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VARIABLE PULSE WIDTH ALARM NETWORK
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ABSTRACT OF THE DISCLOSURE

A system for monitoring conditions along a line, such as a pipeline, sewage line, transmission line, and so forth, includes a detector responsive to abnormal line conditions for generating a pulse of predetermined duration indicative of the abnormal condition. Several detectors may be used at different points along the line, in which event each is characterized by the generation of a pulse of different duration to distinguish the various monitoring points. At the remote central station the incoming pulses on the signal transmission path from the detecting stations are checked for duration, and if of the predetermined pulse width, are effective to energize a non-linear device from its normally non-conducting condition to a conducting state by which an alarm indicative of malfunction or other abnormal condition is actuated. The alarm remains in the actuated condition by virtue of the biasing of the non-linear device in its conducting state, once actuated, with a holding current whose source may be selectively disabled to extinguish the alarm.

The present invention relates to alarm systems and more particularly to a system utilizing variable width pulses that do not require high frequency communication lines.

Many systems have been developed to monitor conditions at unattended, remote locations, such as at points along a pipe, material transmission line or in a sewer system. Ideally, indications of these conditions are transmitted via a readily available low frequency telegraphy or voice frequency line. In the past, these indications have often been transmitted as frequency modulated waves. Such waves require a transmission line of relatively wide band width that is beyond the capabilities of a telegraph line. To avoid this problem, the present invention contemplates an alarm system including a plurality of variable pulse width sensing stations that are coupled via a telegraphy line or other medias to plural pulse width sensing networks at a central station. When a condition indicative of a malfunction occurs at the sensing station, a low duty cycle pulse of predetermined length is transmitted via the line to the central station. The pulse is of low duty cycle so that the low frequency telegraph line may be utilized without significant information loss. The pulse width sensing networks at the central station are arranged to activate separate alarms when pulses of widths commensurate with malfunctions of the monitored stations occur. Sensing networks at the central station and the monitoring locations are provided on a one for one basis to provide indications of the exact points where the malfunctions occurred.

Each network at the central station includes a differentiator responsive to the received pulses. The differentiator output is applied in parallel to an AND gate and a transistorized monostable multivibrator that is responsive to only the leading edges of the received pulses. A predetermined period of time after the multivibrator is activated by the leading pulse edge, the multivibrator generates a time indicating pulse that is supplied to the AND gate. If the time indicating pulse occurs simultaneously with trailing edge of the received pulse, the AND gate is enabled. The AND gate output is coupled to an alarm circuit that includes a negative impedance device, such as

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a four layer diode. The negative impedance device is activated into conduction in response to the AND gate output. This device, once activated, energizes an alarm circuit even after the AND gate output is disabled. Thereby, the alarm produces a malfunction indication until a manually activated reset button is energized to block current through the negative impedance device.

A feature of the invention is that the transistorized monostable multivibrator is switched from a fully cut off to a fully conductive condition in the relatively short time duration of seven microseconds. This is important in the present system where precisely timed pulses must be generated after a first pulse is received. To attain this high speed switching action, a pair of complementary transistors are connected to a resistance-capacitor charging circuit. During the charging portion of multivibrator operation, the resistance-capacitance circuit is coupled between the collector and base of the two transistors via a relatively low impedance path. Once the capacitor attains a predetermined voltage, both transistors are cut off and the capacitor discharges through a circuit that is completely de-coupled from both emitter-base junctions.

It is an object of the present invention to provide a new and improved low band width alarm system utilizing variable width pulses as indicators.

Another object of the invention is to provide a pulse width detector employing a monostable multivibrator activated by the leading edge of a received pulse that is adapted to derive very precisely timed pulses occurring after the received pulse since it is switched from a fully cut off to a completely conducting condition in a relatively short time.

A further object of the invention is to provide a monostable multivibrator activated by the leading edge of a received pulse, which multivibrator is adapted to derive very precisely timed pulses occurring after the received pulse since it is switched from a fully cut off to a completely conducting condition in a relatively short time.

Still another object of the invention is to provide a pulse width detector wherein a short duration impulse is generated when the trailing pulse edge coincides with a time indicating signal derived a predetermined time period after the pulse leading edge, and an alarm circuit is activated in response to said impulse, said alarm circuit remaining activated even after the impulse has terminated.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawing, wherein:

The single figure is a diagram of one preferred embodiment of the invention.

Referring to the figure, a sewer pipe or material transmission pipe line 1 is monitored at a plurality of locations by pressure sensitive transducers 2, 2' which may be piezo-electric crystals or variable reluctance devices. The output of each transducer 2, 2' is coupled to a separate variable pulse width generator 3, 3'. In response to variations in pressure at the point where transducer 2 is located, the transducer reactance is varied to control the width of the pulses deriving from generator 3 in a known manner. The duration of the pulses produced by generators 3, 3' may vary between 100 microseconds and 300 milliseconds but the pulses produced by each generator must lie within a predetermined limit. For example, the pulses deriving from generator 3 may vary between 100 microseconds and 30 milliseconds while those deriving from generator 3' may vary between 60 milliseconds and 300 milliseconds. The duty cycle of each wavetrain supplied to line 4 is quite low, i.e. the period between adjacent pulses is on the order of a few seconds, so that a low frequency line can be utilized.

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The outputs of generators 3, 3' are applied in parallel to telegraphy line 4. At a central monitoring station, a plurality of detecting circuits 5, 5' are provided. Each detecting circuit includes means for activating an alarm when a pulse of predetermined width is transmitted to it via line 4.

In operation, pulse generator 3 is constructed so that a pulse of first predetermined width is generated by it when the pressure sensed by transducer 2 reaches a level indicative of a fault in pipe line 1. When a fault occurs in pipe line 1 at the point where transducer 2' is located, generator 3' supplies a pulse of a second predetermined width different from the first width to line 4. At the monitoring station, sensing circuits 5 and 5' are adjusted to activate alarms when pulses of the first and second widths are transmitted on line 4.

Each of the sensing circuits 5 and 5' is identical except for the values of impedances employed in a timing circuit. Circuit 5 includes a differentiator 10 including capacitor 11 and resistor 12 that is responsive to the variable width polar telegraph pulses transmitted on line 4. The pulses have negative and positive leading and trailing edges, respectively. The negative going, leading pulse edge is coupled through capacitor 11 as a short duration, negative pulse. The negative pulse deriving from differentiator 10 is coupled to the input of monostable multivibrator 13 via blocking diode 14 and current limiting resistor 15.

Monostable multivibrator 13, which derives a pulse a predetermined period of time after a negative input is applied thereto, includes common emitter PNP transistor 16 and NPN transistor 17. The collector-emitter path of transistor 16 is energized by the negative D.C. voltage at terminal 18 via collector load resistor 19 and emitter bias resistor 21. The emitter of transistor 16 is maintained at a negative bias by the negative voltage applied thereto from terminal 22 via diode 23 and currently limiting resistor 24. The base of transistor 16 is normally maintained at zero potential by the path including resistor 25 and series connected diodes 26 and 27, which diodes are connected to shunt positive current away from the transistor 16 base electrode. Since the emitter of transistor 16 has a quiescent negative bias relative to its base, the transistor is normally maintained at cut off.

Because no current normally flows to the collector of transistor 16 via resistor 19, the base of transistor 17 is maintained back biased, under quiescent conditions. Back biasing results since the negative voltage coupled from terminal 18 to the transistor base is greater than the negative voltage coupled from terminal 22 to the transistor emitter via diode 23.

Connected in parallel with the collector of transistor are a pair of parallel paths, the first consisting of resistor 28 and the second of a series circuit including variable timing resistor 31, timing capacitor 32 and diode 26 and diode 27.

To generate short duration pulses in response to sudden voltage transitions developed across resistor 28, a further differentiator 33 including capacitor 34 and resistor 35 is provided. The output of differentiator 33 is coupled to one input of reverse biased diode AND gate 36, the other input of which is responsive to the output of differentiator 10. Gate 36 includes diodes 37 and 38 having their cathodes connected to the outputs of differentiators 33 and 10, respectively, and to the negative voltage at terminal 39, the latter connections being through biasing resistors 41 and 42. Positive voltage is applied to the anodes of diodes 37 and 38 from terminal 43 via current limiting resistor 44. The output of gate 36, at the anodes of diodes 37 and 38, is developed across load resistor 45. Normally, diodes 37 and 38 conduct lightly so that a large positive voltage is maintained across load resistor 45 under quiescent conditions.

Shunting resistor 45 is a series circuit including four layer diode 46, alarm transducer 47, such as an audio and/or visual current activated device, manually activated,

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normally closed switch 48 and the positive voltage at terminal 49. Under quiescent conditions, the positive voltage applied to resistor 45 from terminal 43 is such that the anode cathode voltage of four layer diode 46 is less than the diode firing voltage.

In operation, the negative going, leading edge of the pulse applied to the input of differentiator 10 is shaped into a short duration negative pulse by the differentiator. The negative pulse is applied to the base of transistor 16 via diode 14 and resistor 15 to trigger the transistor collector into conduction. The flow of current through the emitter-collector path of transistor 16 forward biases the base of transistor 17.

In response to transistor 17 being forward biased, negative current flows from terminal 22 to ground through the series path consisting of diode 23, the emitter-collector path of transistor 17, resistor 31, capacitor 32, diode 27 and resistor 25. The resulting negative voltage across resistor 25 maintains the base of transistor 16 forward biased even after the short duration pulse from differentiator 10 has subsided. In consequence, transistor 17 remains forward biased and the current path through resistors 25 and 31 is maintained. Because of the high impedance input circuit of transistor 16 reflected to differentiator 10 and the low impedance regenerative circuit from the collector of transistor 17 to the base of transistor 16, monostable multivibrator 13 is triggered from cutoff to a fully conducting condition in the relatively short time of seven microseconds. This enables the trailing edge of the pulse deriving from monostable multivibrator 13 to be generated at a precisely determined instant.

As current continues to flow through capacitor 32, charge is built up on the capacitor so that the plate connected to diode 27 is positive relative to the plate connected to resistor 31. As charge builds up on capacitor 32, current through the series path including resistor 25 decreases. Ultimately, the current decreases to the point where the negative voltage across resistor 25 is less than the negative voltage at the emitter of transistor 16. When this occurs, collector current for transistor 16 is cut off, the voltage at the base of transistor 17 decreases to the voltage at terminal 18 and collector current through the latter transistor also ceases. In consequence, the current path from terminal 22 through transistor 17 and resistors 25 and 31 no longer exists and the voltage at the base of transistor 16 drops suddenly to zero. When the base voltage of transistor 16 drops to zero, that transistor as well as transistor 17 become more effectively cut off in a regenerative manner.

With transistor 17 cut off, the charge accumulated by capacitor 32 is dissipated through the series path consisting of diode 26 and resistors 28, 31. The impedance of resistor 28 is considerably larger than the combined impedances of resistor 31 and diode 26. As a result, most of the voltage that existed across capacitor 32 when transistor 17 was cut off will be suddenly reflected as a large negative going voltage across resistor 28, i.e. the voltage at the junction between resistor 28 and capacitor 34 suddenly drops to a voltage less than ground. The charge of capacitor 32 is quickly reduced substantially to zero at a rate determined by the impedances of resistors 28, 31 and diode 26, as well as the capacitor value. As the capacitor charge is dissipated, the voltage across resistor 28 rises exponentially to zero.

The voltage waveform across resistor 28 when transistor 17 is conducting is essentially a negative going step of low amplitude. The leading edge of the step occurs simultaneously with the transistors being driven out of cut off. Since transistor 17 is essentially a constant impedance when conducting and resistor 28 is decoupled from capacitor 32 by diode 26, the current through, hence voltage across the resistor 28 remains at a constant value, equal to the step, while the transistor is conducting. It is a low amplitude step because the combined impedance

of transistor 17 and diode 23 is considerably less than the impedance of resistor 28.

It is thus seen that the voltage derived from differentiator 33 includes a low voltage negative pulse occurring simultaneously with the leading edge of the pulse applied to differentiator 10 followed by a large negative pulse that is generated a predetermined time after the low voltage pulse. The second pulse is generated at a time controlled by the value of resistor 31 which determines when transistors 16 and 17 will be again driven to cutoff.

AND gate 36 is biased such that the low negative voltages applied to diodes 37 and 38 by differentiators 33 and 10, respectively, in response to the leading edge of the system input pulse will not reduce the voltage across load resistor 45 to a value where four layer diode 46 will be activated. If the large negative pulse deriving from differentiator 33 does not occur simultaneously with the trailing edge of the system input pulse, a conduction path exists for it through forward biased diodes 37 and 38 to ground via resistor 42 and diode 14. This occurs since the differentiator output is substantially at ground potential except when the leading and trailing edges of the system input pulse occur. In consequence, a significant portion of the negative pulse is not developed across load resistor 45 and the anode-cathode voltage of four layer diode 46 is maintained below the diode firing level.

Only when the trailing, positive going edge of the input pulse and the large negative pulse generated by monostable multivibrator 13 occur simultaneously will the latter voltage have any effect on diode 46. At such time, the positive voltage pulse applied to the anode of diode 38 by differentiator 10 cuts off the diode and substantially all current from the large negative coupled to diode 37 is fed to load resistor 45. In consequence, the voltage difference between the anode and cathode of diode 46 increases to a point beyond the diode firing level. Once the firing level of diode 46 is achieved it remains conducting even though its anode-cathode voltage drops to a level less than the firing level. This is because four layer diodes are negative impedance devices that draw current once their firing level is attained. The amount of current drawn is a function of the value of resistor 45, which in this case allows holding current to flow through diode 46.

With diode 46 conducting heavily, alarm 47 is activated to provide an indication that a pulse having a predetermined width, indicative of pipe line or sewer system failure, has been received. The alarm remains energized until reset button is pressed to terminate the flow of current through alarm 47 and diode 46. The detector is now reset to its original condition, ready to provide an indication of pipe line or sewer system failure. If the pulse durations for the various lines being monitored are different, the present invention is adapted to produce the second pulses at variable times by adjusting the value of resistance 31 in the timing circuit for monostable multivibrator 13.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction and transmission media which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A monitoring system for indicating the existence of a line condition of predetermined character at a station remote from points at which line conditions are being observed, said system comprising a transmission path, means responsive to said line condition of predetermined character for generating pulses of predetermined duration

less than the interval between pulses on said transmission path; and, at said station, display means including a monostable multivibrator normally biased to operate in its stable state, differentiating means responsive to transitions occurring at the leading and trailing edges of each incoming pulse on said path for generating respective short duration pulses in response thereto, means responsive to the short duration pulse generated in response to the leading edge transition of an incoming pulse for triggering said multivibrator to its unstable state, said multivibrator including means for controlling the duration of time said multivibrator remains in said unstable state upon being triggered thereto, said duration of time corresponding to said predetermined pulse duration, a non-linear device having a non-conducting state and capable of being energized to a conducting condition upon application thereto of a voltage having an amplitude equal to or greater than a predetermined firing voltage level, means biasing said device to remain in said conducting condition once energized thereto, means responsive to reversion of said multivibrator to said stable state for generating a short duration pulse thereupon, detection means responsive to coincident occurrence of a short duration pulse generated by said reversion responsive means and of a short duration pulse generated by said transition responsive means in response to the trailing edge transition of the incoming pulse for applying a voltage of said amplitude to said non-linear device, means responsive to assumption of said conducting condition by said non-linear device for indicating the occurrence of a pulse of said predetermined duration, and means for selectively disabling said biasing means to reset said non-linear device to said non-conducting state and thereby to remove said indication.

2. The system according to claim 1 wherein said duration controlling means is variable to permit selective alteration of the time interval over which said multivibrator remains in said unstable state.

3. The system according to claim 1 wherein said non-linear device is a four-layer diode.

4. The system of claim 1 wherein said means responsive to line condition includes a plurality of generating means positioned at different points along the line and each for generating a pulse of different predetermined duration signifying the existence of said line condition of predetermined character at a respective point along the line; and wherein is included at said station a like plurality of said display means, each including a monostable multivibrator with said means for controlling duration establishing a duration corresponding respectively to that of the pulse to be detected by that particular display means.

5. The system according to claim 1 wherein said means responsive to reversion of said multivibrator to said stable state comprises a further differentiator.

6. The system according to claim 1 wherein said coincident detection means comprises an AND gate including a pair of normally reverse biased diodes, each of said diodes responsive to a respective one of said short duration pulses to assume a state of conduction.

References Cited

UNITED STATES PATENTS

2,484,352	10/1949	Miller et. al.
3,122,647	2/1964	Huey.
3,215,852	11/1965	Brode et al.

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