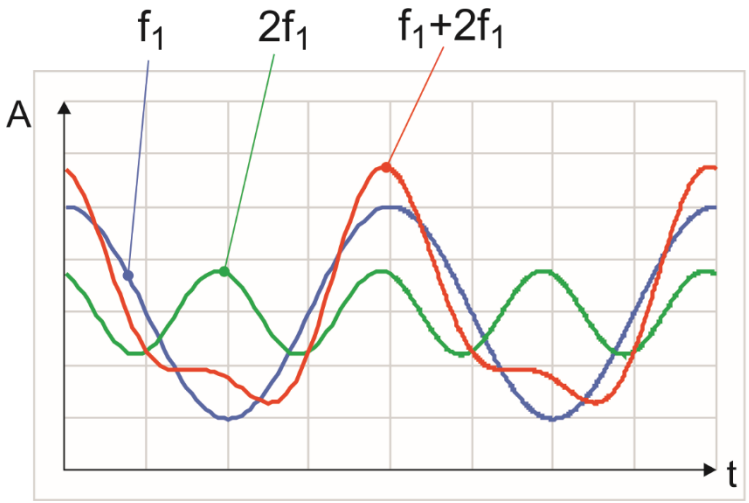
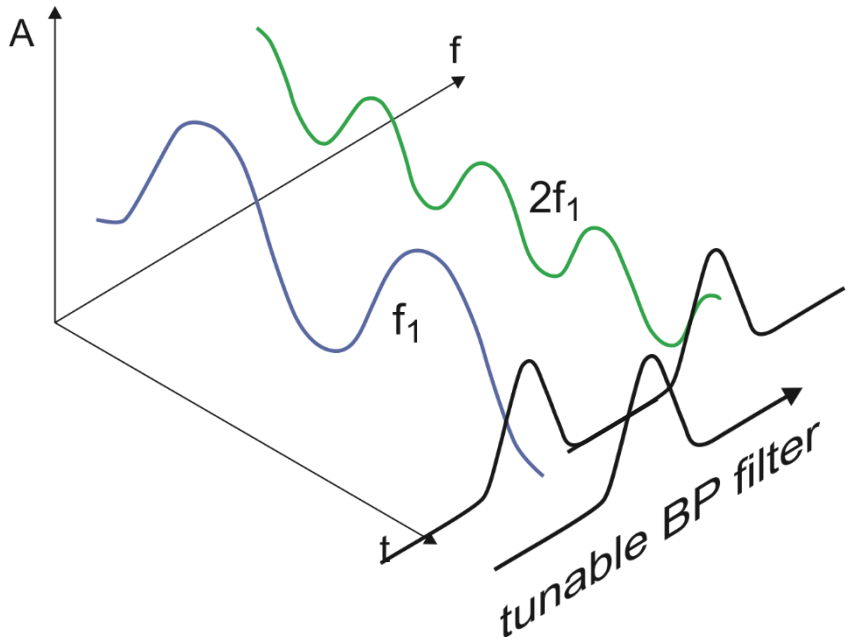
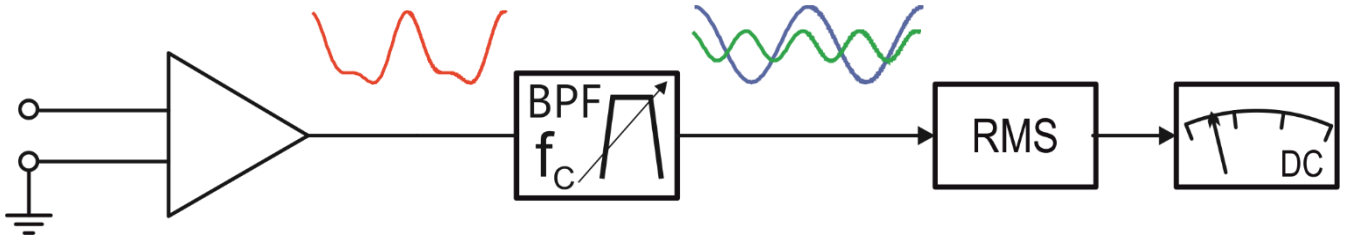
Frequency selection with a tunable filter







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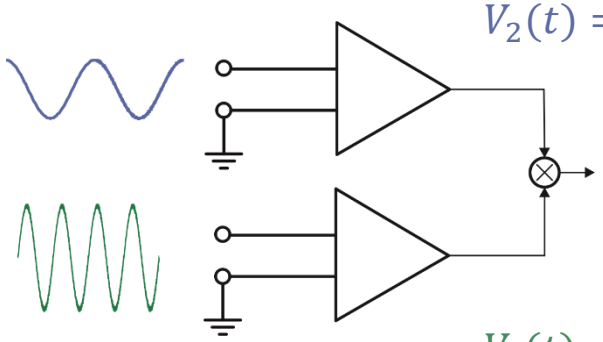
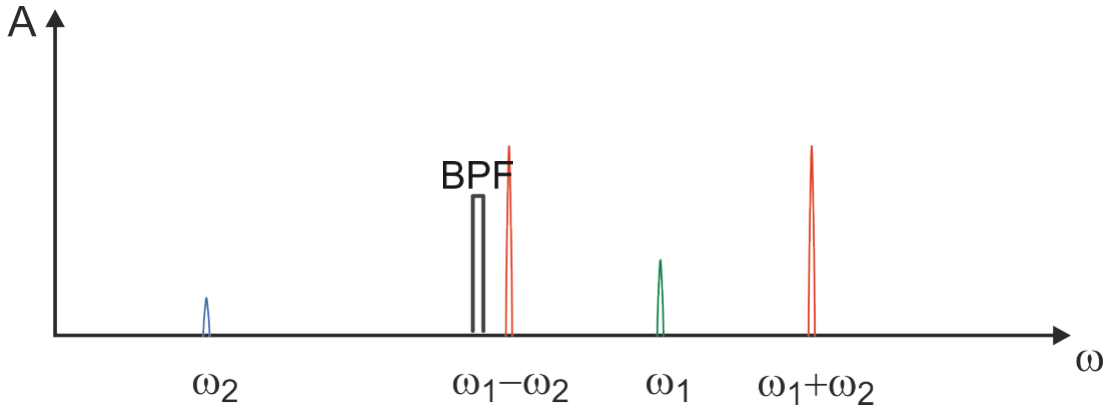
Frequency shift of a signal



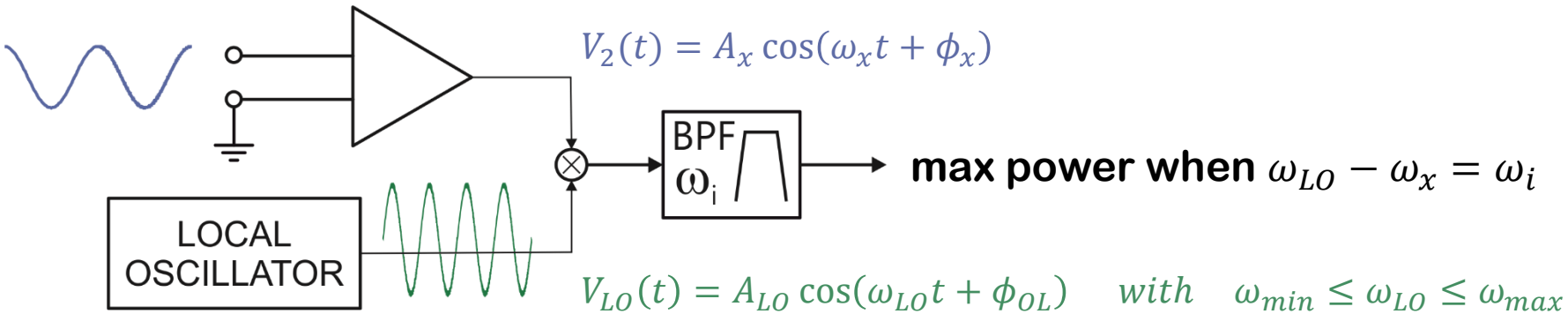
$$V_2(t) = A_2 \cos(\omega_2 t + \phi_2)$$

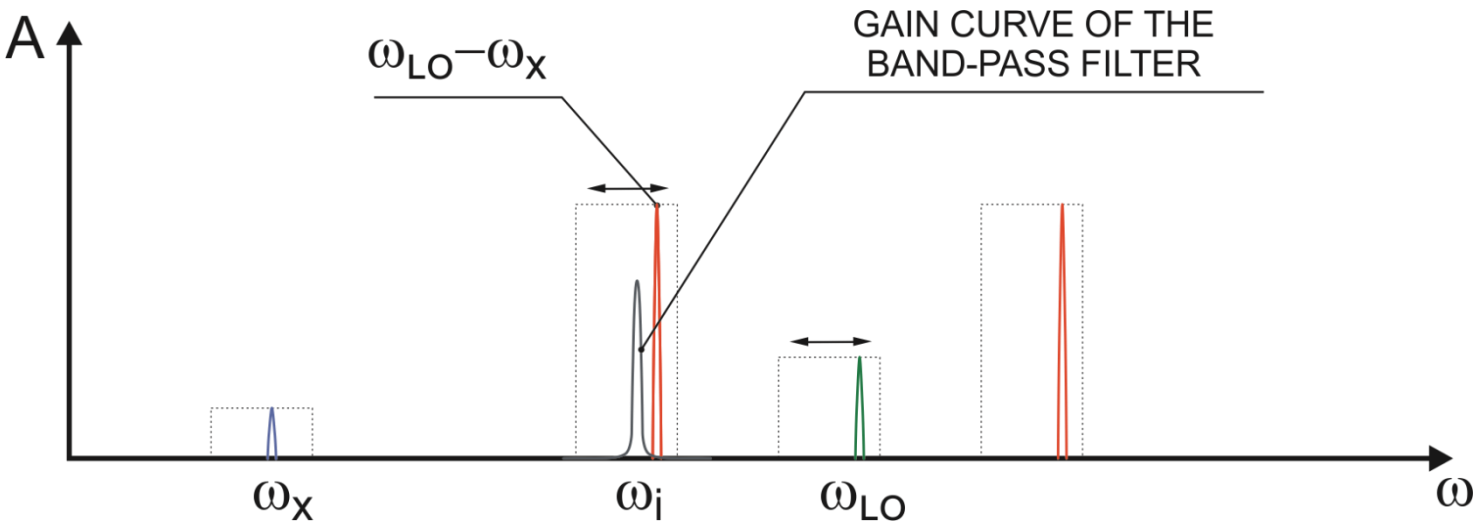
$$V(t) = \frac{A_1 A_2}{2} \cos\big((\omega_1 + \omega_2)t + \phi_1 + \phi_2\big) + \frac{A_1 A_2}{2} \cos\big((\omega_1 - \omega_2)t + \phi_1 - \phi_2\big)$$

$$V_1(t) = A_1 \cos(\omega_1 t + \phi_1)$$



Local oscillator, mixer plus band-pass filter





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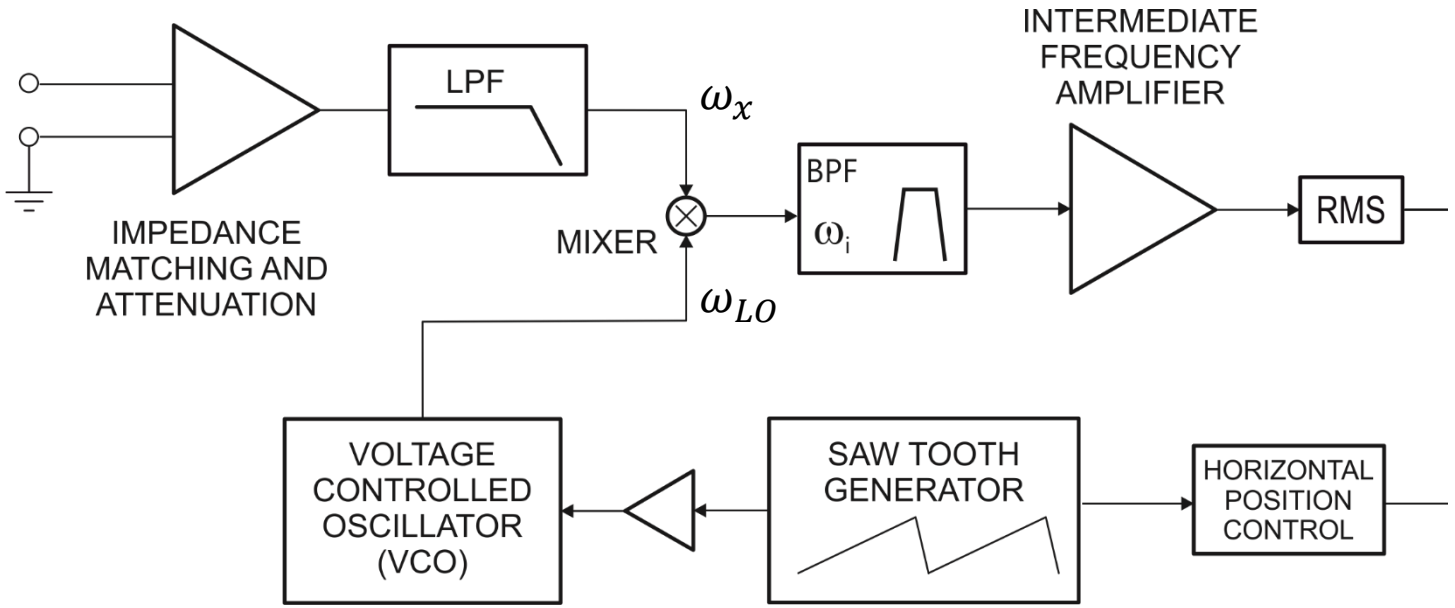
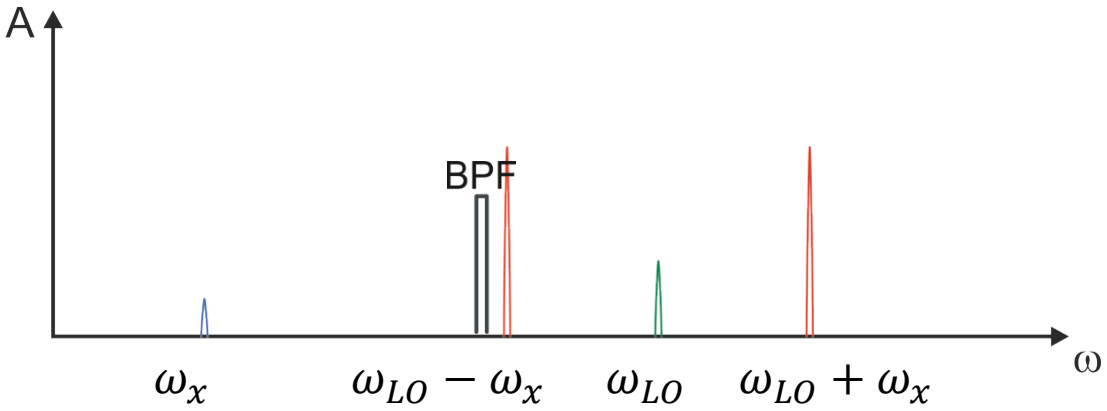
Heterodyne (swept) spectrum analyzer

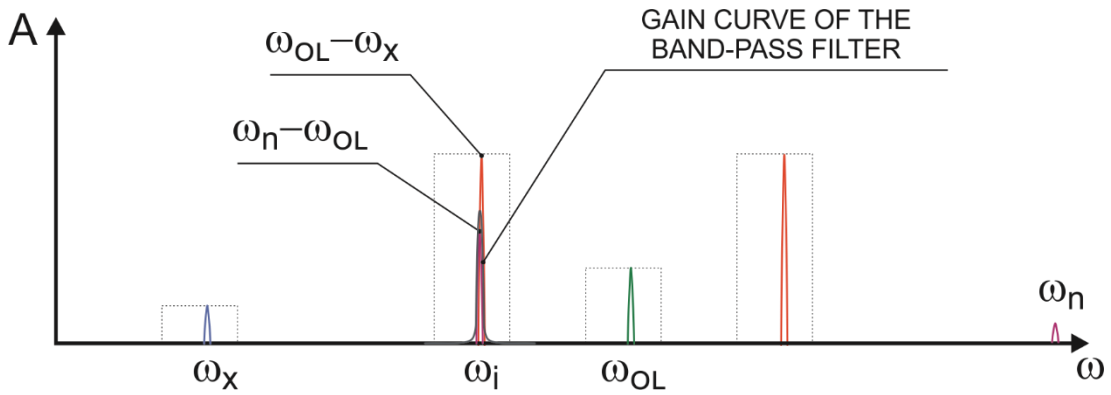




Intermediate frequency choice

- contrasting requirements can arise from different aspects:
  - measuring range
  - the need to operate in a low-noise region of the spectrum
  - the use of an accessible electronics
- example:
  - input frequency 0-10 MHz
  - fixed IF = 20 MHz
  - VCO: 20-->30 MHz
  - the frequency difference (IF) is 20 MHz
  - the sum frequency changes from 20 to 30 MHz
- in an actual spectrum analyzer, the frequency shift is obtained by multiple conversion stages

Image frequency



$$\omega_n - \omega_{OL} = \omega_i \Rightarrow \omega_n - (\omega_i + \omega_x) = \omega_i$$

$$\Rightarrow \boxed{\omega_n = \omega_x + 2 \cdot \omega_i}$$

- a low-pass filter MUST be inserted in front of the mixer to avoid out-of-band frequencies to overlap the in-band signal frequency components

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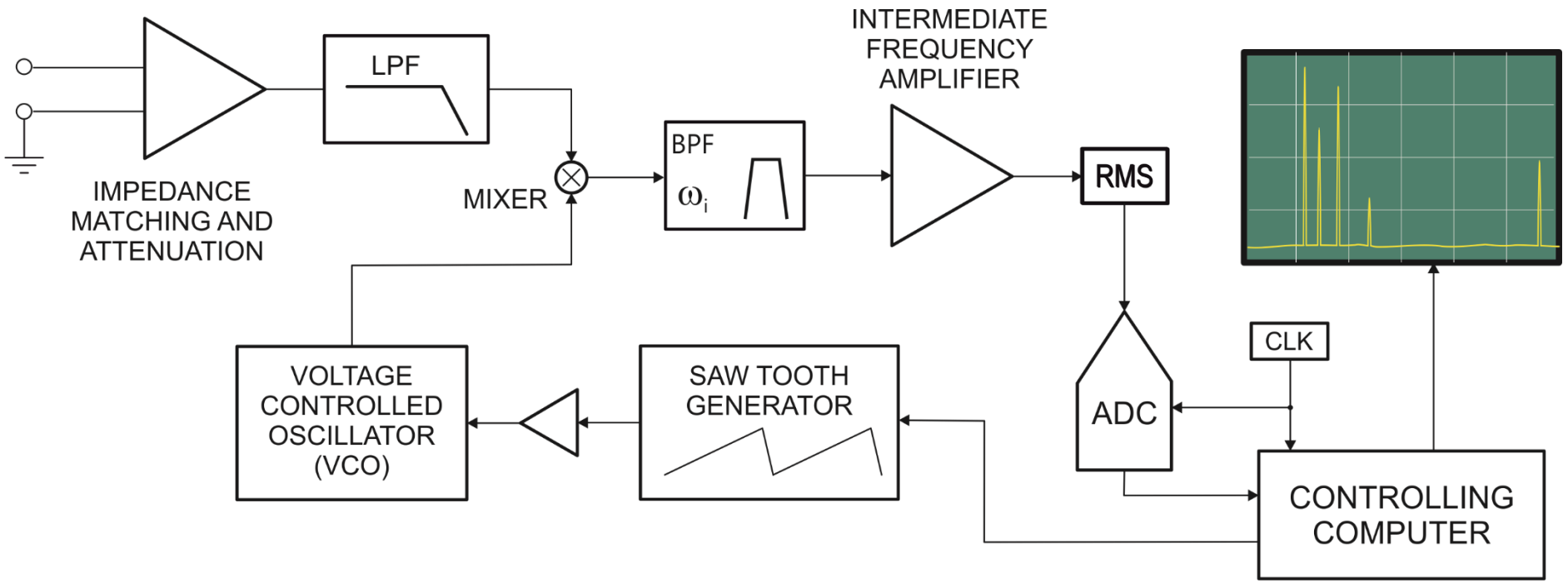
Output on a digital display



- The ADC, given the superb sensitivity of the measuring chain, must have a high resolution (greater than 16 bits)

Specification of a swept spectrum analyzer

- **frequency range:** $10Hz \div 40GHz$
- **resolution bandwidth:** $0{,}01Hz \div 3MHz$
- **equivalent input noise:** $(-100\ dBm) \div (-150dBm)$
- **dynamic range:** $20dB \div 110dB$
- **frequency accuracy:** $50Hz \div 5MHz$
- **amplitude accuracy:** $\%\ f.s.$
- **additional functions**
  - **marker for amplitude and frequency measurements**
  - **auto-ranging**
  - **network connectivity**
  - **……**