

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

NINTENDO CO., LTD., and
NINTENDO OF AMERICA INC.,
Petitioners

v.

RESONANT SYSTEMS, INC.,
Patent Owner

Case No.: IPR2025-01098
U.S. Patent No. 8,860,337
Issue Date: October 14, 2014

Title: LINEAR VIBRATION MODULES AND LINEAR-RESONANT
VIBRATION MODULES

**DECLARATION OF DR. PINHAS BEN-TZVI IN SUPPORT OF PETITION
FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 8,860,337**

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I, Dr. Pinhas Ben-Tzvi, declare as follows:

I. INTRODUCTION

1. I have been retained by counsel for Nintendo Co., Ltd. and Nintendo of America, Inc. (collectively, “Nintendo” or “Petitioner”) in the above-captioned matter as an independent consultant to provide expert opinions regarding the patentability of claims 2 and 3 (the “Challenged Claims”) of U.S. Patent No. 8,860,337 (the “’337 patent” or “Challenged Patent”).

2. In preparing this Declaration, I have limited my analysis to the materials and opinions available at the time of preparing this Declaration, supplemented by my own knowledge and experience in the relevant field. If new materials, analyses, or opinions are introduced after the filing of this Declaration, I reserve the right to submit supplemental Declarations to address such developments.

3. If requested, I am prepared to explain, whether in a deposition or at a trial before the Patent Trial and Appeal Board (the “Board”), the technology disclosed in the Challenged Patent, including the state of the art at the relevant time. I am likewise prepared to discuss the technology disclosed in the prior art references cited herein, which may include, among other topics, background information on waveform generation, embedded systems, and linear actuators.

II. QUALIFICATIONS

4. My qualifications to offer testimony in the field of electronics technology are detailed in my *curriculum vitae* (NINTENDO-1017), which summarizes my educational background, academic appointments, research achievements, and professional experience in both industry and government.

5. I received a Bachelor of Science degree in Mechanical Engineering, summa cum laude, from the Technion—Israel Institute of Technology in 2000. I subsequently earned a Master of Science degree in 2004 and a Ph.D. in 2008, both in Mechanical Engineering, from the University of Toronto.

6. I am currently a tenured Professor in the Department of Mechanical Engineering and the Department of Electrical and Computer Engineering at Virginia Tech (Virginia Polytechnic Institute and State University) in Blacksburg, Virginia. I also serve as the founding Director of the Robotics and Mechatronics Laboratory (RML) at Virginia Tech.

7. I am a licensed Professional Engineer (P.E.) with approximately 25 years of combined academic and industrial experience in mechatronics design, testing, prototyping, control system integration, manufacturing, and overall mechatronic system development. My *curriculum vitae* details the various engineering positions I have held throughout my career.

8. Over the past two decades, my work has centered on embedded systems, electromechanical actuation, digital control architectures, real-time embedded software, robotics, haptic feedback, and human-machine interaction. I have overseen the development of numerous embedded platforms for robotics, wearable assistive technologies, and interactive control systems.

9. I have taught graduate and undergraduate courses, including Mechatronics Design, Mechatronics Laboratory, Controls Engineering, Controls Laboratory, and Advanced Robotics and Automation. These courses emphasize real-time system implementation, including digital control loops executed on microcontrollers such as AVR, PIC18, 8051, and ARM Cortex-M families, all of which were commercially available and widely used prior to 2009.

10. My practical experience includes hands-on development of embedded systems for controlling piezoelectric, voice-coil, and DC actuators, involving real-time firmware for resonance tracking, pulse-width modulation (PWM), signal shaping, and closed-loop feedback. These systems routinely utilized microcontroller peripherals such as timers, Analog-to-Digital Converters (ADCs), and analog comparators.

11. Prototypes and systems developed in my laboratory routinely incorporate timer-controlled PWM generation, sensor feedback (*e.g.*, encoders, accelerometers, tactile sensors), and H-bridge switching logic. I have implemented

H-bridges using both discrete NMOS/PMOS (N-type and P-Type MOSFET¹) configurations and commercial integrated drivers, such as the L298 (STMicroelectronics, datasheet dated 2000) (NINTENDO-1052) and DRV8800 (Texas Instruments, datasheet dated July 2008) (NINTENDO-1071).

12. I have authored more than 180 peer-reviewed journal and conference publications, as well as a textbook, several book chapters, and technical reports covering a wide range of topics including robotic actuation systems, embedded control architecture, electromechanical system integration, and human-machine interaction. My published work also spans areas such as digital control of actuators, sensor fusion, real-time system implementation, and haptic interface design.

13. I am the named inventor on a dozen issued U.S. patents, many of which pertain to precision motor control, closed-loop embedded systems, tactile feedback mechanisms, and modular robotic hardware platforms. These contributions reflect my long-standing expertise in both theoretical research and hands-on prototyping of intelligent electromechanical systems.

14. My technical expertise encompasses cyber-physical systems; robotics and intelligent autonomous systems; machine learning and AI integration in robotics; embedded sensing and control; human-robot interaction; system dynamics

¹ Metal-Oxide-Semiconductor Field-Effect Transistor.

and control; mechatronic product development; mechanism synthesis; and ergonomic system integration.

15. I also possess specialized expertise in the development of mobile robotic systems for military and law enforcement applications, as well as in CAD modeling, embedded system programming, and microprocessor-based system integration.

16. I have served as a consulting and testifying expert in litigation matters involving patent infringement, control system architecture, embedded hardware/software integration, and electromechanical device analysis. My responsibilities have included prior art evaluation, system modeling and analysis, claim construction, patent validity and infringement assessment, and detailed expert reporting.

17. My practical experience includes extensive design and implementation of embedded control systems for electromechanical actuators, including piezoelectric and DC motors. These systems have been developed across multiple funded research projects and prototypes, integrating microcontroller-based firmware to execute functions such as resonance tracking, pulse-width modulation, adaptive amplitude shaping, and signal conditioning. The control architectures I designed leveraged standard peripherals such as timer/counter modules, analog comparators, and ADCs on microcontrollers like the PIC18, AVR, and ARM7 families, which

were widely available and commonly used in industry between 2005 and 2009. My work often involved real-time embedded programming, sensor integration, and closed-loop feedback control tailored for haptic feedback, robotic manipulation, and biomedical applications.

18. My qualifications, experience, and subject matter expertise provide a strong foundation for understanding the technical issues in this matter and evaluating the relevant technologies with respect to embedded control, actuator interfacing, and software-based signal shaping.

19. My *curriculum vitae* contains further details regarding my experience, education, and other qualifications which allow me to render expert opinions in connection with this proceeding.

III. COMPENSATION

20. I am being compensated for my work in this matter at an hourly rate of \$550 for consulting services. My compensation does not depend on the content of my opinions or the outcome of this investigation.

IV. MATERIALS CONSIDERED

21. In preparing this declaration, I reviewed and considered the following materials, along with any other materials referenced in the body of my declaration:

EXHIBIT NO.	DESCRIPTION
1001	U.S. Patent No. 8,860,337 to Elenga et al.

EXHIBIT NO.	DESCRIPTION
1002	U.S. Patent No. 8,860,337 File History
1004	U.S. Patent No. 7,843,277 to Gregorio et al.
1005	U.S. Patent No. 7,005,811 to Wakuda et al. (“Wakuda”)
1006	U.S. Patent Application Publication No. 2008/0294984 to Ramsay et al. (“Ramsay”)
1007	U.S. Patent Application Publication No. 2006/0109256 to Grant et al.
1008	U.S. Patent Application Publication No. 2005/0134561 to Tierling et al.
1010	U.S. Patent Application Publication No. 2008/0198139 to Lacroix et al.
1017	<i>Curriculum Vitae</i> of Dr. Pinhas Ben-Tzvi
1018	Thorsten A. Kern, <i>Engineering Haptic Devices: A Beginner’s Guide for Engineers</i> , Springer, 2009
1019	U.S. Patent No. 6,982,696 to Shahoian
1020	U.S. Patent No. 4,879,641 to Rossi et al. (“Rossi”)
1021	Jack Aldrich, et al, <i>Controller for Driving a Piezoelectric Actuator at Resonance</i> , NASA Tech Briefs, April 2008 (“Aldrich”)
1022	Declaration of June Munford re Aldrich (“Aldrich Decl.”)
1023	U.S. Patent No. 7,027,032 to Rosenberg et al.
1024	U.S. Patent No. 5,736,797 to Motohashi et al.
1025	U.S. Patent No. 5,955,799 to Amaya et al.
1026	J. Peckol, <i>Embedded Systems, A contemporary Design Tool</i> , 2008

EXHIBIT NO.	DESCRIPTION
1039	U.S. Patent Publication No. 2009/0295739 to Nagara
1040	U.S. Patent Publication No. 2011/0133682 to Egger et al.
1041	U.S. Patent Publication No. 2008/0001484 to Fuller et al.
1043	U.S. Patent Publication No. 2005/0275294 to Izumi et al.
1047	Court's Claim Construction Order, Dkt. No. 91, <i>Resonant Systems, Inc. d/b/a RevelHMI v. Apple, Inc.</i> , Case No. 7:23-cv-00077 (W.D. Tex June 3, 2024)
1048	U.S. Patent No. 7,292,227 to Fukumoto et al. ("Fukumoto")
1049	U.S. Patent No. 7,006,641 to Saiki et al. ("Saiki")
1050	U.S. Patent No. 8,917,486 to Masahiko ("Masahiko")
1051	Claim Construction Order, Dkt. No. 107 <i>Resonant Systems, Inc. v. Sony Group Corp. and Sony Interactive Entertainment Inc.</i> , Case No. 22-cv-00424-JRG (E.D. Tex. Aug. 28, 2024)
1052	STMicroelectronics, L298: Dual Full-Bridge Driver Datasheet (2000) ("STMicroelectronics")
1053	<i>Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Resonant Systems, Inc.</i> , IPR2023-00993, Paper 11 (PTAB Oct. 16, 2023) (Patent Owner's Preliminary Response)
1054	<i>Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Resonant Systems, Inc.</i> , IPR2023-00993, Paper 16 (PTAB Nov. 29, 2023) (Corrected Patent Owner's Preliminary Sur-Reply)
1055	<i>Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Resonant Systems, Inc.</i> , IPR2023-00993, Paper 28 (PTAB Apr. 15, 2024) (Patent Owner's Response)

EXHIBIT NO.	DESCRIPTION
1056	<i>Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Resonant Systems, Inc.</i> , IPR2023-00993, Paper 41 (PTAB Aug. 29, 2024) (Patent Owner’s Sur-Reply)
1057	<i>Apple Inc. v. Resonant Systems, Inc.</i> , IPR2024-00807, Paper 10 (PTAB Oct. 15, 2024)
1058	<i>Samsung Electronics Co., Ltd., and Samsung Electronics America, Inc. v. Resonant Systems, Inc.</i> , IPR2023-00993, Paper 48 (PTAB Jan. 8, 2025) (Final Written Decision Determining Some Challenged Claims Unpatentable)
1059	Exhibit 12 to Nintendo Co., Ltd.’s Opposed Motion to Stay Pending <i>Inter Partes</i> Review, Dkt No. 18-13, <i>Resonant Systems, Inc. v. Nintendo Co., Ltd.</i> , Case No. 2:25-cv-00090-JRG (E.D. Tex May 7, 2025)
1060	Exhibit 13 to Nintendo Co., Ltd.’s Opposed Motion to Stay Pending <i>Inter Partes</i> Review, Dkt. No. 18-14, <i>Resonant Systems, Inc. v. Nintendo Co., Ltd.</i> , Case No. 2:25-cv-00090-JRG (E.D. Tex May 7, 2025)
1061	File History of U.S. Patent 8,093,767
1062	File History of Provisional Patent Application No. 61/179,109
1063	U.S. Patent Publication No. 2008/0155415 to Yoon et al.
1064	Exar Databook, <i>XR-8038: Precision Waveform Generator</i> , Chapter 1 at 213–214 (1985)
1065	Water G. Jung, <i>IC Op-Amp Cookbook, Second Edition, The Art of Electronics, 2nd Edition</i> , Howard W. Sams & Co., Inc., at 360–362 (1974)
1066	Herbert Friedman, <i>99 Electronic Projects</i> , Lafayette Radio Electronics, at 126 (1971)
1067	Excerpts from Paul Horowitz and Winfield Hill, <i>The Art of Electronics, 2nd Edition</i> , Cambridge University Press (1980)

EXHIBIT NO.	DESCRIPTION
1068	Jacob Millman, <i>Micro-Electronics: Digital and Analog Circuits and Systems</i> , McGraw-Hill Book Company, at 651-653, (1979)
1069	Atmel Application Note, <i>AVR494: AC Induction Motor Control Using the constant V/f Principle and a Natural PWM Algorithm</i> (2005)
1070	Microchip, <i>AN899: Brushless DC Motor Control Using PIC18FXX31 MCUs</i> (2004)
1071	Texas Instruments, <i>DRV880x DMOS Full-Bridge Motor Drivers</i> (July 2008)
1072	Millman and Halkias, <i>Integrated Electronics: Analog and Digital Circuits and Systems</i> , McGraw-Hill, Inc., at 130-140 (1972)
1073	Mohan et al., <i>Power Electronics: Converters, Applications, and Design, 2nd ed.</i> , John Wiley & Sons, Inc., at 188-190, 386-387 (1995)
1074	Muhammad H. Rashid, <i>Power Electronics: Circuits, Devices, and Applications, 3rd ed.</i> , Prentice Hall, at 230-233 (2003)
1075	Mohamed A. El-Sharkawi, <i>Fundamentals of Electric Drives</i> , Brooks/Cole Publishing Company, at 73-74, 169-170, 258-259 (2000)
1076	Sedra and Smith, <i>Microelectronic Circuits, 4th ed.</i> , Oxford University Press, at 436-441, 994-1002, 1009-1013, 1049-1058 (1998)

22. I may rely on these documents and information, or other information obtained during the course of this proceeding, as well as representative charts, graphs, demonstratives, schematics and diagrams, animations, and models based on

those documents and information, to support and to explain my testimony. I note here that citations in this declaration are to the “endorsed” page numbers placed by counsel in the lower right corner of each exhibit.

23. My opinions are based in part on a review and analysis of the above-mentioned documents and materials. I have also drawn on my education, experience, and knowledge of basic engineering and circuit design principles in forming my opinions.

V. UNDERSTANDING OF THE LAW

A. Legal Principles

24. I am not an attorney, but I have been informed of several legal principles, which I have employed in forming my opinions in this declaration. I understand that each patent claim is considered separately for purposes of patentability, and that a dependent claim incorporates all of the limitations of the claim from which it depends.

1. Claim Construction

25. I have been informed that the claims of the challenged patent in this proceeding are to be construed in accordance with the same standard applied in district court. I understand that claim construction begins with the ordinary meaning of a claim term, as understood by a person of ordinary skill in the art (POSITA) as of the effective filing date of the patent. I have also been informed that the primary

sources for determining the meaning of a claim term—collectively referred to as “intrinsic evidence”—include the claims themselves, the specification, and the prosecution history. Additionally, I understand that “extrinsic evidence,” such as contemporaneous dictionaries, technical treatises, and expert testimony, may also be considered to aid in construing claim terms.

26. I have also been informed that, under 35 U.S.C. § 112, it is permissible for a claim element to be “expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and that such a claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.”

27. For purposes of my analysis, I have used the date of May 18, 2009, for the reasons explained in § V.B below. However, the plain meanings and interpretations that I apply in my analysis would remain accurate even if the date of invention was anywhere within the early to mid-2000s. I have been informed by Counsel that the ’337 patent is the subject of litigation in federal district court and other proceedings before the Patent Trial and Appeal Board (PTAB), in which various claim constructions have been proposed by the parties and adopted by the court or the Board. I have reviewed the proposed constructions from these related proceedings, as well as the constructions adopted by the courts and PTAB panels for the same or related terms in the ’337 patent and related patents. These include:

- *Resonant Sys., Inc. v. Sony Grp. Corp. (Japan) and Sony Grp. Corp.*, Civil Action No. 2:22-cv-00424-JRG (E.D. Tex., filed October 2, 2022) (“Related Sony Litigation”);
- *Resonant Sys., Inc. d/b/a RevelHMI v. Apple, Inc.*, Civil Action No. 7:23-cv-00077-ADA (W.D. Tex., filed June 1, 2023) (“Related Apple Litigation”);
- *Apple Inc. v. Resonant Sys., Inc.*, IPR2024-00807 (PTAB, filed April 12, 2024);
and
- *Samsung Elecs. Co., Ltd., and Samsung Elecs. Am., Inc. v. Resonant Sys., Inc.*, No. IPR2023-00993 (PTAB, filed June 14, 2023).

As discussed below, the asserted claims are rendered obvious by the prior art under the various constructions applied to the relevant claim terms..

28. **“Driving component.”** I understand that Petitioner has construed the term “driving component” in Claim 2 as a means-plus-function term. Claim 2 recites the function of the “driving component” as follows: “drives the moveable component in each of two opposite directions within the housing.” For purposes of evaluating the prior art under this construction, I have interpreted “driving component” as including “a coil of conductive wire 420” (Figures 4A-4G); “coil 514” (Figures 5A-5B); “coil 626” (Figure 6); “electromagnet” (Figures 10-11); “additional coils 1202 and 1204” (Figure 12); “coils 1302 and 1304” (Figure 13); “driving coils 1412 and 1414” (Figure 14); “coil 1510” (Figures 15-17); “stator

coils” (Figures 24A-25), and equivalents thereof. *See* NINTENDO-1001, 5:2-34, 5:54-59, 6:32-35, 9:11-52, 9:64-10:22, 14:5-9.

29. I understand that the Patent Owner has agreed in co-pending litigation that “driving component” should be construed under § 112(6) as a means-plus-function term, consistent with the construction discussed above. This interpretation aligns with constructions adopted by both the PTAB and District Court in related proceedings. *See* NINTENDO-1047, 2; NINTENDO-1057, 11-12. I also understand that, in a final written decision involving the same limitation in the ’830 patent, the PTAB concluded that it was unnecessary to further construe the term beyond acknowledging that “the corresponding structure may be one or more coils.” *See* NINTENDO-1058, 10. As I explain in greater detail below, each Ground demonstrates that this element is disclosed in the prior art references.

30. **“Control component.”** I understand that Petitioner has interpreted the term “control component” in independent Claim 2 as a means-plus-function limitation. Claim 2 specifies that the “control component” performs the function of “control[ling] supply of power from the power supply to the driving component,” and that this function is executed to achieve a defined result: to “cause the moveable component to oscillate at a frequency and an amplitude specified by user input received from the user-input features” and “drives simultaneous oscillation of the moveable component at two or more frequencies to generate complex vibration

modes.” For purposes of analyzing the prior art under this means-plus-function construction, I have treated “control component” as corresponding to:

- one of the switches illustrated in Figures 5A-6 and described at 5:45-65, 6:2-8 and
- “a microcontroller, a processor, a microprocessor, or a CPU that performs the algorithm shown in Steps 706 through 716 in Figure 7A, with reference to the steps shown in Figures 7B and 7C, or the algorithm described in the corresponding text, *See, e.g.* 7:10–7:24, 7:32–8:30 and/or equivalents thereof.”

See NINTENDO-1047, 5. I refer to this interpretation as the “Full Construction.”

31. I understand that the term “control component” has been construed differently in other proceedings. In particular, the PTAB in IPR2024-00807 determined at institution that the corresponding structure consists of a processor and memory performing an abridged two-step algorithm: “1) operating a timer or its equivalent to flip the polarity of a control value periodically corresponding to a user-selected frequency and input the control value to an H-bridge switch circuit to change the direction of the current through the coil as supplied by the power supply, and 2) computing an output value corresponding to a user-selected amplitude of oscillation and outputting the value to the claimed power supply so that the power supply outputs an appropriate current amplitude to a coil.” NINTENDO-1057, 20.

I note that this “Abridged Construction” substantially overlaps with the steps in the

Full Construction, except that it omits monitoring functions described in Steps 710 and 712 of Figure 7A. *See* NINTENDO-1001, Fig. 7A. Because any “control component” satisfying the Full Construction also satisfies the Abridged Construction, the prior art combinations that render the claims obvious under the Full Construction also render them obvious under the Abridged Construction, as discussed in more detail below.

32. I further understand that, in a separate litigation, the Court adopted a construction similar to the Abridged Construction and applied a prosecution disclaimer made by the applicant during examination of the related '830 patent. This disclaimer requires that the “control component” be located “within the device” – that is, within the “vibrating module”. *See* NINTENDO-1051, 11-16. As discussed below, this additional requirement is also disclosed in, or rendered obvious by, the prior art. I understand that the Patent Owner may dispute this disclaimer; accordingly I also address the relevant aspects of the prior art combinations that would be unnecessary if the Board determines that no disclaimer applies.

33. In summary, and as discussed in further detail below, each of the asserted Grounds demonstrates unpatentability of the Challenged Claims under the various means-plus-function constructions.

2. Burden of Proof

34. I have been informed that, in an *inter partes* review, the petitioner bears the burden of establishing unpatentability by “a preponderance of the evidence.” I further understand that this standard requires the petitioner to show that the asserted proposition is more likely than not to be true.

3. Obviousness

35. I have been informed that a patent claim is unpatentable if it would have been obvious to a POSITA at the time of the claimed invention. I understand that a claimed invention is not patentable if the differences between it and the prior art are such that, as a whole, the subject matter would have been obvious to a person having ordinary skill in the relevant field at the time the invention was made. I have also been informed that factors relevant to the determination of obviousness include: (1) the scope and content of the prior art; (2) the level of ordinary skill in the art at the time of the invention; (3) the differences between the claimed invention and the prior art, and (4) “secondary considerations” or objective indicia of non-obviousness.

36. I have been informed that a single prior art reference can render a patent claim obvious if any differences between the reference and the claim would have been known or obvious to a POSITA at the time of the invention. In other words, if a POSITA could have modified or adapted the teachings of the reference using

known techniques to achieve predictable results, then the claim is rendered obvious by that reference.

37. I have been informed that combining familiar elements according to known methods is likely to be considered obvious when the result is merely predictable. I further understand that a patent claim is obvious if it simply arranges known elements, each performing its conventional function, and the combination yields no more than what a POSITA would reasonably expect.

38. I have been informed that a patent claim comprising multiple limitations is not rendered obvious merely because each individual limitation was known in the prior art. I understand that hindsight reasoning is not a proper basis for combining references to establish obviousness. I have also been informed that, in assessing obviousness, it is important to identify a rationale that would have prompted a person of ordinary skill in the relevant field to combine multiple prior art references, or multiple teachings within a single reference. Furthermore, I understand that such a combination must have been accompanied by a reasonable expectation of success on the part of a person of ordinary skill in the art.

39. I have been informed that various “secondary considerations”, also referred to as objective indicia of non-obviousness, may support a determination that a claimed invention is not obvious, and that such considerations must be taken into account as part of the obviousness analysis. I understand that even compelling

evidence of secondary considerations may not be sufficient to overcome a strong showing of obviousness. I have been informed that the patentee bears the initial burden of establishing both the existence and the nexus of any secondary considerations, after which the burden of producing rebuttal evidence shifts to the party asserting obviousness. I have been further informed that the following secondary considerations may weigh in favor of non-obviousness:

40. ***Copying***: evidence that others, including the accused infringer, copied the patented invention.

41. ***Long-standing problem or unmet need***: evidence of a persistent problem or unmet need in the art that was addressed by the patented invention.

42. ***Prior failure***: evidence that others previously attempted and failed to solve the problem addressed by the claimed invention.

43. ***Commercial acquiescence or licensing***: evidence showing the willingness of competitors or industry participants to license the patent at issue.

44. ***Skepticism***: evidence that those of ordinary skill in the art were initially skeptical of the merits or feasibility of the invention.

45. ***Praise***: evidence of recognition or praise for the invention from others in the relevant technical community.

46. ***Unexpected results***: evidence that the performance or results of the claimed invention exceeded the expectations of those skilled in the art.

47. I have also been informed that the near-simultaneous invention by others may serve as evidence that a claimed invention is obvious. Additionally, I understand that the patentee bears the burden of establishing a “nexus” between the claimed invention and any evidence proffered in support of secondary considerations. For example, it is not sufficient to show that a commercially successful product practices the claimed invention; there must be evidence that the commercial success was attributable, at least in part, to the features recited in the claimed invention.

B. Priority Date

48. The application that led to the '337 patent (U.S. Appl. No. 13/345,607) was filed on January 6, 2012, and claims priority to U.S. Provisional Application 61/179,109 filed on May 18, 2009. *See* NINTENDO-1001, Cover. For purposes of my analysis, I have used May 18, 2009, as the effective priority date of the '337 patent. However, in many instances, my analysis would remain valid even if the date of the alleged invention were earlier than May 18, 2009.

C. Level of Skill in the Art

49. A person of ordinary skill in the art at the time of the '337 patent (“POSITA”) would have held a degree in mechanical engineering, electrical engineering, physics, or a related technical discipline, along with at least 2 to 3 years of experience in the design or development of systems incorporating linear actuators.

Alternatively, additional years of relevant experience could substitute for formal advanced education. In my opinion, the conclusions presented in this Declaration would remain the same even if a slightly higher or lower level of skill were applied.

50. I have based my analysis from the perspective of a POSITA as of the date of the provisional application to which the application that led to the '337 patent claims priority, which is May 18, 2009. However, my analysis would remain substantially the same even if the relevant date were slightly earlier or later.

51. Based on my education and experience as of May 18, 2009, I consider myself a POSITA with respect to the subject matter of the '337 patent.

VI. SUMMARY OF OPINIONS

52. I have been asked to evaluate the patentability of claims 2-3 of the '337 patent in light of the prior art references listed above in Section IV. Based on my analysis, it is my opinion that, as of the priority date of the '337 patent, the Challenged Claims are unpatentable as obvious pursuant to the grounds summarized below:

Ground	Challenged Claim(s) ²
1	Claims 2 and 3 are obvious over Wakuda, Ramsay, Rossi, and Aldrich
2	Claim 2 is obvious over Fukumoto and Aldrich
3	Claim 3 is obvious over Fukumoto, Aldrich, Saiki, and Masahiko
4	Claim 2 is obvious over Fukumoto
5	Claim 3 is obvious over Fukumoto, Saiki, and Masahiko

53. My detailed analysis in Section IX explains the basis of my conclusion that the five grounds identified above render the Challenged Claims unpatentable.

54. I further reserve the right to cite and rely upon additional portions of the referenced prior art in any future declarations, depositions, or testimony.

VII. TECHNOLOGY BACKGROUND

55. Before analyzing the '337 patent in detail, it is helpful to provide background of the underlying technology. This includes basic concepts related to embedded systems and their use in generating various types of waveforms.

56. Embedded systems are dedicated computing systems designed for real-time interaction with hardware environments. They typically incorporate

² I have been informed by counsel for Petitioner that the Wakuda, Ramsay, Rossi, Aldrich, Fukumoto, Saiki, and Masahiko references each qualify as prior art to the '337 patent.

microcontrollers equipped with peripherals such as timers, PWM generators, analog-to-digital converters (ADCs), and communication interfaces. By 2005, detailed application notes like Atmel's AVR494 demonstrated how AVR microcontrollers could be used for precise motor control using PWM and feedback algorithms, highlighting their suitability for driving electromechanical systems. Prior to 2009, widely used microcontrollers included Atmel's AVR family, Microchip's PIC16/18 series, Intel's 8051 variants, and Texas Instruments' (TI's) MSP430 series. *See, e.g.,* NINTENDO-1069-1070.

57. Timers are essential in embedded systems for managing asynchronous events and generating control waveforms. In the context of vibration systems, timers serve several key functions, including:

- Generating high-frequency PWM signals to modulate H-bridge output;
- Scheduling sensor sampling intervals (e.g., for measuring vibration amplitude or phase);
- Triggering timed events in digital control loops without blocking the central processing unit (CPU).

See, e.g., NINTENDO-1069-1070; Sedra & Smith, *Microelectronic Circuits*, 4th ed., 1998 (NINTENDO-1076, 26-30).

58. Digital control systems operate using discrete-time feedback mechanisms to ensure desired system performance. Key functions in such systems include:

- Sampling sensor data at regular intervals using ADC or comparator inputs;
- Computing error or state feedback (*e.g.*, deviations in vibration response);
- Updating actuator commands based on control logic, such as PID or resonance-tracking algorithms; and
- Using timers and interrupts to enforce consistent control cycle timing and maintain fidelity.

59. H-bridge circuits are a canonical solution for bidirectional motor control, consisting of four switches arranged to allow current to flow in either direction through a load. These configurations enable precise directional control, dynamic braking, and active current modulation. Even when not explicitly labeled as “H-bridges” in earlier engineering texts, the functional architecture—based on complementary transistor switching and push-pull amplifier structures—was well established and widely understood by practitioners. The STMicroelectronics L298 datasheet (2000) (*see* NINTENDO-1052) explicitly describes such a motor driver. By 2009, the design of switching logic using MOSFETs was standard engineering practice. Foundational references such as Millman and Halkias’ *Integrated Electronics* (1972) (NINTENDO-1072) and Horowitz and Hill’s *The Art of*

Electronics (2nd Ed., 1980) (NINTENDO-1067) provided detailed theoretical grounding for transistor switching behavior and protection strategies essential for H-bridge design. In particular, *Integrated Electronics* explains the use of bipolar junction transistors (BJTs) in digital switching applications. Section 5-7, “The CE Cutoff Region” (pp. 15-17), and Section 5-8, “The CE Saturation Region” (pp. 17-20) describe the BJT’s behavior in the off and on states, respectively—principles foundational to their role in H-bridge circuits and related actuator control topologies. By 2009, H-bridge implementations using MOSFETs and logic-level control signals were commonplace in consumer electronics, mobile devices, robotics, and haptics applications.

60. The foundational principles and applications of H-bridge circuits are extensively documented in established power electronics literature. In *Power Electronics: Converters, Applications, and Design* by Mohan, Undeland, and Robbins (2nd ed., 1995) (NINTENDO-1073), Section 13.6.2 (“Power Electronic Converter”, pp. 16-17) describes the use of H-bridge topologies for four-quadrant control of electromechanical systems, including bidirectional current and voltage operation. Additionally, Section 7.7 (“Full-Bridge DC–DC Converter”, pp. 13-15) provides circuit analysis of the full-bridge converter, which is functionally analogous to H-bridge configurations used in actuator and motor drive systems. These sections reflect the standard engineering understanding of H-bridge behavior

well before May 2009. Rashid's *Power Electronics: Circuits, Devices, and Applications* (3rd ed., 2003) (NINTENDO-1074) further provides a foundational coverage of H-bridge inverters and their application to motor control, emphasizing bidirectional switching for controlling DC motor direction and speed. Section 8.4 ("*Single-Phase Bridge Inverters*", pp. 12-15) illustrates the H-bridge configuration using four switching devices, and explains how modulation techniques, such as simultaneous switching of transistor pairs, enable output voltage polarity reversal across the motor terminals. Figures 8-2a through 8-2c further depict the inverter circuit, waveforms, and load current behavior under inductive conditions, highlighting the operational principles critical for effective motor drive implementations. El-Sharkawi's *Fundamentals of Electric Drives* (2000) (NINTENDO-1075) also discusses the use of H-bridge circuits as core components of electric drive systems. Page 9 introduces the full-bridge (H-bridge) converter topology used to control the polarity of voltage applied to a DC motor, thereby enabling directional control. Page 10 describes a full-wave drive configuration using four SCRs (silicon-controlled rectifiers), which implement controlled switching to sustain unidirectional current while alternating voltage polarity across the motor—functionally analogous to H-bridge operation. Additional control strategies on Page 12 reflect standard design techniques for embedded motor drive systems in use prior to May 2009. Collectively, these texts confirm that by 2009, H-bridge circuits were

well-understood and widely implemented in embedded control system design. *See also* §§ IX.A.2, IX.A.4.g, IX.B.2.g.

61. As detailed in the seminal text *Microelectronic Circuits* by Sedra and Smith (4th ed., 1998) (NINTENDO-1076), NMOS and PMOS transistors were widely recognized as foundational elements in switching and signal modulation circuits used in both digital logic and analog control applications. The text provides a comprehensive coverage of MOSFET operation and switching behavior in Section 5.9 (“The MOSFET as an Analog Switch”, pp. 11-16), digital logic design in Section 13.2 (“Design and Performance Analysis of the CMOS Inverter”, pp. 31-40), and waveform generation circuits in Section 12.4 (“Bistable Multivibrators”, pp. 17-25). These principles underpin the operation of H-bridge motor drivers and microcontroller-based timing circuits used in actuator and vibration control systems. By 2009, and well before, these components and design methodologies were standard in embedded control system engineering.

62. Motor driver integrated circuits (“ICs”) such as the L293D, L298, and DRV8800 were widely used to interface with microcontroller via logic-level inputs and could be configured with external PWM sources and current sensing for closed-loop control. These ICs were extensively documented in publicly available datasheets and reference designs by the early to mid-2000s and most certainly by 2009. For example, the DRV8800 datasheet (TI SLVS855A, July 2008) describes a

full H-bridge driver capable of bidirectional motor control using PWM input, illustrating the straightforward integration of such drivers with embedded systems.

See NINTENDO-1071.

63. To drive haptic actuators effectively, designers often utilize waveforms tailored to the actuator's resonant frequency and/or to a desired tactile feel or effect.

A non-exhaustive list of commonly used waveform categories include:

- **Sinusoidal:** Tuned to the actuator's natural frequency to maximize oscillation amplitude;
- **Modulated:** Amplitude- or frequency-shaped over time to produce dynamic tactile sensations;
- **Aperiodic:** Designed to avoid repetitive feedback and simulate textures or irregular surfaces.

64. In the context of haptic actuator control and waveform generation, several key signal concepts and terms are commonly used:

- **Primary frequency:** The fundamental excitation signal applied to the actuator;
- **Modulating frequency:** A slower frequency that alters the amplitude or frequency envelope of the primary signal;
- **Resonant frequency:** The frequency at which output amplitude is maximized due to mechanical resonance;

- **Beat frequency:** A low-frequency envelope resulting from the interference of two closely spaced frequencies;
- **Aperiodic waveform:** A non-repeating waveform often generated by switching among predefined profiles to simulate irregular tactile sensations.

See, e.g., NINTENDO-1005, NINTENDO-1006, NINTENDO-1020.

65. These waveforms are typically generated using software-configured timers, PWM modules, and DACs embedded within microcontrollers. Pre-2009 platforms like the Atmel ATmega88 or PIC18F4520 supported these capabilities and were accompanied by robust development tools and vendor documentation. Timing-driven actuation control is well illustrated in Aldrich, which discloses a resonance-following algorithm that dynamically adjusts the driving frequency based on sensed impedance changes. By 2008, such algorithms were commonly implemented in firmware using lookup tables or timer-interrupt-based frequency modulation techniques. *See* NINTENDO-1021.

VIII. THE '337 PATENT

A. Overview

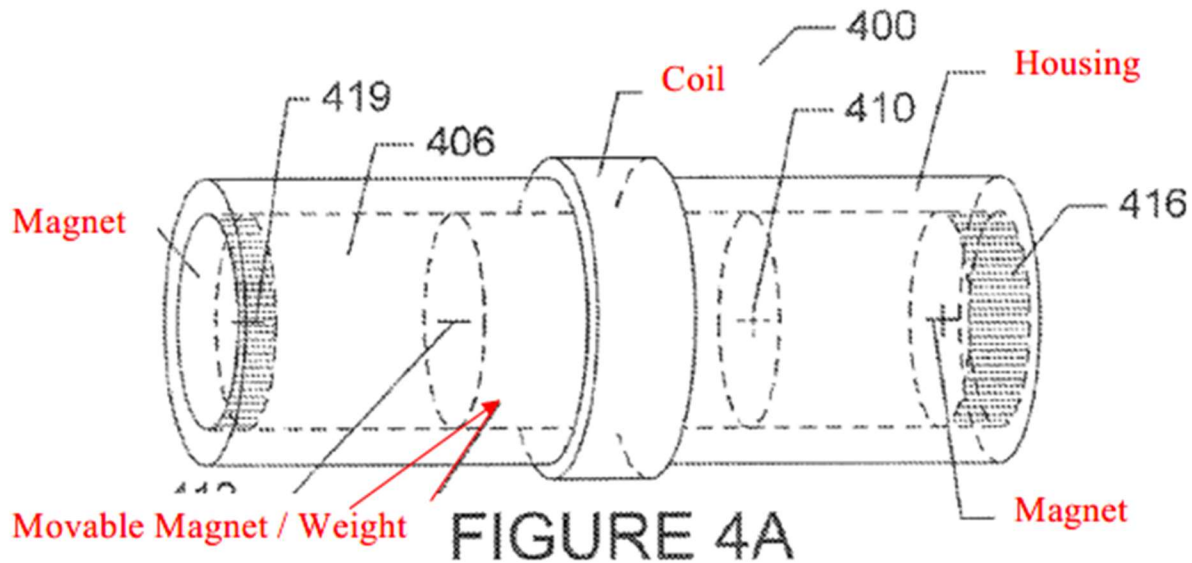
66. The '337 patent discloses “vibration modules that can be incorporated into a wide variety of different types of electromechanical devices and systems to produce vibrations of selected amplitudes and frequencies over a wide range of amplitude/frequency space.” *See* NINTENDO-1001, 1:14-19. It further notes that

these vibration modules “can be incorporated in a wide variety of appliances, devices, and systems to provide vibrational forces,” including “consumer appliances” and “pagers.” *See id.*, Abstract, 1:23-31, 2:63-3:2, 3:6-20; 3:58-60, 4:13-17. In contrast to prior-art motors that generated vibrations as a by-product of unbalanced rotation, the ’337 patent describes systems in which vibrational forces are produced by the linear oscillation of a weight or component within a linear vibration module (LVM) or linear resonant vibration module (LRVM). This approach is presented as a solution to the limitations of earlier unbalanced-mass motor designs. *See id.*, 4:17-32.

67. The Background Section of the ’337 patent identifies several alleged shortcomings associated with the use of vibration-inducing devices that rely on intentionally unbalanced electric motors. According to the patent, these devices suffer from: (1) “rapid deterioration of motor parts” (*see* NINTENDO-1001, 2:11-30), (2) “inefficient at producing vibrational motion” (*see id.*, 2:31-38), (3) “elliptical vibrational modes” (*see id.*, 2:39-45), and (4) “a very limited portion of the total vibrational-force/frequency space is accessible” (*see id.*, 2:46-62).

68. The ’337 patent’s specification discloses features of “linear-resonant vibration modules ... to provide vibrational forces.” *See* NINTENDO-1001, 3:6-9. Referencing the figures of the patent help illustrate such features and components.

Figure 4A, reproduced below, illustrates one embodiment of a linear-resonant vibration module (LRVM):

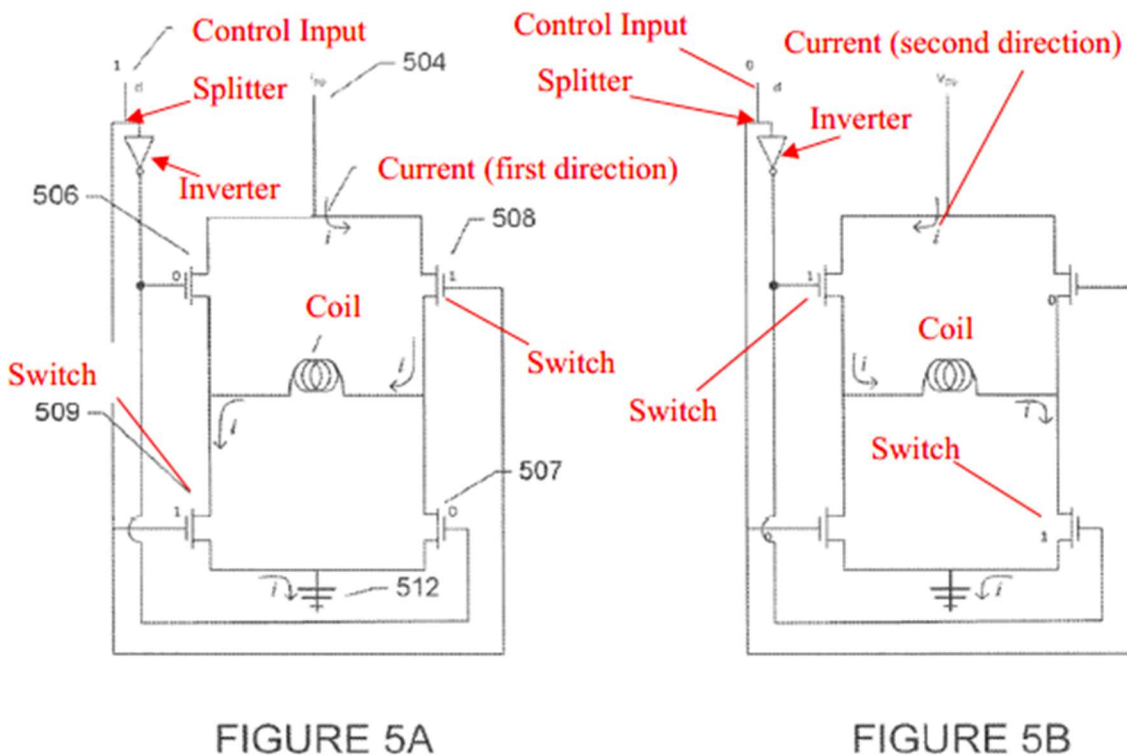


Id., Fig. 4A (annotated).

69. Figure 4A of the '337 patent depicts an LRVM “includ[ing] a cylindrical housing 402 within which a solid, cylindrical mass 404, or weight, can move linearly along the inner, hollow cylindrically shaped chamber 406 within the cylindrical housing or tube 402.” See NINTENDO-1001, 4:49-52. The vibrational forces of such a LRVM “are produced by a linear oscillation of a weight or member.” See *id.*, 3:9-12. The patent describes the use of magnetic force generated by current flowing through the coil, which in turn actuates the magnetic weight in the housing. See *e.g.*, *id.*, 4:44-5:34, Figures 4A-G. The direction of the current through the coil determines the direction of the magnetic force acting on the movable mass. *Id.* Thus,

by alternating the direction of current in the coil allows the direction of the magnetic force (and direction of travel of the weight) to fluctuate between two directions.

70. The '337 patent describes that an H-bridge switch is used to control the direction of current in the coil. *See* NINTENDO-1001, 5:43-65 (describing an H-bridge switch used “to change the direction of current applied to the coil that drives linear oscillation within an LRVM”). Figures 5A and 5B, reproduced below, illustrate an example of the H-bridge switch and its operation:



Id., Figs. 5A, 5B (both annotated).

71. As I discussed above in § VII and further in § IX.B.2.g, H-bridge switches were well known to POSITAs prior to May 18, 2009. For example,

Fundamentals of Electric Drives (NINTENDO-1075), a 2000 undergraduate-level textbook on electrical drive systems, describes such H-bridge switches. The H-bridge configuration shown in Figures 5A and 5B of the '337 patent follows conventional H-bridge switching principles:³ a control input determines which switches are activated to direct current flow through the coil. *See* NINTENDO-1001, 5:52- 61. As with any H-bridge, the direction of current flow (*i.e.*, the first direction (shown in Figure 5A) or a second direction (shown in Figure 5B)) depends on which switches are closed and which are open. *Id.* For example, as shown above, the “input control signal d 502” controls four switches 506-509. *Id.* When the input control signal 502 is a “1” as shown in Figure 5A, “switches 508 and 509 are closed and switches 506 and 507 are open, and therefore current flows ... in the leftward

³ Careful observation shows that the circuit shown in Figures 5A-B includes an inverter, although this component is not described in the Detailed Description of the '337 patent. That said, use of such inverters was (and still is) a known design choice that enables a single control input signal to operate all four switches simultaneously. *See, e.g.*, NINTENDO-1020, FIGS. 1, 4, & 6; NINTENDO-1040, Fig. 4. Alternatively, the controller or CPU could achieve the same functionality by sending separate control signals to each switch.

direction through the coil 514.” *Id.* “When the input control signal d is low, or ‘0’ as shown in FIG. 5B, the direction of the current through the coil is reversed.” *Id.*

72. The ’337 patent also shows that its LRVM includes a CPU microprocessor 602, as shown in Fig. 6 below:

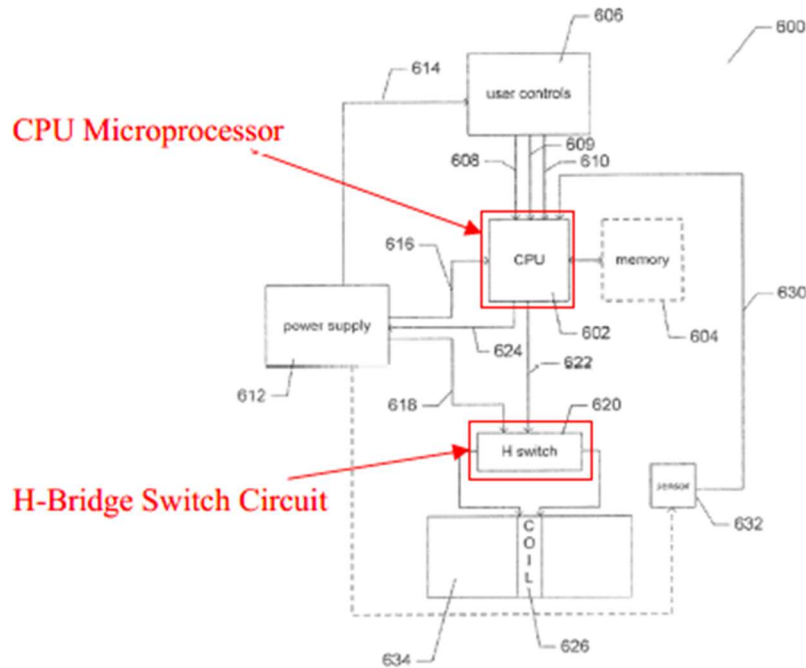


FIGURE 6

NINTENDO-1001, Fig. 6 (annotated).

73. The ’337 patent’s specification states that the “H-bridge switch 620 receives a control-signal input d 622 from the CPU. The power supply 612 receives a control input 624 from the CPU to control the current supplied to the H-bridge switch 618 for transfer to the coil 626.” *See* NINTENDO-1001, 6:32-35. The CPU, in turn, receives input from “one or more electromechanical sensors 632 that

generate a signal corresponding to the strength of vibration currently being produced by the linearly oscillating mass 634.” *Id.*, 6:36-39. Additionally, the patent explains that the “frequency of the oscillation of the solid, cylindrical mass is determined by the frequency at which the direction of the current applied to the coil is changed.” *Id.*, 5:43-45.

74. The CPU can execute a control program to manage the operation of the LRVM. *See* NINTENDO-1001, 6:43-47, Figures 7A-C. This control program is used to regulate both the frequency and vibrational force of the oscillation. *See, id.*, 7:38-42. The ’337 patent discloses that the CPU employs a “monitor” routine that “converts the sensor input into an integer representing the current vibrational force produced by the LRVM.” *Id.*, 7:43-46. Fig. 7B is described as “control flow diagram for the routine ‘monitor.’” *Id.*, 7:33-36. In its default mode, the “monitor” routine enables the “LRVM” to use “continuous feedback control to optimize the vibrational force produced by the LRVM by continuously seeking to operate the LRVM at a frequency as close as possible to the resonant frequency for the LRVM.” *Id.*, 7:38-42.⁴

⁴ The ’337 patent’s specification also discloses that more “complex vibrational modes” may also be used.

75. The LRVM described in the '337 patent includes a feedback control mechanism to maintain the frequency near the device's resonant frequency. *See* NINTENDO-1001, 4:36-41. As stated in the patent, "the frequency of vibration falls close to the resonant frequency of the LRVM, [and] results in optimal power consumption with respect to the amplitude and frequency of vibration produced by the LRVM." *Id.*

B. Prosecution History

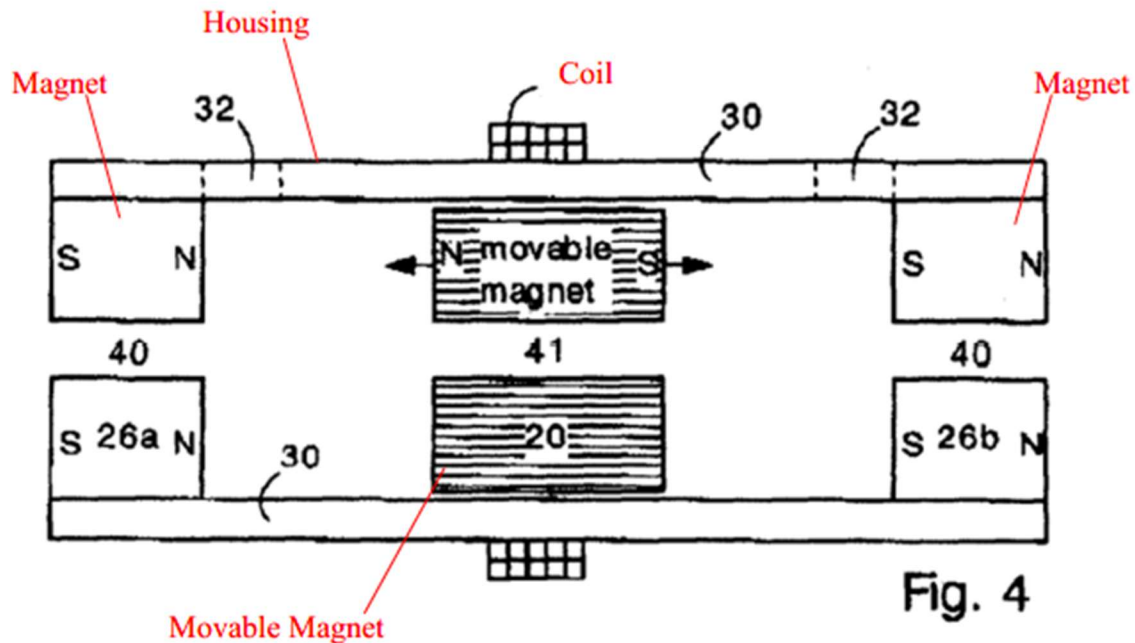
76. The '337 patent issued on October 14, 2014, from U.S. Patent Application No. 13/345,607 ("the '607 application"), which was filed on January 6, 2012. *See* NINTENDO-1002, 2, 120. During prosecution, a first Office Action rejected then-pending claims 1-3 as obvious over U.S. Patent Application Publication No. 2005/0231045 ("Oba"), U.S. Patent Application Publication No. 2005/0275508 ("Orr"), and U.S. Patent Application Publication No. 2011/0248817 ("Houston"). Claims 4-9 were rejected as obvious over Oba, Orr, Houston, and U.S. Patent No. 5,955,799 ("Amaya"), while claims 10-13 were rejected as obvious over Oba, Orr, Houston, U.S. Patent Application Publication No. 2006/0208600 ("Sahyoun"), U.S. Patent No. 6,323,568 ("Zaber"), and U.S. Patent Application Publication No. 2006/0138875 ("Kim"). *Id.*, 51-57. The office action also indicated that claims 14-18 were objected to and would be allowable if rewritten in independent form. *Id.*, 55. In response, then-Applicant cancelled claims 1-13 without

traversing the rejections and rewrote claims 14, 15, 17, and 18 in independent form. *Id.*, 25-30.

77. A notice of allowance followed, concluding prosecution without further examination and without consideration of more pertinent art, including Wakuda, Ramsay, Rossi, Aldrich, Fukumoto, Saiki, and Masahiko. The notice of allowance did not provide any reasons for allowance. *See* NINTENDO-1002, 8-12. Although the '337 patent describes its linear resonant vibration device as an alleged “invention,” the scope was not novel. As I show herein, persons of ordinary skill in the art were already familiar with linear vibration devices that incorporated a microprocessor and feedback control mechanisms, as well as the benefit of reduced power consumption when operating at or near resonant frequency.

78. It's important to note here that the prior art I analyze herein was not reviewed by the Examiner, much less cited or relied upon by the Examiner during prosecution of the '337 patent. The Examiner allowed the claims without considering pertinent references such as Wakuda, Ramsay, Rossi, Aldrich, Fukumoto, Saiki, and Masahiko. Based on my knowledge and experience, and review of the prior art and other references discussed in more detail below, I do not agree that the claims of the '337 are patentable over this prior art. Persons of ordinary skill in the art were already familiar with linear vibration devices exhibiting similar structural design and incorporating microprocessor and feedback control

mechanisms. Moreover, the advantages of operating such devices at or near their resonant frequency were well known. Such advantages are detailed in, *e.g.*, *Fuller*. See *e.g.*, NINTENDO-1041, [0036].

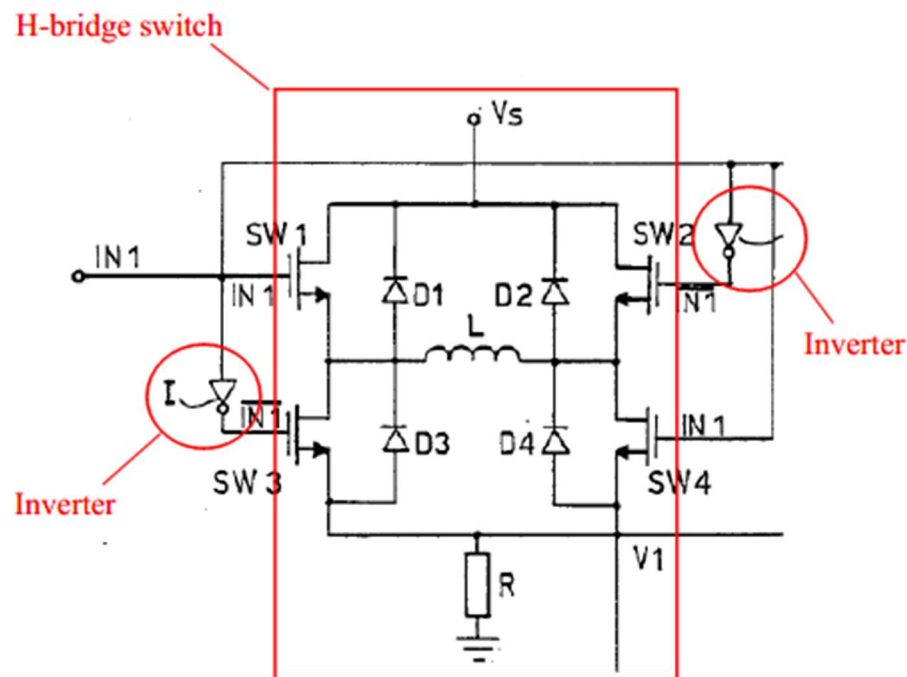


Id., Fig. 4 (annotated).

79. *Fuller* explains that the coil can apply both a pushing force and a pulling force to the movable magnet shown in its Fig. 4. See NINTENDO-1041, [0043]. *Fuller* continues to explain that by alternating the current applied to the field coils, one can operate the device such that the alternating current (and thus force applied to the movable magnet) “has a frequency selected to match a mechanical resonance frequency of the movable magnet 20.” See *id.*, [0036]. *Fuller* further explains that the current applied to the coils may span “a range of frequencies that includes the

mechanical resonance frequency of the movable magnet.” *Id.* Additionally, Fuller discloses the use of feedback control to determine the “proper resonant frequency for the alternating current.” *Id.*

80. As discussed above, the H-bridge switch disclosed in the '337 patent was well known at the time and was commonly used in similar vibration modules. For example, *Rossi* illustrates an H-bridge switch that includes a splitter/inverter, as shown in Fig. 6:

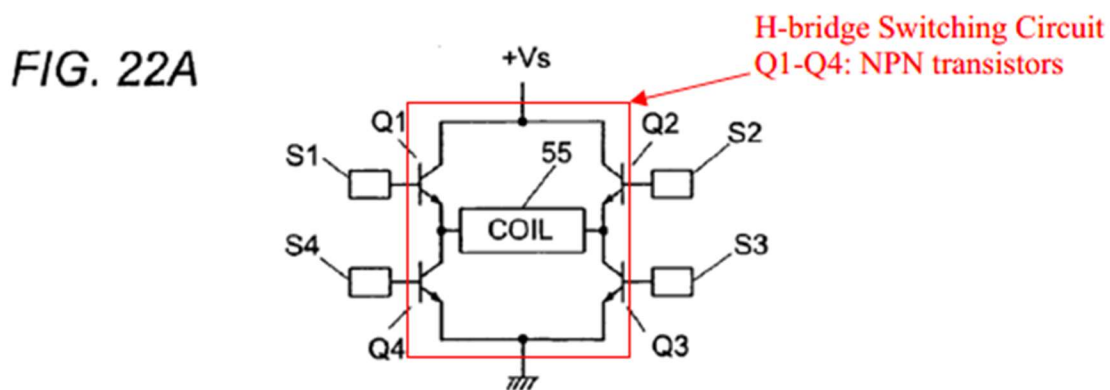


NINTENDO-1020, Fig. 6 (partial) (annotated).

81. As illustrated in this figure the use of an H-bridge switch with inverter/spitter components was a known technique at the time for supplying

oscillating current through a load, such as an electromagnet coil, depicted in Fig. 6 as the “L” component.

82. Yet another example of the usage of H-bridge switches is given by *Izumi*. Specifically, *Izumi* teaches the use of an H-bridge switch for providing bi-directional drive signals to an inductive load, as shown in Fig. 22A. Fig. 22A is reproduced below:



NINTENDO-1043, Fig. 22A (annotated).

83. *Izumi*’s Fig. 22A shows how the alternating voltage output to the coil is “constituted by a series circuit of switching elements Q1 and Q4 ... and a series circuit of switching elements Q2 and Q3.” *See* NINTENDO-1043, [0060]. “The switching elements Q1 to Q4 are controlled by control signals S1 to S4, respectively, which are inputted into the base terminals by the current waveform decider 60.” *Id.* In Figure 22A, the switching elements Q1 to Q4 are NPN transistors. A separate figure in *Izumi* (Fig. 22D) presents a similar configuration but substitutes field effect

transistors (FETs) for the switching elements (the NPN transistors). *Id.*, [0061], Figure 22D.

84. Another example showing the well-known nature of H-bridge circuits is in *Egger* (see NINTENDO-1040). Specifically, Fig. 4 of *Egger* illustrates an H-bridge switch with an inverter/splitter:

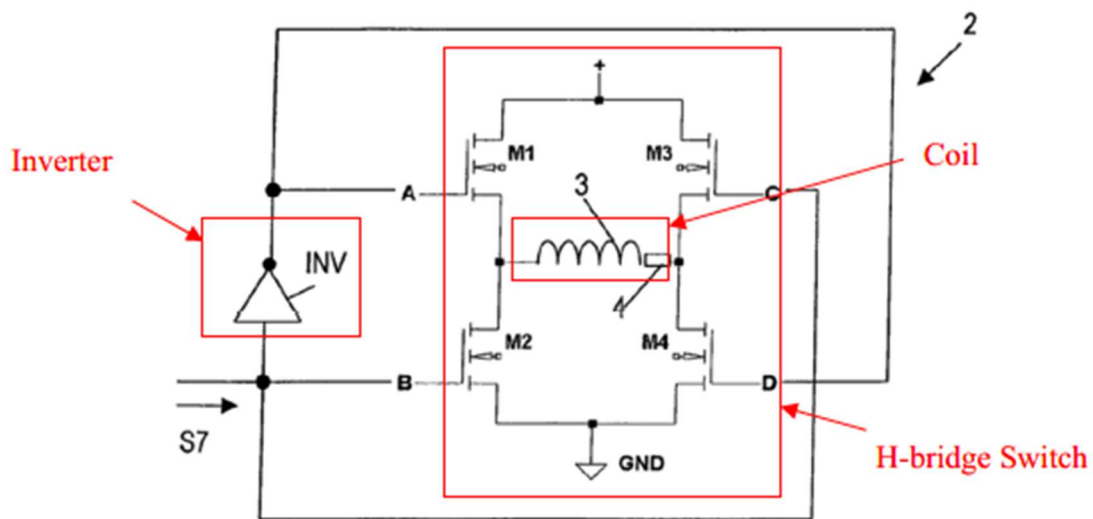


Fig. 4

NINTENDO-1040, Fig. 4 (annotated).

85. Fig. 4 of *Egger* shows a coil 3 “connected into the transverse path between the two half bridges.” See NINTENDO-1040, [0078]. Egger discloses that a control signal is “supplied to the transistors M2, M4 directly as a control signal and to the transistors M1, M3 via an inverter INV in an inverted form. As a result, the transistors always switch on or off diagonally, *i.e.*, either the transistors M1 and

M4 are switched on and the transistors M2 and M3 are switched off, or vice versa.”

Id.

86. In sum, as shown in the various references discussed herein and based on my knowledge and experience in the field, and as demonstrated by the examples discussed above, the LRVM structure recited in the '337 patent, the use of a feedback control mechanism / algorithm to drive the LRVM at its resonant frequency, and the use of an H-bridge switch (including with an inverter) were all well-known techniques for linear resonant vibration modules as of the '337 patent priority date.

IX. UNPATENTABILITY ANALYSIS

87. Below, I present my analysis of each ground and explain how it renders the Challenged Claims unpatentable. My opinions are based on my review of the '337 patent, its prosecution history, and the prior art references cited in this declaration.

A. Ground 1: The Wakuda-Ramsay-Rossi-Aldrich Combination Renders Obvious Claims 2-3

88. For the reasons detailed below, it is my opinion that a POSITA would have understood the combined teachings of Wakuda, Ramsay, Rossi, and Aldrich to render claims 2 and 3 obvious.

1. The Combination of Wakuda and Ramsay

89. Based on my review, it is my opinion that a POSITA would have been motivated to combine Wakuda and Ramsay and that a POSITA would have had a

reasonable expectation of success in making this combination. Specifically, in the combination of Wakuda-Ramsay, Wakuda's system would be implemented in a way such as to allow for users to customize parameters associated with haptic effects, which is a concept taught by Ramsay. In this resulting system, Wakuda's "small-sized terminal devices, such as portable telephones, PDA, portable game equipment[]," would be adapted to store the customized haptic effects for selection and used in generating desired haptic feedback. *See* NINTENDO-1005, 1:11-14. Additionally, the terminal device resulting from the Wakuda-Ramsay combination would include "input/output devices," given that such features are already present in Ramsay's "end user device" which is, in turn, functionally similar to Wakuda's terminal device. *See* NINTENDO-1006, [0018]-[0019], [0022]-[0024].

90. A POSITA would have leaned on Ramsay's teachings to modify Wakuda's haptically-enabled system to embed "[s]oftware and systems" in the combined system "according to the teachings [of Ramsay], to lead a user through the process of entering and/or modify[ing] parameters and characteristics of haptic tracks." *See* NINTENDO-1006, [0015]. In the combination, the memory device of the Wakuda-Ramsay combination (for example, the memory 16 disclosed in Ramsay, *i.e.*, the memory of the "terminal devices"/"end user device") would be used to store "a software program for enabling an end user to create and/or modify haptic effects, the software program of which can be executed by processor," and

would “also store haptic track files created or modified by the user and can also store mixed track files, which include multiple haptic tracks combined together.” *See id.*, [0025], [0027]-[0028]. Additionally, the combined system would allow users to “access[] programmable haptic design software 30 via GUI 24 and open[] a file to be edited,” and to “interact with programmable haptic design software 30 by input and output mechanisms of GUI,” as taught by Ramsay. *See id.*, [0037].

91. It should be clear that the proposed combination does not rely on bodily incorporation of Ramsay into Wakuda. Instead, when combined, Wakuda’s system would be adapted in such a way as to enable a user to specify parameters, such as frequency and amplitude, associated with haptic effects, consistent with the teachings of Ramsay.

92. A POSITA would have been motivated, and found it obvious, to modify Wakuda’s vibration generator system pursuant to Ramsay’s teachings (*i.e.*, to allow for user configuration) for several advantageous reasons. Wakuda discloses that its vibration generator system is used in “terminal devices” such as “portable telephones, PDA, portable game equipments [sic], and so on.” NINTENDO-1005, 1:11-16. A POSITA would have recognized the value of expanding the functionality of existing haptic devices by enabling end users to create and customize haptic effects. *See id.*, [0014]-[0015]. Accordingly, a POSITA would have been motivated to implement user tools in Wakuda’s system, such as those taught by Ramsay, to

provide flexibility and control over haptic feedback customization. Ramsay further describes allowing users to “create or modify the haptic effect files directly on the device.” *Id.*, [0014]. A POSITA would have appreciated the benefit of Ramsay’s GUI, which displays haptic tracks and offers intuitive mechanisms for adjusting haptic parameters. *See id.*, [0053]-[0057].

93. Furthermore, the Wakuda-Ramsay combination would allow the resulting system to “provide a fuller haptic experience” by enabling users to “combine or mix different haptic tracks together if desired.” *See* NINTENDO-1006, [0030], [0047]. A POSITA would have recognized the benefit of Ramsay’s several options for creating mixed tracks, allowing users to “combine haptic tracks to play simultaneously, to overlap in time for a portion of the time, to play end-to-end, or even to start a subsequent track after a short pause at the end of a first track.” *Id.*, [0047]. Specifically, a POSITA would have understood that such capabilities enable the generation of more dynamic and engaging haptic effects, particularly when frequency and amplitude can be controlled independently. *See* NINTENDO-1018, p. 257 (“For tactile applications[,] electrodynamic actuators appear only with linear moving coils or magnets as oscillation sources. The possibility to control frequency and amplitude independently from each other makes them interesting for tactors.”). A POSITA would have also recognized that the ability to produce more complex haptic responses could, for example, enhance user immersion in applications such

as portable gaming systems like the “portable game equipment[]” and “hand-held video gaming device[s], game module[s], [and] game console[s]” depicted in Wakuda and Ramsay. *See* NINTENDO-1005, 1:11-16; NINTENDO-1006, [0019].

94. A POSITA would have had a reasonable expectation of success in implementing the proposed modifications, as both Wakuda and Ramsay describe similar techniques for controlling a linear actuator to produce a desired output. *See* NINTENDO-1005, 3:42-45 (“the movable body reciprocates linearly”); NINTENDO-1006, [0026]. A POSITA would have understood that integrating Ramsay’s software-based configuration features into Wakuda’s hardware system would require only routine knowledge of software implementation techniques—well within the skill of someone in the art. The proposed modification involves incorporating Ramsay’s software functionality into Wakuda’s existing hardware architecture without requiring substantial structural changes. The proposed combination would modify Wakuda’s system only to the extent necessary to implement Ramsay’s software tools, while otherwise preserving Wakuda’s structure and intended functionality. Notably, Wakuda and Ramsay share similar structural components and operational principles that are inherently compatible, further simplifying the combination because significant changes would likely not be required. As one example, Wakuda already discloses, or renders obvious, the specification of frequency and amplitude through stored values (*see* Ground 1), and

Ramsay likewise discloses that “the customized haptic effects created by a user can be stored on the device for use by the user.” *See* NINTENDO-1006, [0017], [0027], [0028]. A POSITA would have recognized that Wakuda and Ramsay are compatible because their objectives are aligned (*e.g.*, they are both directed to providing customized haptic feedback) and would be accomplished by the combination in a manner consistent with each reference individually. Furthermore, the core operations of both systems could be achieved in parallel, allowing the combined system to achieve the benefits disclosed in both references. Therefore, integrating the known techniques of Ramsay’s software customization features into the known device of Wakuda’s vibration generator system ready for improvement constitutes a straightforward application of known techniques to a known device, yielding the predictable results of the benefits articulated above, leading to a high (or at least reasonable) expectation of success.

2. The Combination of Wakuda, Ramsay, and Rossi

95. Based on my review, it is my opinion that a POSITA would have been motivated to combine Wakuda, Ramsay, and Rossi, and that a POSITA would have had a reasonable expectation of success in making this combination. In the proposed combination, the Wakuda-Ramsay actuator system would incorporate a switch – such as an H-bridge switch circuit with a control signal input and a “supply node” voltage (V_s) applied thereto – as described in Rossi. The circuit would include a

control signal input, a splitter, and a control signal inverter that receives the control signal from the processor, consistent with the feedback control framework of Wakuda-Ramsay. This configuration would have yielded the predictable result of oscillating the actuator's magnet by switching the polarity of drive signals based on the closed-loop feedback concepts of the Wakuda-Ramsay combination.

96. Below I discuss several of the reasons that would have motivated a POSITA to modify Wakuda-Ramsay system using Rossi's teachings regarding switching circuits, such as the H-bridge switch. Wakuda itself describes applying current through a coil in opposite directions to drive a movable body in opposite directions. *See* NINTENDO-1005, 6:4-10. A POSITA would have recognized that an H-bridge circuit was a well-known and widely used implementation for achieving such bidirectional current flow in electromechanical systems. *See* NINTENDO-1019, 7:47-50 ("well-known H-bridge circuit"); *see also* §§ VII, IX.B.2.g (explaining that H-bridge switches were well-known).

97. And because the Wakuda-Ramsay combination does not explicitly disclose the full implementation details of a circuit for switching the "current flow direction/polarity," a POSITA would have looked to references and prior art systems such as Rossi for details of the conventional solution to such circuits (*e.g.*, H-bridge configurations) to provide oscillating power. *See, e.g.*, NINTENDO-1020, 1:65-2:11, 3:43-55, Figs. 4, 6.

98. It should be clear that the proposed combination does not require bodily incorporation of Rossi's components. Rather, it relies on Rossi's teachings regarding H-bridge switch circuit control for alternating drive direction—techniques that a POSITA would have predictably implemented in the Wakuda-Ramsay system.

99. A POSITA would have realized that the implementation of a switch (*e.g.*, H-bridge circuit) as suggested by Rossi within the Wakuda-Ramsay system would accrue several benefits, some of which I discuss in detail next. First, while Wakuda discusses the application of current through its coil in opposite directions to oscillate the movable body, the Wakuda-Ramsay combination fails to expressly disclose any implementation details for this switching scheme. NINTENDO-1005, 6:4-10. Thus, a POSITA would have turned to other references, such as Rossi, for well-known solutions that support the same objective. Rossi clearly illustrates the known benefits of an H-bridge circuit that receives a drive signal input (*e.g.*, "IN1"), which is then split and inverted to produce complementary control signals. *See* NINTENDO-1020, Abstract, 1:65-2:49, 2:56-3:54, Figs. 4, 6. A POSITA would have recognized the utility of Rossi's configuration, which provide complementary drive signals to opposing pairs of transistors in the H-bridge, thereby enabling bidirectional current flow through the coil. Rossi further explains that this configuration reliably "functionally switch[es] the load L between the supply node

Vs, and virtual ground nodes,” thereby effectively driving the actuator’s movable magnet head. *See Id.*, 2:4-12.

100. A POSITA would have also recognized that Rossi discloses a simple and reliable method for controlling the amplitude of the signal delivered to a connected actuator, thereby enabling precise control over the actuator’s vibrational strength. Specifically, Rossi describes that a “supply node” (voltage Vs) provided to the H-bridge switch, such that the “bridge configuration [] switch[es] the load L between the supply node Vs, and virtual ground nodes.” *See* NINTENDO-1020, 2:4-12. By adjusting the supply voltage, a POSITA would understand that one could modulate the “magnitude ... of the electric current flowing through the load L of the H-bridge stage,” and thereby control the power output delivered to the actuator. *See Id.*, 3:6-18, Fig. 5.

101. A POSITA would have also been motivated to combine Wakuda-Ramsay and Rossi to take advantage of a simple, cost-effective, and reliable circuit design. For example, the resulting system would require only a small number of components. Given that Linear Resonant Actuators (LRAs) have modest power demands, the switching devices would be lightly loaded, thereby enhancing reliability. Rossi also describes the use of diodes within the H-bridge circuit to protect against high-voltage spikes that may originate from sources within or external to the LRA. A POSITA would have understood the advantages of using a

control signal from the “processor” that is split and inverted—per Rossi’s description—to drive the four transistors of the H-bridge. This configuration produces complementary internal control signals (*e.g.*, IN1 and $\overline{\text{IN1}}$), simplifying both the generation of the control signal and the circuit that delivers the drive signal to the actuator coil.

102. Finally, a POSITA would have had a reasonable expectation of success in making the proposed modifications given the similarity of the function of the H-bridge switch circuit in Rossi and Wakuda-Ramsay, and because the modifications would have been implemented largely through routine circuit design considerations and software instructions for generating the control signal well within the scope of knowledge and capabilities of a POSITA at the time. Specifically, in the combined system, Wakuda-Ramsay would generate a “drive signal S1” to the “drive means 13,” wherein that “drive signal S1” corresponds to Rossi’s “driving signal IN1,” and a signal would be sent to the power supply to provide the necessary supply voltage “Vs” to the H-Bridge implemented within the “drive means 13.” *See* NINTENDO-1005, 6:30-39, Fig. 3; NINTENDO-1020, 1:65-12, Fig. 1. Also, making this combination represents nothing more than the application of known techniques (Rossi’s H-bridge implementation) to a known device (Wakuda-Ramsay actuator system that already operates by switching the polarity of current) ready for improvement to achieve predictable results, as described above.

3. The Combination of Wakuda, Ramsay, Rossi, and Aldrich

103. Based on my review, it is my opinion that a POSITA would have been motivated to combine Wakuda, Ramsay, Rossi, and Aldrich, and that a POSITA would have had a reasonable expectation of success in making this combination. In the proposed combination, Aldrich's control algorithm is implemented within the Wakuda-Ramsay-Rossi system that utilizes sensor feedback to control vibration output around the actuator's resonant frequency. In this combined system, sensor outputs would be processed using control techniques in accordance with Aldrich's teachings, which would have furthered Wakuda's stated goal of "generat[ing] a drive signal S1 tracking the resonance frequency of the movable body." *See* NINTENDO-1005, 10:27-32, 6:48-55. To maintain oscillation at or near resonance, the system would increment or decrement the drive frequency and compare the current vibration strength with a previously measured value. *See* NINTENDO-1021, p. 2. As Aldrich describes, if the change in frequency results in an increase in vibration strength, the same direction of change is continued in the next sampling period. *Id.* Conversely, if the vibration strength decreases, the direction of frequency change is reversed, signaling that the frequency has passed the resonant peak. *Id.*

104. Aldrich describes a process analogous to the algorithm in the '337 patent's Figure 7A, which Aldrich refers to as a "hill-climbing" control strategy. Specifically, Aldrich discloses a feedback control algorithm designed to drive an

actuator to “one of the resonance peaks and eventually to oscillate about the peak.”

See NINTENDO-1021, p. 2. The digital control system is “based partly on an extremum-seeking control algorithm [that] tracks the changing resonance frequency of a piezoelectric actuator or an electrically similar electromechanical device.” *Id.*,

1. Aldrich’s control framework includes “a hill-climbing control algorithm, an estimation-based extremum-seeking control (ESC) algorithm, and a supervisory algorithm.” *Id.*, 2. The hill-climbing algorithm provides “coarse tracking to find and remain within the vicinity of the resonance.” *Id.* In the hill-climbing algorithm, “the excitation frequency during the next sampling period is incremented or decremented by an arbitrary fixed step.” *Id.*, 2. As described above, if the result of the increment or decrement is an increased output (*e.g.*, in the current/voltage ratio), then the direction of change of frequency is accepted and another such change is made during the next sampling period. *Id.* If the change in frequency results in a decrease in output, then the direction of change of frequency is reversed during the next sampling period. *Id.* This process is repeated during oscillation to maintain oscillation about a resonant frequency. *Id.*

105. As shown above, the Aldrich hill-climbing algorithm requires a variable that indicates whether frequency was being increased or not. A POSITA would have implemented this variable using a Boolean variable. In such an implementation, the Boolean value would represent the current operational state of

the hill-climbing algorithm. A POSITA would have recognized that the use of Boolean variables was a well-known and conventional method for tracking and maintaining system state, and would have selected this approach as a matter of routine implementation in light of Aldrich's suggestion to switch between incrementing and decrementing frequency. *See, e.g.,* NINTENDO-1026, p. 29 (discussing conventional use of Boolean variables). Based on my knowledge and experience, and my review of Aldrich and the other materials I have considered, a POSITA would have been inclined to use a Boolean variable to track the direction of frequency change – consistent with Aldrich's description that the “direction of change of frequency during the following sampling period is reversed.” NINTENDO-1021, p. 2.

106. Further, a POSITA would have been motivated to process sensor signals using integer values. Sensor outputs are typically converted to integer representations (*e.g.,* via an analog-to-digital (A/D) converter) which a POSITA would have known facilitates digital processing, enabled more efficient computation, and simplified hardware implementation. *See* NINTENDO-1021, p. 2. A POSITA would have recognized that integer values are conventionally used in embedded systems for storing and manipulating sensor data due to their processing efficiency and reduced memory demands. Typically, sensor values are initially represented and stored as integers, and only converted to floating-point values if

additional precision is needed. Thus, A POSITA would have viewed the use of integer values as a routine design choice, not affecting the functionality of the feedback control system. Indeed, use of integers over floating-point values would allow for increased performance due to, *e.g.*, avoiding (or at least reducing the incidence of) translating data to or from floating-point values. Moreover, A POSITA would understand that converting an integer value to a floating-point representation does not add any new information to the signal itself.

107. As with other prior art combinations discussed above, the integration of Aldrich's teachings into Wakuda-Ramsay-Rossi does not depend on bodily incorporation of Aldrich's components. Rather, it relies on integration of Aldrich's teachings regarding "hill-climbing control algorithm" for "tracking to find and remain within the vicinity of the resonance." *See* NINTENDO-1021, p. 2. A POSITA would have predictably implemented this control approach within the Wakuda-Ramsay-Rossi system to achieve closed-loop resonance tracking in a straightforward and conventional manner.

108. There are several reasons that would have prompted A POSITA to implement a "hill-climbing" control algorithm, consistent with Aldrich's suggestions, in the Wakuda-Ramsay-Rossi combination. First, a POSITA would have combined Wakuda-Ramsay-Rossi with Aldrich to incorporate a known feedback algorithm that can be used for targeting a resonant frequency, thereby

improving Wakuda-Ramsay-Rossi's system using Aldrich's well-understood benefits. A POSITA would have looked to Aldrich's disclosures to fill in gaps in the combination, specifically Wakuda's disclosures. Specifically, although Wakuda describes detecting the position of the movable body to generate a drive signal that tracks the resonant frequency, it lacks specific implementation details. *See* NINTENDO-1005, 6:40-62, 10:22-42. A POSITA, recognizing these gaps, would have predictably looked to other teachings, such as Aldrich, which explicitly describe how to drive an actuator at or near resonance using feedback control techniques. *See* NINTENDO-1021, pp. 1-3.

109. Second, a POSITA would have incorporated Aldrich's feedback control algorithm into the Wakuda-Ramsay-Rossi system to continuously update control outputs throughout operation. Aldrich's method involves comparing current and previous parameters so that the drive signal (*e.g.*, frequency) can be adaptively adjusted to maintain oscillation at or near resonance. This continuous feedback approach directly supports the shared goals of both Aldrich and Wakuda-Ramsay-Rossi.

110. Third, this combination represents the application of known techniques—namely, Aldrich's "hill-climbing" feedback control algorithm—to a known system (Wakuda-Ramsay-Rossi) already employing feedback control and

ready for improvement, resulting in predictable results including performance improvements as discussed above.

111. A POSITA would have had a reasonable expectation of success in implementing these modifications. First, Aldrich's teachings are directly applicable to resonant systems such as those in Wakuda-Ramsay-Rossi. Second, the modifications would primarily involve software executed by the existing processor. For example, in the combination, sensor outputs would have been received and processed using Aldrich's "hill-climbing control algorithm" that maintains operation "within the vicinity of the resonance." *See* NINTENDO-1021, p. 2. It would have been obvious to a POSITA to modify the processor in Wakuda-Ramsay-Rossi's system to execute a control routine based on Aldrich's algorithm. This would have required only routine software implementation using conventional coding techniques well within the understanding and technical skill of a POSITA at the time.

4. Analysis Of How Wakuda-Ramsay-Rossi-Aldrich Renders Claims 2 and 3 Obvious

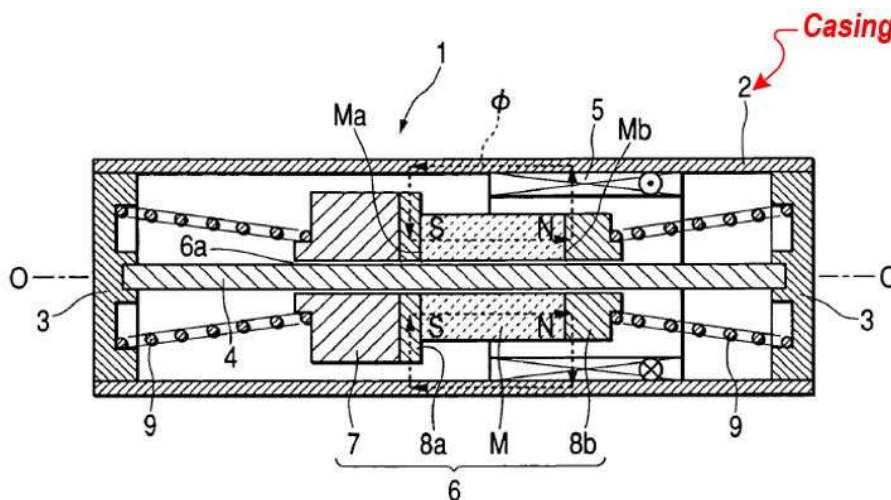
a. [2pre]: A linear vibration module comprising:

112. To the extent the preamble is considered limiting, it is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination renders it obvious. Specifically, the combination discloses a linear vibration module, namely Wakuda's "bodily sensed vibration generator system mountable on small-sized information terminal devices, such as portable telephones, PDA, portable game equipment[], and so on."

NINTENDO-1005, 1:11-16. As described in Wakuda, the resulting system includes “vibration generator means 1” comprising a “casing 2,” “covers 3,” “coil 5,” “movable body 6,” and “control means 10.” *Id.*, 4:30-5:24, 6:11-62. Wakuda also states that the “movable body reciprocates linearly.” *Id.*, 3:43-45. In the Wakuda-Ramsay combination, the vibration module additionally incorporates “input/output devices” as taught in Ramsay. *See* NINTENDO-1006, [0022]-[0024]; *see also* § IX.A.1 (combination of Wakuda and Ramsay).

b. [2a]: a housing;

113. It is my opinion that, the Wakuda-Ramsay-Rossi-Aldrich combination discloses a housing. Specifically, Wakuda’s “vibration generating means” includes “a cylindrical-shaped **casing 2** made of a magnetic substance as a support, and covers 3, 3 made of a non-magnetic substance and being mountable on both ends of the casing.” NINTENDO-1005, 4:34-38.

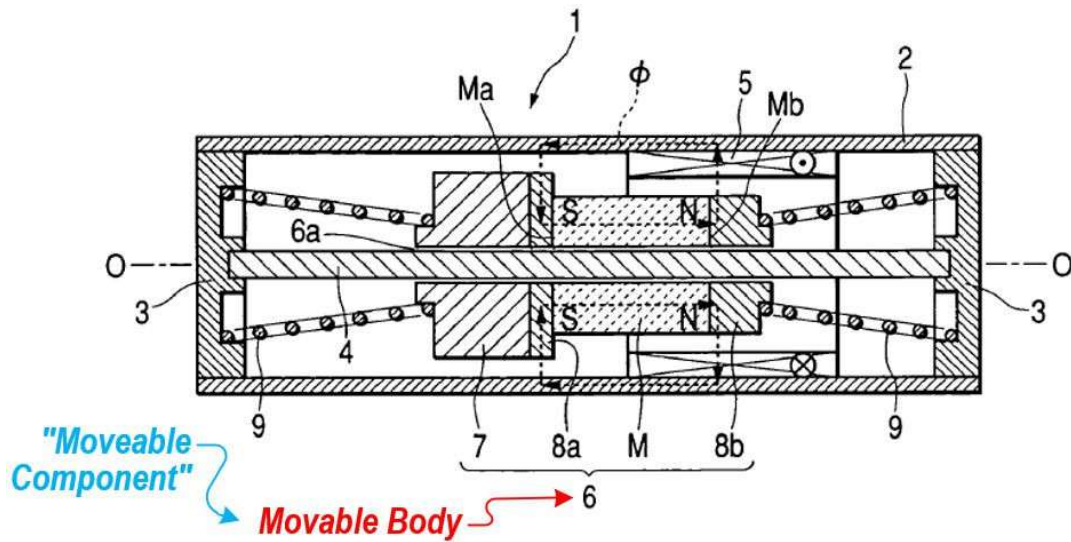


NINTENDO-1005, Fig. 1B (annotated).

114. Additionally, Wakuda also describes that its vibration generator system is mounted at “small-sized information terminal devices, such as portable telephones, PDA, portable game equipment[.]” NINTENDO-1005, 1:11-16. A POSITA would have also understood that such terminal devices inherently include a housing. For example, Grant describes “a housing of the computer or handheld device” that incorporates an actuator. NINTENDO-1007, [0010].

c. [2b]: a moveable component;

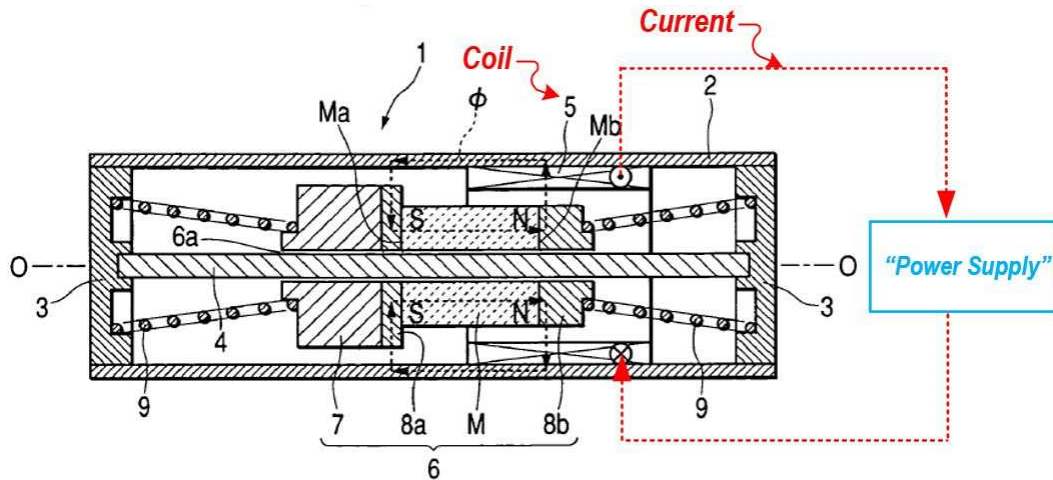
115. It is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination provides a moveable component. Specifically, Wakuda’s discloses that it uses a “movable body 6” (*i.e.*, moveable component) which “is provided inside the casing 2.” NINTENDO-1005, 4:48. Wakuda also discloses that its movable body comprises “a weight 7 made of a non-magnetic substance” and “a magnet M” that “is provided on both end surfaces thereof with yoke members 8a, 8b, which are formed from a magnetic material.” *Id.*, 4:48-54. “The weight 7, yoke member 8a, magnet M, and the yoke member 8b are column- or disk-shaped, and all outer peripheral surfaces thereof are positioned in circles concentric with a center of the shaft 4.” *Id.*, 4:54-57. Wakuda discloses its “movable body 6 moves in the X1 direction or the X2 direction.” *Id.*, 5:34-35. Wakuda’s “movable body” provides the claimed “movable component.”



NINTENDO-1005, Fig. 1B (annotated).

d. [2c]: a power supply;

116. It is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination renders obvious a power supply. Wakuda's device includes a "coil 5," Which would require a power supply so that a current can be applied to the coil. NINTENDO-1005, 4:42-47. Referring to Figure 1B below, Wakuda describes that current is supplied to the coil to generate a magnetic force: "when current in a direction shown in FIG. 1B is given to the coil 5, a magnetic force F is generated by the magnetic flux ϕ and the current in the X2 direction to be able to give to the movable body 6a driving force in the X2 direction." *Id.*, 6:4-10. A POSITA would have understood that Wakuda's system includes a power supply configured to provide current to the coil, as depicted in the annotations of Fig. 1B below:



NINTENDO-1005, Fig. 1B (annotated).

117. A POSITA would have known that Wakuda’s “terminal devices, such as portable telephones, PDA, portable game equipment[], and so on” included a battery or were designed to connect to an external power source to supply power to internal components. NINTENDO-1005, 1:11-14. A POSITA would have also understood and found it obvious that an actuator for a haptic feedback device would necessarily have to be coupled to a power supply to provide electrical power to the actuator. *See* NINTENDO-1019, 5:35-37 (“Power supply 40 can optionally be coupled to actuator interface 38 and/or actuators 30 to provide electrical power.”); NINTENDO-1007 (“Grant”), [0048], [0066], [0103]. For example, Grant describes that its “portable computer 10 including a haptic touchpad” is “powered by batteries or other portable energy source in addition to other more stationary power sources.” *Id.*, [0048]. Grant further explains that “power for the actuators can be drawn off a bus connecting the computer to the touchpad (or touch screen).” *Id.*, [0066], [0103].

e. [2d]: user-input features;

118. It is my opinion that the Wakuda-Ramsay combination provides or at least renders obvious user-input features within the resulting system. Wakuda describes “small-sized information terminal devices, such as portable telephones, PDA, portable game equipment[], and so on,” within which is the vibration generator system. NINTENDO-1005, 1:11-16. Similarly, Ramsay describes “end user device 10,” which may include a “mobile handset, cell phone, personal digital assistant (PDA),” among other devices. NINTENDO-1006, [0019]. Ramsay further explains that “[e]nd user device 10 ... includes input/output devices 12,” which comprise “one or more input mechanisms, which may include any suitable combination of keyboards, keypads, cursor control devices, computer mice, voice activation mechanisms, touch screen with respective stylus or other drafting instrument, touch pads, buttons, sliders, microphones, digital cameras, etc.” NINTENDO-1006, [0022], [0024].

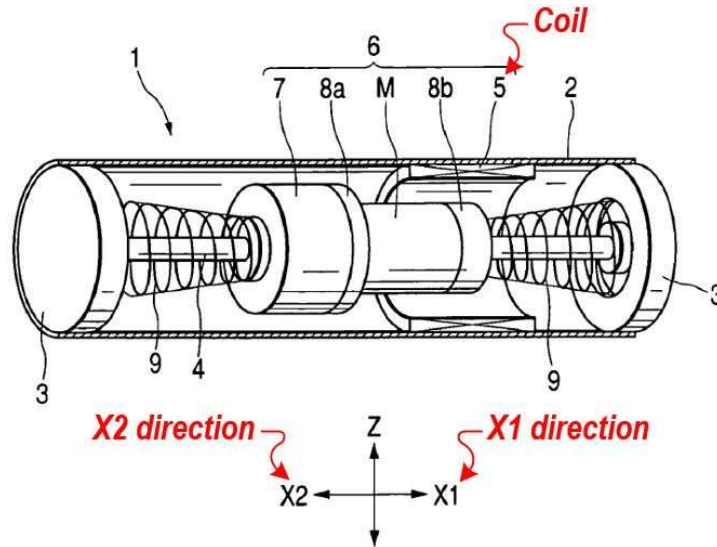
119. Thus a POSITA would have understood (or at least found it obvious) that the device in the Wakuda-Ramsay combination includes user-input features given the disclosure in Ramsay of “input/output devices.” A POSITA would have also recognized (or at least found it obvious) that such terminal devices conventionally include user-input features, such as keypads, buttons, switches, or touch-sensitive screens, for users to input commands or provide other inputs and

thereby allowing users to conveniently interact with the devices. This understanding is further supported by, for example, Lacroix, which describes a “cellular telephone 10” including keys 13 that may be implemented as “mechanical type keys,” “touchscreen keys,” or “using any method,” such as other types of touch-sensitive surfaces. NINTENDO-1010, [0014].

f. [2e]: a driving component that drives the moveable component in each of two opposite directions within the housing; and

120. It is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination renders obvious the recited “*driving component that drives the moveable component in each of two opposite directions within the housing.*” As a reminder, under the MPF construction, the “driving component” is a coil or an electromagnet.” § V.A.1. And as I discussed for claim element [2c] above, Wakuda includes a coil (*i.e.*, “coil 5”) as a “driving component”, which is “fixed to an inner wall of the casing 2” (*i.e.*, within the housing). As shown in Figures 1A and 1B of Wakuda, the coil generates a magnetic force that drives the movable body 6 in either of two opposite directions—X1 and X2—depending on the direction of current applied. Wakuda states: “when current in a direction shown in FIG. 1B is given to the coil 5, a magnetic force F is generated by the magnetic flux ϕ and the current in the X2 direction to be able to give to the movable body 6 a driving force in the X2 direction.

Also, a driving force in the X1 direction can be given to the movable body 6 by feeding a reverse current to the coil 5.” NINTENDO-1005, 6:4-10, Figs. 1A-1B.



NINTENDO-1005, Fig. 1A (annotated); 4:42-47, 5:1-13.

121. Thus, Wakuda expressly teaches that the driving component (“coil 5”) *drives the movable component* (drives “movable body 6”) in each of the two opposite directions within the housing. Specifically, Wakuda explains that “*a magnetic force F is generated ... to give to the movable body 6 a driving force*” in the “X2 direction,” and that “*a driving force in the X1 direction can be given ... by feeding a reverse current to the coil 5.*” NINTENDO-1005, 6:4–10. These teachings directly support the limitation that the driving component actuates the movable component in each of two opposite directions.

- g. [2f]: a control component that controls supply of power from the power supply to the driving component to cause the moveable component to oscillate at a frequency and an***

amplitude specified by user input received from the user-input features,

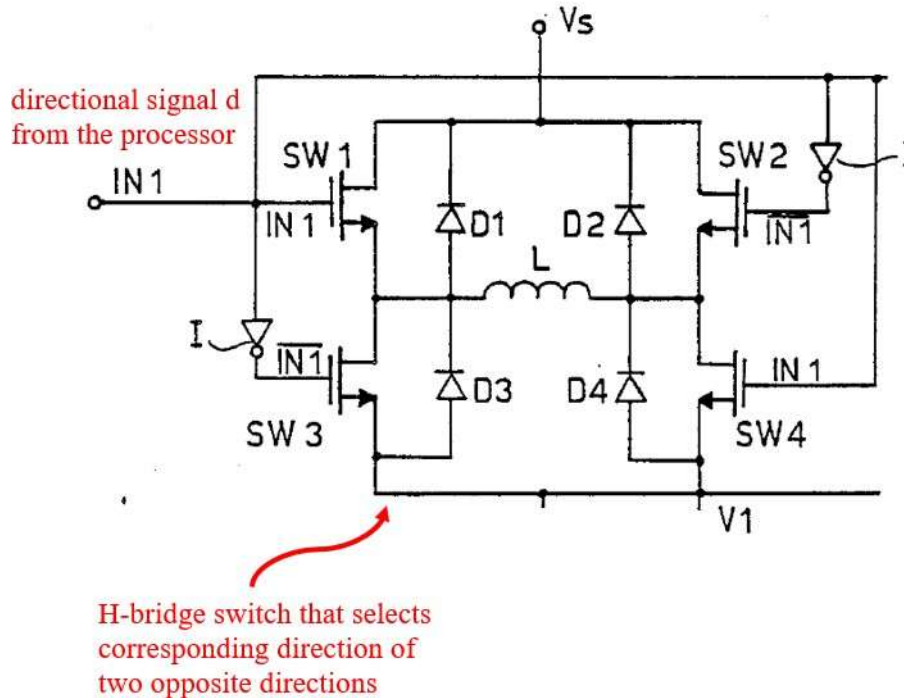
122. It is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination renders obvious the recited control component under either the Full Construction or the Abridged Construction. Under the Full Construction, the control component includes a processor executing a multi-step feedback algorithm (*e.g.*, as shown in Figures 7A–7C of the '337 patent), and Aldrich's teachings are used to satisfy some parts of the corresponding structure. *See* § V.A.1. As I explain below, under the Abridged Construction, however, Aldrich is not needed, as the combination of Wakuda, Ramsay, and Rossi alone renders this limitation—along with the rest of claims 2 and 3—obvious.

123. Ramsay's "end user device 10," which "can be a haptic-enabled device that provides haptic feedback to the user during specific events," includes "processor 14" and "memory 16" as the control component for operating "haptic actuating device 18." NINTENDO-1006, [0020], [0022]. "[P]rocessor 14 controls the functions of end user device 10 and can execute software stored in memory 16." *Id.*, [0024]. Memory 16 stores "[f]iles associated with haptic effects". *Id.*, [0027]. A POSITA would have understood and found it obvious that, in the Wakuda-Ramsay-Rossi-Aldrich combination, Wakuda's "control means 10" would be implemented using the processor and memory teachings of Ramsay to perform control operations

over the haptic actuator in accordance with user-specified parameters such as frequency and amplitude.

124. The combination also includes a switch (e.g., H-bridge switch) per the teachings from Rossi. § IX.A.2. A POSITA would have found it obvious that, in the Wakuda-Ramsay-Rossi-Aldrich combination, the microprocessor is programmed to output: (1) a directional control signal (e.g., signal *d*) to the H-bridge switch to control current direction through the coil, and (2) a supply control signal to the power supply to determine the supply voltage (V_s) provided to the coil. *Id.* Further, the microprocessor outputs a control signal is output to H-bridge transistors to toggle them open or closed depending on the desired drive direction, while a separate signal to the power supply (§ IX.A.4.d) adjusts the supply voltage magnitude provided to the H-bridge and thus the coil. § IX.A.2. In the resulting system, the switch receives a directional signal (e.g., at the input “IN1” to the H-bridge as depicted in the figure below) selecting one of two opposite directions in which the driving component drives the moveable component, and receives a supply voltage (e.g., at “ V_s ”) determined by a control signal from the processor. *See* NINTENDO-1020, 1:65-2:15; 3:44-55, Figs. 1, 6. Illustrated in Rossi Fig. 6 below, Rossi explains that “two pairs of switches (namely SW1, SW4 and SW2, SW3) arranged in a bridge configuration functionally switch the load L between the supply node V_s , and virtual ground nodes,” depending on the directional signal *d* received at “IN1.” *Id.*

Depending on if the signal is high (“1”) or low (“0”) indicates the direction of the current applied to the coil (load “L” of the figure).



NINTENDO-1020, Fig. 6 (partial, annotated).

125. Additionally, to the extent it is required, the Wakuda-Ramsay-Rossi-Aldrich combination shows that it would have been obvious to place the control component within the linear vibration module. *See* § V.A.1. Wakuda does not specify the physical location of its “Vibration Control Means,” instead presenting it in a functional block diagram without structural placement. *See* NINTENDO-1005, Fig. 3, 6:23-39. A POSITA would have found it obvious to integrate the processor and memory comprising the Vibration Control Means *within* the *vibration module* itself, following well-established practices in embedded systems. For example,

NINTENDO-1004 describes a processor and memory used for haptic control, which may be implemented as a separate general-purpose processor, an application-specific integrated circuit (“ASIC”), or a dedicated haptics processor. *See* NINTENDO-1004, 2:18–35. Similarly, NINTENDO-1008 discloses an “interface device” with one or more controllers including a specific haptic device controller. *See* NINTENDO-1008, Figs. 1–2, [0046]–[0048]. A POSITA would have recognized several advantages of placing the control component within the vibration module, including simplifying integration into host devices (*e.g.*, “terminal devices, such as portable telephones, PDA, portable game equipments [sic], and so on,” NINTENDO-1005, 1:11–14), allowing the module to operate autonomously, enabling standalone sale and reuse across products, reducing electromagnetic interference, and improving performance through local control. *Id.*

126. Wakuda describes “control means 10” as a control component. *See* NINTENDO-1005, 6:23–39. The control means includes “signal generation means 12” that “generates a drive signal S1 on the basis of a command from the vibration control means 14 to output the same to the drive means 13.” *Id.* According to the generated drive signal S1, the drive means 13 supplies “a drive current having a predetermined waveform ... to the terminal Ta1 and the terminal Ta2 of the coil 5. *Id.* Because the drive means 13 delivers current to the coil in the vibration generating means, a POSITA would have readily understood and found it obvious that the drive

means 13 includes or is coupled to a power supply (*see* [2c]). A POSITA would have also understood that the control means (*i.e.*, the control component) controls the supply of power to the driving component (coil), for example, through a separate signal to the power supply. Moreover, Wakuda explains that “the signal generation means 12 performs control, such as switching of current direction of the drive signal S1 or the like.” NINTENDO-1005, 6:45–47. This further supports that the control means governs both the frequency and direction of the power supplied to the coil to achieve linear actuation of the movable component. *See also* NINTENDO-1005, Figs. 3–4.

127. Moreover, the Wakuda-Ramsay-Rossi-Aldrich combination provides that the processor is programmed to implement an algorithm consistent with the Full Construction—specifically, the steps recited in Figure 7A (Steps 706 through 716). *See* § V.A.1; NINTENDO-1001, Figs. 7A-7C. As discussed in the following paragraphs, the combined system includes processor-executed logic for selecting frequency and amplitude parameters, adjusting based on sensor feedback, and maintaining resonance tracking—all matching the control behavior required under the Full Construction.

128. A POSITA would have found it obvious that the processor must utilize variables representing user selections (*see, e.g.*, NINTENDO-1024, 5:25-37; NINTENDO-1006, [0028], [0063]), including variables consistent with the seven

variables recited in the '337 patent. Specifically, the '337 patent discloses that its algorithm uses the following seven variables: (1) *mode*, indicating the current operational mode of the device; (2) *strength*, a numerical value corresponding to the user-selected strength of operation, and thus the electrical current applied to the coil; (3) *lvl0*, a previously sensed vibrational strength; (4) *lvl1*, a currently sensed vibrational strength; (5) *freq*, the current frequency at which the direction of current is alternated through the coil; (6) *d*, the direction control signal to the H-bridge switch; and (7) *inc*, a Boolean value indicating whether the frequency is currently being increased.

129. The '337 patent describes “modes” in two ways: (1) “In the default mode, the LRVM uses continuous feedback control to optimize the vibrational force produced by the LRVM by continuously seeking to operate the LRVM at a frequency as close as possible to the resonant frequency for the LRVM.” (col. 7, lines 48-52); and (2) “More complex vibrational modes may systematically and/or periodically alter the frequency or produce various complex, multi-component vibrational modes useful in certain applications, appliances, devices, and systems.” (col. 7, lines 55-58). A POSITA would have found it obvious that these modes correspond to the operation of the combined system based on one of the stored pre-defined haptic effects, such as an effect to maintain oscillation at the mechanical

resonant frequency when initialized, or to operate pursuant to another haptic track created or modified by the user through the GUI as taught by Ramsay.

130. The combination includes an analogous variable representing a current operational “mode” of the device. Indeed, the combined system uses multiple different “haptic tracks” (operational modes) based on haptic parameters including frequency and amplitude as taught by Ramsay. *Id.*; Ramsay, [0028], [0030], [0034], [0042], [0049], [0058]. Particularly, Ramsay describes “ROM 28 may be configured to store a library of preset haptic tracks.” Ramsay, [0028]. Thus, the combined system would operate based on pre-defined haptic effects (*i.e.*, default operational mode), such as one in which feedback control maintains oscillation at or near the mechanical resonant frequency, when initialized. Additionally, the system would operate based on a user-defined haptic track (*i.e.*, a mode) reflecting a haptic effect created or modified via the GUI, as taught by Ramsay. In this case, the mode variable would be set according to the user’s input through the user-input features, as taught by Ramsay. *Id.*; §§ IX.A.1, IX.A.4.

131. Consistent with the “modes” recited by the ’337 patent, the combined system includes one or more alternative or complex modes of operation that systematically and/or periodically alter the frequency or produce complex, multi-component vibrational outputs. NINTENDO-1006, [0035]-[0039], [0047], [0057]-[0059]. For example, Ramsay describes that “ROM 28 can also store haptic track

files created or modified by the user and can also store mixed track files, which include multiple haptic tracks combined together” and that the user “has the opportunity to modify certain characteristics of the haptic track as desired.” NINTENDO-1006, [0028], [0035]. Ramsay explains that “Certain parameters or characteristics of a haptic output or haptic track can be created, entered, changed, modified, etc.” and that “the modifiable parameters may include a frequency of vibration and amplitude of vibration.” *Id.*, [0030]. Ramsay further discloses that “the frequency and amplitude can be set to change over time,” and that “the user is able to combine or mix different haptic tracks together if desired to provide a fuller haptic experience. In this way, a user is capable of programming or customizing a haptic track or track mix to one’s liking.” *Id.*; *See also Id.*, [0035]-[0039], [0047], [0057]-[0059]. Ramsay describes multiple haptic tracks being mixed to drive simultaneous oscillation of the movable component at two or more frequencies. NINTENDO-1006, [0027], [0030], [0046]-[0047]. These teachings align with the ’337 patent’s description of “complex vibrational modes” and demonstrate that Ramsay’s system inherently supports such behavior.

132. The combination also includes a variable related to “strength” (magnitude). Ramsay describes that the user can use the “input/output device” including GUI to configure the magnitude variable. NINTENDO-1006, [0022]-[0026], [0030]-[0033], [0046], [0053]-[0055]; *see also* §§ IX.A.1, IX.A.4. It was

well known that the strength of a haptic effect is determined by the electrical current supplied to the actuator. For instance, NINTENDO-1023 states: “The magnitude or strength of the force is dependent on the magnitude of the current that is applied to the coil.” NINTENDO-1023, 9:65–10:3; *see also Id.*, 17:32-51 (“the gain 332 (or magnitude) of the force” and “gain of 100”), Fig. 6. Similarly, NINTENDO-1025 explains that strength can be modulated by “increasing a period of time T during which the current is supplied and/or by increasing the maximum current.” NINTENDO-1025, 6:19–47. Thus, the combined system would operate based on one of the strength settings (as part of the predefined or user-configured haptic effects) when it is powered on.

133. A POSITA would have recognized the well-known advantages of allowing the system to control the strength of the vibrational output. Vibrational output is directly influenced by both the frequency of the drive signal and the magnitude of the current flowing through the coil. Thus, adjustments of vibrational output strength can be achieved by adjusting the current magnitude (*e.g.*, the power supply input to the H-bridge), and a POSITA would have been able to modulate the strength of vibration in response to available power constraints and potential shifts in resonance frequency that might occur over time.

134. The combination would also include *sensed values* corresponding to at least previously-sensed (“lv10”) and currently-sensed (“lv11”) vibrational strength

values. In the combined system, the control algorithm would have operated by comparing the current vibration strength to a previously sensed value to determine whether to adjust the drive frequency. *See* NINTENDO-1021, p. 2 (describing evaluation of whether a frequency change results in increase or decrease of vibration output). These variables would be initialized with default values (*e.g.*, zero) and subsequently updated with real-time sensor data during operation to perform the algorithm taught by Aldrich. *Id.*

135. The combination includes a ***frequency*** (“freq”) at which current is alternated in the coil, and a directional ***control signal*** (“d”). NINTENDO-1021, pp. 1-3 (“excitation frequency”). In the combination, the frequency variable is initialized with a default value to provide a starting point for operation, such as a frequency specified by a stored “haptic effect” or “haptic track,” or an assumed resonant frequency. Wakuda describes using a default frequency value based on “the natural frequency (resonance frequency) of the movable body 6,” which is “determined by a mass of the movable body 6 and the spring constants (spring constants in the neutral position shown in FIG. 1) of the energizing members 9.” NINTENDO-1005, 7:26-43. The directional signal d is likewise initialized with a default value (*e.g.*, high or low) and is reversed during runtime to induce oscillation according to the feedback control algorithm. The initial value of d is an implementation choice that may depend on the LRVM’s structural configuration, design parameters, or desired

initial direction of movement. *See* NINTENDO-1019 (“Shahoian”), Fig. 5; *see also* NINTENDO-1020, 1:65-2:15; 3:44-55. Notably, the ’337 patent does not prescribe a specific initial value for the directional signal, nor does it ascribe any particular significance to it (*i.e.*, whether it must or should be high or low initially).

136. The combination also includes a ***Boolean value*** (“inc”) that is used, as taught by Aldrich, to indicate whether the frequency is currently being increased. Specifically, the Boolean value is used to track the state of frequency change (*i.e.*, whether the system is incrementing or decrementing the excitation frequency) to support the comparison logic described in Aldrich’s control algorithm. Again, as I explained (*see* § IX.A.3), implementing such a Boolean variable would have been a routine design choice for a POSITA, who would have recognized that Boolean flags are a basic and conventional programming tool for managing binary operational states. *See* NINTENDO-1026, p. 29.

137. While I understand that “step 704” is not strictly required by the Full Construction, I reference and explain its relevance because it frames the execution context for steps 706, 710, and 714 (which are steps included in the Full Construction). *See* NINTENDO-1001, 6:61-65. In the combined system, software running on the microprocessor waits for the occurrence of an event, such as expiration of a timer prompting reversal of the drive signal, receipt of a sensor input to update the control output, or a user input modifying haptic effect characteristics

or powering down the device. *See* NINTENDO-1005, Figs. 4-6; NINTENDO-1006, [0022]-[0026], [0030]-[0033], [0046], [0053]-[0055]. Upon receiving such inputs, the microprocessor adjusts the control outputs accordingly. *See, e.g.*, NINTENDO-1005, 6:40-47 (describing “signal generation means 12 performs control” based on sensor signals received from the “position detection means”). Based on my knowledge and experience, the use of a loop or event handler in a feedback control system was a conventional design choice well understood and readily implemented by a POSITA. These mechanisms allowed software to monitor and respond to specific events in real time. The ’337 patent itself reflects the conventionality of these techniques, stating that “certain implementations may simply employ counted loops or other simple programming techniques for periodically carrying out tasks,” rather than formal timer mechanisms. *See* NINTENDO-1001, 7:7–10.

138. A POSITA would have also recognized it was conventional practice at the time to use one or a combination of an event handler, a loop, and a timer to implement processes in program code. These techniques were well understood and commonly used in embedded systems to control the execution of software routines based on time or external/internal events. For example, a timer was a known method to trigger a process after a defined time interval had elapsed. An event handler was used to initiate a process in response to specific conditions, such as variable change, user input, or sensor signal. A loop was a known technique used to repeatedly

execute a set of instructions until a specified condition was met. These techniques provided flexible and efficient control over program execution. *See, e.g.,* NINTENDO-1026, pp. 6-11. A POSITA would have understood that usage of such mechanisms would have prevented the CPU / processor from becoming monopolized by one segment of code, allowing the CPU / processor to perform the various tasks required by the combination.

139. In “steps 706-708,” the ’337 patent’s control algorithm flips signal d upon expiration of a timer, thereby causing the oscillator circuit (*e.g.*, H-bridge switch) to reverse its output and apply a reverse force on the movable weight to achieve the desired frequency. NINTENDO-1001, Fig. 7A, 7:10-17. Wakuda teaches or renders this behavior obvious. For example, Wakuda’s Figure 4 shows Drive Signal S1 reversing from a “forward direction” to a “reverse direction” in accordance with the desired vibrational waveform frequency. NINTENDO-1005, Fig. 4, 6:63-7:25. A POSITA would have found it obvious to use a timer in the combined system to accomplish this—*i.e.*, to flip the directional signal (*e.g.*, at “IN1”) to Rossi’s switch at the appropriate intervals to produce the intended frequency. *See* NINTENDO-1026, pp. 8-9, 31-32 (discussing the use of timers to trigger control events).

140. In “steps 710-712,” the ’337 patent’s control program algorithm invokes a “monitor” routine at a defined frequency (*i.e.*, upon the expiry of a monitor

timer), as illustrated in Figure 7B. NINTENDO-1001, 7:19-21. Aldrich similarly describes that its control algorithm is part of a “digital control system,” operating at a specific sampling rate (with a “sampling period”), which dictates how frequently the algorithm executes. NINTENDO-1021, p. 2. In my opinion, a POSITA would have found it obvious to implement this periodic process using a timer, resetting the timer at the conclusion of the monitor process (*e.g.*, step 754). *See* NINTENDO-1026, pp. 8-9, 31-32. This approach would prevent monopolization of the CPU’s processing cycles by allowing time for other tasks to execute, while still ensuring that the monitor routine (*i.e.*, Aldrich’s algorithm) runs frequently enough for proper system operation.

141. A POSITA would have recognized that the “monitor” routine in the ’337 patent is a straightforward and well-known routine for implementing a feedback loop to maintain operation of a vibration module at or near resonance. The combined system, as described in the Wakuda-Ramsay-Rossi-Aldrich combination (*see* § IX.A.3), executes the same or substantively similar algorithm. In particular, a POSITA would have found it obvious, especially in light of Aldrich’s descriptions of feedback control technique, to compare sensed vibration parameters while incrementing or decrementing the drive frequency, in order to track the resonance peak. *See* NINTENDO-1021, pp. 2-3. This is consistent with Aldrich’s use of a hill-climbing control algorithm to maintain oscillation about the resonant frequency by

evaluating whether a frequency adjustment results in an increase or decrease in vibration strength and adjusting the direction of change accordingly.

142. The combined system includes one or more sensors to store sensed values (step 730), as taught by Wakuda. *See* NINTENDO-1005, 6:40-62 (“position detection means”). For example, Wakuda describes a closed-loop control scheme used to “generate a drive signal S1 tracking the resonance frequency of the movable body 6.” *Id.*, 10:31-32. Wakuda discloses that “position detection means 11 detects that the movable body 6 has reached the neutral position ... that is, a middle point in the reciprocation stroke.” *Id.*, 6:23-47. The detection signal of the middle point is provided to the signal generation means 12, and “the signal generation means 12 performs control, such as switching of current direction of the drive signal S1.” *Id.* Moreover, Wakuda describes selecting between different modes of operation: a default mode that “excites resonant vibrations at the natural frequency in the movable body” (*Id.*, Fig. 4, 6:63-66, 7:9-12), or operating according to one of a “plurality of [waveform] patterns ... selected on the basis of a command from the vibration control means” (*Id.*, 6:30-39, Figs. 5-6) (corresponding to steps 732-734). Therefore, the software executed by the microprocessor in the combined system receives signals from the sensors, indicative of vibrational strength, and compares a current sensed vibration strength value and a previous sense value to tune the input

frequency about a resonant frequency, consistent with steps 730-754 of Figure 7B of the '337 patent. *See* NINTENDO-1021, pp. 1-3.

143. For example, in accordance with Aldrich's suggestions, at a given time, the sensed vibration strength value at an incrementally increased control signal frequency is compared to a previously sensed vibration strength value. If the vibration strength has increased with the increased input frequency, "then the direction of change ... of frequency is accepted and another such change ... is made during the following sampling period." NINTENDO-1021, p. 2. To be clear, this hill-climbing technique described by Aldrich corresponds to the control logic in steps 736-740 of the '337 patent.

144. Similarly, when the sensed vibration strength does not increase with an incrementally increased input frequency, the control algorithm determines that the resonant frequency has been exceeded. NINTENDO-1021, p. 2. As Aldrich describes, a POSITA would have understood that a decrease in vibration strength indicates the frequency has moved away from a resonant peak. In such a case, the "direction of change of frequency during the following sampling period is reversed," and the frequency is decremented before continuing. *Id.* This technique aligns with the logic implemented in steps 742-744 of the '337 patent.

145. The same feedback process is applied when decrementing the output frequency: the current vibration strength is compared with the previously sensed

value to determine whether the decrease in frequency has resulted in increased vibration. If so, the frequency continues to decrement; if not, the direction is reversed. This implements the same operations described in the '337 patent at steps 746–752 of Figure 7B. *See* NINTENDO-1021, p. 2.

146. As discussed above, the combined system processes and stores currently and previously sensed sensor signals as integer values. A POSITA would have found it an obvious design choice to use the known technique of integer values when implementing the linear resonant vibration module in accordance with Wakuda, Ramsay, Rossi, and Aldrich. Sensor signals are typically converted to integer values using an analog-to-digital (A/D) converter to facilitate digital processing, simplify data handling given integer values are generally easier to process digitally than non-integer values such as floating point numbers (especially in hardware), and improve computational efficiency. *See* NINTENDO-1021, p. 2. Based on my knowledge and experience, A POSITA would have recognized that sensor values in digital systems are conventionally represented and stored as integers, with optional conversion to floating-point values only when necessary. Using integer values avoids unnecessary conversions and reflects a routine design choice between integer values or non-integer values. Accordingly, it would have been obvious to a POSITA to use integer values for processing the sensed force data in the combined system. *See id.*, pp. 2–3.

147. In steps “714” and “716,” the ’337 patent’s control program calls a “control” routine (step 716), which is illustrated in Figure 7C, “when the event corresponds to a change in the user input through the user interface.” NINTENDO-1001, 7:21-24, 8:10-22. In the combined system, this user input determines the mode and modifies the vibration strength (step 760), consistent with Ramsay’s teachings. In particular, the processor responds to the input by outputting a signal to adjust the supply voltage to the H-bridge (step 762), consistent with the control strategy described in both Ramsay and Rossi. A POSITA would have recognized that the user input is received during the monitoring period and is processed by the control algorithm, which requires a reset of the monitor timer interval (step 764). When such input is received, the microprocessor-executed software outputs a corresponding control signal to the power supply. For example, in the combined system, the software receives user input via a GUI, which adjusts the waveform magnitude (*e.g.*, height, frequency, etc.), consistent with Ramsay’s disclosures. NINTENDO-1006, [0022]-[0026], [0030]-[0033], [0046], [0053]-[0055]. The control component then changes the current and voltage provided from the power supply to the driving component. Because the current applied to the coil directly affects the magnitude of the oscillations, this implements the user-directed change in vibration strength. NINTENDO-1023, 9:65-10:3 (“The magnitude or strength of the force is dependent

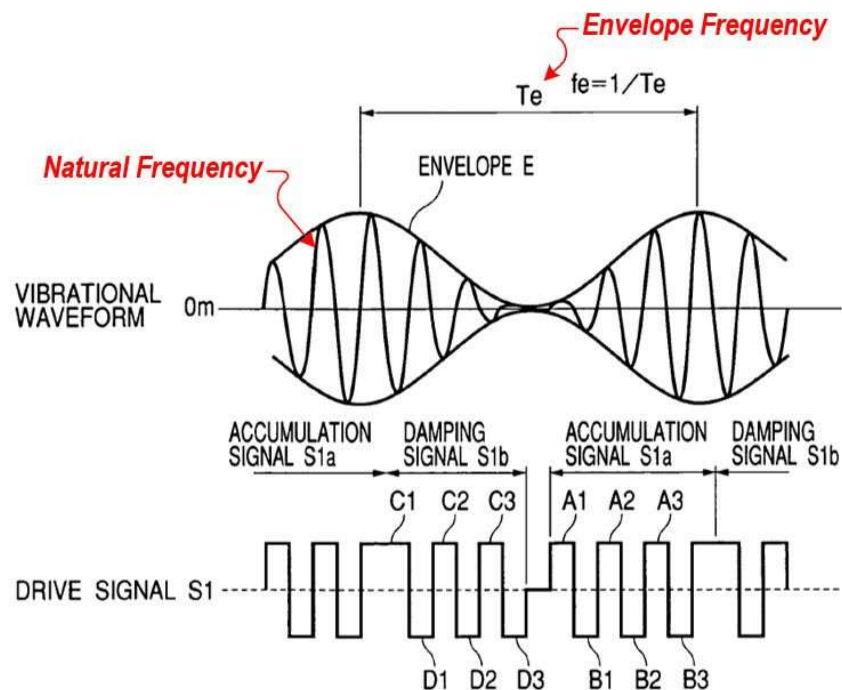
on the magnitude of the current that is applied to the coil.”), 17:32-51 (“the gain 332 (or magnitude) of the force” and “gain of 100”).

148. As such, the combined system includes the algorithm of the Full Construction as described in the '337 patent. However, if the two-step Abridged Construction is adopted (§ V.A.1), Aldrich becomes unnecessary, and the combination of Wakuda-Ramsay-Rossi alone discloses or renders obvious this element of claim 2. Specifically, as discussed above, Wakuda’s control component (“control means”) is implemented using a processor and memory consistent with Ramsay’s disclosures. *See* §§ IX.A.1, IX.A.4. Additionally, the Wakuda-Ramsay-Rossi combination includes a switch (*e.g.*, an H-bridge switch) in accordance with Rossi’s teachings. *See* §§ IX.A.2, IX.A.4. Because the “monitor” routine is excluded from the Abridged Construction, Aldrich’s feedback algorithm is not necessary for the combination to render this claim element obvious.

h. [2g]: wherein the control component drives simultaneous oscillation of the moveable component at two or more frequencies to generate complex vibration modes.

149. It is my opinion that the Wakuda-Ramsay-Rossi-Aldrich combination renders it obvious that the control component (*see* [2f] above) causes the moveable component to simultaneously oscillate at multiple frequencies to generate complex vibration modes. Wakuda itself discloses that its vibration generator system drives the movable body at a combination of frequencies, such as a higher frequency

oscillation near the natural or resonant frequency, and a lower-frequency envelope modulation, resulting in complex vibration outputs. *See* NINTENDO-1005, 2:18-46, 9:12-10:42, Figs. 5-6. A POSITA would have understood and found it obvious that such simultaneous multi-frequency operation produces complex vibration modes, as required by this limitation.



NINTENDO-1005, Fig. 5 (annotated).

150. Furthermore, Ramsay states that “one or more frequencies” can be entered for each haptic track. NINTENDO-1006, [0046]. Ramsay further enables users to “combine or mix different haptic tracks together if desired to provide a fuller haptic experience,” and such mixed track files can be stored in memory. *Id.*, [0030], [0027]. When multiple haptic tracks are mixed to overlap in time, “two or more

haptic tracks can be programmed to be simultaneous or partially overlapping in time in any desirable manner.” *Id.*, [0047].

151. Based on these disclosures and teachings from Wakuda and Ramsay, a POSITA would have understood and found it obvious that the Wakuda-Ramsay system drives simultaneous oscillation of the movable component at two or more frequencies—either within a single haptic track containing multiple frequencies or through mixed tracks combining multiple haptic effects with distinct frequencies. A POSITA would have further recognized and found it obvious that such multi-frequency operation generates complex vibration modes, thereby producing “a fuller haptic experience.” NINTENDO-1006, [0030].

- i. [3]: The linear vibration module of claim 2 wherein the complex vibration modes include: a primary oscillation frequency modulated by a modulating oscillation frequency; a beat frequency; and an aperiodic oscillation waveform.*

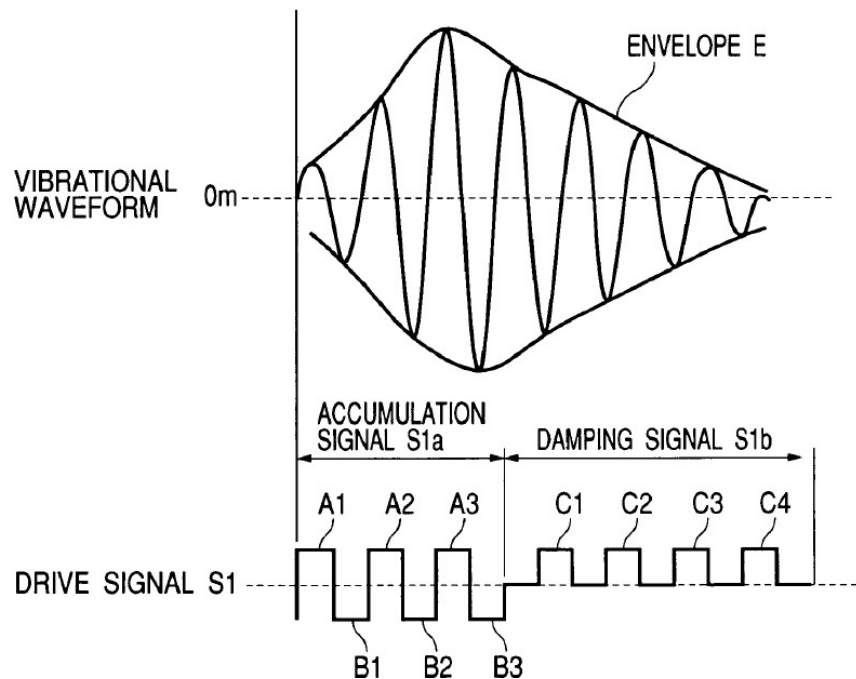
152. It is my opinion that the complex vibration modes in the Wakuda-Ramsay-Rossi-Aldrich combination include: (1) *a primary oscillation frequency* (e.g., a natural or resonance frequency) *modulated by a modulating oscillation frequency* (lower envelope frequency in [2g]) , as shown in Wakuda’s Figure 5; (2) *a beat frequency* caused by the interference of two slightly different oscillation frequencies, also depicted in Wakuda’s Figure 5; and (3) *an aperiodic oscillation waveform*, characterized by irregular, non-repeating vibrations, as illustrated in

Wakuda's Figure 6. NINTENDO-1005, Figs. 5-6; *see also* NINTENDO-1057, 31, 34-36.

153. Specifically, Wakuda discloses that the “vibrational waveform of the movable body 6” includes a primary oscillation at the natural or resonance frequency and an envelope frequency defined by “a line connecting peaks of amplitude of the movable body 6 together,” which is adjustable to be “bodily sensed.” NINTENDO-1005, 8:63-67, 9:12-48, Fig. 5. Wakuda's waveform results from driving the movable body at two nearby frequencies—such as the resonance frequency and a slightly offset modulation frequency—producing a beat frequency equal to the difference between those frequencies. This beat frequency manifests as the envelope frequency that modulates the amplitude of the overall vibration, generating a bodily sensed effect. As in the '337 patent, the beat frequency corresponds to the low-frequency modulation observed when two higher-frequency signals interfere. *See* NINTENDO-1001, 13:13-41, Figs. 22A-23; NINTENDO-1005, 2:29-46, Figs. 4-6.

154. Wakuda also discloses generating irregular and therefore aperiodic vibrational waveforms by adjusting the envelope of the vibration. Specifically, Wakuda teaches that the envelope can be “freely adjusted” by “changing contents of an accumulation signal S1a and a damping signal S1b” to create various feedback sensations. NINTENDO-1005, 9:49-62. Figure 6 illustrates such a waveform, where “the envelope E is shaped to abruptly rise and gently converge.” *Id.* Moreover,

Wakuda explains that “By giving the inhibition signals and the reverse inhibition signals alternately, it is possible to abruptly damp vibrations to set the envelope in a steep shape.” *Id.*, 3:12–14. A POSITA would have recognized that such irregular and non-repeating envelopes constitute aperiodic oscillation waveforms, as recited in claim 3 of the ’337 patent.



NINTENDO-1005, Fig. 6.

155. It also would have been obvious to use the combined system to generate complex vibration modes that include additional aperiodic waveforms in which the resonance frequency changes irregularly over time. It was well-known that the resonance frequency changes irregularly over time. It was well-known that the resonant frequency of a linear resonant actuator (LRA) could shift due to various dynamic conditions, including a user’s interaction with a haptic-enabled device. *See*

NINTENDO-1004, 3:50-55, 3:65-4:5, 2:5-9. For example, “when an LRA is mounted to a floating device (*i.e.*, system 10 held softly in a hand), the LRA resonant frequency shifts up significantly.” NINTENDO-1004, 3:50–55. Additional factors, such as whether “a cell phone [is] flipped open/closed or the phone held tightly” also affects the apparent mounting weight and thereby alter the resonance frequency. *Id.* It was also known that “constantly and dynamically determine[ing] the resonant frequency of [the] LRA” and adjusting the drive signal accordingly helps “maximize the haptic feedback.” *Id.*, 3:65-4:5, 2:5-9. Therefore, a POSITA would have found it obvious that when the user aperiodically changes how the device is held or positioned, the resulting system would need to adaptively vary the drive frequency, producing an aperiodic vibrational waveform due to the shifting resonance frequency. Furthermore, the inclusion of the ability to generate aperiodic waveforms according to irregular changes of the resonance frequency would have enabled the use of more realistic or complex tactile sensations, further enhancing a user’s experience of the device with the LRA.

B. Ground 2: The Fukumoto-Aldrich Combination Renders Obvious Claim 2

156. For the reasons I describe in detail below, a POSITA would have understood that the teachings of Fukumoto and Aldrich render obvious claim 2.

1. The Combination of Fukumoto and Aldrich

157. In the Fukumoto-Aldrich combination, Fukumoto's vibration system would implement Aldrich's control algorithm to utilize sensor feedback to control vibration output near or at a resonant frequency. A POSITA would have recognized that Fukumoto already discloses using an 'encoder' (*i.e.*, a type of sensor) to detect the position of the vibrator in certain embodiments. *See* NINTENDO-1048, 19:61-20:8. Accordingly, a POSITA would have found it obvious to apply Aldrich's feedback-based control algorithm in Fukumoto's system using outputs from such sensors to dynamically adjust the drive frequency for resonance tracking, thereby improving system performance and enabling resonant operation.

158. In the Fukumoto-Aldrich combination, outputs from Fukumoto's sensors—such as an encoder sensing the vibrator's position—would be processed using Aldrich's control algorithm techniques. A POSITA would have recognized that this combination would help achieve Fukumoto's stated goals, such as driving the actuator at a target “frequency f_0 of the drive signal” to induce resonance and “thereby imparting larger vibration to the user using small drive power.” NINTENDO-1048, 16:38-50. Aldrich's feedback-based algorithm incrementally adjusts the drive frequency and compares current and previous vibration strength values to maintain operation at or near resonance. NINTENDO-1021, p. 2. Accordingly, a POSITA would have found it obvious to apply Aldrich's algorithm

to Fukumoto's system to achieve more efficient and controlled resonant actuation *see also* § IX.A.3 (discussing implementation using variables, including Boolean and integer values).

159. A POSITA would have had several reasons to implement Aldrich's control algorithm in Fukumoto's system. First, the Fukumoto-Aldrich combination employs a known feedback algorithm to target a resonant frequency, and a POSITA would have recognized that Aldrich's algorithm could improve the performance of Fukumoto's system. Although Fukumoto identifies the need to apply a drive signal at a specific frequency to cause resonance and "impart[] larger vibration to the user using small drive power," it does not provide sufficient implementation details on how to accomplish this. NINTENDO-1048, 16:38-50. To address this shortcoming, a POSITA would have predictably turned to Aldrich, which expressly describes using control algorithms—such as extremum-seeking and hill-climbing—to drive an actuator at or near resonance based on feedback from vibration strength measurements. NINTENDO-1021, pp. 1-3.

160. Another reason a POSITA would have been motivated to combine Aldrich with Fukumoto is that Aldrich's algorithm enables continuous updating of control outputs during system operation. A POSITA would have recognized that implementing this algorithm in Fukumoto's system would allow real-time comparison of current and prior parameters—such as vibration strength—thereby

enabling the system to adjust its control outputs (*e.g.*, frequency of the drive signal) to maintain oscillation at or near resonance. This would directly support the goals of both Fukumoto and Aldrich, including efficient drive control and enhanced vibrational performance. *See* NINTENDO-1048, 16:38-50.

161. A POSITA would have recognized that implementing Aldrich’s “hill-climbing” feedback control algorithm in Fukumoto’s system constitutes the application of a known technique (Aldrich’s feedback control algorithm) to a known system—namely, Fukumoto’s actuator system that uses a CPU or processor to control a drive circuit for an oscillatory actuator. *See* § IX.A.3. A POSITA would have reasonably expected this combination to yield predictable improvements, including real-time resonance tracking and more efficient drive control, consistent with the objectives of both references.

162. A POSITA would have also had a reasonable expectation of success in combining Aldrich’s control algorithm with Fukumoto’s system because Aldrich’s method is readily applicable to Fukumoto’s resonant system architecture. The required modifications would primarily involve software updates to the code executed by Fukumoto’s CPU or processor. Specifically, sensor outputs (recall, Fukumoto already discloses the use of sensors in some embodiments) would be received and processed using Aldrich’s “hill-climbing control algorithm” to “find and remain within the vicinity of the resonance.” NINTENDO-1021, p. 2. It would

have been obvious to a POSITA to incorporate Aldrich's algorithm into Fukumoto's processor as a control program. Implementing such a program to enable continuous feedback control about a resonant frequency would have been a routine software adaptation using known coding techniques readily known to a POSITA and within the scope of the POSITA's skills at the time.

2. Analysis Of How Fukumoto-Aldrich Renders Obvious Claim 2

a. [2pre]: A linear vibration module comprising:

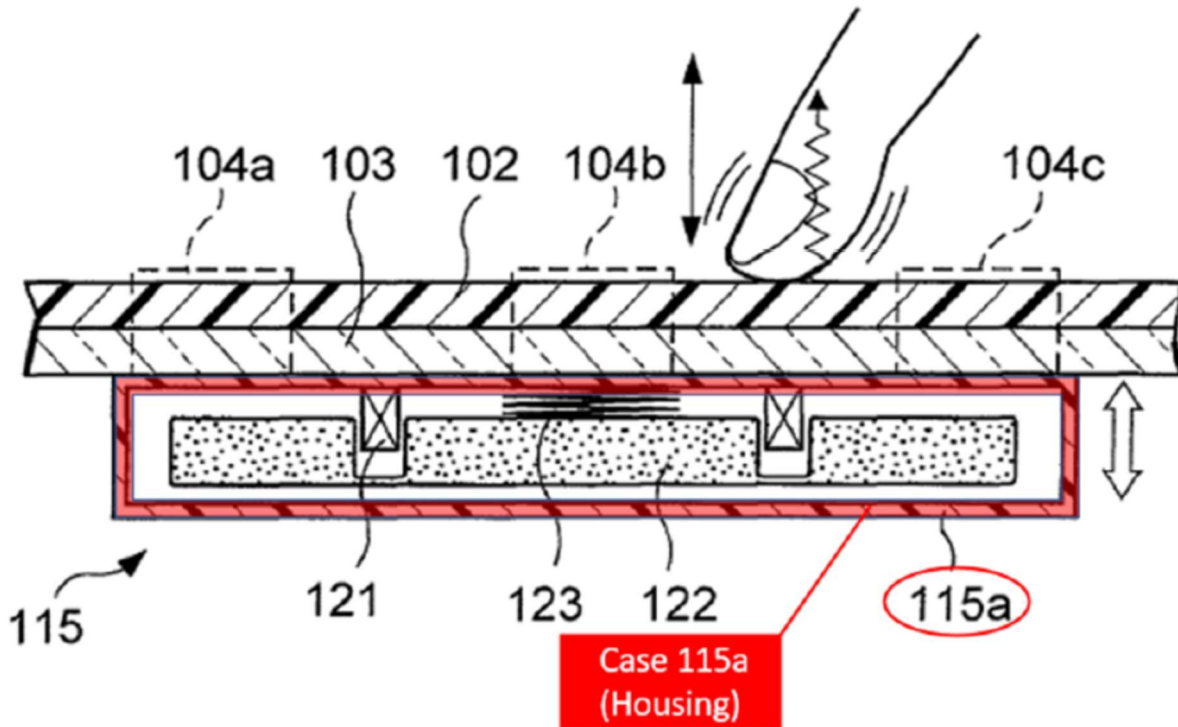
163. To the extent the preamble is limiting, it is my opinion that Fukumoto discloses this limitation. Specifically, Fukumoto discloses “[a]n electronic device drives an oscillatory actuator to cause generation of vibration ... in a direction perpendicular to their respective front surfaces.” NINTENDO-1048, Abstract. Fukumoto's oscillatory actuator oscillates in the same way as described in the '337 patent. *Id.*, 14:20-24 (“oscillatory actuator 115 is a linear oscillatory actuator”), Fig. 3; *see also* NINTENDO-1001, 4:17-23. A POSITA would have understood that Fukumoto's controller and vibrating actuator are integrated within the same device, and thus would constitute a linear vibration module as recited in the preamble.

b. [2a]: a housing;

164. It is my opinion that Fukumoto discloses this limitation. Specifically, Fukumoto's case 115 is the “housing.” Fukumoto explains that the components of

the oscillatory actuator are “housed inside the case 115a,” shown in Figure 3 below.

NINTENDO-1048, 15:56–59.

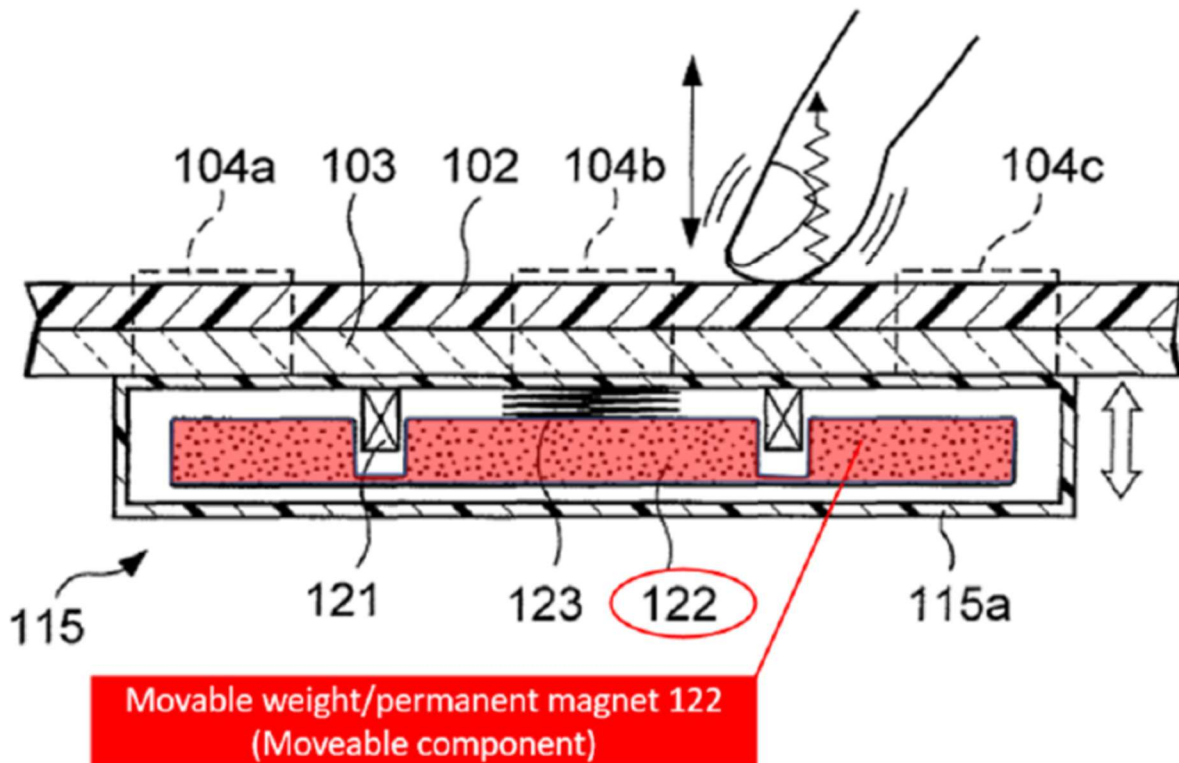


NINTENDO-1048, Fig. 3 (annotated). Alternatively, it is my opinion that Figure 1 (reproduced and annotated below) shows Fukumoto’s PDA with a main case 101, which also discloses or suggests a “housing,” particularly if the claims are read as to require the “housing” correspond to the outer body of the large device containing the “linear vibration module.”⁵

⁵ See also ¶¶ 113–114, where I explain that, in Ground 1, “housing” may be met either by the actuator casing itself or the terminal device enclosure that integrates the actuator module depending on how the term is interpreted.

c. [2b]: a moveable component;

165. It is my opinion that Fukumoto discloses this limitation. Specifically, Fukumoto discloses a “columnar movable weight 122 made of permanent magnet,” as shown in Figure 3 below. NINTENDO-1048, 14:32-37.



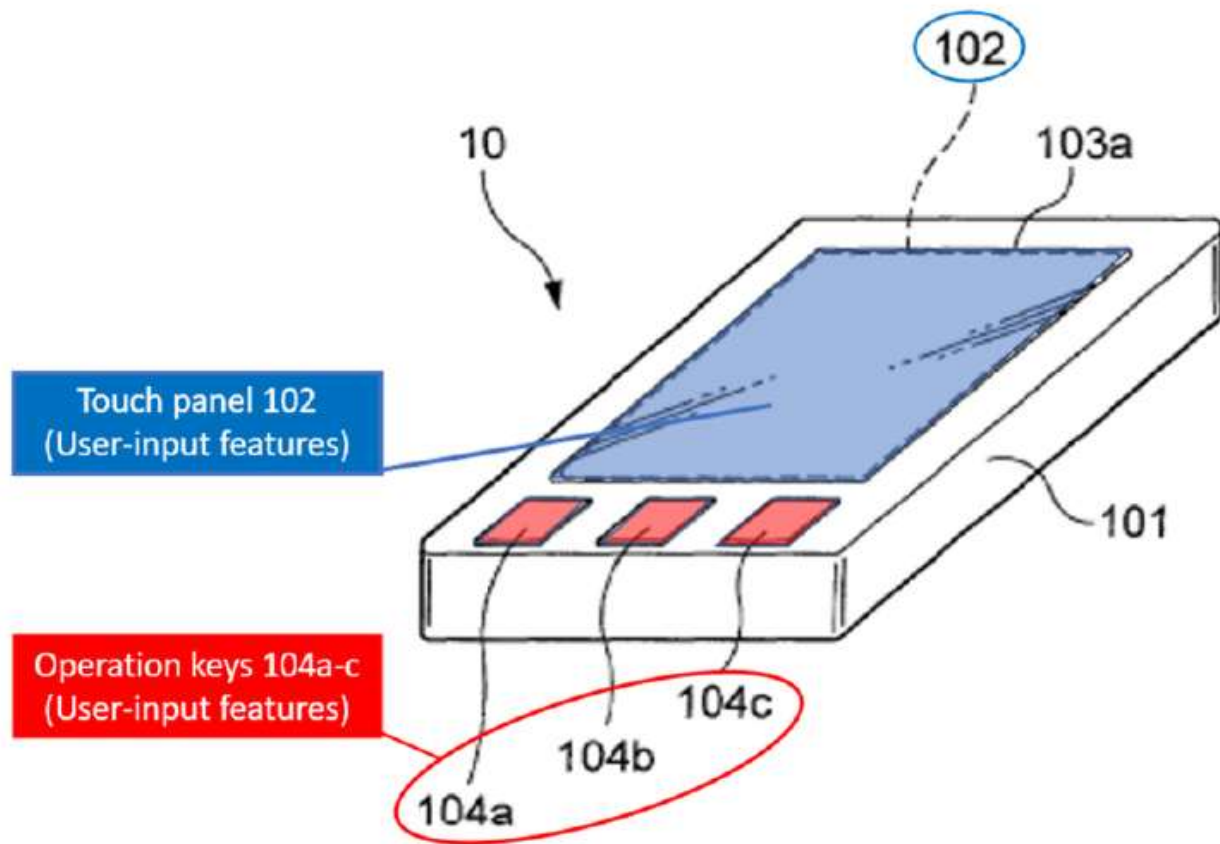
NINTENDO-1048, Fig. 3 (annotated). Fukumoto further describes that “[t]he movable weight 122 linearly reciprocates in the vertical direction in the figure.” *Id.*, 14:57–60. Thus, Fukumoto’s movable weight 122 discloses or suggests a “moveable component” (*i.e.*, a moving weight that performs the recited function (“moves”)).

d. [2c]: a power supply;

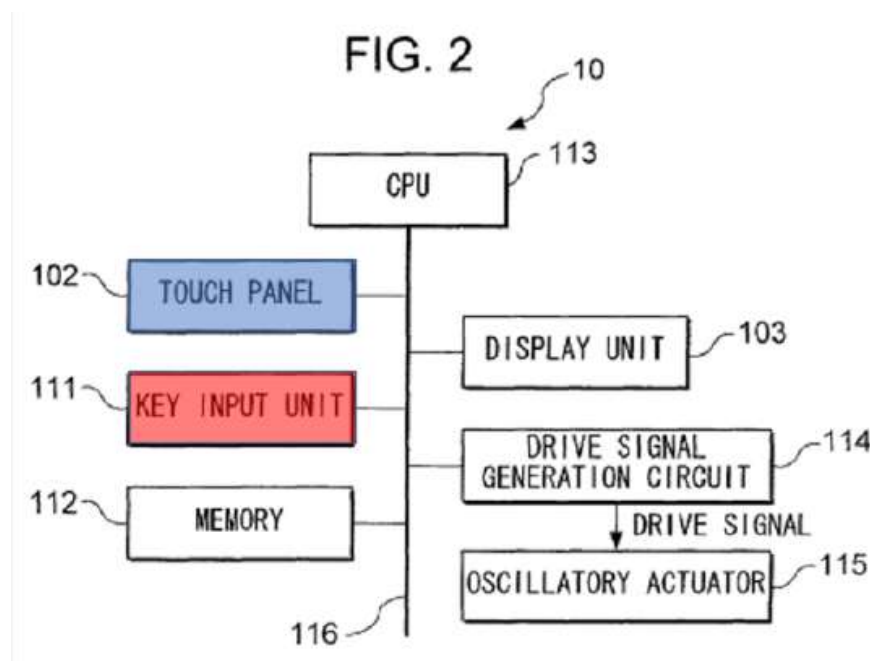
166. It is my opinion that Fukumoto discloses or renders obvious this limitation. Fukumoto states that “[t]he movable weight 122 linearly reciprocates in the vertical direction in the figure by the magnetic force generated from the coil 121 when an AC (alternating) current (drive signal) is applied to the coil 121.” NINTENDO-1048, 14:57–60. Fukumoto further emphasizes that to vibrate at a resonant frequency, the oscillatory actuator 115 requires “small drive power,” which serves to “reduce[] the power consumption.” *Id.*, 16:44–50. A POSITA would have understood that this “small power” must be supplied to the coil as alternating current from a power supply, and therefore Fukumoto discloses or at least suggests the presence of a “power supply.”

e. [2d]: user-input features;

167. It is my opinion that Fukumoto discloses this limitation. Fukumoto discloses a PDA that includes a “touch panel” and “push-button type operation keys” that allows a user to “input[] operation instructions to the PDA 101.” NINTENDO-1048, 13:40–14:13. This is shown below in Figures 1 and 2, both annotated:



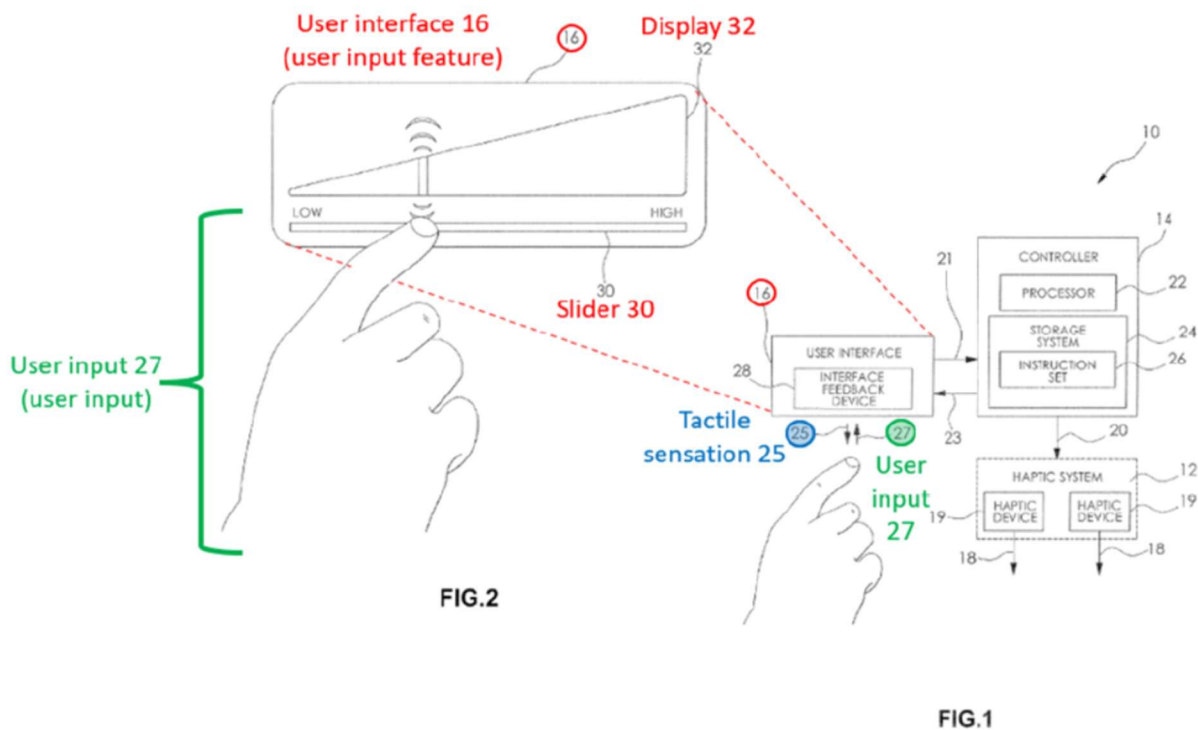
NINTENDO-1048, Fig. 1 (annotated).



NINTENDO-1048, Fig. 2 (annotated). Fukumoto discloses that “[t]he CPU 113 executes a program stored in the memory 112” which includes a “vibration control processing” routine. Upon detecting “an operation input from the touch panel 102 or any one of operation keys 104a to 104c,” the system “drives the oscillatory actuator 115 through the drive signal generation circuit 114 to cause the touch panel 102 or one of the operation keys 104a to 104c to vibrate.” *Id.*, 14:8–13, 30:48–53, 31:27–29, Fig. 41. These user-input mechanisms in Fukumoto (such as touch panels and buttons) are consistent with Ramsay’s description of “input/output devices” including “keyboards, keypads, cursor control devices, computer mice, voice activation mechanisms, touch screens,” and the like. NINTENDO-1006, [0022], [0024]. Therefore, a POSITA would have understood and found it obvious that the Fukumoto-Aldrich combination includes user-input features as recited in [2d].

168. Although Fukumoto discloses how a user manipulates, for example, a hardware touch panel (*i.e.*, a “user input feature”) to initiate processor-driven software instruction for controlling oscillatory actuator vibrations via drive signals, Fukumoto does not depict exactly how the user-input features may be manipulated. A POSITA would have recognized that Fukumoto’s user-input features would allow for a variety of interaction capabilities to control the oscillatory actuator. For example, U.S. Patent Application 2009/0295739 (“Nagara,” NINTENDO-1039) depicts a system in which a user manipulates a screen-based interface – like

Fukumoto's touch panel – to control vibration characteristics. In Nagara, a user provides a “user input 27” (*see* Fig. 1 and exploded view Fig. 2) to “user interface 16” in order to select a desired “tactile sensation 25.” *Id.*, [0020]–[0021]. These user interactions are controlled by software instructions executed by a processor.

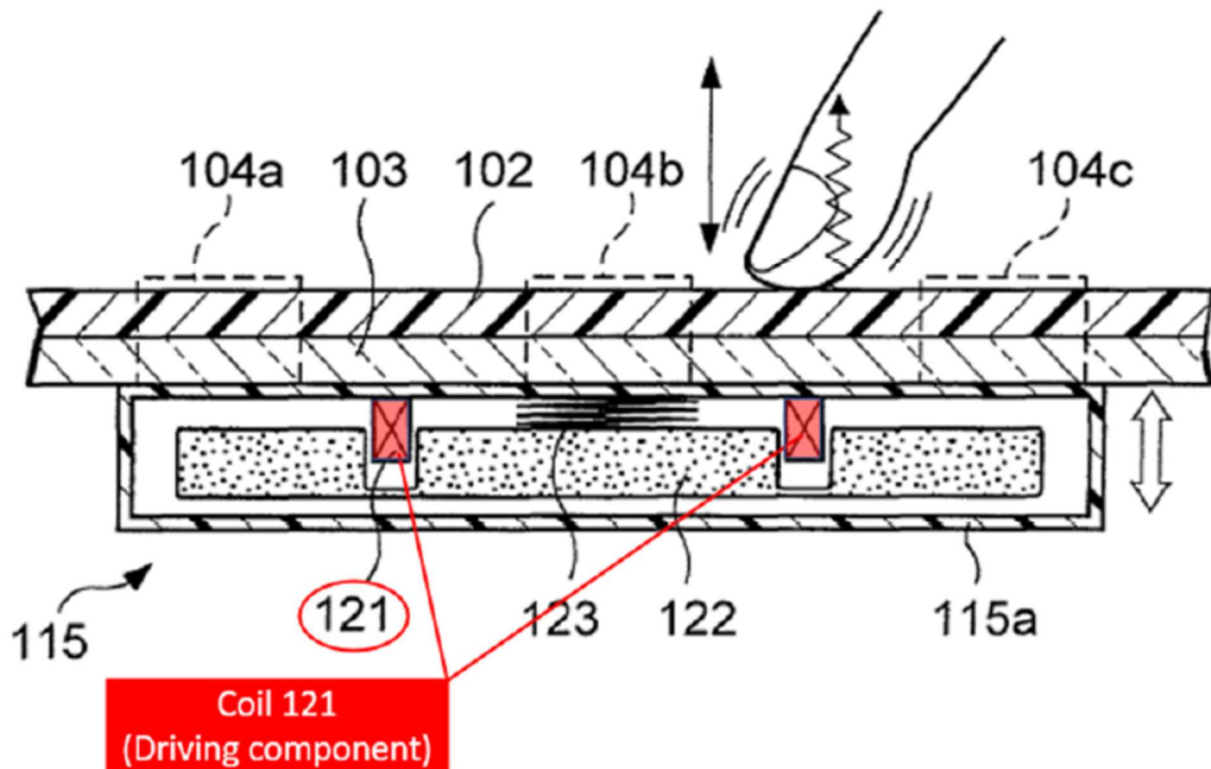


NINTENDO-1039, Figs. 1-2 (combined and annotated). Such teachings reinforce that a POSITA would have understood or found it obvious that the control system in Fukumoto would or at least can be used to receive user input through physical or screen-based interfaces to adjust haptic effects. These teachings are also consistent with Ramsay's user-input features, which include physical and graphical input

devices for receiving user commands and adjusting haptic outputs. NINTENDO-1006, [0022], [0024].

f. [2e]: a driving component that drives the moveable component in each of two opposite directions within the housing; and

169. It is my opinion that Fukumoto discloses this limitation. Fukumoto discloses a “movable weight 122 linearly reciprocates in the vertical direction in the figure by the magnetic force generated from the coil 121 when an AC (alternating) current (drive signal) is applied to the coil 121.” NINTENDO-1048, 14:57–60.



NINTENDO-1048, Fig. 3 (annotated).

170. Like the '337 patent which discloses “driving **coils 1412 and 1414**” that “control the plunger to linearly oscillate” (NINTENDO-1001, 10:7-13 (bolding added)), Fukumoto discloses that “[M]ovable weight 122 linearly reciprocates in the vertical direction in the figure [3] by the magnetic force generated from the **coil 121** when an AC (alternating) current (drive signal) is applied to the coil 121.” NINTENDO-1048, 14:57–60 (bolding added). Thus, Fukumoto discloses or suggests a coil 121 (the “driving component”) drives movable weight 122 (the “moveable component”) in each of two opposite directions within housing 115a when alternating current is applied to the coil, thereby satisfying limitation [2e].

g. [2f]: a control component that controls supply of power from the power supply to the driving component to cause the moveable component to oscillate at a frequency and an amplitude specified by user input received from the user-input features,

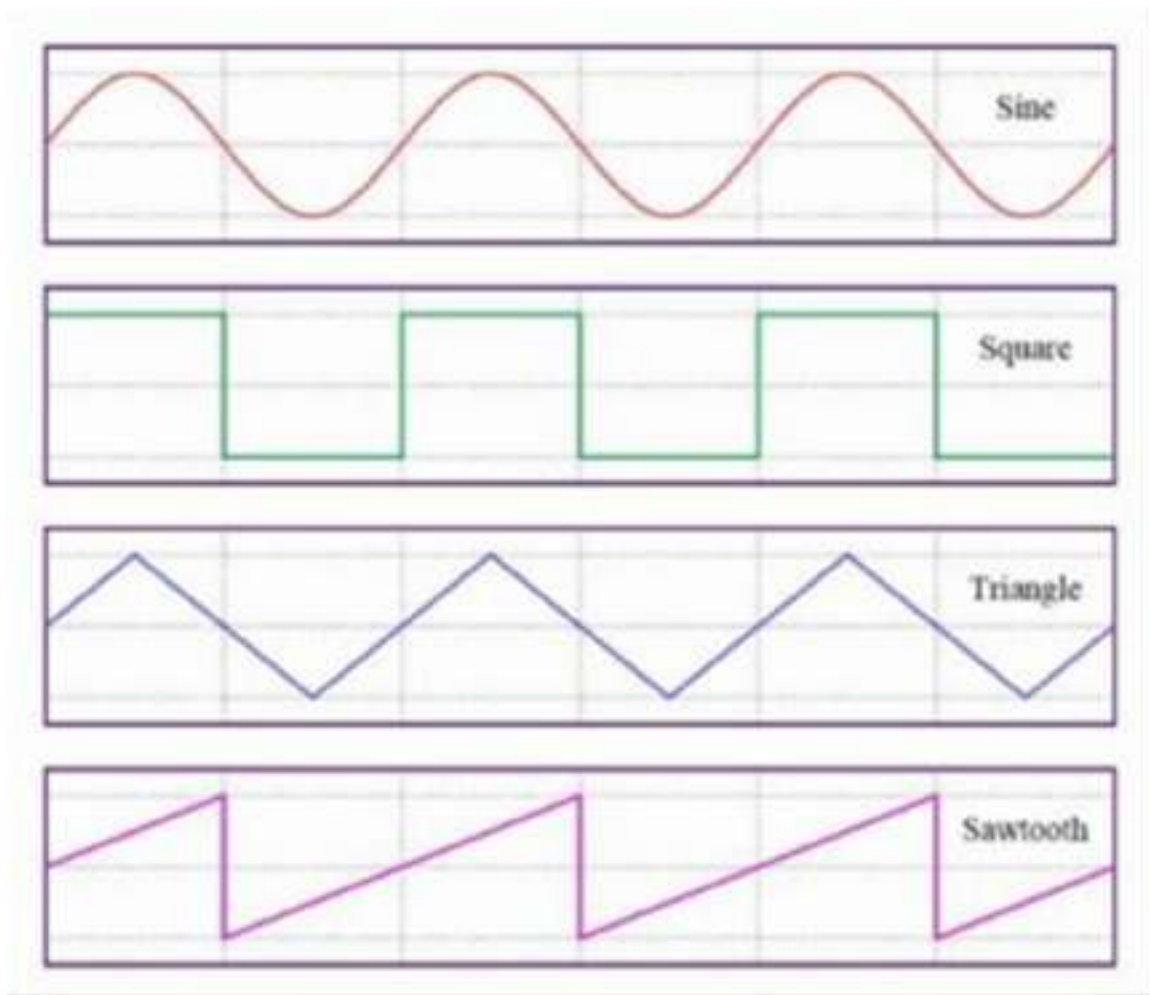
171. It is my opinion that the Fukumoto-Aldrich combination renders obvious this limitation (the recited control component within the resulting system), regardless of whether the Full Construction or the Abridged Construction is adopted. Under the Full Construction, the control component is implemented using Aldrich’s control algorithm based on user input. Under the Abridged construction, Aldrich becomes unnecessary, and Fukumoto alone renders this limitation, and indeed all limitations of claim 2, obvious.

172. First, Fukumoto discloses the use of a *processor* and memory (“CPU 113” and “memory 112,” NINTENDO-1048, Fig. 2, 13:54-59) but does not expressly disclose an H-bridge switch. Instead, Fukumoto teaches applying an AC drive signal to coil 121 (*Id.*, Fig. 2, 14:57–60), without providing specific details regarding the circuitry used to convert power from a source (*e.g.*, a battery within the electronic device), into the AC drive signal delivered to the coil.

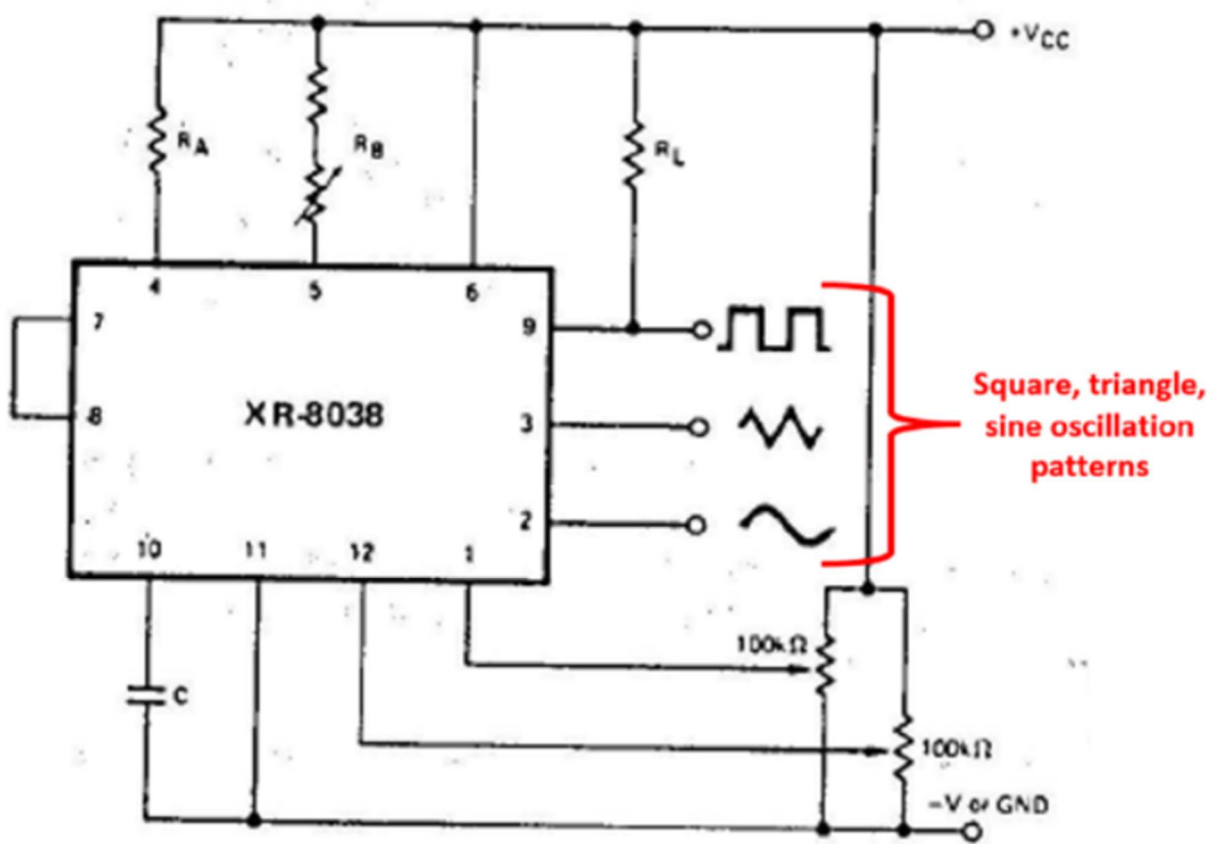
173. A POSITA would have appreciated that the components necessary to perform this power conversion – such as H-bridge switches, oscillator circuits, and inverters – were well-known at the relevant time. *See also* § VII, VIII.A. Many people are likely familiar that electrical power may be delivered via either AC (alternating current) or DC (direct current) delivery. For example, typical home outlets in the United States provide power at, *e.g.*, 110V AC, whereas the power delivered to devices via batteries, such as AA or AAA batteries, is delivered in the form of DC power. A simple DC power provides a constant voltage, while AC power oscillates between two voltage values. Both types of signals are commonly used in electronic and electromagnetic circuits. For example, U.S. Patent Application Publication 2008/0155415A1 (“Yoon ’415”) (NINTENDO-1063) discloses a mobile terminal that includes a battery module and a power supply unit configured to convert the battery power into a voltage level corresponding to a control signal and deliver it to a vibration unit. *See* NINTENDO-1063, Fig. 1, [0023]–[0025].

174. For example, and as particularly relevant to the '337 patent, an AC signal is useful for generating an alternating magnetic field, which can be used to induce motion and vibration in an electromagnetic transducer. A common example is a battery-powered portable radio, in which electronic circuits generate an AC signal that drives a speaker coil back and forth and produce audible sounds.

175. AC signals may be created many ways, but a fundamental and basic way to create these signals is by using a circuit called an oscillator. An oscillator produces an electronic signal that oscillates between two values—typically voltages. This oscillation can take several forms, corresponding to different methods of transitioning between the two peak values. As shown in the figure below, common waveforms include sine, square, triangle, and sawtooth. Each of these waveforms can be used to power an electromagnetic transducer, and the choice of waveform can influence the characteristics of the resulting vibration.



176. Oscillators are a basic electronic building block that would have been familiar to any POSITA. An example of such an oscillator chip is the Exar XR8038, an integrated circuit which was commercially available by the late 1980s. Such integrated circuits were widely used to produce AC signals for applications including touch-sensitive displays. The XR8038 was a versatile function generator capable of producing sine, triangle, and square waveforms, making it well-suited for driving various types of electromagnetic actuators. *See* Exar XR8038 Datasheet (NINTENDO-1064), pp. 4-7.



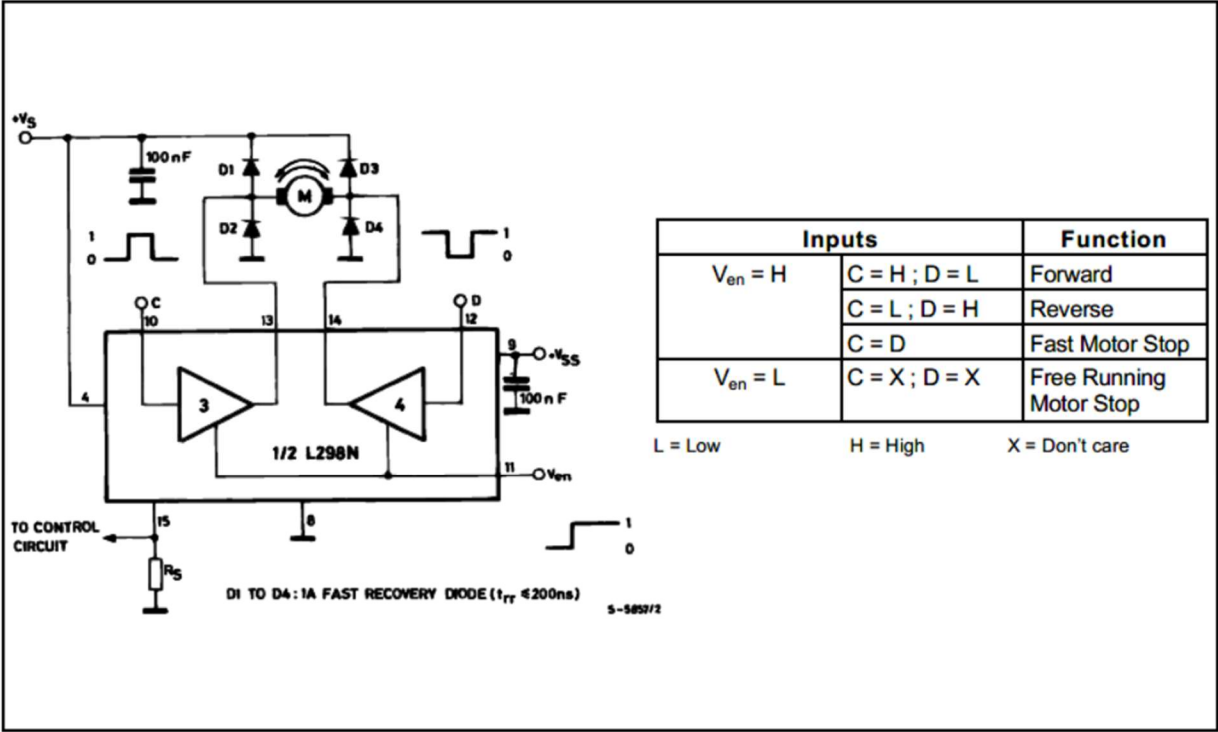
NINTENDO-1064, p. 7 (annotated). The figure above shows how the XR8038 produces several output signals: square, triangle, and sine oscillation patterns.

177. A POSITA would have also known how to build an oscillator from resource such as electronics textbooks or design guides. Many examples of these resources can be given but at least two electronic hobbyist books from the relevant time period are *Jung* (NINTENDO-1065) and *Friedman* (NINTENDO-1066). Both include complete instructions for designing oscillators capable of driving electromagnetic devices like speakers or resonant actuators. In addition, several standard college-level textbooks, such as *Horowitz* (NINTENDO-1067) and

Millman (NINTENDO-1068), also describe oscillator circuits suitable for producing audio-frequency signals or other signals in the range useful for haptic feedback applications. These references confirm that such designs were within the routine skill of a POSITA prior to the priority date.

178. Yet another well-known technique for generating an oscillating drive signal for an electromagnetic actuator is the use of an H-bridge circuit. An H-bridge can receive a supply of power from a power supply and control signals from a microprocessor to switch the polarity of the voltage applied across the actuator's terminals, thereby creating an alternating current and inducing oscillatory motion. One widely used example is the L298 dual full-bridge driver IC from STMicroelectronics, which integrates two H-bridges and has been commonly used to drive inductive loads such as DC motors and vibratory actuators. Documentation for the L298 has been available since at least 2000. *See* NINTENDO-1052, 1-13.

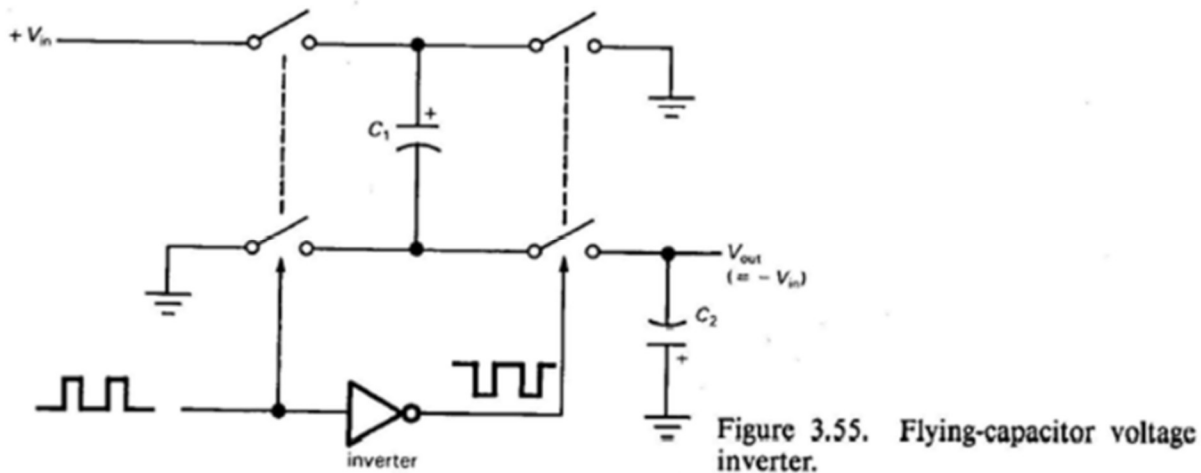
Figure 6 : Bidirectional DC Motor Control.



Id., Fig. 6.

179. An AC signal—regardless of whether it is sinusoidal, square, triangular, or otherwise—oscillates around its average value and causes an electromagnetic actuator (such as a speaker or linear resonator) to move back and forth at the oscillation frequency. A POSITA would have appreciated that such a signal can be generated using either a single-voltage supply or dual-polarity voltage supply with a separate ground. *See NINTENDO-1064*, p. 7. If only a single battery is available, a dual-polarity supply can still be created using a voltage inverter (also known as a charge pump), which generates a negative voltage from a positive one. Designs for voltage inverters are well-known and can be found in standard

electronics textbooks. One such example is the circuit below from the textbook “The Art of Electronics” by Horowitz and Hill, which provides the following basic voltage inverter circuit:



NINTENDO-1067, p. 4. This circuit is used to convert a positive supply voltage V_{in} to a corresponding negative supply voltage $-V_{in}$. *Id.*

180. A POSITA would have viewed any of these well-known techniques—such as oscillators, inverters, or H-bridge switches—as equivalent and obvious options for generating an alternating drive signal required in Fukumoto’s device. In particular, H-bridge switches were well-known and commonly used to efficiently convert control signals into alternating current as needed for Fukumoto’s oscillatory actuator. *See* NINTENDO-1020, Fig. 1, 1:50-53 (describing an H-bridge switch as a “known technique”). Although the ’337 patent describes an H-bridge switch in detail, a POSITA would have understood that other methods (in addition to the H-bridge switch) for generating alternating drive signals—such as inverters or

dedicated oscillator ICs—could be substituted without changing the overall system functionality.

181. Should it be required that the “control component” must be situated “within the linear vibration module” (*see* § V.A.1), a POSITA would have found this to be an obvious implementation in Fukumoto. Fukumoto does not explain where the CPU and memory are physically located, but instead depicts their relationship in a high-level block diagram. *See, e.g.*, NINTENDO-1048, Fig. 2, 13:54-14:26. A POSITA would have found it obvious to place Fukumoto’s CPU and memory, or a secondary CPU and memory, *within the vibration module*, as was common practice in similar systems. *See* NINTENDO-1004, 2:18-35 (“The haptic feedback system includes a processor 12. Coupled to processor 12 is a memory 20 Processor 12 may be any type of general purpose processor, or could be a processor specifically designed to provide haptic effects, such as an application-specific integrated circuit (‘ASIC’). Processor 12 may be ... a separate processor”); NINTENDO-1008, Figs. 1-2, [0046]-[0048] (disclosing an “interface device” with haptics that includes “one or more controllers,” including a dedicated “haptic device controller”). A POSITA would have understood that this implementation simplifies integration of the *linear vibration module* into end-user devices, such as Fukumoto’s “PDA 10”, “personal computers, ATMs ...,” and other portable or embedded electronic devices. NINTENDO-1048, 1:13-25, 13:41-43. Embedding the control

component within the module would allow the module to manage its own functionality without relying on the host device's main processor. This arrangement would have also facilitated modular integration, reduced electromagnetic interference, and provided improved performance.

182. Moreover, the Fukumoto-Aldrich combination provides that the processor is programmed with the algorithm pursuant to the Full Construction (that is, Steps 706 through 716 of Figure 7A). *See* § V.A.1; NINTENDO-1001, Figs. 7A-7C.

183. A POSITA would have understood that Fukumoto's control program, which is software executing on its CPU / processor, would require multiple variables to track operation of its device (*e.g.*, PDA 10) and the haptic feedback. Fukumoto explains that when "at least one of the touch signal or key operation signal has been input," the CPU "reads from the memory 112 the waveform data of the drive signal to be applied to the oscillatory actuator 115." NINTENDO-1048, 17:7–11. Fukumoto also explains that its memory "stores a plurality of types of waveform data" to "give a greater variation to the mode of vibration used," and "[f]or example, the vibration time, the magnitude of vibration, and the period of the strength of the vibration may be freely changed." *Id.*, 47:43–51. A POSITA would have understood that such flexibility requires tracking several control variables, including a **mode** (*e.g.*, whether to operate the actuator at a "frequency for causing resonance in the

housing,” NINTENDO-1048, 48:42-45, or according to a “plurality of types of waveform data,” *Id.*, 47:43-51) and **strength** (*i.e.*, “magnitude of vibration”). Fukumoto also describes that its processor “instruct[s] generation of drive signal,” which a POSITA would have understood to operate based on an output control variable supplied to the drive signal generation circuit. NINTENDO-1048, Figs. 2, 5-6, 11, 13-15, 17-18. Furthermore, because both the desired operation and vibration strength are user-adjustable, the values of these mode and strength variables must reflect selections made via the user input features. To implement Aldrich’s feedback control method, the Fukumoto-Aldrich combination would also include additional—such as **lv10**, **lv11**, **freq**, **d**, and **inc**—as discussed in Ground 1 (§ IX.A.4.g). For example, Fukumoto discloses that, by default, “the frequency F_o [(*i.e.*, “freq”)] of the drive signal ... is made to match with the natural frequency f_1 of the main case 101,” but other frequencies may be set, as it “is not limited to the frequency for causing resonance.” NINTENDO-1048, 16:38-59, 48:42-47. Similarly, the directional control signal **d** would be initialized to a default high or low value and reversed during operation to induce oscillation, consistent with the feedback algorithm. *See* § IX.A.4.g.

184. Although “step 704” is not required by the Full Construction, I reference and explain it here because the events shown as steps 706, 710, and 714 (which are a part of the Full Construction) are the “events” for which the control

program is waiting. NINTENDO-1001, 6:61-65. Similarly, Fukumoto discloses that its method of reading waveform data and driving the oscillating actuator does not begin until it “detect[s] operation input.” NINTENDO-1048, 22:21-32, Figs. 5, 11, 14-15. A POSITA would have understood that this means Fukumoto’s control program waits for an event—such as a user input or expiration of a timer—because otherwise, the program would simply end, making it incapable of monitoring and controlling the oscillatory actuator as required.

185. In the ’337 patent’s steps 706-708, the expiration of a timer triggers the control program algorithm to output a flipped signal *d*, which causes the oscillator circuit (*e.g.*, an H-bridge switch) to reverse its output and apply a reverse force on the movable weight, thereby achieving the desired frequency. NINTENDO-1001, Fig. 7A, 7:10-17. This is taught or rendered obvious by Fukumoto. In particular, Fukumoto discloses using a “count value” to control when the CPU outputs a signal to “the drive signal generation circuit.” NINTENDO-1048, 17:20-40. Furthermore, Fukumoto’s figures showing the “waveform of the drive signal” demonstrate that, to drive the linear oscillatory actuator of Figure 3, the system must provide a signal which alternates between high and low values at frequency f_0 to induce resonance. *Id.*, Fig. 4, 16:54-56. A POSITA would have recognized that a well-known and effective way to implement this is to flip the signal input to the drive signal generation circuitry (*e.g.*, H-bridge switch) based on a timer that expires at the

desired frequency. This is consistent with Fukumoto's disclosure of using a "count value" to control signal output, and with known techniques described in § VII and NINTENDO-1026, pp. 8-9, 31-32 (discussing the use of timers to trigger actions).

186. The Fukumoto-Aldrich combination also discloses or renders obvious the '337 patent's "monitor routine," including triggering that routine based on the expiration of a timer, as described in steps 710-712 of the '337 patent (Figs. 7A, 7B). As I explained in Ground 1 at § IX.A.4.g, a POSITA would have recognized that the "monitor" routine is a conventional feedback control mechanism. A POSITA would have found it obvious, based on Aldrich's disclosure of feedback control to operate at or near a resonant frequency, to execute a monitor routine with a defined sampling rate (*i.e.*, triggering execution upon expiration of a timer and resetting the timer after each cycle (step 754)) to compare vibration parameters while incrementing or decrementing the drive frequency to converge on the desired resonant frequency. *See* NINTENDO-1021, pp. 2-3; § IX.A.4.g. The reasoning I provided in Ground 1 regarding Aldrich's implementation of the monitor routine applies equally here: in both instances, Aldrich's teachings would be largely implemented in the CPU or processor of the combined system through routine software modifications.

187. A POSITA would have understood that the Fukumoto-Aldrich combination uses one or more sensors to sense values that are then stored (per step 730 of the '337 patent). Specifically, Fukumoto's processor routine may include a

monitoring routine that senses the circuit and oscillatory actuator conditions, as required by Aldrich's feedback control algorithm. NINTENDO-1048, Fig.1; NINTENDO-1021, pp. 2-3. A POSITA would have recognized that Aldrich's algorithm would be implemented within Fukumoto's CPU / processor to control the oscillatory actuator via the drive signal generation circuit, particularly because Fukumoto's block diagrams of PDA 10 show no other component for such device control. NINTENDO-1048, Fig. 2. Fukumoto also describes in a separate embodiment the use of a sensor to "detect [] position" in order to "cause the same vibration to be generated by the vibrator [] every time." *Id.*, 19:56-60. Although this embodiment uses a "DC motor" (*Id.*, 19:5-10), a POSITA would have found it obvious to apply such sensors in the embodiment using a linear oscillatory actuator—such as in the Fukumoto-Aldrich combination—to sense values in Aldrich's feedback control algorithm. NINTENDO-1048, Figs. 2-5, 13:41-19:3. Furthermore, Fukumoto discloses that the actuator may be operated in different modes, either at a "frequency for causing resonance in the housing" (*Id.*, 48:42-45) or according to a "plurality of types of waveform data" (*Id.*, 47:43-44) stored in memory, consistent with steps 732-734 of the '337 patent.

188. In sum, the CPU / processor and its software in the combined Fukumoto-Aldrich system receives signals from one or more sensors indicative of vibrational strength. The software then compares a currently sensed value with a

previously sensed value to tune the input frequency about a resonant frequency, consistent with steps 730-754 of Figure 7B of the '337 patent. NINTENDO-1021, pp. 1-3; § IX.A.4.g.

189. In the combined system, and consistent with Aldrich's disclosures, a currently sensed vibration strength value at an incrementally increased control signal frequency is compared with a previously sensed vibration strength value. When the vibration strength increases in response to increased frequency input, "then the direction of change ... of frequency is accepted and another such change ... is made during the following sampling period." NINTENDO-1021, p. 2. This process corresponds to steps 736-740 of the '337 patent.

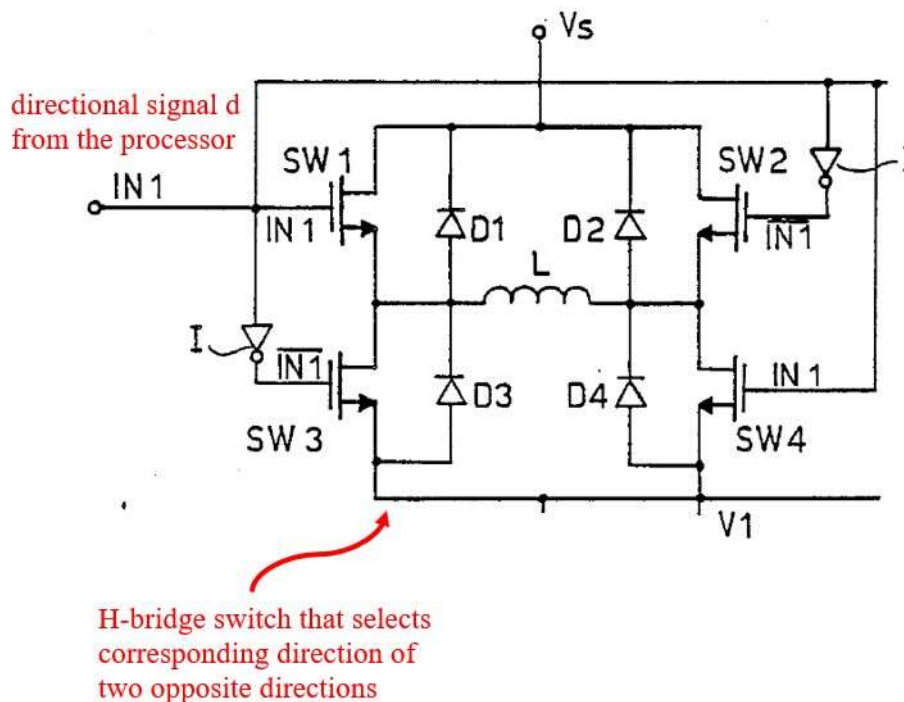
190. When the vibration strength does not increase with increased frequency input, the control program determines that the resonant frequency has been exceeded. NINTENDO-1021, p. 2. In response, the "direction of change of frequency during the following sampling period is reversed," such that the frequency is decremented, and the process continues. *Id.* This process corresponds to steps 742-744 of the '337 patent. The combined system similarly follows steps 746-752 when decrementing the input frequency and evaluating the resulting vibration strength.

191. In the combined system, the currently and previously sensed sensor signals are processed and stored as integer values. As discussed above, the use of integer values was a well-known technique and considered a mere design choice—

for example, between integer or non-integer values (*e.g.*, floating-point) representations. A POSITA would have recognized that using integer values simplifies digital processing and reduces computational overhead. *See* §§ IX.A.3, IX.A.4.g, IX.B.1.

192. Fukumoto’s CPU executes a control routine triggered by user input—corresponding to steps 714-716 of the ’337 patent’s algorithm as shown in Figure 7C. In particular, Fukumoto explains that when user input is detected, the CPU “instructs the drive signal generation circuit 114 to generate a drive signal,” and in response, “the drive signal generation circuit 114 generates a drive signal using the waveform data supplied from the CPU 113.” NINTENDO-1048, 17:20–26. Fukumoto further discloses that its memory “stores a plurality of types of waveform data” to “give a greater variation to the mode of vibration used,” including changes to both frequency and magnitude (*i.e.*, “strength”). *Id.*, 47:43-51. These include operating modes at a “frequency for causing resonance in the housing” or based on “plurality of types of waveform data” stored in memory. *Id.*, 48:42–45. Fukumoto’s control routine adjusts the actuator operation based on the waveform type and magnitude of vibration selected by the user. The processor retrieves waveform data, initiates the drive signal, and maintains it for a prescribed duration. *See id.*, Fig. 5. A POSITA would have understood or found it obvious that providing a “drive signal” would also involve controlling the supply of power, *e.g.*, from a battery, to

the actuator-driving circuitry such as an H-bridge. For example, adjusting the “supply voltage” to the H-bridge based on the user-selected magnitude (and thus the required amplitude) would be a routine implementation. *See* NINTENDO-1020, 2:4-12, 3:6-18, Fig. 5. This reflects steps 760 and 762 of the '337 patent. Furthermore, because the user input is received during a monitoring period, the system must reset the monitor timer interval to ensure proper scheduling and processing of control routines (step 764). §§ IX.A.4.g, IX.B.2.g. These actions are equivalent to the '337 patent's control logic wherein the processor adjusts power supply outputs in accordance with user input. *See also* NINTENDO-1020, 2:4-12, 3:6-18, Figs. 5, 6; §§ IX.A.4.g (describing voltage adjustments at the V_s node of the H-bridge. *See, e.g.,* the annotated reproduction of Fig. 6 below), IX.B.2.g.



NINTENDO-1020, Fig. 6 (partial, annotated).

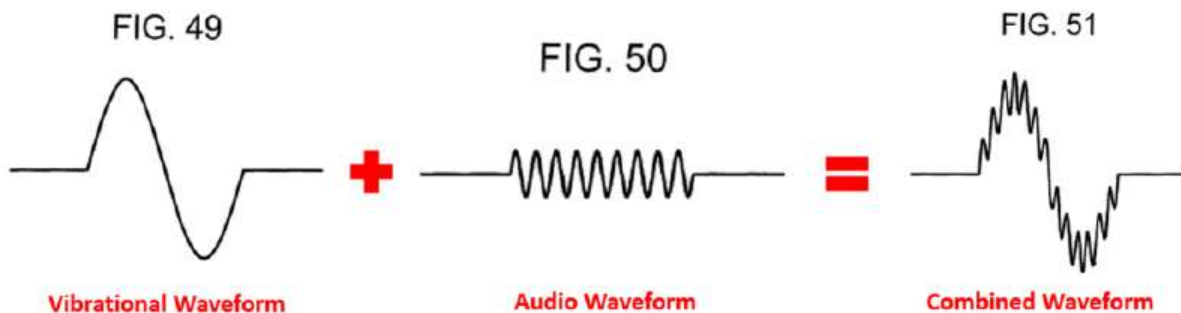
193. Thus, it is my opinion that, based on my review of the material, the Fukumoto-Aldrich combination discloses or suggests a processor, circuitry to convert power supplied from, for example, the battery in the electronic device into an AC drive signal (functionally equivalent to the H-bridge switch disclosed in the '337 patent), and an equivalent algorithm that performs the claimed function using at least steps equivalent to those disclosed in the '337 patent's specification.

194. As such, the combined system includes the algorithm described in the Full Construction. However, if the Abridged Construction is adopted (§ V.A.1), Aldrich would be rendered unnecessary, and Fukumoto alone discloses or renders obvious this element of claim 2. Specifically, as discussed above, Fukumoto's control component ("control means") is implemented using Fukumoto's CPU / processor and memory. A POSITA would have recognized that Fukumoto includes (or it would have been obvious to include) a switch (e.g., an H-bridge switch). Because the "monitor" routine is excluded from the Abridged Construction, Aldrich is not needed to render this claim element obvious.

h. [2g]: wherein the control component drives simultaneous oscillation of the moveable component at two or more frequencies to generate complex vibration modes.

195. It is my opinion that Fukumoto discloses or renders obvious the limitation of the control component driving simultaneous oscillation of the movable

component at two or more frequencies to generate complex vibration mode. For example, Fukumoto discloses that “by applying an audible band audio signal to the coil 121 of the oscillatory actuator 115, it is possible to use the oscillatory actuator 115 also as a sound source.” NINTENDO-1048, 18:15-17. In this embodiment, Fukumoto uses the oscillatory actuator 115 as both a vibration actuator and a speaker by combining a vibration-causing waveform (Figure 49) and a sound-causing waveform (Figure 50) into a composite waveform, which is then used as the drive signal for the actuator (Figure 51):



NINTENDO-1048, Figs. 49-51 (combined and annotated), 34:38-35:9. Specifically, “FIG. 51 is an example of the waveform of the drive signal for causing the oscillatory actuator 115 to generate vibration and sound simultaneously. The waveform shown in the figure is a combination of the waveform for generating vibration shown in FIG. 49 and the waveform for generating sound shown in FIG. 50.” *Id.*, 34:51–53. This results in simultaneous excitation at multiple frequencies, corresponding to the superimposed vibration and audio signals, thereby producing complex vibration modes.

196. A POSITA would have recognized that the vibrational and audio waveforms shown in Figures 49 and 50, respectively, exhibit different frequency and amplitude characteristics. Combining these two signals into a single drive waveform, as shown in Figure 51, would result in simultaneous oscillation of Fukumoto's movable component at a plurality of different frequencies. As a result, this combination would generate a complex vibration mode consistent with the recited limitation.

C. Ground 3: The Fukumoto-Aldrich-Saiki-Masahiko Combination Renders Obvious Claim 3

197. For the reasons I describe in detail below, it is my opinion that a POSITA would have understood that the combination of Fukumoto, Aldrich, Saiki, and Masahiko render obvious claim 3 of the '337 patent.

1. The Combination of Fukumoto, Aldrich, and Saiki

198. A POSITA would have found it obvious to implement Saiki's complex vibration modes in the mobile device of the Fukumoto-Aldrich combination. A POSITA would have recognized that Fukumoto-Aldrich and Saiki are combinable because they are both directed to electromagnetic vibration generation in mobile devices using compact, self-contained actuators. *See* NINTENDO-1048, Fig. 3, Fig. 16 (elements 115a–b), 14:38–15:4, 16:17–37, 50:48–59; NINTENDO-1049, Abstract, Figs. 2, 3B, 1:9–13, 8:58–9:28.

199. A POSITA would have been motivated to make this combination for several reasons. One reason is that integrating Saiki's teachings would provide greater flexibility and variety in available vibration waveforms. *See* NINTENDO-1049, 15:20–23, 15:46–60.

200. Another reason is that a POSITA would have recognized that the more complex waveforms taught by Saiki enable application of various “preferred vibration[s] ... with which a large vibration force is maintained over time.” NINTENDO-1049, 15:20-23. Incorporating such waveforms would have furthered Fukumoto's goal of providing a device with a “vibration generation mechanism” capable of delivering clear haptic feedback or notifications “in a noisy environment” where audio alerts may be “ineffective.” NINTENDO-1048, 1:5-41.

201. A POSITA would have recognized that the proposed combination merely involves applying a known technique (Saiki's frequency signal synthesis) to a known system (Fukumoto's mobile device with its oscillatory actuator and drive signal generation circuit) to achieve predictable results, namely, generating a broader set of vibration output options. Additionally, a POSITA would also have been motivated to make this combination to enhance flexibility and variety in available vibration waveforms. Saiki teaches, for example, a synthesized waveform “[in] which a large vibration force is maintained over time,” and the ability to tailor the

strength of vibration and sound signals separately to achieve a preferred result. *See* NINTENDO-1049, 15:20–23, 15:46–60.

202. A POSITA would have had a reasonable expectation of success in making this combination, as it would have required only minor software modifications to the generation of complex vibration waveforms in the Fukumoto-Aldrich system. Implementing such changes—such as adding signal synthesis routines or modifying stored waveform data—would have been well within the skill of a POSITA at the relevant time.

2. The Combination of Fukumoto, Aldrich, Saiki, and Masahiko

203. As an initial matter, I understand that Masahiko was filed on July 26, 2011. In my opinion, Masahiko qualifies as prior art for claim 3 because that claim is entitled to a priority date no earlier than January 6, 2012. Based on my review, the only portions of the '337 patent that appear to support claim 3 are Figures 22B and 23 and the corresponding description at 13:16–41. These figures and associated text do not appear in the May 18, 2009, provisional application (*see* NINTENDO-1062), or the May 18, 2010, non-provisional application (*see* NINTENDO-1061). Rather, they first appeared in the continuation-in-part application filed on January 6, 2012. *See* NINTENDO-1002. Accordingly, in my opinion, the earliest possible priority date for claim 3 is January 6, 2012, and thus Masahiko qualifies as prior art. I also note that Patent Owner did not contest that Masahiko is prior art in IPR2023-00993,

which concerns a related child patent to the '337 patent. *See generally* NINTENDO-1053-1056.

204. A POSITA would have found it obvious to further implement Masahiko's beat vibration and aperiodic complex vibration modes in the mobile device of the Fukumoto-Aldrich-Saiki combination. A POSITA would have recognized that the Fukumoto-Aldrich-Saiki combination and Masahiko are compatible because they are all directed to electromagnetic vibration generation in mobile devices. *See* NINTENDO-1048, 14:38–15:4, 16:29–33, 50:48–59; NINTENDO-1049, Abstract, 1:9-13, 8:58–9:28; NINTENDO-1050, 1:17–21, 8:50–10:61.

205. A POSITA would have been motivated to make this combination for several reasons. First, a POSITA would have recognized that using Masahiko's beat and aperiodic waveforms with the Fukumoto-Aldrich-Saiki combination's drive circuit would predictably improve the "tactile haptic effects" experienced by users of a mobile device. In particular, Masahiko's waveforms enable more abrupt starts and stops to the vibrations, enhancing the haptic response. *See* NINTENDO-1050, 2:13–47, 4:40–46, 10:7–10, 12:55–61.

206. Another reason is that Masahiko discloses its invention advantageously provides "a vibration generating apparatus which is high in yield [and] low in cost." NINTENDO-1050, 4:40-46. A POSITA would have recognized that incorporating

Masahiko's teachings into the Fukumoto-Aldrich-Saiki combination would improve haptic effects while also maintaining—or potentially enhancing—manufacturing yield and reducing overall cost.

207. A POSITA would have recognized that the proposed combination merely applies a known technique (Masahiko's beat frequency and aperiodic oscillation waveforms) to a known system ready for improvement, namely the Fukumoto-Aldrich-Saiki mobile device with an oscillatory actuator. This would predictably result in enhanced functionality, such as the ability to generate beat waveforms that abruptly stop voltage application—and thus vibration—and produce aperiodic waveforms. Additionally, a POSITA would have been motivated to adopt Masahiko's waveforms in Fukumoto-Aldrich-Saiki's drive circuit to achieve more abrupt initiation and termination of vibrations, thereby improving the "tactile haptic effects" experienced by users. *See* NINTENDO-1050, 2:13–47, 4:40–46, 10:7–10.

208. In addition, a POSITA would have had a reasonable expectation of success in implementing the proposed modification. Incorporating Masahiko's complex vibration waveforms into the Fukumoto-Aldrich-Saiki combination would have required only minor software modifications—changes that would have been well within the capabilities of a POSITA at the relevant time. *See* NINTENDO-1050.

3. Analysis Of How Fukumoto-Aldrich-Saiki-Masahiko Renders Obvious Claim 3

a. [2pre]-[2g]

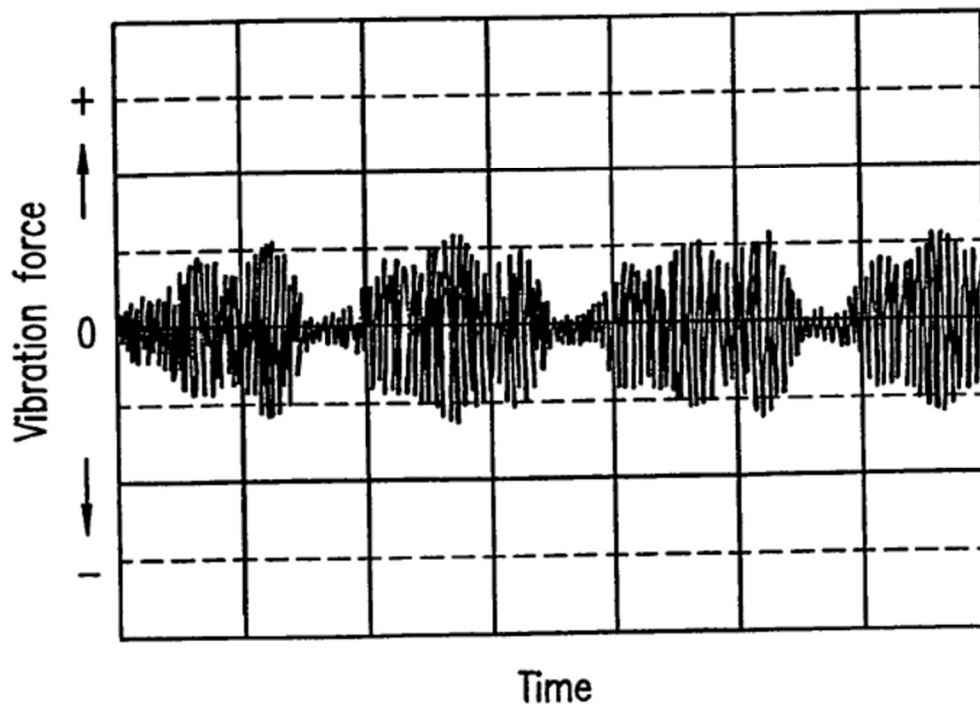
209. Based on my review, and as I explained above in connection with Ground 2, the Fukumoto-Aldrich-Saiki-Masahiko combination discloses or renders obvious all limitations of Claim 2. *See* §§ IX.B.2.a-IX.B.2.h; *see generally* § IX.B.

b. [3]: The linear vibration module of claim 2 wherein the complex vibration modes include: a primary oscillation frequency modulated by a modulating oscillation frequency; a beat frequency; and an aperiodic oscillation waveform.

210. It is my opinion that the Fukumoto-Aldrich-Saiki-Masahiko combination discloses or renders obvious claim 3. As discussed below, Saiki teaches “a primary oscillation frequency modulated by a modulating oscillation frequency,” while Masahiko teaches both a “beat frequency” and “an aperiodic oscillation waveform.” A POSITA would have found it obvious to implement these complex vibration modes in Fukumoto’s system. Accordingly, the combination of Fukumoto, Aldrich, Saiki, and Masahiko renders claim 3 unpatentable as obvious.

211. First, Saiki discloses or renders obvious “a primary oscillation frequency modulated by a modulating oscillation frequency.” In particular, Figures 17A and 17B of Saiki (shown below) illustrate a waveform where a POSITA would have recognized that P1 represents the “primary oscillation frequency,” and P2 represents the “modulating oscillation frequency.”

FIG. 17B



NINTENDO-1049, Fig. 17B. The resulting vibration force, as shown in Figure 17B, includes a combination of these frequencies including P1 and P2. *Id.*, 15:24-36. The waveform output in Saiki Figure 17B is substantively like the complex vibration mode in the '337 patent's Figure 22B. *Compare* NINTENDO-1001, Fig. 22B with NINTENDO-1049, Fig. 17B.

212. In addition, a POSITA would have understood that P1 is modulated by P2 because the two frequencies are in reverse phase, as described in Saiki. NINTENDO-1049, 15:24-36. As discussed above (§ IX.C.1), a POSITA would have been motivated to implement Saiki's complex vibration modes in Fukumoto's system to enhance the range and effectiveness of vibration patterns.

213. Second, Masahiko teaches a “beat frequency.” Specifically, Masahiko describes a beat vibration frequency f_B , which is the difference between the two frequencies. For example, when $f_d < f$, such as when $f = 196.25$ Hz and $f_0 = 157$ Hz, “the beat vibration f_B is 39.25 Hz.” NINTENDO-1050, 12:55–56, Fig. 5.

214. A POSITA would have been motivated to use Masahiko’s beat frequency teachings with the Fukumoto-Aldrich-Saiki combination. Masahiko teaches that beat vibration can be advantageously used to stop vibration at a minimum amplitude (valley), thereby “shorten[ing] the time until stopping vibration.” NINTENDO-1050, 12:55-61. A POSITA would have realized that this beneficial feature could be used to achieve faster vibration cessation in the Fukumoto-Aldrich-Saiki system. A POSITA would have understood that rapidly damping vibration when a haptic response is no longer required—such as confining vibration to a specific haptic event window—would enhance the haptic experience and enable broader range of effects, including discrete tactile events like ticks and jolts.

215. Third, Masahiko discloses “an aperiodic oscillation waveform.” In particular, Masahiko explains that while a pure sine wave eventually produces a steady-state vibration, other drive signals—such as bipolar or square-based waveforms—can be designed to alter the excitation and damping phases in a gradually varying, non-repetitive manner. This results in changes to the total system

energy that are not periodic, thereby producing an aperiodic oscillation waveform. *See* NINTENDO-1050, Fig. 6, 14:26-53, Figs. 15, 16, 22:56-23:59.

216. As I previously explained at § IX.C.2, a POSITA would have been motivated to incorporate Masahiko's aperiodic oscillation waveform into the Fukumoto-Aldrich-Saiki combination due to the benefits a POSITA would recognize in making this combination. For example, a POSITA would have recognized that the use of aperiodic waveforms, in contrast to patterns that vary only in frequency or amplitude, would provide additional expressive capabilities and a wider range of tactile sensations. A POSITA would have found such enhancements beneficial in improving the haptic output options in the Fukumoto-Aldrich-Saiki combination to allow for a more diverse and engaging use of haptic feedback as well as allowed the ability to communicate different information in portable electronic devices.

D. Ground 4: Fukumoto Renders Obvious Claim 2

217. Based on my review, it is my opinion that Fukumoto alone renders claim 2 obvious under the Abridged Construction, for the same reasons I explained in Ground 2—namely, that Aldrich is rendered unnecessary under this construction. *See* §§ V.A.1, IX.A, IX.B. This opinion is also consistent with the PTAB's findings in a related IPR, where the Board found the same limitations of a related patent unpatentable solely on Fukumoto. *See* NINTENDO-1058, 18-34, 67.

E. Ground 5: The Fukumoto-Saiki-Masahiko Combination Renders Obvious Claim 3

218. Based on my review, it is my opinion that the combination of Fukumoto, Saiki, and Masahiko renders claim 3 obvious under the Abridged Construction, for the same reasons explained in Ground 3—namely, that Aldrich is rendered unnecessary under this construction. *See* §§ V.A.1, IX.A, IX.C. This conclusion is also consistent with the PTAB’s findings in a related IPR, where the Board found the same limitations of a related patent unpatentable based on the Fukumoto-Saiki-Masahiko combination. *See* NINTENDO-1058, 18-34, 57, 67-69.

X. SECONDARY CONSIDERATIONS

219. Based on my review of the prosecution history of the ’337 patent and other proceedings involving the ’337 patent, I have seen no evidence that secondary considerations of non-obviousness—such as commercial success, long-felt but unsolved need, failure of others, industry praise, or unexpected results—were raised in connection with the asserted claims. Nor am I presently aware of any such evidence relating to the ’337 patent. As I have discussed throughout this declaration, it is my opinion that the subject matter of the challenged claims was known in the art and would have been obvious to a POSITA in view of the prior art. If arguments or evidence related to secondary considerations are later presented, I reserve the right to evaluate those issues and to submit supplemental opinions as necessary.

XI. CONCLUSION

220. I am aware that this declaration will be filed as evidence in an IPR proceeding before the PTAB. I am aware that willfully false statements made in this declaration are subject to penalties under 18 U.S.C. § 1001, including fine and/or imprisonment, and may affect the validity of the Petition. All statements made herein of my own knowledge are true, and all statements made on information and belief are believed to be true.

221. I declare under penalty of perjury that the foregoing is true and correct.

Executed this 12th day of June, 2025, in Fairfax, Virginia.



Pinhas Ben-Tzvi, Ph.D.