electronic components often come into use for the control/evaluation unit, which is disadvantageous, since these components have relatively strict component tolerances. It is also disadvantageous that there is no protection against reverse engineering in the case of known detectors comprising electronic components: A competitor can replicate a vibration detector with knowledge of the components without possessing detailed knowledge of the functional principle of the detector.

Embodiments~~An object~~ of the invention ~~is to~~ provide a method and an apparatus, which permit the equipping of different types of vibration detectors with a largely identical control/evaluation unit.

In one aspect, there is provided a method for determining or monitoring a predetermined fill level, a phase boundary or a density of a medium in a container with an oscillatable unit, wherein the oscillatable unit is placed at the height of the predetermined fill level; wherein the oscillatable unit is excited to oscillate by means of a frequency scanning operation (sweep) within a predeterminable frequency band in the working range of the oscillatable unit successively with discrete exciter frequencies following one another; wherein the corresponding oscillations of the oscillatable unit are received in the form of received signals; wherein that exciter frequency is ascertained in the frequency scanning operation, at which the oscillatable unit oscillates with an oscillation frequency, which has a predetermined phase shift between the transmission signal and the received signal; and wherein the transmitting/receiving unit (S/E) excites the oscillatable

unit to oscillate with the oscillation frequency ascertained or wherein the following frequency scanning operation is started, wherein the oscillation frequency at the predetermined phase shift between the transmission signal and the received signal is ascertained by evaluating amplitudes of the received signals received by the transmitting/receiving unit (S/E).

~~Regarding the method, the object is achieved by features including that:~~ The oscillatable unit is excited to oscillations with successive discrete exciter frequencies, following one another in time, by means of a frequency scanning operation within a predeterminable frequency band in the working range of the oscillatable unit; the corresponding oscillations of the oscillatable unit are received in the form of received signals; and that exciter frequency is ascertained in the frequency scanning operation, in which the oscillatable unit oscillates with an oscillation frequency, which has a predetermined phase shift between the transmission signal and the received signal. Either the transmitting/receiving unit excites the oscillatable unit to oscillations with the ascertained oscillation frequency (in fill level measurement or in phase boundary level monitoring), or the following frequency scanning operation is started, so that permanent frequency scans take place (in density measurement).

Especially, the oscillation frequency of the oscillatable unit with a predetermined phase shift is the oscillation frequency of the fundamental mode - fundamental wave excitation - at the predetermined phase shift, or it is the oscillation frequency of a higher mode - harmonic excitation - at the predetermined phase shift.

An advantageous embodiment of the method of the invention provides that, when the oscillatable unit is oscillating outside the oscillation frequency for the predetermined phase shift between transmission signal and received signal, frequency scanning is started anew, until the right oscillation frequency is found.

In contrast to known analog vibration detectors, the solution as per embodiments of the invention is implemented largely digitally. The oscillatable unit is operated with its oscillation frequency at the predetermined phase shift between the transmission and received signals, independently of the current damping. Each current oscillation frequency of the oscillatable unit, e.g. the current resonance frequency, is ascertained. For this, the working range of frequencies of the oscillatable unit is completely scanned. In order to determine the current resonance frequency of the oscillatable unit, it is necessary, moreover, to free the oscillations of the oscillatable unit of noise and disturbance signals.

Known vibration detectors have - as already mentioned - a closed oscillatory circuit comprising an oscillatable unit and a control/evaluation unit. Here, the resonance frequency in the working range of the oscillatable unit tunes automatically to a fixed phase shift between the transmission and received signals.

In contrast, an oscillation of a determined frequency and a determined phase relationship coupled therewith are predetermined by the digital apparatus as per embodiments of the invention. A forced excitation of the oscillatable unit is effected. Then, the oscillatable unit sweeps through its entire working range of frequencies, i.e. the current resonance frequency of the oscillatable unit is ascertained, in time, by an excitation of successive discrete frequencies, which are closely spaced to one another. This method is also referred to as a frequency sweep.

Preferably, the oscillation frequency of the oscillatable unit at the predetermined phase shift between the transmission signal and the received signal is ascertained by evaluating the amplitudes of the received signals received by the transmitting/receiving unit. Alternatively, it is provided that the oscillation frequency of the oscillatable unit at the predetermined phase shift between the transmission signal and the received signal is ascertained by evaluating the phase shift between the transmission signal and the received signal. Thus, a phase shift of 180° arises in the receiver signal both in the case of resonance as well as in the case of no resonance.

An embodiment of the method of the invention provides that the solution is implemented completely on a digitized basis. In this case, the received signal is digitized by an analog/digital converter and further processed purely digitally. Alternatively, the opportunity exists to implement the solution as per embodiments of the invention by means of switchable circuit variants. For this, analog circuit technology can largely be retained; each required signal path is controlled by a microcontroller and so arranged by means of analog switches that each required circuit part can be brought into the signal path.

Preferably however, the control/evaluation unit of the solution as per embodiments of the invention is embodied as a digital circuit, especially as a digital signal processor DSP, as an FPGA, FPAA or as a PSoC - programmable system on chip. Configurable analog and digital resources are arranged in a PSoC together with a microcontroller in one integrated circuit. Since only few external components are necessary, the PSoC option saves much space and, moreover, is cost effective.

In an advantageous embodiment of the method of the invention, it is provided that the evaluation of the phase shift between the transmission signal and the received signal is done by a phase selective rectification, which produces a direct voltage proportional to the phase and amplitude. In such case, the received signals of the phase selective rectifier are formed by the received signal of the transmitting/receiving unit and a signal derived from the transmitting unit. The derived signal is preferably a periodic square or sinusoidal signal.

Moreover, it is provided that the frequency range in the working range of the oscillatable unit is swept during a frequency scanning.

In a first form of embodiment of the method of the invention, it is provided that the oscillation frequency of the oscillatable unit at the predetermined phase shift between the transmission signal and the received signal is ascertained based on two frequencies, which lie essentially symmetrically to the oscillation frequency of the oscillatable unit at the predetermined phase shift between the transmission signal and the received signal and in the case of which predetermined

Regarding the apparatus, the object is achieved by features including that: A transmitting/receiving unit is provided; the transmitting/receiving unit excites the oscillatable unit to oscillations with successive discrete exciter frequencies following one another in a frequency scanning operation within a predeterminable frequency band in the working range of the oscillatable unit and receives the corresponding oscillations of the oscillatable unit; a control/evaluation unit is provided, which ascertains the exciter frequency at which the oscillatable unit oscillates at an oscillation frequency with a predetermined phase shift between the transmission signal and the received signal; and the transmitting/receiving unit excites the oscillatable unit to oscillations with the ascertained oscillation frequency at the predetermined phase shift between transmission signal and received signal.

Furthermore, the control/evaluation unit is so embodied that it ascertains the oscillation frequency of the oscillatable unit at the predetermined phase shift between the transmission signal and the received signal via evaluation of the phase between the transmission signal and the received signal or the amplitude of the received signal during the frequency scanning operation.

Advantages of the solution as per embodiments of the invention are summarized as follows:

- The control/evaluation unit comprises identical components for all embodiments of oscillatable units and for all areas of application of the vibration detectors. The solution as per embodiments of the invention is, thus, platform capable.