Obsah

Real Voltage Sources

Linear Voltage Sources

Their internal resistance is non-zero, so their voltage depends on the load connected to the terminals.

Figure 1

$$-U + R_i \bullet I_S + U_S = 0$$
$$U_S = U - R_i I_S$$
$$U_S = 0 \Rightarrow I_S = I_{KS} = \frac{U}{R_i}$$
$$I_S = 0 \Rightarrow U_S = U$$

Plot 1 Load Line

Figure 2

$$U_n = U \bullet \frac{R_2}{R_i + R_1 + R_2}; R_n = \frac{(R_i + R_1)\, R_2}{R_i + R_1 + R_2}$$

Voltage Stabilizer with Zenor Diode

Figure 3

$$R = \frac{U - U_D}{I_D}; I_{Dmin} < I_D < I_{Dmax}$$

Voltage stabilizer operates from the certain value of voltage up to certain value of current.

Voltage Stabilizer with Transistor

Figure 4

$$(U_L \& = U_D - U_{BE} @ 0.65 < U_{BE} < 0.7 @ \& I_E = (h_{21E} + 1) \bullet I_B @ I_{R1} \& = I_D + I_B \approx I_D @ R_1 \& = \frac{U - U_D}{I_D} @ I_D \& \gg I_B; U_L \approx U_D)$$

$$I_{Cmax} < I_C$$

$P_C = U_{CE} \bullet I_C < P_{Cmax}$ – power deception

Sources using Rectifiers and Transformes

- **Single Phase Transformer**
  Figure 5 – Single Phase Transformer consists of a core (typically iron with magnetic features) forming a magnetic circuit; around it we can found a primary wiring connected to a input source of sine AC, and a secondary wiring where appears output voltage U_2 of sine AC.
  - It galvanically separates the wirings – the DC cannot pass through the SPT.
  - It operates on the Faraday Electromagnetic Law –changes of magnetic flux in the core induce the output voltage on the secondary wiring.
  - $\frac{U_1}{U_2} = n = \frac{N_1}{N_2} = \frac{I_2}{I_1}; P_1 = P_2; \eta = \frac{P_2}{P_1}; 75\% < \eta < 98\%$
- **Half-Wave Rectifier**
  Figure 6
- **Bridged Full-Wave Rectifier**
  Figure 7

- **Smoothing Capacitor**
  Figure 8
  The difference $\Delta U = U_{1m} - U_{1\,\min}$ is called **ripple**.

Switched Power Voltage Sources

They have much greater efficiency than linear sources, are lighter and smaller. They don't operate continuously, but on switching regimes which switch at high frequency, so they seem to be continuous.

Property	Linear Power Sources	Switched Power Sources
Efficiency	$\eta < \mathbf{40\%}$	$\eta > 75\%$
Size and Weight	heavy	small
Complexity	not complex	more complex
Noise and Ripple	$f = 50\ Hz$, noisy, ΔU can be small	$20\ kHz < f < 1\ MHz$, quiet, ΔU is large
Reliability	high	worse

- **AC to DC Switched Convertor**
- **Buck-Boost Convertor**

Feedback

Put part of output back to the input in such manner, that the input is increased, we speak about **positive feedback** (leads to instability in system, is used in oscillators), in otherwise it's **negative feedback** used to maintain stability in amplifiers.

Operational Amplifier

Non-inverting Amplifier

Figure 1

The polarity of input voltage is the same as the polarity of output voltage. It has high input resistance

Figure 2

$$\begin{aligned} I_1 - I_2 &= 0 \\ I_1 &= \frac{U_{R1}}{R_1} \\ I_2 &= \frac{U_{R1}}{R_1} \end{aligned} \quad ; \quad \begin{aligned} -U_2 + U_{R2} + U_{R1} &= 0 \\ -U_2 + U_{R2} + U_1 &= 0 \\ U_{R2} &= U_2 - U_1 \end{aligned} \quad ; \quad \begin{aligned} \frac{U_1}{R_1} - \frac{U_2 - U_1}{R_2} &= 0 \\ \mathbf{U_1} \bullet \frac{\mathbf{R_1} + \mathbf{R_2}}{\mathbf{R_1}} &= \mathbf{U_2} \end{aligned}$$

Amplification factor $\frac{R_1+R_2}{R_1}$ is greater than one. When we replace resistor R_2 by the short, we get the **voltage follower** – output voltage is the same as input voltage.

Real Operational Amplifier

Figure 3

$$\begin{aligned} I_B \sim I_A &\sim 10 \cdots 80\ nA \\ I_S &= I_A + I + B \\ I_O &= I_A - I_B \\ U_{CM} &= \frac{U_A + U_B}{2} \\ U_2 &= A_{CM} \bullet U_{CM} \\ H_{CMR} &= 20 \bullet \log\left(\frac{A_0}{A_{CM}}\right) \\ [H_{CMR}] &= 1\ dB \end{aligned} \quad ; \quad \begin{aligned} U_d = U_A - U_B &\sim 3 \cdots 10\ mV \\ R_d &\sim 1\ M\Omega \\ R_{CM} &\sim 100\ M\Omega \\ R_O &\sim 50\ \Omega \\ A_0 &\sim 10^4 \cdots 10^5 \\ A_{CM} \& &\sim 0.1 \\ H_{CMR} &\sim 100\ dB \end{aligned}$$

Transfer Voltage Characteristic

Figure 4 – non-inverting amplifier

We supply our amplifier by the symmetrical sourceU_{CC} and $-U_{CC}$ with a common ground.

$$|U_{2SAT}| = |U_{CC}| - 1.5$$

For the **rail to rail** amplifiers, it holds true: $|U_{2SAT}| \approx |U_{CC}|$. In all real cases, the linear amplifier is only about $3\ mV$.