Measurement of frequency, period, time, phase, …

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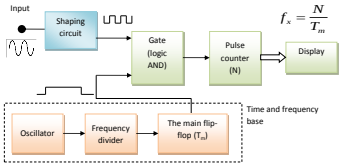
Úvod

- Analog instrumentation is obsolete - used only rarely
- Time parameters can be measured by some general instrumentation such as oscilloscope and spectrum analyzer
- Special digital instruments are called counters because of the basic principle
  - Usually measure all common time parameters

$$\Delta\phi = \frac{\Delta t}{T} \cdot 360^\circ$$

  - Measurement is very accurate and precise - time (frequency) is the most accurate measurement because we can create the most accurate and precise etalon of frequency - atomic clock (based on quantum physic effects)

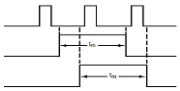
The basic principle



T_m – duration of measurement (time interval when the gate is open)
N – number of pulses from measured signal registered by counter within T_m

The uncertainty of measurement

- Stability of oscillator in frequency base (synchronization from GPS)
- Time quantization - the time coincidence of measured pulses and period of measurement can cause the difference of 1 pulse



$$\Delta_{max} f = \frac{1}{N}$$

- Uncertainty decreases with number of registered pulses in counter N
- Increasing N means longer measurement
- Not convenient for low frequency measurement, e.g., for 1Hz with uncertainty <1mHz (0,1%), measurement takes more than 1000s>16 minutes

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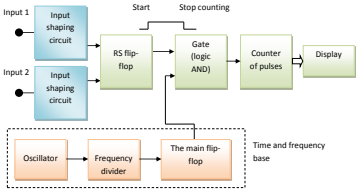
Measurement of time interval (delay, …)

- Time interval is given by slopes of two signals



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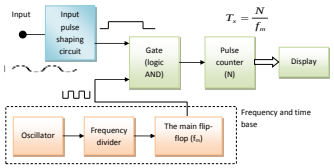
Measurement of signal period



- Time/frequency base generate pulses with known exact frequency
- Pulses are registered in counter (N) during signal period derived from input measured signal
- Uncertainty of measurement: 1/n

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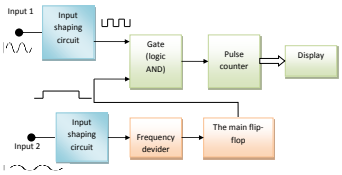
Ratio of two signal frequencies



Slower signal }after frequency division) determines the period of counting pulses derived from the other signal

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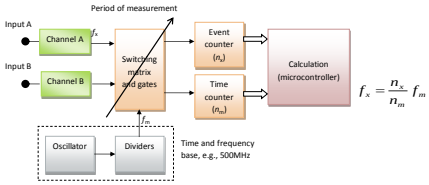
Reciprocal counter

- Removing dependence between measured frequency/period and measurement period
- Period of measurement: more-less arbitrary and measured by time counter (pulses are derived in accurate time base)
- Even counter registers pulses from measured unknown signal
- The measured frequency is calculated from content of both counter



$$f_x = \frac{n_x}{n_m} f_m$$

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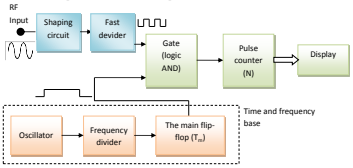
Counter accessory

- Spreading frequency range up to GHz - fast pre-divider with fixed dividing ratio working up to GHz



- Calculation
  - Statistics (mean, standard deviation, histogram, ….)
  - Analysis: changes of measured parameters in time

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