Description

This invention relates generally to an apparatus and a method for sensing the velocity of a movable member, such as a gear, and more particularly to an apparatus and a method for comparing the sensed velocity to a reference velocity and delivering a controlling signal in response to the comparison.

Previous gear speed sensors typically determine velocity by counting pulses representative of gear teeth for a preselected duration of time. While this method is relatively simple to implement electronically, it does suffer from an inherent disadvantage of decreased accuracy at high or low operational speeds. For example, a small change in velocity at high gear speed will result in a difference of only a few pulses while at low gear speeds this same change in velocity will be insufficient to produce a different pulse count and, although actual speed has changed, the measured speed is unaffected.

Additionally, at low gear speeds a relatively small sampling of gear teeth will be taken, leading to erroneous gear speeds being measured. These errors are induced by the torsional effect caused by the firing of each cylinder of an engine. If an adequate number of gear teeth are counted in a sample period, then the torsional effects will be averaged out. However, where the sample period is sufficiently short to occur within an acceleration or deceleration of the gear, caused by the firing of a single cylinder, then an erroneously high or low gear speed is measured.

Alternatively, at high gear speeds a relatively large sampling of gear teeth will be taken, resulting in an average speed that does not adequately reflect transitions in gear speed. At these higher speeds, major changes in gear speed can occur rapidly and cause damage to the engine. If the sampling of gear teeth is large, then these transitions will be averaged out or, at best, detection can be delayed sufficiently to allow overspeed damage to occur.

Subsequent gear speed sensors have attempted to overcome this disadvantage by developing an apparatus that has a sampling time which is inversely proportional to the gear speed. In this way the range of accuracy has been greatly extended, but the attractive simplicity of the previous apparatus has been foregone for a gear speed sensor that is unduly complicated and constructed from a myriad of components. Each of these components is subject to failure, thereby endangering the reliability of the entire apparatus.

US—A—3500375 discloses a speed sensing apparatus for measuring the velocity of a movable member having at least one protuberance, the speed sensing apparatus having a sensor adjacent said movable member for delivering a first signal in response to the protuberance moving past the sensor, counting means for receiving a sensor signal, timing means triggered by the sensor signals and generating a reset signal for the counting means.

The present invention is directed to extending the range of accuracy of the gear speed sensor without inordinately complicating the apparatus.

In accordance with the present invention, a speed sensing apparatus is provided for measuring the velocity of a movable member having at least one protuberance, the speed sensing apparatus having a sensor adjacent said movable member for delivering a first signal in response to the protuberance moving past the sensor;

counting means for receiving the first signal and delivering a second signal in response to receiving a predetermined number of the first signals from the sensor;

timing means for receiving the second signal and delivering a third signal in response to receiving the second signal, the third signal being delivered for a preselected duration of time; and,

logic circuit means for receiving the second and third signals, comparing the presence and absence of the second and third signals, and delivering a fourth signal in response to receiving a predetermined combination of the second and third signals, the fourth signal being a controlling signal responsive to the sensed velocity of the movable member.

The invention also includes a method for measuring the speed of a movable element having at least one protuberance, the method comprising:

delivering a series of first signals having a frequency directly related to the speed of the movable element;

counting the first signals and delivering a second signal in response to receiving a predetermined number of the first signals;

delivering a third signal of predetermined duration in response to receiving the second signal; and,

delivering a control signal in response to receiving said second signal while receiving said third signal.

One example of apparatus according to the invention will now be described with reference to the accompanying drawing which is a schematic circuit diagram of one embodiment of the present invention.

Figure 1 illustrates a speed sensing apparatus 10 for measuring the velocity of a movable member 12 having at least one protuberance 14. For example, the movable member 12 can be a gear 16 having gear teeth 18 and being driven by a motor 8. A sensor 20 is disposed adjacent the movable member 12 and delivers a first signal in response to the protuberance 14 moving past the sensor 20. This type of sensor 20 is well-known in the art and employs a permanent magnet and an inductive coil or Hall effect device to sense a change in flux density as the gear teeth 18 move past the sensor 20. A signal with a frequency directly related to the speed of the movable element is delivered by the sensor 20 to a signal shaping circuit 22 over the line 23.

The line 23 is connected to a resistor 24. The resistor 24 delivers the first signal to a capacitor 30, a zener diode 32, and a diode 34, all connected in

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counting means for receiving the first signal and delivering a second signal in response to receiving a predetermined number of the first signals from the sensor;

timing means for receiving the second signal and delivering a third signal in response to receiving the second signal, the third signal being delivered for a preselected duration of time; and,

logic circuit means for receiving the second and third signals, comparing the presence and absence of the second and third signals, and delivering a fourth signal in response to receiving a predetermined combination of the second and third signals, the fourth signal being a controlling signal responsive to the sensed velocity of the movable member.

The invention also includes a method for measuring the speed of a movable element having at least one protuberance, the method comprising:

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One example of apparatus according to the invention will now be described with reference to the accompanying drawing which is a schematic circuit diagram of one embodiment of the present invention.

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The line 23 is connected to a resistor 24. The resistor 24 delivers the first signal to a capacitor 30, a zener diode 32, and a diode 34, all connected in

parallel to ground. A resistor 26 is connected to the resistor 24 and delivers the first signal to the base of a transistor 36. The transistor 36 has its emitter connected to ground and its collector connected to system voltage V_{DD} through a resistor 28. The collector is additionally connected to a counting means 38 by a line 39.

The counting means 38 receives the first signal and delivers a second signal in response to receiving a predetermined number of first signals. This counting means 38 includes a commercially available divide by N counter 40 and a pair of logical AND gates 42, 44. The input of the counter 40 is connected to the collector of transistor 36. The Q8 output of the counter 40 is connected to both inputs of the AND gate 42 and to one of the inputs of AND gate 44. The second input of the AND gate 44 is connected to the Q4 output of the counter 40 and the output of the AND gate 44 is delivered to the RESET of counter 40.

A timing means 46 receives the second signal from the counting means 38 and delivers a third signal for a preselected duration of time in response to receiving the second signal. The timing means 46 includes a commercially available monostable multivibrator 48 whose trigger input is connected through a capacitor 50 to the output of the AND gate 42. The trigger input is additionally connected to the system voltage V_{DD} through a parallel connection of a resistor 52 and a diode 54. An input to the multivibrator 48 is connected to a first means 66 for altering the duration of delivery of the third signal. The first means includes a potentiometer 56 connected to system voltage V_{DD} and to ground through a capacitor 58. The timing means 46 also includes a second means 68 for temporarily altering the duration of delivery of the third signal. This second means 68 is connected in parallel to the capacitor 58 and includes a switch 62 and a capacitor 60. The output of the multivibrator 48 is delivered to a logic circuit means 70. The logic circuit means 70 includes a NAND gate 64 having one input connected to the output of AND gate 42 and a second input connected to the output of the multivibrator 48. The output of the NAND gate 64 is connected to a first input of a pair of NAND gates 72, 74 connected as a latch 75. The second input to the latch 75 is connected to system voltage V_{DD} by a pair of resistors 76, 78. A switch 80 is provided for resetting the latch 75 by grounding the second input of the latch 75.

The output of the latch 75 is connected to the base of a transistor 84 via a resistor 82. When biased on, the transistor 84 conducts current from system voltage V_{DD} through a light emitting diode 86 and a resistor 88. Current is additionally conducted through a coil 94 of a relay 92 in parallel with the resistor 88 and LED 86. For example, the LED 86 is used as an annunciator 96, to indicate an overspeed condition, the relay is used as an engine shutdown device 98 by providing power to a solenoid to shut off fuel supplied to the engine.

A number of timer circuits and logic circuits similar to those shown here can be operated from the output of the AND gate 42 to provide a number of different speed level sensors, all using the same sensor 20, signal shaping circuit 22, and counting means 38.

The operation of the circuit shown in Figure 1 will now be described with reference to application in determining the speed of rotation of an engine drive gear of a work vehicle. Rotation of the gear 16 results in a varying flux density being detected by the sensor 20 as the gear teeth 18 move past the sensor 20. The sensor 20 responds to the varying flux density by supplying a signal of varying voltage. This varying voltage is applied to the base of the transistor 36, thereby alternately biasing the transistor 36 "off" and "on". When the transistor 36 is biased "off", system voltage is delivered to the input of the divide by N counter 40; correspondingly, when the transistor 36 is biased "on", a signal approximating ground is delivered to the counter 40.

As these pulses are received by the counter 40 an 8-bit binary number, representative of the number of pulses delivered, is available as outputs from the counter 40. By selecting the Q8 output as the input to the AND gate 42, a logically "high" signal is delivered during the period from (10000000) 128 pulses until (10001000) 136 pulses. At the 136th pulse, both the Q8 and Q4 outputs are logically "high", thereby causing the AND gate 44 to deliver a reset signal to the counter 40.

The "high" to "low" transition at the output of the AND gate 42 causes a trigger signal to be delivered to the monostable multivibrator 48, resulting in the multivibrator 48 delivering a pulse of predetermined duration. The duration of the pulse is determined by the time constant of the RC circuit 56, 58, 60, 62 connected at the multivibrator's input. The potentiometer 56 is utilized for adjustment of the duration of the output signal by changing the time constant of the RC circuit 56, 58, 60, 62. Additionally, if the switch 62 is held closed, then the capacitor 60 is added to the capacitor 58, thereby lengthening the time constant of the RC circuit 56, 58, 60, 62 and, consequently, increasing the duration of the output pulse.

Should the counting means 38 receive 128 pulses before the multivibrator 48 has timed out, then the NAND gate 64 will deliver a logically "low" signal to the latch 75 in response to receiving the logically "high" signals from both the multivibrator 48 and the AND gate 42. The latch 75 responds by biasing the transistor 84 "on", providing a path for current to flow through the LED 86 and the coil 94 of the relay 92.

The relay 92 can be used to activate a variety of engine shutdown devices or warning devices, any of which are well-known to those skilled in the art. This condition is indicative of a detected engine speed being greater than a desired limit

and the latch 75 continues to bias the transistor 84 "on" even if engine speed falls below the desired limit. Closing the switch 80 provides a logically "low" signal to the latch 75 resetting its output and biasing the transistor 84 "off".

If at this time the engine is running below the desired speed limit, the multivibrator 48 will time out before the timing means 38 receives 128 pulses and the NAND gate 64 will not set the latch 75 to bias the transistor 84 "on".

It can now be appreciated that the potentiometer 56 assists the speed sensing apparatus 10 in detecting any of a plurality of engine speeds by varying the duration of the multivibrator's output. The switch 62 and capacitor 60 provides a means for testing the operation of the device without exceeding possibly critical speed limits. As described earlier, while the switch 62 is closed, the duration of the output from the multivibrator 48 is lengthened such that the desired speed limit is temporarily reduced allowing an overspeed condition to occur at a speed less than during normal operation (i.e., when the switch 62 is open).

It is easily recognized, by those skilled in the art, that minor changes to the logic circuit means 70 allows the apparatus 10 to detect engine speeds at a level less than a predetermined value without departing from the spirit of the intended invention.

Claims

1. A speed sensing apparatus (10) for measuring the velocity of a movable member (12) having at least one protuberance (14), the speed sensing apparatus (10) having:

a sensor (20) adjacent said movable member (12) for delivering a first signal in response to the protuberance (14) moving the sensor (20);

counting means (38) for receiving the first signal and delivering a second signal in response to receiving a predetermined number of the first signals from the sensor (20);

timing means (46) for receiving the second signal and delivering a third signal in response to receiving the second signal, the third signal being delivered for a preselected duration of time, and,

logic circuit means (70) for receiving the second and third signals, comparing the presence and absence of the second and third signals, and delivering a fourth signal in response to receiving a predetermined combination of the second and third signals, the fourth signal being a controlling signal responsive to the sensed velocity of the movable member (12).

2. A speed sensing apparatus (10), as set forth in claim 1, wherein the fourth signal is delivered in response to the logic circuit means (70) receiving the second and third signals concurrently.

3. A speed sensing apparatus (10), as set forth in claim 1, including an annunciator (96) connected to the logic circuit means (70) and adapted to receive the fourth signal.

4. A speed sensing apparatus (10) as set forth in claim 1, including an engine shutdown device (98) connected to the logic circuit means (70) and adapted to receive the fourth signal.

5. A speed sensing apparatus (10), as set forth in claim 4, wherein the logic circuit means (70) includes a logical NAND gate (64).

6. A speed sensing apparatus (10), as set forth in claim 1, wherein the timing means (46) includes a first means (66) for altering the duration of delivery of the third signal.

7. A speed sensing apparatus (10), as set forth in claim 6, wherein the first means (66) includes a potentiometer (56).

8. A speed sensing apparatus (10), as set forth in claim 6, wherein the timing means (46) includes a second means (68) for temporarily altering the duration of delivery of the third signal.

9. A speed sensing apparatus (10), as set forth in claim 8, wherein the second means (68) includes a switch (62) and a capacitor (60).

10. A method for measuring the speed of a movable element having at least one protuberance, the method comprising:

delivering a series of first signals having a frequency directly related to the speed of the movable element;

counting the first signals and delivering a second signal in response to receiving a predetermined number of the first signals;

delivering a third signal of predetermined duration in response to receiving the second signal; and,

delivering a control signal in response to receiving said second signal while receiving said third signal.

Patentansprüche

1. Geschwindigkeitsabfühlvorrichtung (10) zur Messung der Geschwindigkeit eines beweglichen Glieds (12) mit mindestens einem Vorsprung (14), wobei die Geschwindigkeitsabfühlvorrichtung (10) folgendes aufweist:

einen Fühler (20) benachbart zu dem beweglichen Glied (12) zur Lieferung eines ersten Signals infolge des an dem Fühler (20) vorbeilaufenden Vorsprungs (14):

Zählmittel (38) zum Empfang des ersten Signals und zur Lieferung eines zweiten Signals infolge des Empfangs einer vorbestimmten Anzahl der ersten Signale vom Fühler (20);

Zeitsteuermittel (46) zum Empfang des zweiten Signals und zur Lieferung eines dritten Signals infolge des Empfangs des zweiten Signals, wobei das dritte Signal für eine vorgewählte Zeitdauer geliefert wird;

logische Schaltungsmittel (70) zum Empfang der zweiten und dritten Signale, zum Vergleich des Vorhandenseins und Nichtvorhandenseins der zweiten und dritten Signale und zur Lieferung eines vierten Signals infolge des empfangs einer vorbestimmten Kombination der zweiten und dritten Signale, wobei des vierte Signal ein Steuersignal ist, welches auf die abgefühlte Geschwindigkeit des beweglichen Gliedes (12) anspricht.

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and the latch 75 continues to bias the transistor 84 "on" even if engine speed falls below the desired limit. Closing the switch 80 provides a logically "low" signal to the latch 75 resetting its output and biasing the transistor 84 "off".

If at this time the engine is running below the desired speed limit, the multivibrator 48 will time out before the timing means 38 receives 128 pulses and the NAND gate 64 will not set the latch 75 to bias the transistor 84 "on".

It can now be appreciated that the potentiometer 56 assists the speed sensing apparatus 10 in detecting any of a plurality of engine speeds by varying the duration of the multivibrator's output. The switch 62 and capacitor 60 provides a means for testing the operation of the device without exceeding possibly critical speed limits. As described earlier, while the switch 62 is closed, the duration of the output from the multivibrator 48 is lengthened such that the desired speed limit is temporarily reduced allowing an overspeed condition to occur at a speed less than during normal operation (i.e., when the switch 62 is open).

It is easily recognized, by those skilled in the art, that minor changes to the logic circuit means 70 allows the apparatus 10 to detect engine speeds at a level less than a predetermined value without departing from the spirit of the intended invention.

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a sensor (20) adjacent said movable member (12) for delivering a first signal in response to the protuberance (14) moving the sensor (20);

counting means (38) for receiving the first signal and delivering a second signal in response to receiving a predetermined number of the first signals from the sensor (20);

timing means (46) for receiving the second signal and delivering a third signal in response to receiving the second signal, the third signal being delivered for a preselected duration of time, and,

logic circuit means (70) for receiving the second and third signals, comparing the presence and absence of the second and third signals, and delivering a fourth signal in response to receiving a predetermined combination of the second and third signals, the fourth signal being a controlling signal responsive to the sensed velocity of the movable member (12).

2. A speed sensing apparatus (10), as set forth in claim 1, wherein the fourth signal is delivered in response to the logic circuit means (70) receiving the second and third signals concurrently.

3. A speed sensing apparatus (10), as set forth in claim 1, including an annunciator (96) connected to the logic circuit means (70) and adapted to receive the fourth signal.

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6. A speed sensing apparatus (10), as set forth in claim 1, wherein the timing means (46) includes a first means (66) for altering the duration of delivery of the third signal.

7. A speed sensing apparatus (10), as set forth in claim 6, wherein the first means (66) includes a potentiometer (56).

8. A speed sensing apparatus (10), as set forth in claim 6, wherein the timing means (46) includes a second means (68) for temporarily altering the duration of delivery of the third signal.

9. A speed sensing apparatus (10), as set forth in claim 8, wherein the second means (68) includes a switch (62) and a capacitor (60).

10. A method for measuring the speed of a movable element having at least one protuberance, the method comprising:

delivering a series of first signals having a frequency directly related to the speed of the movable element;

counting the first signals and delivering a second signal in response to receiving a predetermined number of the first signals;

delivering a third signal of predetermined duration in response to receiving the second signal; and,

delivering a control signal in response to receiving said second signal while receiving said third signal.

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einen Fühler (20) benachbart zu dem beweglichen Glied (12) zur Lieferung eines ersten Signals infolge des an dem Fühler (20) vorbeilaufenden Vorsprungs (14):

Zählmittel (38) zum Empfang des ersten Signals und zur Lieferung eines zweiten Signals infolge des Empfangs einer vorbestimmten Anzahl der ersten Signale vom Fühler (20);

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logische Schaltungsmittel (70) zum Empfang der zweiten und dritten Signale, zum Vergleich des Vorhandenseins und Nichtvorhandenseins der zweiten und dritten Signale und zur Lieferung eines vierten Signals infolge des empfangs einer vorbestimmten Kombination der zweiten und dritten Signale, wobei des vierte Signal ein Steuersignal ist, welches auf die abgefühlte Geschwindigkeit des beweglichen Gliedes (12) anspricht.

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2. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 1, wobei das vierte Signal geliefert wird infolge des gleichzeitigen Empfangs der zweiten und dritten Signale durch die logischen Schaltungsmittel (70).

3. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 1 mit Anzeigemitteln (96) verbunden mit den logischen Schaltungsmitteln (70) und geeignet zum Empfang des vierten Signals.

4. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 1 mit einer Motorabschaltvorrichtung (98) verbunden mit den logischen Schaltungsmitteln (70) und geeignet zum Empfang des vierten Signals.

5. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 4, wobei die logischen Schaltungsmittel (70) ein logisches NAND-Gatter (64) aufweisen.

6. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 1, wobei die Zeitsteuermittel (46) erste Mittel (66) aufweisen, um die Lieferzeit des dritten Signals zu ändern.

7. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 6, wobei die ersten Mittel (66) ein Potentiometer (56) umfaßt.

8. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 6, wobei die Zeitsteuermittel (46) zweite Mittel (68) aufweisen, um zeitweise die Lieferdauer des dritten Signals zu ändern.

9. Geschwindigkeitsfühlvorrichtung (10) nach Anspruch 8, wobei die zweiten Mittel (68) einen Schalter (62) und einen Kondensator (60) aufweisen.

10. Verfahren zur Messung der Geschwindigkeit eines beweglichen Elements mit mindestens einem Vorsprung, wobei folgendes vorgesehen ist:

Lieferung einer Serie von ersten Signalen mit einer Frequenz, die direkt in Beziehung steht mit der Geschwindigkeit des beweglichen Elements;

Zählen der ersten Signale und Lieferung eines zweiten Signals infolge des Empfangs einer vorbestimmten Anzahl der ersten Signale;

Lieferung eines dritten Signals von vorbestimmter Dauer infolge des Empfangs des zweiten Signals;

Lieferung eines Steuersignals infolge des Empfangs des zweiten Signals, während das dritte Signal empfangen wird.

Revendications

1. Détecteur de vitesse (10) destiné à mesurer la vitesse d'un organe mobile (12) possédant au moins un élément saillant (14), ce détecteur de vitesse (10) comprenant:

— un capteur (20) situé au voisinage dudit organe mobile (12) pour délivrer un premier signal en réponse au passage de l'élément saillant (14) devant le capteur (20);

— des moyens de comptage (38) destinés à recevoir le premier signal et à délivrer un second signal en réponse à la réception d'un nombre prédéterminé de premiers signaux en provenance du capteur (20);

— des moyens de cadencement (46) destinés à recevoir le second signal et à délivrer un troisième signal en réponse à la réception du second signal, le troisième signal étant délivré sur un intervalle de temps présélectionné; et

— des moyens formant un circuit logique (70) destiné à recevoir les second et troisième signaux, à comparer la présence et l'absence des second et troisième signaux, et à délivrer un quatrième signal en réponse à la réception d'une combinaison prédéterminée des second et troisième signaux, le quatrième signal étant un signal de commande fonction de la vitesse détéctée de l'organe mobile (12).

2. Détecteur de vitesse (10) selon la revendication 1, dans lequel le quatrième signal est délivré en réponse au fait que les moyens formant circuit logique (70) reçoivent simultanément les second et troisième signaux.

3. Détecteur de vitesse (10) selon la revendication 1, comprenant un avertisseur (96) raccordé aux moyens formant circuit logique (70) et apte à recevoir le quatrième signal.

4. Détecteur de vitesse (10) selon la revendication 1, comprenant un dispositif (98) d'arrêt d'un moteur, raccordé aux moyens formant circuit logique (70) et apte à recevoir la quatrième signal.

5. Détecteur de vitesse (10) selon la revendication 4, dans lequel les moyens formant circuit logique (70) comprennent une porte logique NON-ET (64).

6. Détecteur de vitesse (10) selon la revendication 1, dans lequel les moyens de cadencement (46) comprennent un premier moyen (66) pour modifier la durée de délivrance du troisième signal.

7. Détecteur de vitesse (10) selon la revendication 6, dans lequel le premier moyen (66) comprend un potentiomètre (56).

8. Détecteur de vitesse (10) selon la revendication 6, dans lequel les moyens de cadencement (46) comprennent un second moyen (68) pour modifier temporairement la durée de délivrance du troisième signal.

9. Détecteur de vitesse (10) selon la revendication 8, dans lequel le second moyen (68) comprend un contacteur (62) et un condensateur (60).

10. Procéde pour mesurer la vitesse d'un organe mobile comportant au moins un élément saillant, ce procédé consistant à:

— délivrer une série de premiers signaux possédant une fréquence liée directement à la vitesse de l'organe mobile;

— compter les premiers signaux et délivrer un second signal en réponse à la réception d'un nombre prédéterminé de premiers signaux;

— délivrer un troisième signal possédant une durée prédéterminée en réponse à la réception du second signal et

— délivrer un signal de commande en réponse à la réception dudit second signal et à la réception simultanée dudit troisième signal.

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