Danfoss Flow Division: Trigger algorithm for ultrasonic flow metering

An ultrasonic flow meter determines the flow rate by measuring the transit time of an ultrasonic pulse travelling downstream and upstream in a duct carrying a fluid. The velocity is calculated by $V = \frac{K \cdot (T2-T1)}{T1 \cdot T2}$, in some applications the difference between the upstream transmit time and the downstream transmit time (T2 - T1) can be as low as 2ns. Hence, an accuracy of 1% leads to a maximal systematic error on the estimate of T2 - T1 of 20 ps! The base frequency of the burst is typically 1MHz. The sound burst is traditionally generated and received by piezoelectric transducers.

An essential part of all ultrasonic flow meters is the circuit or algorithm that determines the time of arrival of the ultrasonic pulse. A typical signal can be seen here:



Over time the shape of the signal can change and the signal upstream and downstream can be slightly different due to contamination, temperature, flow rate, noise, etc. Generally speaking, it is not possible to use the first period of the received signal as the sole indicator of the arrival due to noise.

In the past Danfoss has used several techniques, the most recent will be explained in the final notes.

Ideas for algorithms can be evaluated by simulation on sampled real world signals