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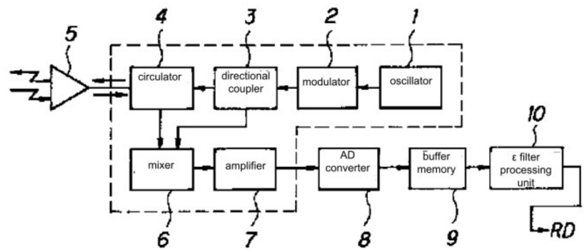
(54) **[Title of the invention]** Onboard Radar Device

(57) **[Abstract]**

[Purpose] To be able to eliminate noise components when the radar detection signal suddenly changes greatly due to, for example, detection loss of an object such as a vehicle traveling in front, which is characteristic of onboard radar devices.

[Constitution] A constitution is adopted with which, when the radar detection signal changes in excess of a threshold value within a fixed time, it is possible to use a nonlinear filter processing means that holds the value from immediately before the change, and to continuously hold the value from immediately before the change, for a prescribed time span.



[Claims]

[Claim 1] In an onboard radar device that continuously detects the relative distance to an object or the relative speed or the like, an onboard radar device characterized by using a nonlinear processing means that, when the detection signal of the radar device changes in excess of a preset threshold value within a fixed time, holds the value of the detection signal from immediately before the change.

[Claim 2] An onboard radar device as recited in claim 1 above, characterized by continuously holding the value of the detection signal from immediately before the change, limited to a prescribed time span.

[Claim 3] An onboard radar device as recited in claim 2 above, characterized by variably setting the prescribed time for holding the value of the detection signal from immediately before the change, in accordance with the amount of change when the detection signal changes in excess of a threshold value, or the magnitude of the detection signal at that time.

[Claim 4] An onboard radar device as recited in claim 2 above, characterized by variably setting the prescribed time for holding the value of the detection signal from immediately before the change, in accordance with the reception level of the detection signal when the detection signal changes in excess of a threshold value.

[Claim 5] An onboard radar device as recited in claim 1 above, characterized by variably setting the threshold value for the change in the detection signal when the value of the detection signal from immediately before the change is to be held, in accordance with the travel speed on the vehicle.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] The present invention relates to an onboard radar device that takes a vehicle traveling in front or the like as an object, and detects the relative distance to the object or the relative speed or the like.

[0002]

[Prior art] In recent years systems have been developed in which a Doppler radar, FM-CW radar, pulse radar, or such a radar device is put aboard an automobile or other traveling vehicle, and for example a vehicle traveling in front is taken as an object, the relative distance to the object and relative speed are continuously detected, and according to the detection results, the travel speed of one's own vehicle is controlled so as to keep the spacing between one's own vehicle and the vehicle traveling in front to an appropriate inter-vehicle distance at all times.

[0003] With such an onboard radar device, due to effects such as relative wavering left and right or pitching of the vehicle body in the space between one's own vehicle and the vehicle traveling in front, sometimes the detection of the object gets lost, or misdetection occurs, and the detection signal changes greatly in a short time span. Such sudden changes in the detection signal become a source of noise for control when controlling the travel speed of one's own vehicle so as to maintain a proper inter-vehicle distance between one's own vehicle and the vehicle traveling in front at all times.

[0004] Heretofore, to eliminate noise in the signal, linear filtering has been done using a FIR filter or the like. But with such linear filter processing, the sudden change in the signal is only suppressed to some extent, so it is impossible to effectively eliminate the noise of large sudden changes, such as detection loss, that occur in the detection signal of an onboard radar device as described above.

[0005] For example, if the detection signal of an onboard radar device changes as shown in FIG. 2, then if the detection signal is processed using a FIR filter, a signal such as shown in FIG. 5 will result, and in particular, effects such as detection loss will largely remain, and desirable processing results will not be obtained.

[0006] In FIG. 2, A shows a detection loss portion in one sampling period, B shows a misdetection portion, C shows a detection loss portion that continues over multiple sampling periods, and D shows a detection signal change portion when a new object comes in between one's own vehicle and the previous detection object. And A3, B3, C3, and D3 in FIG. 5 show, respectively, the FIR filter processing portions that correspond to portions A to D in FIG. 2.

[0007]

[Problems to Be Solved by the Invention] The problem to be solved is that it is impossible to effectively eliminate the noise of sudden large changes such as detection loss, which is characteristic of onboard radar devices.

[0008]

[Means for Solving the Problems] The present invention is made so as to eliminate the noise in the detection signal, by using a nonlinear filter processing means to hold the value of the detection signal as it was immediately before the change, when the detection signal of an onboard radar device changes suddenly.

[0009]

[Operation] The present invention makes it possible to effectively eliminate the noise of sudden large changes such as detection loss, which is characteristic of onboard radar devices, such that when the travel speed of one's own vehicle is controlled in accordance with such noise-eliminated detection signals, so as to maintain the proper inter-vehicle distance between one's own vehicle and the vehicle traveling in front at all times, the controllability will no longer be degraded.

[0010]

[Working examples] FIG. 1 shows an example of the composition of an onboard radar device when FM-CW radar is used.

[0011] In the configuration of this drawing, after a signal at the transmission frequency that is emitted from the oscillator 1 is modulated at a fixed frequency by the modulator 2, the modulated transmission signal goes through the directional coupler 3 and the circulator 4 and is emitted as an electromagnetic wave from the antenna 5, the reflected waves from the object are received by the antenna 5, the received signal goes through the circulator 4 and is sent to the mixer 6, where a beat frequency is generated with the transmission signal that is sent from the directional coupler 3, the beat frequency signal is amplified by the amplifier 7 to a fixed level and is made into a radar detection signal, the radar detection signal is converted to a digital signal in the AD converter 8, then it is temporarily accumulated in the buffer memory 9, and the digitized radar detection signal that is read from the memory 9 undergoes nonlinear digital filter processing by the ε filter processing unit 10. In the drawing, RD represents the radar detection signal that has undergone this filter processing.

[0012] The beat frequency that arises between the transmission signal and the reception signal is proportional to the distance to the object, so the relative distance to the object can be directly determined by the radar detection signal. And the relative speed with the object can be determined indirectly by calculating the time change of the distance to the detected object.

[0013] Here, the ε filter processing unit 10 is set so that when the radar detection signal changes greatly and exceeds a preset threshold value within a fixed time, the value of the detection signal from just before the change is held. And the ε filter processing unit 10 is actually constituted by a microprocessor, so that the content of the ε filter processing is executed by arithmetic processing that follows a prescribed algorithm.

[0014] Now, if for example the radar detection signal changes as shown in FIG. 2, then if the detection signal is processed by the ε filter processing unit 10, it becomes the signal that is shown in FIG. 3, and it is possible to almost completely eliminate the effect when the radar detection signal suddenly changes greatly due to detection loss, misdetection, or the like. In FIG. 3, A1, B1, C1, and D1 represent, respectively, the ε filter processing portions that correspond to the portions A to D in FIG. 2.

[0015] Thus, with the present invention, ε filter processing is done limited to only the portion in which there is a great change exceeding the preset threshold value, so with respect to the portion where the change is small, being no greater than the threshold value, by way of ε filter processing, the value from immediately before the change is held, and filter processing for optimum noise-elimination can be done without causing any degradation in the properties of the radar detection signal.

[0016] Shown in FIG. 6 are the properties of the threshold values (TH1, TH2) that correspond to the amount of change in the radar detection signal in order to put the ε filter processing unit 10 in the operational state (ON) or in the non-operational state (OFF).

[0017] And with the present invention, means are adopted whereby, in the ε filter processing unit 10, the signal of the travel speed of one's own vehicle is read and the threshold value for when to hold the value from immediately before the change in the radar detection signal is variably set in accordance with the travel speed of one's own vehicle, according to a pre-registered table.

[0018] And by adopting such a means, it is made possible to selectively detect only an object that has the speed, acceleration, or the like that should be watched.

[0019] Also, in performing the ε filter processing, because this to be done for each sampling of the radar detection signal, if, for example, as shown in portion C in FIG. 2, the period during which there is detection loss or the like is prolonged and continues over the sampling periods for multiple times (in FIG. 2, the sampling periods for two times are shown), then the value of the detection signal from immediately before, which should be held during ε filter processing for the second and subsequent times no longer exists, and processing cannot be completely done, and the detection loss or the like at the second and subsequent times gets output as-is.

[0020] Because of this, the present invention is further characterized in that, in order to make it possible to deal with detection loss and the like that continues for a certain extent, a means is adopted that continuously holds the value of the detection signal from immediately before, limited to a prescribed time span, when the radar detection signal changes in excess of a preset threshold value and the value of the detection signal from immediately before the change is to be held.

[0021] Specifically, if ε filter processing is to be done for each sampling of the radar detection signal, in the ε filter processing unit 10, when the radar detection signal has greatly changed continuously over a relatively long period due to detection loss or the like, the value from immediately before the first time is held continuously during an interval of sampling periods from the first sampling time when the radar detection signal changed greatly to a preset n^{th} sampling time.

[0022] And by adopting such a means, if, for example, the radar detection signal changes as shown in FIG. 2, a portion such as portion C, in which the period of detection loss or the like is prolonged and continues to within the n^{th} sampling period, is processed to an optimum state as shown in portion C2 in FIG. 4, with almost none of the effect remaining.

[0023] Furthermore, in a detection signal change portion when, as shown in portion D in FIG. 2, a new object comes in between one's own vehicle and the previous detection object, as shown in portion D2 in FIG. 4, from the time the radar detection signal first changes greatly, the value from immediately before the change is held continuously for interval period of a prescribed number of times (n times), and then a switchover is made to the detection signal of the new object, which is output as the radar detection signal.

[0024] Also, if FIR filter processing is done after the above-described ε filter processing has been carried out, processing is done to further smooth out the portions A2, B2, C2, and D2 in FIG. 4, and it becomes possible to obtain a radar detection signal in which the noise components are more effectively eliminated.

[0025] In addition, in the present invention, a means is adopted that variably sets the prescribed time for holding the value from immediately before the change, according to the amount of change when the radar detection signal changes in excess of a threshold value.

[0026] Specifically, in the ε filter processing unit 10, when the value as it was immediately before the change at the first time is to be held continuously for the interval from the first-time to the n^{th} time sampling period, when the radar detection signal changes in excess of a threshold value, the amount of change in the radar detection signal is detected stepwise, and the value of n is optimally set according to the amount of change detected at that time, so that the greater the amount of change is, the greater the value of n is, according to a pre-registered table.

[0027] And by adopting such a means, in the ε filter processing unit 10, it becomes possible to carry out ideal processing to fit the state of change of the radar detection signal, for example as follows.

[0028] That is, if the amount of change in the radar detection signal is large, then with many sampling times that can adequately compensate for the interval during which the radar detection signal has changed such as to exceed the threshold value, the value from immediately before the change can be held continuously. If the amount of change in the radar detection signal is moderate, for example if a new object has come in, then after continuously holding, for a moderate number of sampling times, the value of the radar detection signal from immediately before the change, the detection signal for the new object can be output. And if the amount of change in the radar detection [signal[1]] is small, then n=0 applies, and the radar detection signal can be output as-is, without holding any value as it was immediately before the change.

[0029] And with the present invention, it is also possible to use a means that variably sets the prescribed time for holding the value from immediately before the change, according to the magnitude (absolute value) of the radar detection signal when the radar detection signal changes in excess of a threshold value.

[0030] Specifically, in the ε filter processing unit 10, when the value as it was immediately before the change at the first time is to be held continuously for the interval from the first-time to the n^{th} time sampling period, when the radar detection signal changes in excess of a threshold value, the magnitude of the radar detection signal is detected stepwise, and the value of n is optimally set according to the magnitude of radar detection signal detected at that time, so that the greater (smaller) the value of the radar detection signal, which is to say, the nearer (farther) the detected object is, the greater the value of n is, according to a pre-registered table.

[0031] And by adopting such a means, in the ε filter processing unit 10, it becomes possible to carry out ideal processing to fit the state of change of the radar detection signal, as in the aforementioned case.

[0032] And with the present invention, it is also possible to use a means that variably sets the prescribed time for holding the value from immediately before the change, according to the reception level of the radar detection signal when the radar detection signal changes in excess of a threshold value.

[0033] Specifically, in the ε filter processing unit 10, when the value as it was immediately before the change at the first time is to be held continuously for the interval from the first-time to the n^{th} time sampling period, when the radar detection signal changes in excess of a threshold value, the reception level of the radar detection signal is detected stepwise, and the value of n is set optimally according to the reception level of radar detection signal detected at that time, so that the weaker the reception level of the radar detection signal is, the greater the value of n is, such that the holding time is prolonged, and the stronger the reception level is, the smaller the value of n is, such that the holding time is shortened.

[Effects of the invention] Thus, because the onboard radar device according to the present invention uses a nonlinear filter processing means that holds the value from immediately before the change when, within a fixed time, the radar detection signal changes in excess of a threshold value, it has the advantage of being able to effectively eliminate, with no degradation in the characteristic properties of the radar detection signal, the noise components when the radar detection signal suddenly changes greatly due to detection loss of the object or the like, which is characteristic of onboard radar devices.

[Brief Description of the Drawings]

[FIG. 1] This is a block diagram showing a configuration example of an onboard radar device according to the present invention.

[FIG. 2] This is a characteristics diagram showing an example of a radar detection signal in which noise is mixed in due to detection loss of the object or the like.

[FIG. 3] This is a characteristics diagram when nonlinear filter processing is done on the radar detection signal in FIG. 2 according to a working example of the present invention.

[FIG. 4] This is a characteristics diagram for when nonlinear filter processing is done on the radar detection signal in FIG. 2 according to another working example of the present invention.

[FIG. 5] This is a characteristics diagram for when conventional FIR filter processing is done on the radar detection signal in FIG. 2.

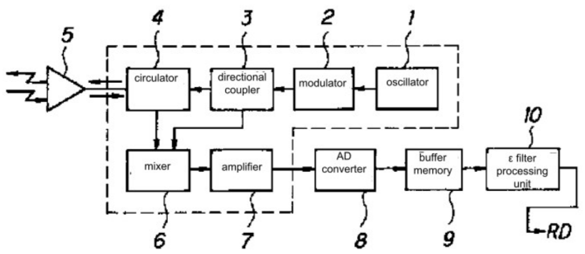
[FIG. 6] This is a diagram showing the characteristics of threshold values according to the amount of change in the radar detection signal that determines whether or not to perform nonlinear filter processing according to the present invention.

[Explanation of the symbols]

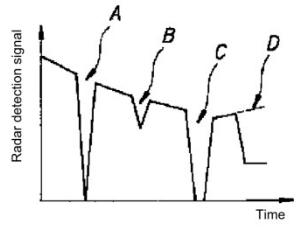
1 … oscillator
2 … modulator
3 … directional coupler
4 … circulator
5 … antenna
6 … mixer
7 … amplifier
8 … AD converter
9 … buffer memory
10 … ε filter processing unit

[1] *There is a typographical error in the original Japanese text. -- trans.*

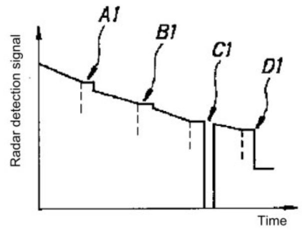
[FIG. 1]



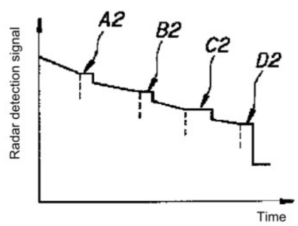
[FIG. 2]



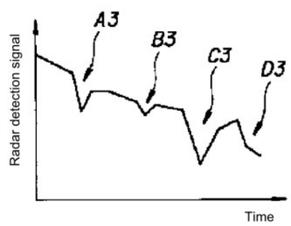
[FIG. 3]



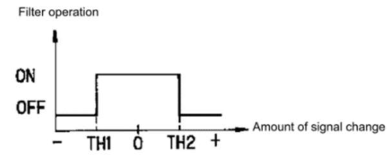
[FIG. 4]



[FIG. 5]



[FIG. 6]



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