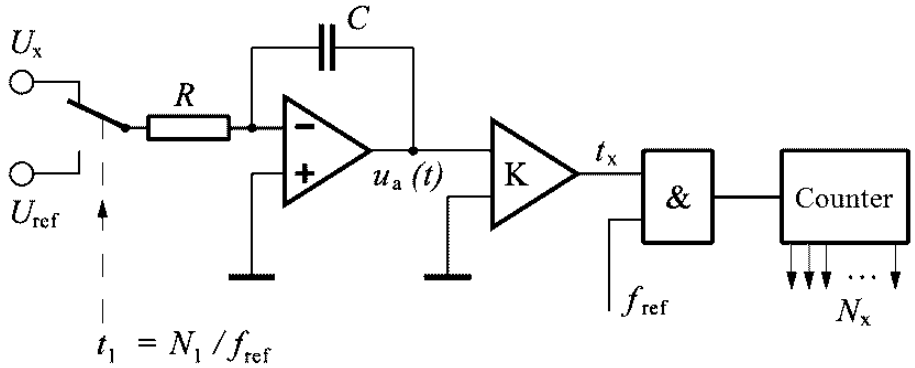
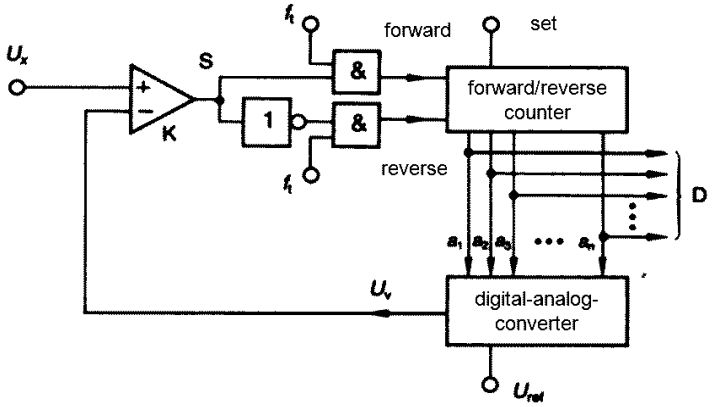
Dual Slope ADC

The dual slope analog-digital-converter according to the figure is an integrating converter. The unknown voltage U_x is integrated up during known measurement time t_1. Subsequently the reference voltage U_{ref} is integrated down to zero. The measurement time t_x is proportional to the unknown voltage U_x. Integrating converters are useful to suppress inductive coupled disturbing frequencies



a) During down integration time t_x pulses with the frequency f_{ref} at the output of the AND-gate are counted. What is the relationship between the counter N_x and the factor N_1, the unknown voltage U_x (U_x = constant!) and the reference voltage U_{ref}?
b) An unknown voltage of U_x = -1/3 U_{ref} should be measured with an accuracy of 0,1 %. What must be the corresponding value of the factor N_1?
c) How long is the minimum measurement time $t_{1,min}$ to suppress disturbing frequencies of 50Hz, 60Hz and 50Hz and 60Hz simultaneously?
d) An unknown voltage of U_x = -1/3 U_{ref} should be measured with an accuracy of 0,1% and disturbing frequencies of 50Hz and 60Hz should be supressed. What is the corresponding value of the reference frequency f_{ref}?
e) The values of R, C and f_{ref} are changing because of aging of the components. What is the influence on the counter N_x?

Incremental Follow-Up-Converter

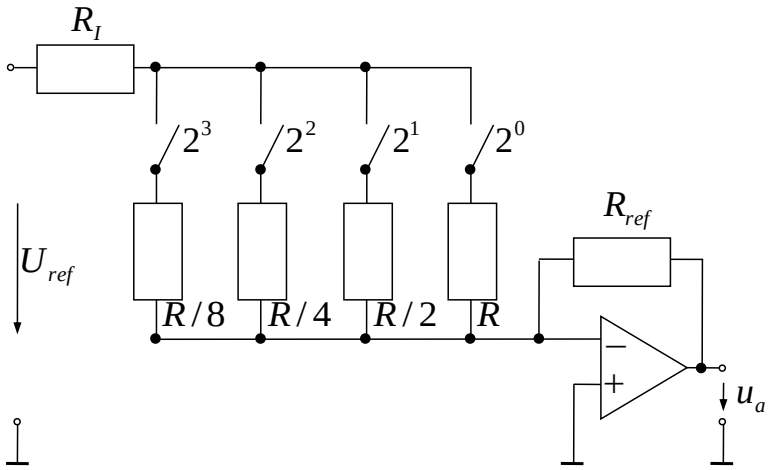


The Incremental Follow-Up-Converter: has the following technical data:

- Input voltage range U_x = (0V. . .5 V)
- resolution ≤ 20 mV
  a) What is the bit-resolution of the digital analog converter?
  b) A sinusoidal input voltage with 5V amplitude and 10kHz frequency should be converted without any delay. What is the allowed minimum clock rate?

c) The digital analog converter has a delay time of 10ns. The comparator has a delay time of 250ns. What is the effect on the output digital word? The input voltage is a constant DC voltage.
d) The converter should work without any disturbing effects. This is fulfilled while $|U_x - U_v| \leq U_{LSB}$. What is the maximum allowed delay time of the comparator? The input voltage is a constant DC voltage.

Digital-Analog-Converter



a) Calculate the value of the reference resistor R_{ref}. The following values are known: R_I = 0Ω, R = 100kΩ, U_{ref} = 1,2 V. The digital word is Z = 1111 what means that all switches are closed and the corresponding output voltage is $u_{A,min}$ = -5 V.
b) The inner resistor R_I of the voltage source U_{ref} causes an error. Which digital word Z causes the biggest error on the output voltage u_A?
c) The inner resistor R_I of the voltage source U_{ref} has an value of R_I = 100 Ω. Calculate the value of the error on the output voltage u_A. Use the values of a).
d) The error on the output voltage should be constant at all digital words D. How the resistor network must be changed?