} \approx 20\log A_U = 20\log 2 = 6.02dB$

17. $n_{dB} = 10\log A_P = 10\log \frac{P_{out}}{P_{in}}$

a) 30 dB
b) 17 dB
c) 3 dB
d) 0 dB
e) -3 dB
f) -10 dB
g) -∞ dB

18. $n_{dB} = 10\log A_P = 10\log \frac{P_{out}}{P_{in}} \Rightarrow P_{out} = P_{in} \cdot 10^{\frac{n_{dB}}{10}}$

a) 500 kW
b) 25 kW
c) 50 W
d) 6.3 W
e) 5 W
f) 3.97 W
g) 0 W

19. $n_{dB} = 10\log A_P = 10\log \frac{P_{out}}{P_{in}} \Rightarrow P_{out} = P_{in} \cdot 10^{\frac{n_{dB}}{10}}$

$$P_{out,1} = P_{in} \cdot 10^{\frac{30}{10}} = P_{in} \cdot 1000$$

$$P_{out,2} = P_{in} \cdot 10^{\frac{27}{10}} = P_{in} \cdot 501$$

$$\frac{P_{out,1}}{P_{out,2}} = \frac{P_{in} \cdot 1000}{P_{in} \cdot 501} \approx 2$$

20. $\frac{P_{out,1}}{P_{out,2}} = \frac{P_{in} \cdot 10^{\frac{50}{10}}}{P_{in} \cdot 10^{\frac{33}{10}}} = 10^{5-3.3} \approx 50$

21. $n_{dB} \approx 20\log A_U \Rightarrow A_U \approx 10^{\frac{n_{dB}}{20}} = 10^{\frac{50}{20}} = 316.23$

$$A_{U,NFB} = \frac{A_U}{1 + A_U \cdot \beta} = \frac{316.23}{1 + 316.23 \cdot 0.01} = 75.98$$

$$n_{dB} \approx 20\log A_U = 20\log 75.98 = 37.61 dB$$

22. $n_{dB} \approx 20\log A_U \Rightarrow A_U \approx 10^{\frac{n_{dB}}{20}}$

$$A_U = 10^{\frac{13}{20}} = 4.4668$$

$$A_{U,NFB} = 10^{\frac{10}{20}} = 3.1623$$

$$A_{U,NFB} = \frac{A_U}{1 + A_U \cdot \beta} \Rightarrow \beta = \frac{1}{A_{U,NVCS}} - \frac{1}{A_U} = \frac{1}{3.1623} - \frac{1}{4.4668} = 0.0924$$

23. $A_{U,NFB} = \frac{A_U}{1 + A_U \cdot \beta} \Rightarrow \beta = \frac{1}{A_{U,NVCS}} - \frac{1}{A_U} = \frac{1}{10^{\frac{20}{20}}} - \frac{1}{10^{\frac{26}{20}}} = 0.05$

24. a) $n_{dB} \approx 20 \log A_U = 20 \log 100 = 40 dB$

b) $A_{U,NFB} = \frac{A_U}{1 + A_U \cdot \beta} = \frac{100}{1 + 100 \cdot 0.03} = 25$

c) $n_{dB} \approx 20 \log A_U = 20 \log 25 = 28 dB$