

Firearm Analysis Device

Technical area

The invention relates to a firearm analysis device for determining parameters which are indicative for a shot which is discharged from a firearm, and to a corresponding firearm analysis method for determining parameters which are indicative for a shot which is discharged from a firearm by means of such a firearm analysis device. The invention also comprises a firearm which includes a firearm analysis device. Furthermore, the invention also comprises a computer program product which includes computer-readable instructions for performing some of the method steps.

In this application, positional designations such as "up," "down," "left," "right," "front," "rear," etc. refer to a firearm which is held in a normal firing position with the axis of the sighting located as horizontal and firing forwards away from the shooter.

State of the art

It is known method to utilise shot counters in order to record whether a shot was fired with a firearm and to thereby count the shots fired with a firearm.

In particular, shot counters are known which count the number of shots which have been fired by means of electrical signals. The signals hereby consist of electrical voltages which are induced by a magnet-coil arrangement which is installed in the weapon when a shot is fired.

US 8,046,946 B2 (Packer Engineering, Inc.) discloses a shot counter device for a firearm which comprises a specific solenoid-coil arrangement. In this case, the coil is formed by continuous wire windings which have a reverse loop on non-magnetizable elements, whereby the induced voltages of adjacent magnetizable coil elements add up. Due to this setup, the field currents which are induced by the sweeping movable bar magnets therefore accumulate and add up to a maximum, rectified total current. The resulting signal serves as the basis for determining the number of shots which have been fired.

EP 3 140 605 B1 (Heckler & Koch GmbH) discloses a battery-free shot counter with a solenoid-coil arrangement in which alternately poled permanent magnets sweep a coil with a soft-magnetic core during the recoil and counterrecoils travel of the breech. The coil winding surrounds the soft magnetic tine-shaped core or one of its tines. Unlike the coil which is described in US 8,046,946 B2 (Packer Engineering, Inc.), this coil does not indicate reversing

loops and, because the tines are utilized in this case, the magnetic fields are added up rather than voltages i.e., when the permanent magnets sweep the coil, then they generate a sequence of voltage pulses with oppositely oriented voltage amplitudes i.e., a (non-added) AC voltage. Based on the additional phase information which is obtained in this way, this signal makes it possible to distinguish not only between the number of shots which have been fired but also between the counterrecoils and recoil travel of the breech.

For example, conclusions can be drawn about the wear and tear of a firearm via the information gained regarding the firing of a firearm as well as obtained from known shot counters.

Task and solution of the invention

It is a task for the present invention to improve the diagnostics for firearms and, in particular, to enable a more advanced analysis of the firing of shots beyond the mere counting of shots.

The invention resolves this problem with each of the objects of claims 1, 19 and 20.

One aspect of the invention relates to a firearm analysis device for determining indicative/characteristic parameters for a firearm from a shot which is discharged from it.

The firearm analysis device can also be a firearm diagnostic device.

For example, the firearm analysis device includes a voltage generation unit, a signal processing unit, a signal evaluation unit and a time determination unit.

The voltage generation unit generates an AC voltage signal when the slide, for example, moves backwards and forwards as a result of a shot being fired. If necessary, this is pre-processed in the signal processing unit into a usable measurement signal e.g., by an analog-to-digital converter (ADC) or a rectifier circuit. The signal evaluation unit subsequently analyzes the measurement signal and uses it to determine information about the weapon and/or shot discharged. For this purpose, it refers back to time information such as durations which are determined in the time determination unit, if necessary.

The voltage generation unit is therefore designed to generate an alternating voltage during the counterrecoils travel and/or recoil of a movable weapon part e.g., the slide of a pistol, during firing. The voltage can be generated along a section of the distance which is covered by the movable weapon part during recoil or counterrecoils travel. The voltage can be generated by means of a solenoid-coil arrangement as described, for example, in US 8,046,946 B2 (Packer

Engineering, Inc.) or in EP 3 140 605 B1 (Heckler & Koch GmbH). The inductively generated alternating voltage signals known from EP 3 140 605 B1 can therefore be utilized for the firearm analysis device of the present invention. Use of these signals has the advantage that no new, additional basic signals need to be generated and components which are already known for firearms can be used for voltage generation. However, alternating voltage signals generated in other ways, e.g., via Piezo elements or electromechanical inverters, are also conceivable. Regardless of how they are generated, the AC voltage signals subsequently serve as input signals to the signal processing unit.

The signal processing unit can therefore be utilized to convert the generated AC voltage into a usable measurement signal in the further device components. For example, the analog AC voltage signal can be provided without pre-processing. In this case, the measurement signal would be identical to the AC voltage signal. Alternatively, it can be digitalized by using an analog-to-digital converter (ADC), for example, and additionally pre-processed as an alternative or additional option. For this purpose, the signal processing unit can comprise further suitable switching elements such as filters, rectifiers.

According to some embodiments, a reference signal and/or a supply voltage for the downstream signal evaluation unit is additionally generated in the signal processing unit. The reference signal can be utilized, for example, as a dynamic comparison value for the analysis of the measurement signal. The measurement signal and/or reference signal is subsequently evaluated in the downstream signal evaluation unit.

The signal evaluation unit can comprise a microcontroller, for example. It is generally utilized for evaluating and analyzing signals. In particular, it can serve in order to determine time points and parameters such as speed, acceleration, cadences/firing rates or firing modes. For example, the signal evaluation unit can be designed to determine a first and a second point in time during the counterrecoil travel and/or recoil of the moving weapon part. These can be, for example, specific points in time in the course of the measurement signal, such as at the beginning and at end of the signal or the beginning and end of a period or half-period within a signal.

The time determination unit or time measurement unit is generally utilized for time measurement and it can quite generally determine durations such as signal durations, durations of signal or time sections, or distances between individual signals or time points which are located within a signal or distributed over several signals. In particular, it is utilized to determine the time intervals between first and second time points. Time determination units can therefore

be any devices which are suitable for the relative or absolute determination of durations. For example, cycles, cycle generators in combination with a timer which counts the cycles and knows the time intervals between successive cycles, and capacitors whose degree of discharge serves as a measure of an elapsed time.

The described firearm analysis device can be utilized in order to obtain a wide range of information from which parameters such as speeds and accelerations of the slide/breech during firing, rates of fire or ammunition types can be derived. New additional information can therefore be obtained in an advantageous manner from the signals which are already known. The additional information relating to firing such as number and intensity, for example, provides more concrete indications for estimating firearm wear. The servicing and maintenance of firearms can therefore be improved and facilitated, ultimately increasing safety in their handling. In addition, such advanced information can be utilized for documentation and monitoring, as well as for logistical purposes (e.g., stocking of spare parts and ammunition) for firearm use. Manufacturers can incorporate such data, for example, in the improvement and additional, ongoing development of weapons. Finally, detailed information regarding the shots fired with a weapon also facilitates forensic investigations.

Another aspect of the invention relates to a firearm comprising a firearm analysis device.

Another aspect of the invention relates to a method for determining parameters which are indicative of a firearm from a shot which has been discharged.

The method can be used generally to determine parameters and further information about firearms and firearm discharges. To this end, it can comprise, for example: detecting AC voltages, providing at least one measurement signal based on the AC voltage, determining at least a first and a second time point of counterrecoil travel and/or recoil, and determining at least one time period duration i.e., a duration of time periods which are defined by the first and second time points.

The method can therefore utilize the components of the firearms analysis device which is described above.

The alternating voltages can have been generated during a counterrecoil travel and/or recoil travel of a moving weapon part during a firing operation; for example, by the voltage generation unit which is described above.

The measurement signal can be generated based on the generated AC voltages.

The first and second time points include the examples as described above.

The determination of the durations can be executed, for example, by means of the time determination unit which is described above. While the invention is defined in the independent claims, further features of preferred design examples or embodiments can result from the dependent claims, the accompanying technical drawings and the following description.

Another aspect of the invention relates to a computer program product which includes computer-readable instructions for executing some of the method steps.

In the following, the subclaims will be dealt with initially, from which further features of possible embodiments of the invention result.

In one embodiment (Claim 2 and 18), a reference signal will be generated from each generated AC voltage or signal based thereon; for example, by a rectifier circuit located in the signal processing unit. The generation of a reference signal has the advantage that it can serve as a dynamic reference value or threshold value for the measurement signal. In this case, dynamic means that, at each point in time, the value for each weapon and even each signal will be determined individually. For example, a first time and a second time can then be determined, for example, by the signal evaluation unit on the basis of a comparison of the measurement signal and the reference signal; for example, by means of a comparison of the time courses. It is hereby exploited so that variations in the amplitude of the AC signal (e.g., by variations of the distances between the solenoid and coil or for the speeds) will amend the amplitude of the reference signal as well as of the measurement signal, although the ratio of the reference signal and the measurement signal remains the same.

In another embodiment (Claim 3), the voltage generating unit can comprise a minimum of two magnetic poles and a coil. In this case, the minimum of two magnetic poles can be arranged in succession in such a way that they move on a path which is relative to the coil in response to a shot being fired. Successive poles thereby each have opposite polarizations to each other. The poles can pass the coil successively in such a way that they induce oppositely directed voltages in the coil, one after the other, during a recoil travel and/or counterrecoil travel. Such voltage generation units are easy to manufacture and reliably provide suitable AC voltage signals.

In a further embodiment (Claim 4 and 19), the time points are determined according to when the measurement signal exceeds or falls below the reference signal or a threshold value which is derived therefrom. For example, the first time point can be determined according to when the measurement signal exceeds or falls below the reference signal or a threshold value which is derived therefrom. Furthermore, the second time can be determined according to when the measurement signal exceeds or falls below the reference signal or a threshold value which is derived therefrom again after the first time. The reference signal thereby serves as the dynamic reference value which is described above for the analysis of the measurement signal. The desired time points can therefore be determined in a simple way from the course of the two signals over time. For example, the duration of a period of the measurement signal can also be determined in this way. This is executed, for example, in the signal evaluation unit.

In a further embodiment (Claim 5 and 20), the speed of a moving part of the firearm during recoil and/or counterrecoil travel is determined using the measurement signal and the reference signal. For this purpose, the first time period and the second time period can be determined during a single recoil or a single advance of the moving parts of the firearm. Based on the determined time interval duration of the time interval, which is defined by these two instants and a length of a distance along which the alternating voltage of this time interval underlying the measurement signal is generated during the recoil travel and/or counterrecoil travel, then the speed of the moving weapon parts during this time interval can therefore be determined. For example, a corresponding first and a corresponding second position on a path along which the voltage generation unit generates the AC voltage underlying the measurement signal can be assigned to the first time and the second time via the measurement signal. The speed is then determined from the time interval duration and the distance between the first and second positions. The speed determination can be executed, for example, by the signal evaluation unit, with the duration being determined, for example, by one of the time determination units. In this way, the speed of, for example, the slide can therefore be determined for each shot which is fired, which is advantageous, for example, for monitoring, servicing and maintenance of the weapon.

In a further embodiment (Claim 21), the respective speeds of the moving weapon parts are determined during at least two successive time intervals and the acceleration of the moving weapon parts during their recoil or counterrecoil travel is determined from the determined speeds and a time interval between a minimum of at least two successive time intervals. In this way, the acceleration of the moving weapon parts can additionally be determined in a simple

manner from the signal which is already present, which enables conclusions to be drawn about the ammunition which has been utilized for example.

In another embodiment (Claim 6), the signal processing unit provides a supply voltage based on the AC voltages for operation of the signal analysis unit. This enables the entire firearm analysis device to be operated without batteries.

In a further embodiment (Claim 7 and 22), the reference signal is rectified e.g., during its generation. For this purpose, the signal processing unit comprises, for example, a rectifier circuit for rectifying the voltages. For example, the reference signal can therefore be distinguished from the measurement signal by the fact that it is not modulated or only slightly modulated and/or is non-periodic. A rectified reference signal can also advantageously be evaluated by signal evaluation units which can only detect direct currents. This is usually the case, for example, with microcontrollers. Finally, the rectified reference signal can also be utilized in order to supply DC current to the signal evaluation unit.

In a further embodiment (Claim 8 and 23), the measurement signal is half-wave rectified or non-rectified during its generation e.g., by the signal processing unit. It thereby remains distinguishable from the reference signal e.g., because it is modulated and/or non-periodic. Moreover, it still contains the phase information of the generated AC voltage. The half-wave rectification can be executed in this case, for example by the rectifier circuit utilized for rectifying the reference signal or parts thereof.

In a further embodiment (Claim 9 and 24), the reference signal is also added up during its generation. A voltage doubling circuit can therefore be utilized in this case. For example, the signal processing unit comprises a Delon circuit as the rectifying circuit for this purpose. In addition to rectifying, the Delon circuit also acts as a voltage doubler. The rectified signals are thereby additionally amplified.

In another embodiment, the time determination unit comprises a timer and a cycle source, wherein the timer determines durations via a number of the cycles and a time interval between the cycles. The time intervals and durations can therefore be determined in a simple and verified manner.

In a further embodiment, the time determination unit comprises a capacitor which is connected to a load, whereby the capacitor is charged during a recoil travel and/or counterrecoil travel by the AC voltage generated in the process and the durations are determined via the degree of

discharge of the capacitor. In this way, time measurement is possible over a certain period of time, even when the power supply is not present.

In a further embodiment (Claim 10 and 25), it will be determined whether a shot is fired in single fire or in continuous fire. For this purpose, for example, the time interval between individual firings can be determined. For example, by determining the first time as the end of a measurement signal which is generated during a preliminary firing and determining the second time as the beginning of a measurement signal generated during a recoil fire following this preliminary firing. The durations of the time periods defined by the first and second time points can subsequently determine the time interval between individual firings. The duration of the time interval as defined by the first time point and the second time point can then be utilized in order to determine whether a shot has been fired in continuous fire or single fire mode. This can be executed, for example, in the signal evaluation unit. In this case, it is determined that continuous fire is present when the time interval duration between the multiple counterrecoil travels or multiple recoil travels of moving weapon parts are below a time limit value or voltage limit value, and otherwise that single fire is present. Additional conditions can also be incorporated as criteria for the presence of continuous fire e.g., that the firearm can be fired in continuous fire and/or that several counterrecoil travels and recoil travels have been detected. In this way, information about the load on the firearm is accessible in a reliable and simple manner, e.g., for maintaining it.

In a further embodiment (Claim 11 and 26), time intervals are defined on the basis of the time interval limit value and/or a further time interval limit value. Based thereon, at least two different firing rates are determined in single fire and/or continuous fire. The determination is made based on which of these time interval intervals contains the time interval duration. This can all be done, for example, in the signal evaluation unit. This has the advantage that more detailed information is accessible e.g., for maintenance.

In a further embodiment (Claim 12 and 27), the measurement signal is digitalized. For example, it can be converted into a binary signal. This can be executed, for example, by the signal evaluation unit. In the presence of a reference signal, it can therefore be converted into a digital measurement signal e.g., according to the following rule:

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if (measuring signal  $\geq$  reference signal)
    digital measuring signal = 1
else if (measuring signal  $\leq$  U0)
    digital measuring signal = 0
else
    digital measuring signal = empty
where U0  $\leq$  minimum (reference signal).

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In this way, the phase information can be converted into a binary signal and thereby a quickly and easily readable signal, with which, for example, recoil travel and counterrecoil travel can be encoded. The distinction of the barrel direction can therefore be inspected via the binary signal or the resulting coding.

In one embodiment (Claim 13), the voltage generation unit uniquely codes the AC voltage it generates to the movable weapon part. For example, it can generate a signal uniquely by identifying the movable weapon part. For example, in a solenoid-coil arrangement, the magnets can be arranged in the movable weapon part and the number of magnets can therefore be indicative of the movable weapon part. Additional information about the firing and the weapons can therefore be obtained from the signal in a simple manner.

In one embodiment (Claim 28), the digital measurement signal is utilized in order to determine first and second time points. For example, a first time point is determined according to when the digital measurement signal amends from "0" or "empty" to "1", and a second time point is determined according to when the digital measurement signal amends from "1" or "empty" to "0". The first and second time points can advantageously also therefore be determined from the digital measurement signal.

In a further embodiment (Claims 14 and 29), the digital measurement signal is utilized in order to determine whether a recoil or an advance has been executed. For example, the sequence of signal sections in which the digital measurement signal is uninterrupted "1" or "0" can be used to determine whether the measurement signal is based on a counterrecoil travel or a recoil travel of the moving weapon parts e.g., by the signal evaluation unit. In this way, additional information can be obtained from the digital signal in a simple and reliable manner.

Another embodiment includes a cycle in order to determine the time and/or date a shot was fired. For example, a logbook can be maintained with the date and time of weapon use and the data obtained therefrom.

A further embodiment (Claim 15) comprises an acceleration sensor by means of which the acceleration of the counterrecoil travel and/or recoil travel of the moving weapon parts can be determined. In this way, the acceleration of the moving weapon parts can be determined in a simple and proven manner, which enables conclusions to be drawn about the ammunition which has, for example, been utilized.

Examples of embodiments of the invention are explained below with reference to the accompanying schematic drawings.

In the drawings shows:

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| FIG. 1 | A part of a firearm with a voltage generating unit; |
| FIG. 2a | A full voltage signal at the induction coil when the breech slide of the firearm is moved backwards with the voltage generating unit; |
| FIG. 2b | A complete voltage signal on the induction coil when the breech slide of the firearm is moved forwards with the voltage generating unit; |
| FIG. 2c | A voltage waveform with a complete signal at the induction coil when the firearm is fired with the voltage generating unit having a breech return signal and a breech advance signal; |
| FIG. 3a - 3d | Arrangements of magnets and coils for generating the usable voltages; |
| FIG. 4 | A circuit for generating, processing and evaluating the signals; |
| FIG. 5 | A circuit for generating, processing and evaluating the signals, in which a Delon circuit is utilized for signal processing; |
| FIG. 6 | A Delon circuit; |
| FIG. 7 | Sequences for a measurement signal and a reference signal as well as examples of first and second time points and the digitalization of the measurement signal; |

FIG. 8a and 8b The uniqueness of the digital measurement signal.

All figures utilize the same reference signs throughout for the same or similar elements. Explanations of one figure thereby also apply *mutatis mutandis* to the other figures.

The firearm analysis devices, which are described below, are basically suitable for analyzing and counting shots which are fire and other movements of firearm parts. For example, breech movements during manual loading or unloading of a firearm can also be detected, analyzed and, if desired, counted.

During analyzing, indicative parameters are determined for the firearm, especially for a movement of parts of the firearm. This includes, for example, parameters such as number of shots fired, time and date of firing, duration of firing, as well as speed, acceleration and time intervals of movements of parts of the firearm. Furthermore, cadences and firing modes (continuous fire, single fire) can be determined.

The firearms can be, for example, short weapons or long weapons. Within the scope of the following explanations, breechblocks, breech mechanisms and slides will serve as examples of weapon parts which move during firing, and grips or weapon housing elements will serve as examples of stationary weapon parts. In principle, all weapon parts which move relative to one another when a shot is fired can be utilized in order to generate signals. In particular, this includes, on the one hand, parts which move when the weapon is loaded or during any other comparable occurrence and, on the other hand, parts which therefore remain stationary relative to these. In this respect, the parameters which are determined also provide specific information about the respective moving weapon parts and the firearm analysis devices can thereby also serve as a sensor for data on the corresponding weapon parts e.g., for the slide.

In the embodiments described, the voltage generating unit can have alternating pole permanent magnets which are arranged in a row in a movable part of the firearm, for example in the slide or breech of the firearm. When the movable part moves forwards or backwards, then the permanent magnets therefore move with their alternating pole ends on a path which is relative to a stationary coil with a soft magnetic core arranged, for example, in the grip of the firearm. The permanent magnets pass through the coil sequentially and thereby induce an alternating voltage signal due to the alternating polarity.

Using the example of a shot counter as described in EP 3 140 605 B1 (Heckler & Koch GmbH) and which is shown in FIG.1, an example of a possible embodiment of a voltage generation unit will initially be explained.

The voltage generating unit 110, which is therefore indicated there comprises, for example, a first magnetic pole 113, a second magnetic pole 111, and a coil 114. The first and second magnetic poles 111, 113 are thereby arranged one after the other in such a way that they have opposite polarizations to one another and they move on a path which is relative to the coil 114 in response to a shot being fired. In doing so, they pass through the coil in succession in such a way that they induce voltages of opposite signs in the coil in succession during a recoil travel or counterrecoil travel, respectively. The first and second magnetic poles 113, 111 are arranged here in the slide 120 of the firearm 100. The soft magnetic core and the coil 114 are arranged in the grip 130. The soft magnetic core is configured with three prongs and the coil 114 is wound around the center prong.

More generally, any arrangement of two or more alternately poled permanent magnets is suitable. In particular, the arrangement can consist of an even number of $2N$ permanent magnets. More than one coil can be present also and the coil/coils can indicate other shapes.

Due to an even-numbered arrangement of the permanent magnets, two different voltage waveforms with oppositely oriented voltage amplitudes are induced when the slide moves forwards and backwards. Figures 2a and 2b show examples of such voltage characteristics during recoil travel and counterrecoil travel (FIG. 2a and 2b, respectively); here for the case of two permanent magnets and a coil with a soft magnetic core.

Figure 2a is a representation of the voltage waveform $U(t)$ over time of the voltage between a first coil terminal and a second coil terminal during a slide recoil which has been caused by a shot release. Before the first or second magnets move into the region of the coil 114, a voltage value U_0 is measurable. When the first magnet 113 enters the area of the center prong of the coil core, then the magnetic field alters there, inducing a first voltage swing U_1 . When the second magnet 111 subsequently enters the area of the center tine of the coil core, then the magnetic field is reversed by 180° , which induces a second voltage swing of U_2 . Due to the reversal of polarity, its course is opposite to that of the first voltage swing of U_1 and its amplitude, due to the greater relative alteration in field strength, is substantially greater than that of the first voltage swing of U_1 . In the embodiment shown, the amplitude of the second voltage swing U_2 is at least one and a half times greater than the amplitude of the first voltage

swing of U_1 . As soon as the magnets leave the area of the center prong of the coil core again, then the magnetic field in the center prong weakens. This renewed alteration in the field causes the third voltage swing of U_3 . However, since no polarity reversal is associated with the weakening, then the amplitude of the third voltage swing of U_3 is much smaller than the amplitude of the second voltage swing of U_2 . In the embodiment shown, the amplitude of the second voltage swing of U_2 is at least one and a half times as large as the amplitude of the third voltage swing of U_3 . After the third voltage swing of U_3 , the voltage returns to the permanent voltage value of U_0 .

The voltage curve of $U(t)$ also indicates smaller voltage swings of U_{01} , U_{30} . The first smaller voltage swing of U_{01} occurs when the first magnet 113 passes the front tine without coil windings. The second smaller voltage swing of U_{30} occurs when the second magnet 111 passes the rear tine without coil windings.

The voltage curve which is induced during the counterrecoil travel is quite analogous, but with the opposite sign. This is indicated with its corresponding voltage values of U_0 , U_4 , U_5 , U_6 , U_{04} and U_{60} in FIG. 2b.

In addition to the sign, the signals of the recoil travel and the counterrecoil travel also differ quantitatively in the magnitudes of the amplitudes and in their durations. This can be seen for example, in Fig. 2c. The signal resulting from a slide recoil is seen within a first-time range of t_1 and the signal resulting from a slide counterrecoil is seen within a second, later time range of t_2 . As one can see here, t_1 is therefore shorter than t_2 in this case. This is due to the fact that the recoil travel of the slide, which is caused directly by the firing, occurs at a higher speed than the counterrecoil travel which is caused by the slide spring. The faster recoil also provides faster amendments in the magnetic field and thereby higher induced voltages. Therefore, the voltage value U_2 is also higher than the voltage value U_5 .

Such induced signals can then be fed to a signal evaluation unit e.g., consisting of a microcontroller, for analysis. Before this, the signals can be further processed and/or pre-processed in one or more signal processing units, such as filter circuits, rectifier circuits or amplifier circuits.

Furthermore, if more than two solenoids 111, 113 are utilized, then the signal can be extended accordingly. A longer signal can, for example, be amplified by a circuit which cumulates the

voltage. A correspondingly long-lasting and strong signal can then also be utilized in order to supply voltage to additional components, e.g., e-paper displays.

Due to the manufacturing process, there can be varying distances located between the moving and stationary weapon parts during a movement. The distances can also vary from weapon to weapon. Since the magnetic field strength alters with the square of the distance, the signal strengths vary greatly depending on these tolerances. This can make reliable shot detection problematic. For example, required general signal thresholds can be difficult to establish reliably due to signal variations. And, for example, due to the aforementioned signal fluctuations, a general tolerance setting of signal thresholds to determine possible shot releases or manual through-loads is difficult to implement in practice. In addition to the fluctuations, the signal can be too weak overall due to too large distances. Ultimately, therefore, signal fluctuations must either be reduced and/or the required threshold values must be determined dynamically i.e., taking individual signal fluctuations into account. In addition, or possibly independently of this, it must therefore always be ensured that the measured signals are sufficiently strong for a meaningful measurement.

Theoretically, permanent sliding contacts or spring-loaded contacting signal generating elements can be utilized. They would retain the distances between the permanent and coil cores and thereby their tolerances, which enter into the signal intensity precisely as the square of their distances, sufficiently constant and also low. In practice, however, this would require considerable additional design effort.

One advantageous manufacturing solution for increasing the induced voltages is to arrange several rows of permanent magnets in parallel i.e., next to each other. In particular, 2N permanent magnets can be utilized. In this case, the coil with a three-angled soft magnetic core, which has already been explained for FIG 1, would be rotated by 90°. For example, if difficulties arise in the arrangement of the signal-generating magnets as indicated in FIG. 1 due to large or varying distances between the signal-generating magnets and coils caused by the equipment, then the magnets can therefore be assembled in several parallel rows with alternating polarities on the moving part of the shot counter device.

FIGURES 3a-d indicate some examples of the arrangement of a coil with a three-angled magnetizable core and a row of alternately poled permanent magnets. The signal can be amplified and prolonged by extending the series with additional soft magnets. If the induced voltage is also utilized in order to operate the signal evaluation unit, e.g., a microcontroller, as

explained e.g., in EP 3 140 605 B1 (Heckler & Koch GmbH), then the duration of the available operating voltage will depend on the number of magnets arranged in series. The more magnets which are arranged in series, the longer the signal duration and thereby the duration of the available operating voltage for signal processing.

FIG. 3a schematically indicates four alternately poled permanent magnets 301 – 304, which are arranged in series, sweeping over a coil with a three-pronged core. The tines 321 - 323 are arranged in a horizontal direction. Each rectangle represents one tine 321 - 323 as viewed from above. The magnets sweep over the coil in the direction of the arrow. By arranging the magnets in a row, the induced signal is extended, but still not yet amplified.

FIG. 3b schematically indicates an arrangement in which the rows of permanent magnets are arranged in the vertical direction, i.e., parallel. There are a total of twelve permanent magnets 301 - 312 in this instance, with the polarity alternating both horizontally and vertically. The coil with a three-pronged core is rotated by 90° here, so that the prongs 321 - 323 are arranged along the vertical direction. The tines of the core are swept over simultaneously by three magnets respectively. This thereby increases the field strengths of the magnetic fields which are generated in the core. This also increases the voltages induced in the coil and thereby the signal strengths. In this way, larger distances between the permanent magnets and the coil can be achieved without the signal being too weak.

FIGURES 3c and 3d schematically indicate variations of the arrangement shown in FIG 3b with only two rows and eight permanent magnets respectively.

The specific arrangement of permanent magnets can also be utilized, for example, in order to identify the weapon parts in, or on, which they are arranged. For example, different breech systems can be coded and thereby identified by a corresponding selection of permanent magnets and lengths of permanent magnet arrangements. For example, FX or UTM practice breech systems whose breeches differ from standard live-fire breech systems are utilized in realistic practice with paint-marked ammunition. These can have, for example, longer or shorter arrays of permanent magnets. For example, the standard slide can include four permanent magnets, while the practice slide can include five or six. Another way to differentiate this is to use magnets of different sizes and strengths and code different closures over them. Both approaches can also be combined. For example, an odd number with $2N+1$ for the magnets can be utilized and the additional $(2N+1)$ th magnet can be selected to be much smaller or weaker, for example, or its distance from the magnet in front of it cannot match the distance between the other

magnets. The signal of this magnet is recognizable in the overall signal, so that the distinction between counterrecoil and recoil travel still remains possible despite an odd number of magnets. In a microcontroller which is utilized for signal evaluation, these slide codings can subsequently be stored accordingly for recognition and evaluation.

In addition to the measurement signal, a reference signal can be generated which can be incorporated, for example, as a dynamic threshold value, i.e., one which is thereby dependent on the course of time and the individual geometries. This and other aspects of the invention will be explained in the following.

FIG. 4. shows a block diagram of an example circuit for generating a measurement voltage IN_+ and optionally an additional reference voltage V_{in} , which are supplied to a signal evaluation unit 420. In this case, an AC voltage of U_e is generated by a voltage generation unit 401, in this example inductively by a coil. Measurement signals and reference signals are generated therefrom in a signal processing unit 410. The signal processing unit 410 can comprise, for example, only an ADC and a rectifier circuit for rectifying voltages and/or can comprise further elements. Utilizing a rectifier, for example, means that the measurement signal IN_+ can be half-wave rectified and the reference signal V_{in} can be rectified. By means of the ADC, signals which can be processed for the signal evaluation unit 420 can then be generated from the IN_+ and V_{in} , and these signals can be evaluated in the signal evaluation unit 420.

Additionally, as shown in FIG. 4, one or more time determination units 450 can be provided. These can be utilized in order to measure the elapsed times between different points in time.

In one embodiment, one of the timing units comprises, for example, an internal or external cycle source in combination with a timer. The timer hereby counts the cycles and knows the time intervals between the individual cycles. It can then calculate a time from this.

One of the timing units can also include a capacitor which discharges in a defined manner across a load. In this case, the capacitor charges electrically with each shot signal via the AC voltage U_e generated during a recoil travel and/or counterrecoil travel and is then rectified, and discharges in a defined manner via the load, e.g., a resistor. The capacitor thereby discharges continuously across the load even when the signal evaluation unit 420 no longer has an operating voltage available. As soon as the signal evaluation unit 420 is supplied with a supply voltage again after a shot being fired, then it measures the voltage at the capacitor by means of

an analog-digital converter and evaluates it. The time intervals/time durations are thereby estimated via the degree of discharge of the capacitor or the voltage at the capacitor.

In addition, the output voltage U_e can be used to generate a supply voltage V_{cc} for operating the signal evaluation unit 420 and the time calculation unit 450.

FIG. 5 indicates an embodiment in which the signal processing unit 410 for rectification comprises a voltage multiplier circuit, in particular a signal doubling circuit, especially a Delon circuit.

FIG. 6 indicates such a Delon circuit 600. The Delon circuit consists of two diodes D1 and D2 respectively (one-way rectifier circuits), as well as two capacitors C1 and C2, with a load (not represented) which is connected downstream. Now, when a time-limited AC signal (e.g., one induced during a shot being fired) U_e is coupled into the Delon circuit, then the following occurs:

Diode D1 generates a pulsating DC voltage from the positive half-wave of the AC voltage signal U_e . Diode D2 generates a pulsating DC voltage from the negative half-wave of the AC voltage signal. The reverse voltage of the two diodes D1 and D2 must be at least twice as large as the peak value of the coupled AC voltage signal. The two capacitors C1 and C2 are thereby alternately charged, almost to the peak value of the AC voltage signal U_e . The rectified voltage U at the output of the two diodes D1 and D2 must be at least twice as high as the peak value of the coupled AC voltage signal. The rectified voltage U_a at the output of the Delon circuit is then approximately twice the peak value of the coupled AC voltage signal in the unloaded case.

Returning to FIG. 5, when the coil is swept over by the 401 alternately poled permanent magnets, then an AC voltage U_e is induced in the coil. In the following, the U_e measurable signal directly at the coil 401 as an AC voltage U is referred to as the base signal/output signal IN_0 . The qualitative curve of IN_0 is indicated in Plot 531. The measurement signal IN_+ and the reference signal V_{in} are subsequently generated from IN in the signal processing unit 410. The qualitative progressions of IN_+ and V_{in} are indicated in Plots 533 and 535. In addition, in this example, a linear regulator is utilized in order to generate a 540-operating voltage V_{cc} for operating the signal evaluation unit 420.

In order to be able to generate the reference signal V_{in} , the voltage is tapped via both diodes D151 and D251. It corresponds to the sum of the voltages which are to be applied to the capacitors C511 and C512 and would theoretically increase with each half-wave until both

capacitors are completely charged. The base signal IN_0 is therefore rectified and added up in the usual way at the Delon circuit. The voltage would theoretically be doubled. In practice, however, when each of the diodes D511 and D512 is passed through, then there is a voltage loss ΔU , e.g., 0.3 V, which depends on the diode. The voltage of the signal present after passing through the Delon circuit is therefore reduced by $2x\Delta U$, in this case e.g., by 0.6 V. The reference signal V_{in} can be additionally reduced to a lower voltage by means of a voltage divider following the Delon circuit.

To generate the measurement signal IN_+ , in this embodiment example the basic signal IN_0 is half-wave rectified in the signal processing unit 41, whereby additional, ongoing signal processing steps are possible before or after this. This means that a pulsating signal IN_+ is generated from the AC voltage signal IN_0 , in which only the half-waves with negative or positive voltage amplitudes are included. For example, as shown in FIG. 5 only the voltage applied to diode D512 is tapped for the measurement signal IN_+ . A voltage is therefore present there only for negative half-waves, while no voltage is present for positive half-waves due to diode D512 being switched to through flow forwards. This produces a half-wave rectified measurement signal IN_+ which is added by the capacitors C511 and C512. Since IN_+ is tapped at only one diode, namely D512, its voltage during the negative half-waves is ΔU greater than that of the reference signal V_{in} tapped across both diodes. In some embodiments, the measurement signal IN_+ can still be brought to a lower voltage by means of a voltage divider which is not represented here. Again, the ratio of the resistors of the voltage divider must be selected so that the peak value of IN_+ does not become larger than the supply voltage V_{cc} to ensure that the signal IN_+ is within the voltage range detectable by the ADC.

In this embodiment, the voltage tapped across the two diodes D511 and D512, and/or across the two capacitors C511 and C512, is also regulated to 540 for an operating voltage V_{cc} , for example 3.3 V, by means of the linear regulator. V_{cc} is then utilized in order to operate the signal evaluation unit, which can in particular comprise a microcontroller. As soon as V_{cc} is greater than the voltage value which is required to operate the signal evaluation unit, for example 1.8V, then the signal evaluation unit becomes active and measures the voltages IN_+ and V_{in} . This measurement can be executed, for example, via an internal analog-to-digital converter (ADC) of the signal evaluation unit.

There is a voltage interval of V_{cc} within which the detection of the breach movement takes place. The power generation that continues after this interval and after detection is complete is

utilized in order to operate the signal evaluation unit and its associated equipment until all specified shot analysis functions have been concluded.

The length of this interval is determined by the time at which the signal evaluation unit 420 receives sufficient energy in order to commence signal sampling and evaluation and the time at which the measurement signal definitely falls below the reference signal. This point in time is reached when the time intervals between the amplitude lows and amplitude highs, i.e., the edge widths between these amplitude positions are exceeded by a certain period of time (e.g., twice the duration of the two largest edge widths is exceeded).

If, as described above, V_{in} passes through a voltage divider, then the ratio of the resistors of the voltage divider must be selected in such a way that the peak value of V_{in} does not become greater than the supply voltage V_{cc} . This ensures, for example, that for sampling the signal, V_{in} is within a voltage range detectable, for example, by an ADC of the signal evaluation unit 420.

FIG. 7 now graphically illustrates how a comparison of the measurement signal IN_+ and the reference signal V_{in} is utilized in order to determine points in time which are indicative, for example, of a counterrecoil or recoil of the breech of a weapon. In principle, for the procedure described, the measurement signal needs only to oscillate and need not necessarily be half-wave rectified, as shown in FIG. 7. The measurement signal can therefore in principle also comprise half-waves with negative and positive half-waves.

The time points t_{701} - t_{706} and t_{711} - t_{714} which are indicated in FIG. 7 are determined as follows:

At times t_{701} , t_{703} and t_{705} , the measurement signal IN_+ exceeds the reference signal V_{in} . In the signal waveforms which are indicated in FIG. 7, this corresponds to the points at which the initially smaller measurement signal crosses the initially larger reference signal. At times t_{702} , t_{704} and t_{706} , the measurement signal falls below the reference signal or a threshold voltage U_0 . Which is derived from it. In the signal characteristics indicated in FIG. 7, this subsequently corresponds to the points at which the initially larger measurement signal crosses the initially smaller reference signal. Furthermore, time points t_{711} - t_{714} can be determined between which the measurement signal is smaller than and/or equal to a an additionally predetermined threshold value. In the signal waveforms which are indicated in FIG. 7, the threshold value is zero and time points t_{711} and t_{713} correspond to the points at which the initially larger

measurement signal becomes zero, and time points t_{712} and t_{714} correspond to the points at which the measurement signal becomes greater than zero.

The threshold voltage U_0 thereby serves as a predeterminable threshold value and is in any case less than, or equal to, the minimum value of the reference signal.

The time intervals between two points in time, and/or the elapsed time durations (time segment durations) of the time segments which are defined by the first and second points in time, can be determined by utilizing one of the time determination units 450 described above.

For example, the pass-through duration, i.e., the temporal pass-through length of the determined signals, can be determined. For example, the first time point t_{701} , the respective moment at which the measurement signal, i.e., the first amplitude of this signal, is greater than the reference signal for the initial time, can be selected, and the second time point t_{706} , the moment at which it is definitely lower than the reference signal and remains so, can be selected. The difference in time of these two time points therefore gives the pass-through time mentioned above. Alternatively, the second time point t_{706} can also be determined, for example, as in the case of the voltage interval of V_{cc} described above within which the detection of the slide movement takes place, and/or the first time point t_{701} can also be defined, for example, by the time point at which the operating voltage becomes greater than the voltage value which is necessary for the operation of the signal evaluation unit. If the length of the path along which the alternating voltage U_e on which the measurement signal IN_+ is generated is known, then the average speed of a recoil travel or counterrecoil travel can be determined from this together with the pass-through time.

In another example, the time intervals between two successive positive edges can alternatively or additionally also be determined for speed determination. In FIG. 7, this corresponds, for example, to the time points t_{701} (first time) and t_{703} (second time) or t_{703} (first time) and t_{705} (second time). The time interval between these first and second time points subsequently corresponds approximately to one period of the AC voltage U_e . In the case of the solenoid-coil arrangements for voltage generation which is described in FIGURES 3a-d, for example, one period corresponds exactly to one sweep of the coil by two successive permanent magnets. Again, if the distances d and widths x of the magnets are known, then the speed during this period can be determined, e.g., via:

$$v = \frac{2x + 2d}{t_{705} - t_{703}}.$$

Preferably, the speed is estimated by the distance between two magnets and the time interval:

$$v = \frac{d}{t_{705} - t_{703}}.$$

Analogously, the time intervals between negative edges over the time points t_{702} , t_{704} and t_{706} or the time intervals between time points t_{711} and t_{713} or t_{712} and t_{714} can also be utilized.

From several speeds which are determined in this way and which belong to successive time periods/time intervals, an average speed of movement or even the acceleration of the respective slide movement can be estimated. The acceleration is determined over at least two speeds and the time intervals between the associated time segments; For example, in the case of two speeds in accordance with

$$a = \frac{dv}{dt} \approx \frac{v(t_2) - v(t_1)}{t_2 - t_1}.$$

Generally speaking, if the distance and length of the voltage-generating part of the voltage-generating unit 110 are known, then the duration of the signal or the durations of individual signal sections can be utilized in order to determine the speed and, if necessary, the acceleration with which the voltage-generating part of the weapon moves during firing or manual reloading. This makes it possible, for example, to distinguish between the fast movements of the breech block during firing and the slower movements during manual reloading. The acceleration can also be utilized in order to determine the propellant charge which is used.

In one embodiment, a battery-independent or also battery-dependent acceleration sensor is provided in the firearm analysis device in addition to, or as an alternative to, the measurement of the acceleration of the breech movement which is described above.

Until now, one problem encountered with battery-free shot counters with regard to the measurement of dynamic accelerations on the weapon by means of sensors was that these accelerations could not be measured and registered because the signal evaluation unit can still have been deenergized at the time the signal was generated.

In one embodiment, this problem is solved by temporarily storing the acceleration signal in a charging capacitor until the signal evaluation unit has been supplied with sufficient current in order to evaluate the stored acceleration signal.

Based on the measured acceleration, the firing of different types of ammunition (combat ammunition, manoeuvre ammunition, training ammunition) can be detected and, if necessary, stored. This can be executed, for example, on the basis of the different acceleration pulses of moving parts such as the breech or the different recoil pulses on the overall system.

In a further embodiment, the measurement signal is converted into a digital measurement signal dIN_+ . This can be implemented, for example, according to the rule

```

if ( $IN_+ \geq V_{in}$ )
     $dIN_+ = 1$ 
else if ( $IN_+ \leq U_t$ )
     $dIN_+ = 0$ 
else
     $dIN_+ = \text{empty},$ 

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where U_t minimum (V_{in}), happens.

In a further embodiment, a digital measurement signal dIN'_+ is generated according to the rule

```

if ( $IN_+ \geq V_{in}$ )
     $dIN'_+ = 0$ 
else if ( $IN_+ \leq U_t$ )
     $dIN'_+ = 1$ 
else
     $dIN'_+ = \text{empty}$ 

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FIG. 7 illustrates both exemplary principles. If the measurement signal is greater than or equal to the reference signal, then the digital measurement signal has the value 1 (and/or 0) in this time interval. If the measurement signal is smaller than a threshold voltage U_0 , then the digital

measurement signal has the value 0 (and/or 1) in this time interval. The threshold voltage of U_0 serves as a predeterminable threshold value and is, in any case, smaller than or equal to the minimum value of the reference signal. In all other cases, no value is assigned to the digital measurement signal. In FIG. 7, this is indicated by shaded and non-shaded blocks. The durations of the signal intervals (width of the blocks) during which the digital measurement signal is 1 or 0, and if necessary, possibly also during which no value is assigned to it (empty), can again be determined, for example, via the time points t_{701} - t_{706} or t_{711} - t_{714} . For example, the time points t_{701} , t_{703} and t_{705} can be determined via the time points at which the digital measuring signal $dIN+$ alters from "0" or "empty" to "1", and the time points t_{702} , t_{704} and t_{706} via the time points at which the digital measuring signal ($dIN+$) alters from "1" or "empty" to "0".

In one embodiment, the sequence of digits, i.e., the zeros and ones of the respective measured signal can be utilized in order to determine whether the slide is located in recoil or counterrecoil. This is because if the poles of the respective magnets facing the coil and the sign of the voltage they induce when sweeping the coil are known, then the measured 1-0 sequence unambiguously identifies whether a counterrecoil travel or recoil travel is present. If the recoil travel leads to sequence 10101, as shown in FIG. 8a, then the counterrecoil travel will necessarily lead to sequence 01010, as shown in FIG. 8b, which is the inverse of this sequence. Advantageously, such identification of the direction of movement of the slide can be determined even when the signal evaluation unit was unable to acquire the signal completely, for example because the operating voltage required for signal evaluation was not reached until later. This is illustrated by FIG. 8a and 8b, in which it can be seen that the sequence of digits which is typical of a direction of travel is suitable for determining the direction of travel down to a minimum number of three digits. It is therefore possible to determine unambiguously, with only three digits of the digital measurement signal, whether a counterrecoil travel or recoil travel took place. Depending on when the signal was registered, a recoil travel will lead to the sequences 10101, 0101 and 101 and a counterrecoil travel will lead to the sequences 01010, 1010 and 010. If, for example, the voltage generation for the signal evaluation unit is delayed or if it ramps up too slowly for whatever reason, then a certain characteristic minimum section of the signal will be sufficient in order to determine the direction of travel, even after the start of the signal has not been registered. By determining these at least three end digits as a direction-specific signal, one can prevent false messages or no messages for signal detections.

In further embodiments, the signal evaluation unit determines whether a shot was fired in single fire or continuous fire. In addition, it is also possible to determine the various cadences/firing

rates in single fire. For this purpose, for example, predetermined time limit values, which are e.g., based on measured values determined in the laboratory, can define time intervals/time limit intervals. The interval within which the determined duration lies will subsequently determine whether continuous fire or single fire is present, and/or also the firing rate. The following examples illustrate this procedure.

Example 1: One timed limiting value, automatic weapon. If the duration is located above the limit (time interval 1), then single fire is assumed; if it is located below the limit (time interval 2), then continuous fire.

Example 2: One timed limiting value, semi-automatic weapon. If the duration is located above the limit (time interval 1), then slow single fire is assumed; if it is located below the limit (time interval 1), then rapid single fire.

Example 3: Two timed limiting values, automatic weapon. If the duration is located above the second, larger limiting value (time interval 1), then slow single fire is assumed. If it is located between the first and the second limiting value (time interval 2), then rapid single fire is assumed. If it is located below the limiting value (time interval 3), then continuous fire is assumed.

Instead of a timed limiting value and time durations, a voltage limit value and measured voltage values can also be utilized, depending on the embodiment and/or the time determination unit which are utilized.

In order to determine the duration, for example, for the end of the measurement signal generated during the counterrecoil from a first shot as the first time and the beginning of the measurement signal generated during the recoil of a second, subsequent shot as the second time. From the duration between the first and second time point, the time interval between individual shot firings can be inferred and from this the firing mode and possibly also the firing rate.

In one embodiment, the timing determination unit described above, comprising a cycle source and timer, determines the duration between the first and second time points.

In another embodiment, in order to determine single-fire or continuous-fire sequences, the timing unit described above, comprising a capacitor and a resistor, is integrated after rectification of the signal. As described, the capacitor charges when a shot is fired and then discharges continuously through the resistor. Depending on the state of charge of the capacitor

when the signal evaluation unit is reactivated during the subsequent firing, the delivery of single fire (long sequences or pauses lead to lower state of charge) or continuous fire (very short sequences lead to higher state of charge) can be determined. Theoretically, the degree of discharge can be converted into a time value. However, the detour via a time value determination need not be taken and the voltage values which are applied to the capacitor can be utilized directly. They then represent a corresponding time value without having to calculate it explicitly. For example: if the voltage value in the capacitor falls below a specified threshold value, then this can be evaluated as a firing sequence in single fire when the discharge time of the capacitor with resistor is known. If the voltage value in the capacitor does not fall below the threshold value, then this can be evaluated as a shot sequence in continuous fire.

Another embodiment distinguishes single fire sequences or continuous fire sequences by the following devices and methods:

If the alternatively poled magnets brush over the stationary coil, then the induced voltage will supply the signal evaluation unit, e.g., consisting of a microcontroller, and the upstream capacitors with energy. If the operating voltage is sufficient, then the signal evaluation unit is ready for operation and is in an active mode. In this mode, it will evaluate the AC voltage signal as described, then it activates an internal or external cycle source, as well as a timer and configures an interrupt-capable pin, e.g., of a microcontroller.

The signal evaluation unit is then set to a low-power mode in which it requires only a fraction of the current and can thereby remain active for a relatively long time during the slide cycle. In low-power mode, the signal evaluation unit is supplied with electrical energy exclusively from pre-charged backup capacitors.

After a recoil travel, it therefore remains active until the voltage is induced again during the subsequent counterrecoil travel in order to operate the signal evaluation unit. The renewed voltage induction is subsequently communicated to the signal evaluation unit via an additional synchronization circuit. The synchronization circuit can, for example, apply a voltage to the interrupt-capable pin, whereupon this generates an interrupt in the signal evaluation unit and the signal evaluation unit alters from low-power to active mode again.

While the signal evaluation unit is located in low-power mode, the timer counts the cycles of the cycle altered source. Since the cycle frequency of the cycle source is known, the signal evaluation unit can convert the number of cycles retrieved by the timer into a time value.

This happens as soon as it is again supplied with an operating voltage by a shot signal and has altered to the active mode so that it can utilize the counted cycles of the timer. In this way, the signal evaluation unit determines the time between two active phases and can therefore determine the different firing sequences.

When using a low-power mode, two basic scenarios can occur:

If the time between two shots is short enough, then the voltage in the back-up capacitors is sufficient in order to retain the signal evaluation unit in low-power mode until the next shot signal. A synchronization circuit subsequently generates a voltage at an interrupt-capable pin. As soon as the voltage is generated at the interrupt-capable pin in low-power mode, then an interrupt signal is generated, which informs the signal evaluation unit of the presence of a new shot signal. The signal evaluation unit subsequently switches back to active mode and starts measuring and evaluating the AC voltage signal as described above.

One advantage of this low-power circuit is therefore that the signal evaluation unit remains permanently activated during slide recoil and slide counterrecoil, and this activation is not interrupted and has to be restarted.

In the second case, the time between two shot signals is so far apart that the charge of the back-up capacitors is not sufficient to permanently supply the signal evaluation unit. In this case, the operating voltage would be below the minimum voltage which is required for proper operation and the signal evaluation unit is deactivated. At the next shot signal, the signal evaluation unit is started with a hardware reset.

The difference for whether switching to the active mode from a low-power mode or from the off-state will be executed is detected by means of an internal register of the signal evaluation unit.

Another embodiment uses these both scenarios in order to distinguish between continuous fire and single fire. In the extremely short firing cycles of a continuous fire, in contrast to single fire, the signal evaluation unit can remain active in low-power mode even during the slide counterrecoil and until the next shot is fired and is continuously ready. This permanent activation over several firing cycles subsequently serves as a distinguishing feature between continuous fire and single fire, since in the latter, the activation will usually be interrupted. In addition, the times which go beyond one firing cycle can also be measured in this way.

The result with this solution, is directly a time (cycles). In addition, an activation after an off-state can be concluded to a slow rate of fire in the single fire.

In another embodiment, the shot analysis system described is peripherally equipped with a battery and an additional cycle for integrating a time stamp. In this way, all activities in the shot analysis system which is associated with the measurement signal can be verified with time accuracy, in particular the date and time at which the registered shots took place. By using a battery exclusively for the time measurement, batteries with only very small capacities and small external dimensions are required, which furthermore guarantee a reliable power supply for this real-time measurement, even after years or even decades. If such a battery fails, then all other described functions of the shot analysis system can still be guaranteed.

List of references

100	Firearm
110, 401	Voltage generation unit
111,113, 301-312	Permanent magnets
114	Coil
120	Slide
130	Grip, receiver
U0	Voltage value
U1, U4	First voltage swing
U2, U5	Second voltage swing
U3, U6	Third voltage swing
U01, U30, U04, U60	Smaller voltage swings
t1, t2	Time range
321-323	Tines
301-312	Permanent magnet
Ue	AC voltage
IN+	Measuring voltage, measuring signal
Vin	Reference voltage, reference signal
Vcc	Supply voltage
dIN+, dIN'+	Digital measuring signal
410	Signal processing unit
450	Time determining units
420	Signal evaluation unit
600	Delon circuit
D1, D2, D511, D512	Diode
C1, C2, C511, C512	Capacitor
531, 533, 535	Plot
540	Linear regulator
Ua	Rectified voltage
t70-t706, t711-t714	Time points

Claims

1. Firearm analysis device for determining parameters as indicative of a firearm (7) which has fired a shot, comprising

a voltage generating unit (401) arranged to generate an alternating voltage (U_e) during a counterrecoil travel and/or recoil travel of a movable weapon part (120) during a firing operation,

characterized by:

- a signal processing unit (410) which is arranged to generate a measurement signal (IN_+) from the generated AC voltage (U_e),
- a signal evaluation unit (420), which is arranged to determine a first and a second time point (t_{701} - t_{705} , t_{702} - t_{706}) during the counterrecoil travel and/or recoil travel of the movable weapon part (120), and
- a time determination unit (450) arranged to determine a time interval duration between the first and second time points (t_{701} - t_{705} , t_{702} - t_{706}).

2. The firearms analysis device according to Claim 1, whose signal processing unit (410) is also set up to generate a reference signal (V_{in}) from the generated AC voltage (U_e), and whose signal evaluation unit (420) is set up to determine the first and second time points (t_{701} - t_{705} , t_{702} - t_{706}) on the basis of a comparison of the time characteristics of the measurement signal and the reference signal (IN_+ , V_{in}).

3. A firearm analysis device according to Claim 1 or 2, whereby the voltage generating unit (401) of which comprises

at least two magnetic poles (113, 111); and

a coil (114);

wherein the at least two magnetic poles (113, 111) are arranged in succession in such a way as to move in a path which is relative to the coil (114) in response to firing a shot, whereby successive poles each having opposite polarizations to each other passing the coil (114) in succession so as to induce alternating voltages in the coil (114) during a recoil travel and counterrecoil travel respectively.

4. A firearm analysis device according to any one of the preceding claims, the signal evaluation unit (420) of which is arranged,

in order to determine the first time point (t_{701} - t_{705}) according to when the measurement signal (IN_+) exceeds or falls below the reference signal (V_{in}) or a threshold derived therefrom, and

to determine the second time point (t_{702} - t_{706}) according to when the measurement signal (IN_+) again exceeds or falls below the reference signal (V_{in}) or a threshold derived therefrom.

5. A firearm analysis device according to any one of the preceding claims, the signal evaluation unit (420) of which is arranged,

in order to determine the first time point (t_{701} - t_{705}) and the second time point (t_{702} - t_{706}) within the measurement signal (IN_+) of a single recoil travel or a single counterrecoil travel of the movable weapon part (120),

assigning to the first (t_{701} - t_{705}) and the second time point (t_{702} - t_{706}), on the basis of the measurement signal (IN_+), a corresponding first and a corresponding second position on a path along which the voltage generating unit (401) generates the AC voltage (U_e) underlying the measurement signal (IN_+), and

determining the speed of the movable weapon part (120) during recoil travel or counterrecoil travel from the time interval duration which is determined by the time determination unit (450) and the distance between the first and second positions.

6. A firearm analysis device according to any one of the preceding claims, the signal processing unit (410) of which provides a supply voltage (V_{cc}) based on the AC voltages (U_e) for the operation of the signal evaluation unit (420).

7. A firearm analysis device according to any one of the preceding claims, the signal processing unit (410) of which comprises a rectifier circuit for rectifying voltages with which it rectifies the reference signal (V_{in}) during its generation.

8. A firearm analysis device according to Claim 7, whose signal processing unit (410) is arranged to half-wave rectify the measurement signal (IN_+) by means of the rectifier circuit or parts thereof during its generation.

9. A firearm analysis device according to Claim 7 or 8, whereby the rectifier circuit of which is a voltage multiplier circuit, in particular a Delon circuit (600).

10. A firearm analysis device according to any one of the preceding claims, the signal evaluation unit (420) of which is arranged,

determining a time interval between two successive counterrecoil travels or recoil travels over the time interval duration which is determined by the time determination unit (450), the first time point (t_{706}) corresponding to an end of the measurement signal (IN_+) generated during a counterrecoil travel and the second time point (t_{701}) corresponding to a beginning of the measurement signal (IN_+) generated during a recoil travel following this counterrecoil travel, and

determining, on the basis of the time interval between two successive counterrecoil travels or recoil travels, whether a shot has been fired in continuous fire or single fire, determining that

the firing has occurred in continuous fire when the time interval between multiple pre-counterrecoil travels or multiple recoil travels is below a predetermined time interval limit, and

in all other cases, that the shot was fired in single fire.

11. A firearm analysis device of Claim 10, wherein the signal evaluation unit (420) thereof is adapted to determine firing rates whereby

it is based on the time interval limit value and/or at least one additional time interval limit value, at least a two-time interval is defined, to each of which a firing rate can be assigned, and

determines in which of these time interval intervals the time interval lies.

12. A firearm analysis device according to one of the preceding claims, whose signal evaluation unit (420) is set up to convert the measurement signal (IN_+) into a digital measurement signal (dIN_+) according to the following rule when a reference signal (V_{in}) is present:

if (measuring signal $\geq$ reference signal)

digital measuring signal = 1

else if (measuring signal $\leq U_0$)
 digital measuring signal = 0
 else
 digital measuring signal = empty

where $U_0 \leq$ minimum (reference signal).

13. A firearm analysis device according to any one of the preceding claims, the voltage generating unit (401) of which is arranged in such a way to generate a signal uniquely identifying the movable weapon part.
14. A firearm analysis device according to Claim 12 or 13, the signal evaluation unit (420) of which is set up to determine, on the basis of the sequence of signal sections in which the digital measurement signal (dIN₊) is "1" or "0", whether the measurement signal (IN₊) is based on a counterrecoil or a backward travel of the movable weapon part (120).
15. A firearm analysis device according to any one of the preceding claims, comprising an acceleration sensor by means of which the acceleration of the counterrecoil travel and/or recoil travel of the movable firearm part (120) can be determined.
16. A firearm comprising a firearm analysis device according to any one of the preceding claims.
17. Method for determining parameters indicative of a firearm (7) from a shot which has been discharged, comprising:
 - Detection of alternating voltages (U_e) generated during a counterrecoil travel and/or recoil travel of the movable weapon part (120) during a firing operation;
 characterized by:
 - Providing at least one measurement signal (IN₊) which is based on the generated AC voltages (U_e);
 - Determining at least first and second time points (t701 -, t706) of counterrecoil travel and/or recoil travel of the movable weapon member (120); and,
 - Determining at least one time interval duration between the first and second time points (t701 - t705, t702 - t706).
18. Method according to Claim 17 comprising,

providing a reference signal (V_{in}) which is based on the generated AC voltages (U_e), wherein the first and second time points ($t_{701} - t_{705}$, $t_{702} - t_{706}$) are determined from a comparison between the measurement signal (IN_+) and the reference signal (V_{in})

19. Method according to Claim 18, further comprising,

determining the first time point ($t_{701} - t_{706}$), based on a time at which the measurement signal (IN_+) exceeds or falls below the reference signal (V_{in}) or a threshold derived therefrom, and

determining a second time point ($t_{701} - t_{706}$), based on a time point at which the measurement signal (IN_+) again exceeds or falls below the reference signal (V_{in}) or a threshold derived therefrom after the first time point ($t_{701} - t_{706}$).

20. Method according to Claim 19, further comprising,

determining the first and second time points ($t_{701} - t_{705}$, $t_{702} - t_{706}$) within the measurement signal (IN_+) of a single recoil travel and/or a single counterrecoil travel of the movable weapon part (120), and

determining the speed of counterrecoil travel and/or recoil travel of the movable weapon part (120) by means of the previously determined time interval duration between the first and the second time points ($t_{701} - t_{705}$, $t_{702} - t_{706}$) and the length of the path along which the AC voltage (U_e) underlying the measurement signal (IN_+) is generated.

21. Method according to Claim 20, further comprising,

determining at least one further first point in time and at least one further second point in time within the measurement signal (IN_+) of the recoil travel or counterrecoil travel of the movable weapon part (120), and

determining the respective speeds of the movable weapon member (120) during at least two successive time periods which have been defined by the first and second time points and by the, at least, one further first time point and the, at least, one further second time point, and

determining the acceleration of the movable weapon part (120) during its recoil travel or counterrecoil travel from the determined speeds and a time interval between the, at least, two successive time intervals.

22. Method according to any one of the preceding method claims, in which a signal based on the AC voltages (U_e) is rectified in order to generate the reference signal (V_{in}).

23. Method according to any of the preceding method claims, in which a signal based on the AC voltages (U_e) is half-wave rectified in order to generate the measurement signal (IN_+).

24. Method according to Claim 22, wherein a signal based on the AC voltages (U_e) is added in order to generate the reference signal (V_{in}).

25. Method according to any one of the preceding method claims, further comprising:

determining the end of a measurement signal (IN_+) which is generated during a counterrecoil travel as the first time point (t_{706}) and the beginning of a measurement signal (IN_+) generated during a recoil travel following this counterrecoil travel as the second time point (t_{701});

determining the time interval between a plurality of counterrecoil travels or a plurality of recoil travels of the movable weapon member (120) based on the time interval duration; and

determining that the firing occurred in continuous fire when the firearm can be fired in continuous fire, multiple counterrecoil travels and recoil travels have been detected, and the time interval duration is below a time interval threshold, and otherwise that the firing occurred in single fire.

26. Method according to Claim 25, further comprising

defining at least two time spacing intervals, for which each of which a firing rate is assignable, on the basis of the time spacing limit value and/or at least one further time spacing limit value; and

determining the shot rate according to which time interval the time interval duration is in.

27. Method according to any of the preceding method claims, comprising:

generating a digital measurement signal (dIN_+) from the measurement signal (IN_+) when the reference signal (V_{in}) is present according to the following rule:

if (measuring signal $\geq$ reference signal)

digital measuring signal = 1

else if (measuring signal $\leq$ U0)

digital measuring signal = 0

else

digital measuring signal = empty

where $U0 \leq$ minimum (reference signal).

28. Method according to Claim 27, comprising:

determining the first time point (t701a) after when the digital measurement signal (dIN₊) alters from "0" or "empty" to "1", and the second time point (t701b) after when the digital measurement signal (dIN₊) alters from "1" or "empty" to "0".

29. Method according to Claim 27 or 28, comprising:

determining, on the basis of the sequence of signal sections (710-718) in which the digital measurement signal (dIN₊) is uninterruptedly "1" or "0", for whether the measurement signal (IN₊) is based on a counterrecoil travel or a recoil travel of the movable weapon part (120).