[0069] **FIG. 11** is a diagram of parameters associated with a smooth effect according to an embodiment of the invention. **FIG. 12** is a diagram of parameters associated with a strong effect according to an embodiment of the invention. **FIG. 13** is a diagram of parameters associated with a sharp effect according to an embodiment of the invention.

[0070] A system and method for controlling audio output associated with haptic effects are discussed. Specific embodiments have been described above in connection with separately controlling multiple frequencies, either using a single controller or using multiple controllers, each of the multiple controllers being equally associated with a frequency range. Additionally, other embodiments have been discussed in connection with controlling an audio output associated with a haptic effect in at least one of the frequency ranges. Also, the audio effect can be changed, such that a user senses a change in frequency in the overall effect and perceives that change in a haptic effect; in some cases, this can occur above the frequency range where a user can tactilely detect variations in frequency (e.g., within a diminished-sensitivity region). Thus, as the frequency of the audio effect is increased, the user perceives an increase in a frequency of the haptic effect associated with the audio effect, even where such an increase results in a change in haptic frequencies within the diminished-sensitivity region. Similarly, as the frequency of the audio effect is decreased, the user perceives a decrease in frequency of the corresponding haptic effect, even where such changes result in variations of haptic effect frequencies, which are undetectable to a user (e.g., within the diminished-sensitivity region).

[0071] It will be appreciated, however, that embodiments of the invention can be in other specific forms without departing from the spirit or essential characteristics thereof. For example, while some embodiments have been described in the context of periodic or magnitude sweep control signals for causing haptic effects, any suitable signal can be used. Also, although control signals have been described as square-waves or PWM signals having square-wave-like shapes, other pulse shapes can be used. Additionally, although a specific reference has been made to devices configured to output periodic haptic effect (e.g., rotating haptic devices such spinning mass motors, etc.), any type of haptic device capable of outputting haptic effects associated with an audio output can be used according to one or more embodiments of the invention.

[0072] The presently disclosed embodiments are, therefore, considered in all respects to be illustrative and not restrictive.

What is claimed is:

1. A processor-readable medium comprising code representing instructions to cause a processor to:

send a signal configured to cause a haptic effect and an audio effect to be output substantially concurrently, the haptic effect having a frequency and the audio effect having a frequency different from the frequency of the haptic effect, the signal being further configured to vary at least one of the frequency of the haptic effect and the frequency of the audio effect while maintaining substantially constant an average energy of the haptic effect.

2. The processor-readable medium of claim 1, wherein the signal is further configured to cause the frequency of the audio effect to vary while causing the frequency of the haptic effect to remain substantially constant.

3. The processor-readable medium of claim 1, wherein the signal includes a plurality of pulses, the signal being configured to cause a frequency of the plurality of pulses to vary while causing a magnitude of the plurality of pulses to vary inversely.

4. The processor-readable medium of claim 1, the frequency of the haptic effect being a first frequency of the haptic effect, wherein the audio effect is configured to cause a user to perceive the haptic effect as having a second frequency different from the first frequency of the haptic effect.

5. The processor-readable medium of claim 1, the frequency of the haptic effect being a first frequency of the haptic effect, wherein the audio effect is configured to cause a user to perceive the haptic effect as having a second frequency different from the first frequency of the haptic effect, the second frequency being higher than the first frequency.

6. The processor-readable medium of claim 1, wherein the frequency of the audio effect is higher than the frequency of the haptic effect.

7. The processor-readable medium of claim 1, wherein the haptic effect has a frequency from a frequency range from a plurality of frequency ranges, each frequency range from the plurality of frequency ranges being uniquely associated with a control scheme.

8. An apparatus, comprising:

a controller configured to output a control signal, the control signal being configured to cause a haptic effect and an audio effect to be output substantially concurrently, the haptic effect having a frequency and the audio effect having a frequency different from the frequency of the haptic effect, the control signal being further configured to vary at least one of the frequency of the haptic effect and the frequency of the audio effect while maintaining substantially constant an average energy of the haptic effect; and

an interface component coupled to the controller and configured to be coupled to a component external to the controller, the interface component configured to provide a haptic instruction to the component based at least partially on the control signal.

9. The apparatus of claim 8, wherein the control signal is further configured to cause the frequency of the audio effect to vary while causing the frequency of the haptic effect to remain substantially constant.

10. The apparatus of claim 8, wherein the control signal includes a plurality of pulses, the controller being configured to cause a frequency of the plurality of pulses to vary while causing a magnitude of the plurality of pulses to vary inversely.

11. The apparatus of claim 8, wherein the audio effect is configured to cause a user to perceive the haptic effect as having a perceived frequency different from the frequency of the haptic effect.

12. The apparatus of claim 8, wherein the audio effect is configured to cause a user to perceive the haptic effect as having a perceived frequency different from the frequency of the haptic effect, the perceived frequency being higher than the frequency of the haptic effect.