[0006] Other types of digital radio broadcasting systems include satellite systems such as XM Radio, Sirius and WorldSpace, and terrestrial systems such as Digital Radio Mondiale (DRM), DRM+, Eureka 147 (branded as DAB), DAB Version 2, and FMeXtra. As used herein, the phrase "digital radio broadcasting" encompasses digital audio broadcasting including in-band on-channel broadcasting, as well as other digital terrestrial broadcasting and satellite broadcasting.

[0007] Antenna diversity techniques are used to mitigate the effects of distortion and outages due to multipath propagation of the received FM signal. Diversity can also accommodate the directional characteristics of glass-embedded window antennas. A variety of diversity antenna techniques have been developed and deployed for use with automotive FM receivers. Although all FM receivers, including tabletop, home theater, and portable receivers, could benefit from antenna diversity, only automotive receivers presently employ diversity techniques. Furthermore, the diversity algorithms developed for analog FM receivers are generally not appropriate for HD Radio digital reception.

[0008] It would be desirable to have a metric for the quality of a received radio signal that can be used to control antenna diversity switching, as well as switching control logic appropriate for the IBOC signals.

SUMMARY

[0009] Herein disclosed is~~In a first aspect, the invention provides~~ a method for detecting the quality of a radio signal, including: receiving a radio signal including a digital portion modulated by a series of symbols each including a plurality of samples; computing correlation points between endpoint samples in cyclic prefix regions of adjacent symbols; and using the correlation points to produce a digital signal quality metric.

[00010] Herein disclosed is~~In another aspect, the invention provides~~ an apparatus including: a radio receiver including an input for receiving a radio signal having a digital portion modulated by a series of symbols each including a plurality of samples, and a processor for computing correlation points between samples in cyclic prefix regions of adjacent symbols to produce a digital signal quality metric.

[00011] Herein disclosed is~~In another aspect, the invention provides~~ a method including: receiving a radio signal including an analog-modulated portion; digitally sampling an analog-modulated portion of the radio signal to produce a plurality of samples; and using a ratio between an average

magnitude and an RMS magnitude of a block of the samples to compute an analog signal quality metric.

[00012] Herein disclosed is~~In another aspect, the invention provides~~ an apparatus including: a radio receiver including an input for receiving a radio signal having an analog-modulated portion; and a processor for digitally sampling the analog-modulated portion to produce a plurality of samples; and using a ratio between an average magnitude and an RMS magnitude of a block of the samples to compute an analog signal quality metric.

[00013] In one~~another~~ aspect, the invention provides a method including: (a) receiving a radio signal on a plurality of antenna elements; (b) computing a signal quality metric for the signal received on each of the antenna elements; (c) determining a difference value between the signal quality metric for a~~the~~ currently selected antenna element and the signal quality metric for each of the other antenna elements; (d) finding the minimum difference value; (e) determining (1) if a dwell value for the currently selected antenna element is greater than a multiple of the minimum difference value and (2) if the signal quality metric computed for the currently selected antenna element is less than a threshold value; and (f) if either or both of (1) or (2) in step (e) is true, then switching from the currently selected element to one of the other antenna elements for supplying the radio signal to a receiver, and repeating steps (b) through (e).

[00014] In another aspect, the invention provides an apparatus including: a plurality of antenna elements configured to receive~~for receiving~~ a radio signal; a switch configured to connect~~for connecting~~ one or more of the antenna elements to an input of a receiver; and a processor configured to (a) compute~~for (a) computing~~ a signal quality metric for the signal received on each of the antenna elements, (b) determine~~determining~~ a difference value between the signal quality metric for the currently selected antenna element and the signal quality metric for each of the other antenna elements, (c) find~~ing~~ the minimum difference value, (d) determine~~determining~~ (1) if a dwell value is greater than a multiple of the minimum difference value and (2) if the signal quality metric computed for the currently selected~~first~~ antenna element is less than a threshold value, and (e) if either or both of (1) or (2) in step (e) is true, then control~~ling~~ the switch to switch from the currently selected element to one of the other antenna elements to supply~~for supplying~~ the radio signal to the receiver and repeat~~ing steps~~ (a) through (d).

[00015] In another aspect, the invention provides a method including: receiving a radio signal on a plurality of antenna elements, wherein the radio signal includes a digitally modulated component; computing a digital signal quality metric for the signal received on each of the antenna elements; using the digital signal quality metric for an antenna element currently supplying the radio signal to a receiver to determine if diversity switching is desired;

and producing a synthesized FM intermediate frequency proxy control signal that causes a diversity switch control to implement a desired switching of the antenna elements.

[00016] Herein disclosed is~~In another aspect, the invention provides~~ a method including: receiving a radio signal on a plurality of antenna elements, wherein the radio signal includes an analog modulated portion and a digitally modulated portion; computing an analog signal quality metric for the analog modulated portion of the received radio signal; computing a digital signal quality metric for the digital modulated portion of the received radio signal; and using either the analog signal quality metric or the digital signal quality metric to select one or more of the antenna elements to be connected to a receiver input, wherein a reaction time for selecting the antenna elements based on the analog signal quality metric is shorter than a reaction time for selecting the antenna elements based on the digital signal quality metric.

[00017] Herein disclosed is~~In another aspect, the invention provides~~ an apparatus including: a plurality of antenna elements for receiving a radio signal, wherein the radio signal includes an analog modulated portion and a digitally modulated portion; a switch for connecting one or more of the antenna elements to an input of a receiver; and a processor for computing an analog signal quality metric for the analog modulated portion of the received radio signal, computing a digital signal quality metric for the digital modulated portion of the received radio signal, and using either the analog signal quality metric or the digital signal quality metric to produce a switch control signal for selecting one or more of the antenna elements to be connected to a receiver input; wherein a reaction time for selecting the antenna elements based on the analog signal quality metric is shorter than a reaction time for selecting the antenna elements based on the digital signal quality metric.

BRIEF DESCRIPTION OF THE DRAWINGS

[00018] FIG. 1 is a block diagram of an FM receiver for use in an in-band on-channel digital radio broadcasting system.

[00019] FIG. 2 is a block diagram of isolation filters that can be used in the receiver of FIG. 1.

[00020] FIG. 3 is a graph of quality values for upper and lower digital sidebands over several measurement samples.

[00021] FIG. 4 is a graph of analog signal quality metric as a function of carrier-to-noise ratio.