UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TOYOTA MOTOR CORPORATION,

Petitioner,

v.

BUNKER HILL TECHNOLOGIES, LLC

Patent Owner

Case No.: IPR2026-
U.S. Patent No. 11,374,508

DECLARATION OF MAHDI SHAHBAKHTI

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I. INTRODUCTION

1. I have been retained by Toyota Motor Corporation ("Toyota" or "Petitioner") as an independent expert in this proceeding before the Patent Trial and Appeal Board ("PTAB" or "Board"). I understand that Toyota is requesting that the Board institute an *inter partes* review ("IPR") proceeding of U.S. Patent No. 11,374,508 ("the '508 Patent") (EX1001), currently assigned to Bunker Hill Technologies, LLC ("Patent Owner" or "PO").

2. I am not and have never been an employee of Toyota. I am being compensated at my usual and customary rate of $330 per hour. No part of my compensation depends on the outcome of this proceeding, and I have no other interest in this proceeding.

3. I have been asked to provide my independent analysis of the '508 Patent in light of the prior art publications cited below. I have also been asked to consider the state of the art and prior art available as of December 3, 2012. Based on the prior art discussed in this declaration, it is my opinion that claims 1-17 of the '508 Patent are unpatentable for the reasons provided below.

A. Qualifications

4. I am over 18 years of age and, if I am called upon to do so, I would be competent to testify as to the matters set forth herein. A copy of my current curriculum vitae, which details my education and professional and academic

experience, is attached to this declaration. The following provides an overview of some of my experience that is relevant to the matters set forth in this declaration.

5. I am a Professor of Mechanical Engineering at the University of Alberta and an Adjunct Professor of Mechanical Engineering at Michigan Technological University. At the University of Alberta, I serve as the Director of the Energy Mechatronics Laboratory. The Energy Mechatronics Laboratory (EML) conducts research in a multidisciplinary area of engineering that includes mechanical and electrical systems, design of thermo-fluid systems, and control engineering. A large portion of EML research centers on automotive powertrain systems and vehicles.

6. I am also a professional engineer (PEng) registered in Alberta (license # 284744). Over the past several years, I have led various projects in the area of automotive and mechatronics systems. I currently lead several design, fabrication, and testing projects in the field of mechanical and electrical engineering including, among other things, hybrid electric and electric powertrain systems, and also internal combustion engines running with conventional and alternative fuels.

7. Before joining Michigan Technological University in 2012, I spent two years as a post-doctoral scholar at the Mechanical Engineering Department at the University of California, Berkeley. My post-doctorate work focused on model-based design and adaptive control of automotive systems, including powertrains and others and consisted of working closely with the Toyota Motor Company.

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8. I earned a Ph.D. in Mechanical Engineering from the University of Alberta in 2009 and a Master of Science degree from KNT University of Technology in 2003. Both my Ph.D. and MSc. dissertations were in the area of automotive powertrain systems. A large portion of my research activities in the past 25 years have centered on design, modeling, and control of automotive propulsion systems, including conventional, hybrid electric, and electric vehicles.

9. I have direct industry experience related to the control of automotive propulsion systems. From 2001 to 2004, I worked as a researcher in the automotive industry. During this time, I was involved in the research and development of internal combustion engines and powertrain management systems for gasoline and natural gas bi-fuel vehicles. In the past 14 years, I, along with my research group, have performed a number of research projects sponsored by various companies such as Ford Motor Company, Toyota Motor Corporation, General Motors Corporation, Hyundai, Cummins, Westport, IAV GmbH, Hitachi, and Denso.

10. For example, I, along with my research group at Michigan Tech, built a hybrid electric powertrain test platform including a 100-kW AC electric motor and a 201-kW GM Ecotec engine. The testbed was used for testing various aspects of powertrain performance including real-time torque control during transient and steady state operations. In addition, I, along with my research group at Michigan Tech, tested and evaluated different hybrid electric vehicle platforms for at least eight years. For instance, my research group in partnership with GM, worked on the

Chevy Volt Gen II hybrid electric vehicle for powertrain modeling and control to maximize energy saving via utilization of vehicle connectivity data and automation. This was part of a $2.8M funded project by the US Department of Energy Advanced Research Projects Agency-Energy (ARPA-E) program that took place from 2017 to 2020. A number of peer-reviewed journal and conference publications from my research group documented our research studies covering different hybrid electric vehicle architectures including series, parallel, and powersplit powertrains ranging from mild to full hybrid, plug-in hybrid, and extended range electric vehicles. Another example of my work is a 2014–2017 National Science Foundation (NSF)-funded project, 'Easily Verifiable Controller Design,' focused on automotive powertrain applications. Serving as the Principal Investigator, I led a collaborative effort among Toyota Motor North America R&D (Ann Arbor), UC Berkeley, and Michigan Tech. My research group developed adaptive control frameworks for complex and nonlinear engine control problems and engineered an online uncertainty prediction mechanism to mitigate analog-to-digital conversion (ADC) imprecision in control software.

11. I have also worked on various aspects of internal combustion engines including design, modeling, benchmarking, experimental studies, calibration, and electronic control unit (ECU) design and implementation since 2000. These include dual fuel, bi-fuel, and single-fuel engines. I along with my research group have covered various engine types including spark ignition (*e.g.*, gasoline), compression

ignition (*e.g.*, diesel), lean burn, low temperature combustion (HCCI, PPCI, RCCI) engines, and their exhaust aftertreatment systems.

12. I also have experience with automotive control systems including modeling, design, and implementation. This work encompasses numerous projects in the past 25 years for vehicles including conventional, hybrid electric, electric, and connected and automated vehicles. Many of these projects include the design of prototype systems for collecting required vehicle/powertrain data and implementing and testing designed real-time automotive controllers.

13. I have taught undergraduate and graduate courses in mechanical engineering departments in the U.S. and Canada since 2004, taking the role as a primary instructor for more than 27 academic semesters, and a teaching assistant for eight academic semesters. I have frequently taught graduate and undergraduate courses in the areas of Internal Combustion Engines, and Advanced Propulsion Systems for Electric and Hybrid Electric Vehicles in the past 17 years. For instance, I regularly taught a graduate course (MEEM 5295) on Advanced Vehicle Propulsion Systems for Hybrid Electric Vehicles at Michigan Tech (2016-2019) and have taught technical electric undergraduate course (MECE 442) on Vehicle Propulsion Systems at the University of Alberta. I am teaching MECE 442 in this semester and in this course I discuss design of electric, hybrid electric, and conventional powertrain systems and optimal operating modes for vehicles to meet target fuel consumption and emission standards in the US and Canada. Other relevant courses include a

graduate course on Internal Combustion Engines and Alternative Fuels, graduate courses in the area of Machine Learning Control, Model Predictive Control and undergraduate courses in the area of Applied Thermodynamics.

14. I have led international workshops in the areas of controls and data systems including "Methods of Easily verifiable Control Design," "Connected and Automated Vehicles (CAVs)," and "From Data to Models and Decisions in Engineering Systems" at conferences such as the American Control Conference and ASME (American Society of Mechanical Engineers) Dynamic Systems and Controls conference.

15. I have supervised 148 graduate and undergraduate students for mechanical engineering research projects or dissertations. These include 37 Ph.D., 77 M.S., and 34 B.S. students in the mechanical engineering departments in four academic institutions from 2010 to 2026. Many of these mentorships have centered on automotive engineering, covering modeling, design, experimentation, diagnostics, and control. A large number of the graduates from my research group have joined the automotive industry after graduation. These companies include Ford Motor Company, General Motors, Fiat Chrysler Automobiles, Toyota Motor Company, Karma Automotive, Tesla, Rivian, Cummins, Electra Vehicles, Bosch, APTIV, GKN Driveline, etc.

16. I am currently the Technical Editor for the International Journal of American Society of Mechanical Engineers (ASME)/ Institute of Electrical and

Electronics Engineers (IEEE) Transactions on Mechatronics. In addition, I served six years as the Associate Editor for ASME Journal of Dynamic Systems, Measurement, and Controls (2017–2023), Associate Editor (2014-2020) for the International Journal of Powertrains (Inderscience Publishers) and a guest editor for a special issue on "Optimal Design and Operation of Energy Systems" in the International Journal of Optimal Control Applications and Methods (2020–2022). In these roles, I have regularly evaluated research work in the field of mechanical and electrical engineering systems. In addition, I serve as an Editorial Board Member in the International Journal of Vehicle Autonomous Systems, International Journal of Automobiles and Automobile Technologies, International Journal of Powertrains.

17. I have also served on the United States' National Science Foundation (NSF) and U.S. Department of Energy (DOE) review panels in the areas of mechanical engineering systems, controls, and energy systems. I have been a reviewer for: (i) international grant proposals from funding agencies from the United States, Canada, Croatia, France, Germany, Poland, and the Netherlands, (ii) the U.S. Academy of Engineering research program of the US DRIVE Partnership, (iii) 24 international engineering journals, and (iv) Springer International Publishing for books in the areas of controls and automotive systems.

18. I have been a member of the Society of Automotive Engineers (SAE) (membership #6109271569) for about 20 years. I have organized a number of technical sessions in the area of automotive systems at SAE World Congress in

Detroit during 2016 and 2022. In addition, I have been a member of SAE Technical Committee on New Engines, Components, Actuators and Sensors since 2016.

19. I have been a member of the American Society of Mechanical Engineers (ASME) for the past thirteen years (membership #125958). I am a very active member of ASME's Dynamic Systems & Control Division and have served as the chair of the Energy Systems technical committee (2018–2020), chair of the Automotive Transportation Systems technical committee (2020–2022), and chaired 45 sessions and co-organized more than 70 technical sessions in the areas of modeling, design, optimization, and control of mechanical engineering systems. I am currently part of the ASME executive committee for the Dynamic Systems & Control Division.

20. I have been awarded over $6.1 million in grants/support as a Principal Investigator (PI) and over $9.0 million as a co-PI from international, federal, provincial, and industry sources for conducting research in the areas of design, modeling, optimization, and control of mechanical/electrical engineering systems. Energy Mechatronics Laboratory (EML) under my supervision specializes in the instrumentation, testing, and analysis of emerging vehicle technologies — from light-duty passenger cars to heavy-duty commercial trucks and buses. To date, we have led third-party evaluations of more than $40 million in commercial vehicle technologies, including electric, hybrid electric, fuel cell, and hydrogen-diesel platforms, benchmarking them against conventional diesel and gasoline powertrains.

These projects have been supported by the automotive industry along with the federal and provincial funding agencies committed to advancing alternative vehicle technologies suited to the Canadian climate and ecosystem.

21. I have been recognized by many different awards. Some of the recognitions/awards for my work related to automotive systems include:

- Transport Canada 2023 Technology Achievement Award Finalist, 2023.
- Best Presentation Award, SAE Int. Powertrain, Fuels & Lubricants Conference, Baltimore, MD, USA, 2016.
- Best Presentation in the Session, American Control Conference (ACC), 2012 (Montreal), 2015 (Chicago).
- Society of Automotive Engineers (SAE) International Ralph R. Teetor Educational Award, 2016 (An international award recognizing top engineering educators for outstanding contributions).
- Best Paper Award, ASME Automotive and Transportation Systems Technical Committee – ASME Dynamic Systems Control Conference, Columbus, OH, USA, 2015.
- Best Paper Award, ASME Automotive and Transportation Systems Technical Committee – ASME Dynamic Systems Control Conference, Fort Lauderdale, FL, USA, 2012.
- Canada NSERC (Natural Science and Engineering Research Council) Postdoctoral Fellowship, 2010 – 2012.

- Zita and John Rosen Teaching Excellence Award for Principal Instructor, University of Alberta, 2009. I received this award for teaching Internal Combustion Engine (MECE 541) course. Only one award, across the university, is granted annually to give special recognition to a graduate student principal instructor who is an especially skilled and dedicated teacher.
- David Morris Graduate Scholarship in Automotive Engineering, University of Alberta, 2008.
- Winning Team (first prize) of a Total of 66 Research Teams from 26 Canadian Universities, Canada Automotive21 High Qualified Personnel Competition, Windsor, Canada, June 11-13, 2007.
- Chevron Graduate Scholarship in Natural Gas Engineering, University of Alberta, 2005.
- Best Paper Award in 3rd International Conference on Internal Combustion Engines, Tehran, Iran, 2004.
- Summa Cum Laude (ranked first among graduates) in MSc Mech Eng – Powertrain (2003), K. N. Toosi University of Technology, Tehran, Iran

22. My publications can be found at https://sites.ualberta.ca/~mahdi/Shahbakhti_Publications.html. These include more than 260 peer-reviewed publications in the field of mechanical/electrical engineering. Many of these publications are in the area of automotive systems.

According to Google Scholar, these research publications have been recognized and cited over 7,000 times from more than 90 different countries.

23. I have been retained as an expert in twelve IPR proceedings and two International Trade Commission investigations in the past eight years to provide expert opinions in connection with different areas of mechanical engineering systems and mechatronics/control systems including: vehicles, powertrains, internal combustion engines, heating ventilation air conditioning (HVAC) systems, buildings, and vacuum systems.

24. Based on my experience and education, I believe that I am qualified to opine as to the knowledge and level of skill of a person of ordinary skill in the art ("POSITA") at the time of the alleged invention of the '508 Patent, as well as the state of the art at that time.

B. Materials Considered

25. In forming my opinions, I have reviewed the following documents:

EX1001	U.S. Patent No. 11,374,508 ("the '508 Patent")
EX1002	Prosecution History of the '508 Patent
EX1005	JP2010-036880 ("Tsuzuki")
EX1006	JP2010-221979 ("Imai")
EX1007	U.S. Patent No. 8,618,752 ("Zing")
EX1008	US2006/0098390 ("Ashtiani")
EX1009	JP2001-218380 ("Satoru")
EX1010	US2014/0100726 ("Reynolds")
EX1011	Ehsani, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles

II. LEGAL STANDARDS

26. In forming my opinions and considering the subject matter of the '508 Patent and its claims in view of the prior art, I am relying on certain legal principles that counsel in this case explained to me. My understanding of these concepts is summarized below.

27. I understand that earlier publications and patents may act to render a patent unpatentable for one of two reasons: (1) anticipation and (2) obviousness.

A. Anticipation

28. It is my understanding that the claims of a patent are anticipated by a prior art reference if each and every element of the claim is found either explicitly or inherently in the reference. I understand that inherency requires a showing that the missing descriptive matter in the claim is necessarily present in the allegedly anticipating reference, and that it would have been so recognized by a POSITA.

29. I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

30. Although anticipation typically involves the analysis of a single prior art reference, I understand that additional references may be used to show that the prior art reference has enabling disclosure (*i.e.*, allows a POSITA to make the invention without undue experimentation), to explain the meaning of a term used in the prior art reference, and/or to show that a characteristic is inherent in the prior art reference.

B. Obviousness

31. I understand that a claim is invalid as obvious if it would have been obvious to a POSITA at the time the alleged invention was made. This means that even if all of the elements of the claim cannot be found in a single prior art reference that would anticipate the claim, a POSITA who was aware of the prior art would have been able to come up with the claimed invention. This may be the case, for example, where the missing element represents only an insubstantial difference over the prior art or a reconfiguration of a known system. I understand that in an obviousness determination, the POSITA is presumed to have knowledge of all material prior art.

32. I understand that an obviousness analysis requires an understanding of the scope and content of the prior art, any differences between the alleged invention and the prior art, and the level of ordinary skill in evaluating the pertinent art.

33. I understand that when a product is available, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a POSITA can implement a predictable variation, obviousness likely bars its patentability. For the same reason, if a technique has been used to improve one device and a POSITA would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

34. I understand that whether a prior art reference renders a patent claim unpatentable as obvious is determined from the perspective of a POSITA at the time

of the alleged invention. I have been told that there is not a requirement that the prior art contain an express suggestion to combine known elements to achieve the claimed invention, but a suggestion to combine known elements to achieve the claimed invention may come from the prior art, as filtered through the knowledge of a POSITA. In addition, I have been told that the inferences and creative steps a POSITA would employ are relevant to the determination of obviousness.

35. I understand that a POSITA may consider, for example, whether (1) the change was merely the predictable result of using prior art elements according to their known functions, or whether it was the result of true inventiveness; (2) there is some teaching or suggestion in the prior art to make the modification or combination of elements claimed in the patent; (3) the claimed innovation applies a known technique that had been used to improve a similar device or method in a similar way; (4) the claimed invention would have been obvious to try, meaning that the claimed innovation was one of a relatively small number of possible approaches to the problem with a reasonable expectation of success by those skilled in the art; (5) the invention merely substituted one known element for another known element in order to obtain predictable results; (6) the invention merely applies a known technique to a known device, method, or product to yield predictable results; or (7) known work in one field of endeavor may have prompted variations of it for use in either the same field or a different one based on design incentives or other market forces that would have been predictable to a POSITA.

36. I further understand that certain factors may support or rebut the obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the patented invention, skepticism of those having ordinary skill in the art at the time of the invention, unexpected results of the invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I understand that there must be a nexus—that is, a connection—between any such secondary considerations and the alleged invention. I also understand that contemporaneous and independent invention by others is a secondary consideration tending to show obviousness. In any event, I am not aware of any relevant secondary considerations here.

37. Additionally, I understand that in considering obviousness, it is important not to use the benefit of hindsight derived from the patent under consideration.

C. Level of Ordinary Skill in the Art

38. When interpreting a patent, I understand that it is important to identify the relevant art pertaining to that patent, as well as the level of ordinary skill in that art at the time of the claimed invention. The "art" is the field of technology to which the patent is related.

39. I am informed and understand that a POSITA is a hypothetical person who is presumed to know the relevant prior art. I understand that the actual inventor's skill is not determinative of the level of ordinary skill. I further understand that factors that may be considered in determining level of skill include: (i) the types of problems encountered in the art; (ii) prior art solutions to those problems; (iii) the rapidity with which innovations are made; (iv) the sophistication of the technology; and (v) the educational level of active workers in the field. I understand that not all such factors may be present in every case, and one or more of them may predominate.

40. I understand that a POSITA is one who is presumed to be aware of all pertinent art, thinks along conventional wisdom in the art, and is a person of ordinary creativity.

41. Based on my review of the '508 Patent, and my own knowledge and skill based on my experience with the design and control of vehicle propulsion systems, it is my opinion that a POSITA in December 2012 is someone with at least a bachelor's degree in electrical engineering or mechanical engineering and at least three years of technical experience in designing, implementing, testing, or otherwise working with, automotive powertrains, electric drive systems, or a related field. Additional higher graduate education could substitute for work experience, and additional work experience/training could substitute for formal education.

42. A POSITA in the field of the '508 Patent would have had knowledge of and experience with propulsion systems in hybrid and electric vehicles. This experience would enable the POSITA to understand, for example, electric drive systems and energy transmission between and among energy storage devices and electromechanical components of such vehicles.

43. Based on my education and experience, I meet the criteria for a POSITA.

D. Claim Construction

44. I understand that the United States Patent and Trademark Office ("USPTO") interprets claim terms in an *inter partes* review proceeding under the same claim construction standard that is used in a United States federal court. I also understand that under this standard, the meaning of claim terms is considered from the viewpoint of a POSITA at the time of the alleged invention.

45. I have been informed that claim terms are generally given their ordinary and customary meaning as understood by a POSITA in light of the specification and the prosecution history pertaining to the patent. I understand, however, that claims terms are generally not limited by the embodiments described in the specification.

46. I understand that in addition to the claims, specification, and prosecution history, other evidence may be considered to ascertain the meaning of claim terms, including textbooks, encyclopedias, articles, and dictionaries. I have been informed

that this other evidence is often less significant and less reliable than the claims, specification, and prosecution history.

47. I have thus interpreted each of the terms in the claims as would be understood by a POSITA in light of the specification and the prosecution history of the '508 Patent.

III. SUMMARY OF OPINIONS

48. For the reasons explained in more detail below, it is my opinion that:

- Claims 1, 2, 4, 7, 8, 12, 13, and 15 are anticipated by Tsuzuki;
- Claims 1, 2, 4, 7, 8, 12, 13, and 15 are obvious over Tsuzuki;
- Claims 1, 2, 4, 7, 8, 12, 13, and 15 are obvious over Tsuzuki in view of Reynolds;
- Claims 12, 13, and 15 are obvious over Tsuzuki in view of Imai (or Tsuzuki in view of Reynolds and Imai);
- Claims 3, 9, and 14 are obvious over Tsuzuki in view of Ashtiani (or Tsuzuki in view of Reynolds and Ashtiani)
- Claims 5, 10, and 16 are obvious over Tsuzuki in view of Satoru (or Tsuzuki in view of Reynolds and Satoru)
- Claims 6, 11, and 17 are obvious over Tsuzuki in view of Zing (or Tsuzuki in view of Reynolds and Zing);
- Claims 1 and 12 are anticipated by Imai; and
- Claims 1 and 12 are obvious over Imai in view of Reynolds.

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49. In connection with these opinions, I have considered the scope and content of the prior art, the similarities and differences between the prior art and the patent claims, and the level of ordinary skill in the art. I am currently unaware of any objective evidence of non-obviousness of the ’508 Patent claims. I reserve the right to consider and comment on any such evidence provided to me after I sign this declaration.

IV. BACKGROUND ON THE TECHNOLOGY

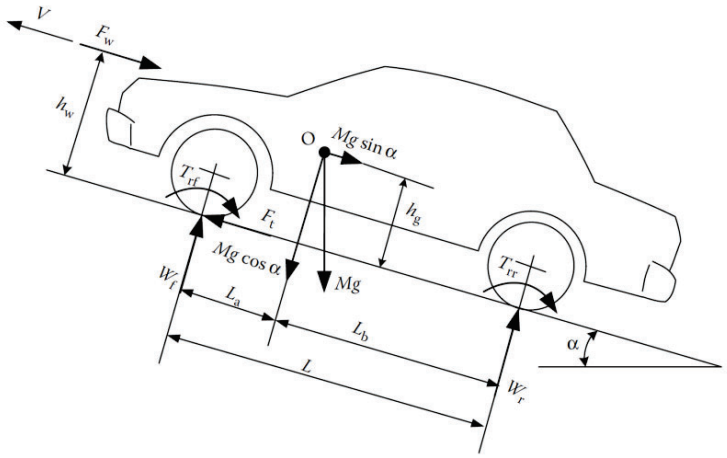
A. Vehicle movement and resistive forces/torques at different driving conditions

50. The dynamics of a vehicle are determined by the balance of forces in its direction of travel.

Propulsion: The powertrain generates torque, translated into tractive effort (F_t) at the tire-road interface to move the vehicle forward.

Resistance: Opposing this motion are three primary forces: rolling resistance (F_{ro}), aerodynamic drag (F_w), and the gravitational pull (F_{mg}) of uphill grades.

As illustrated in the following figure, a vehicle climbing a grade is influenced by both propelling and opposing forces.



EX1011 (Ehsani, Modern Electric, Hybrid Electric, and Fuel Cell Vehicles) at 20.

51. The following equation describes the total resistive forces (FR) on a vehicle where Fro is the rolling resistance force, Fw is the aerodynamic drag force, and Fmg is the climbing resistance or gravitational resistance force.

$$F_R = F_{ro} + F_w + F_{mg}$$

52. Changes of the vehicle speed is governed by the following relation:

$$\frac{dV}{dt} = \frac{\sum F_t - F_R}{\delta M}$$

where, V is the speed of the vehicle, $\sum F_t$ is the total tractive effort (forces) of the vehicle, F_R is the total resistance, M is the total mass of the vehicle, and δ is the mass factor that equivalently converts the rotational inertias of rotating components into translational mass. When the total tractive forces (F_t) are equal to the total resistive forces (F_R), the vehicle speed remains constant. In order for a vehicle to accelerate the tractive forces need to exceed the total resistive forces.

53. Launch Conditions: When a vehicle initiates motion from rest on a flat road, it must overcome resistive forces, primarily rolling resistance and aerodynamic drag. To increase the vehicle speed (e.g., from 0 to 5 mph), the traction force generated by the powertrain must exceed the total resistive forces. If the same vehicle is on an incline, an additional gravitational resistive force must be overcome compared to a flat surface. Furthermore, if the vehicle is towing a boat during launch, the total effective mass (M) increases, requiring even greater traction force to initiate movement.

54. Cruising Conditions: During cruising, the vehicle travels at a constant speed, meaning the traction force produced by the powertrain exactly balances the total resistive forces acting on the vehicle. These resistive forces typically include rolling resistance, aerodynamic drag, and—if the vehicle is on an incline—the gravitational component along the slope. Because there is no net acceleration, the required traction force is significantly lower than during launch or acceleration. In this condition, if road grade and wind velocity do not change, the powertrain operates in a relatively steady state, often at an efficient operating point, and energy consumption is primarily dictated by road load forces and vehicle speed.

55. Uphill Conditions: The steeper the grade (α), the larger the gravitational resistive force component (F_{mg}= Mg sin α). Power demand increases significantly with slope angle, even if speed is constant. For heavy loads (e.g., towing), grade-climbing can become the limiting performance condition. The simple illustration

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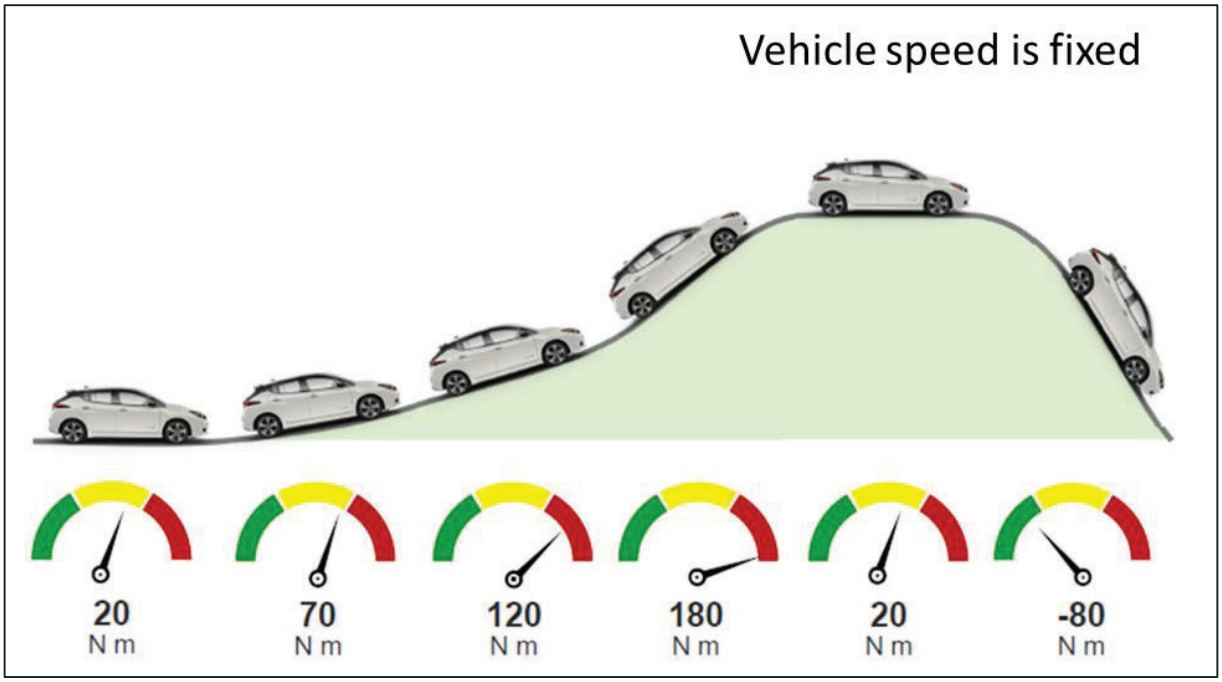
below of a vehicle traveling at constant vehicle speed (for example when operating on cruise control) over different grades shows that the torque in Newton meters (Nm) required to propel the vehicle may vary drastically depending on whether the vehicle is on a flat road, traveling up a hill, or traveling down a hill. When the vehicle is traveling up the hill, the instantaneous torque to propel the vehicle is the greatest while the instantaneous torque to propel the vehicle will actually be negative while traveling down a hill.



In addition, the instantaneous torque required to propel the vehicle is also dependent on whether the driver is requesting that the vehicle accelerate or decelerate.

56. High vs. Low Speed Conditions: The instantaneous force (torque) required to propel the vehicle increases as vehicle speed increases. The gravitational resistive force is independent of vehicle speed (V), but the aerodynamic drag force

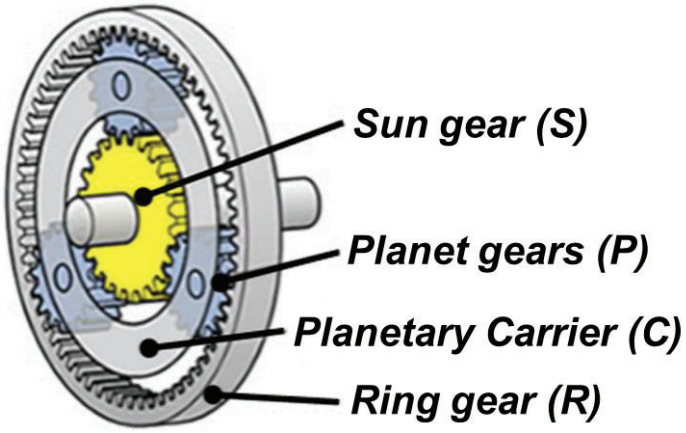
and rolling resistance force are directly a function of vehicle speed, where aerodynamic drag force is a function of V^2 and rolling resistive force is a function of $V^{2.5}$ or V, depending on the required accuracy. EX1011 at 22-24. Thus, the required traction forces increase sharply as the vehicle velocity increases. Consequently, a vehicle at a high speed requires more power (torque) from electric machines to propel the vehicle, compared to that at a low speed.

B. Planetary gears and power transfer

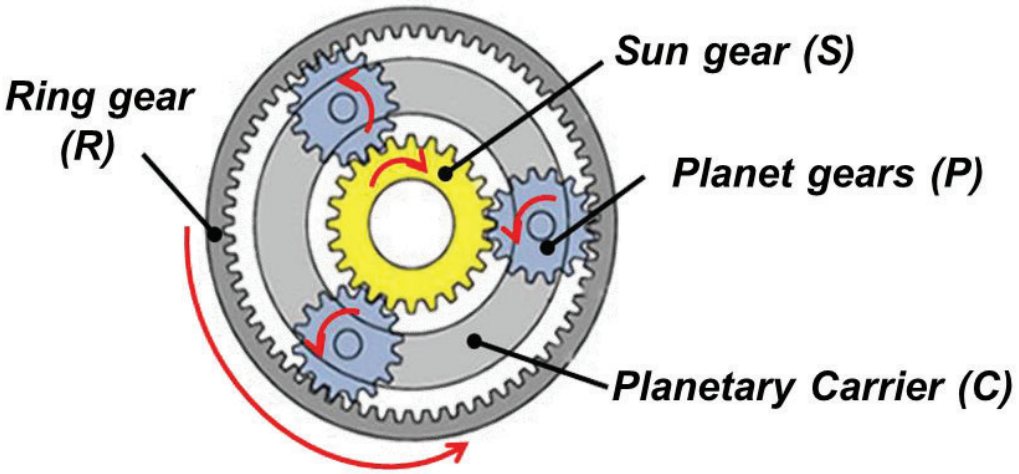
57. Here, the fundamental for the operation of planetary gear sets (epicyclic gearing), specifically focusing on their application in electrified vehicles is explained.

58. A planetary gear set consists of four main components aligned along a concentric axis:

- Sun Gear (S): The center gear. Drives or is driven by the planet gears;
- Planet Gears (P): Multiple small gears, also called pinions, orbiting the sun gear and they are mounted on the carrier and transfer torque between sun and ring gears;
- Planet Carrier (C): Holds the planet gears which mesh with both the sun and the ring gears; and
- Ring Gear (R): Large outer gear with internal teeth.



59. The planetary gear set is an epicycloidal train. The rotational movement of the four components is illustrated in the following image, where all components can rotate:



60. In the planetary gear set, each of the following three components can be fixed: planetary carrier, ring gear, sun gear. Depending on the fixed component, the ratio and direction of movement of other components change. Below, some sample operating scenarios are described:

- Hybrid Mode (Power Split) – There are two inputs in this mode: the Planet Carrier (C), and the Sun Gear (S). For instance, the motor/generator 1 (MG1) can drive the carrier and motor/generator 2 (MG2) can drive the sun gear. The output is taken from the Ring Gear (R), which is connected to the wheels. All three components rotate simultaneously. This is the "two input" scenario:
    - Input 1: Carrier
    - Input 2: Sun
    - Output: Ring connected to wheels
- Reduction Gear (Low Speed, High Torque) – In this mode, the Sun Gear (S) is the input, driving the planet gears. The Ring Gear (R) is held stationary by a brake. The output is taken from the Planet Carrier (C), which rotates in the same direction as the sun gear but at a much slower speed and with multiplied torque.
    - Input: Sun Gear
    - Output: Carrier
    - Fixed (locked): Ring Gear
- Overdrive (High Speed, Low Torque) – This is the inverse of reduction mode. The Planet Carrier (C) is the input, and the Sun Gear (S) is held stationary. The output is taken from the Ring Gear (R), which rotates

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in the same direction as the carrier but at a higher speed and with reduced torque.

  - Input: Carrier
  - Output: Ring Gear
  - Fixed (locked): Sun Gear

- Reverse – To achieve reverse rotation, the Planet Carrier (C) is held stationary. The Sun Gear (S) is the input. The planet gears act as idlers, reversing the direction of rotation for the output Ring Gear (R).
  - Input: Sun Gear
  - Output: Ring Gear
  - Fixed (locked): Carrier
- Lock-up – In this mode, any two members of the gear set are locked together (*e.g.*, the Sun Gear and the Ring Gear are connected by a clutch). This forces the entire assembly to rotate as a single, solid unit at the same speed as the input.
  - Input: Any two members locked together (*e.g.*, Sun and Ring)
  - Output: Carrier (or remaining member)
  - Condition: The entire unit rotates as a solid block.

C. Power conversion devices

61. Electric vehicles (EVs) rely on a high-voltage battery pack to store energy. However, not all components in the car operate at this high voltage. Therefore,

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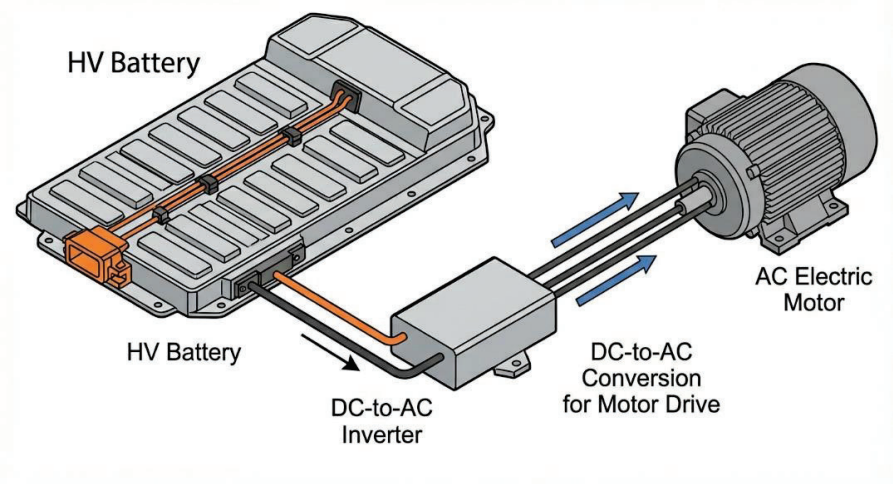
special devices are needed to convert electrical power into the correct form and voltage for different systems. The two primary power conversion devices are the DC-to-AC inverter and the DC-to-DC converter.

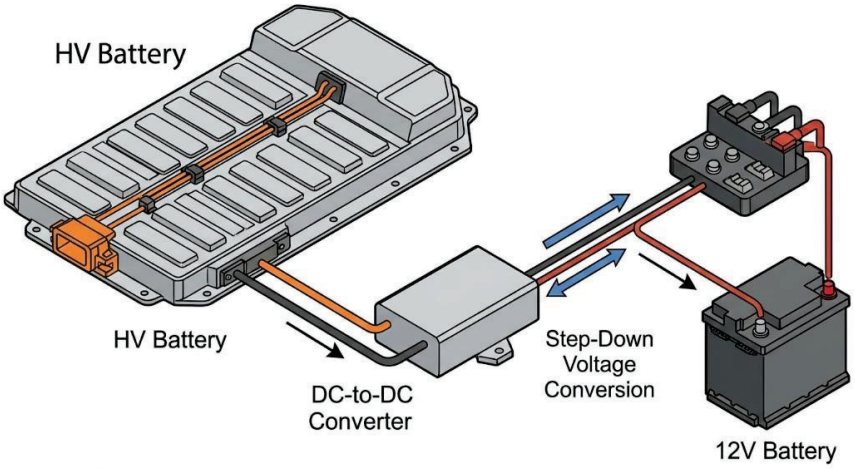
62. DC-to-AC Inverter: The main battery stores energy as direct current (DC), but most electric motors used for vehicle propulsion are alternating current (AC) motors. The inverter's job is to convert the DC power from the battery into the precise AC power required to drive the motor. It also manages the speed and torque of the motor by adjusting the frequency and amplitude of the AC output. The following image shows the DC-to-AC inverter taking high-voltage DC power from the battery and converting it into three-phase AC power to drive the electric motor.



63. DC-to-DC Converter: This converter is an essential component in electric vehicles. There are two types/functions: “Buck” (step-down) DC-to-DC Converter, “Boost” (step-up) DC-to-DC Converter. These two converters are briefly explained in the following.

64. Buck (step-down) DC-to-DC Converter: The primary role of this converter is to step down the high voltage from the main battery pack (e.g., 400V) to a lower voltage (usually 12V) to power the vehicle's low-voltage systems. This includes the headlights, infotainment system, wipers, and other accessories, as well as charging the auxiliary 12V battery.

65. The image below illustrates the function of a buck DC-to-DC converter. High-voltage DC power from the main battery pack (HV Battery) is converted to lower-voltage DC power, which is then used to charge the 12V battery and power vehicle accessories.



66. Boost (step-up) DC-to-DC Converter: While the Buck converter steps voltage *down* for accessories, the Boost converter steps voltage *up* for the main propulsion system. It sits between the High-Voltage Battery and the Motor Inverter. Its primary job is to step up (increase) the voltage from the battery to a higher level needed by the motor for optimal performance. Under heavy acceleration, the battery experiences a massive draw of current, causing its voltage to temporarily drop ("sag"). A Boost converter compensates for this sag,

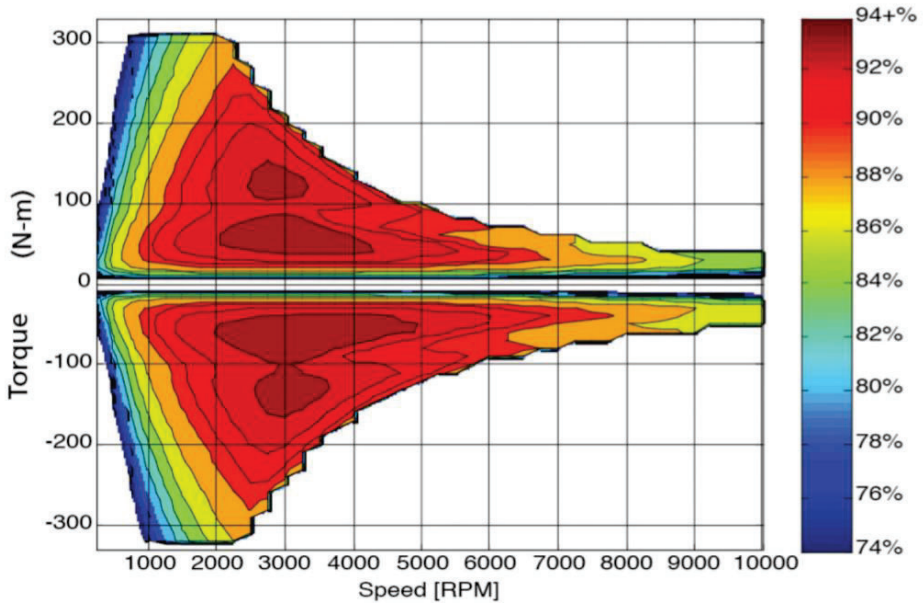
maintaining a stable, high voltage for the inverter so performance doesn't suffer when you need it most. In addition, as an electric motor spins faster, it generates an opposing internal voltage called "Back Electromotive Force" (Back EMF). To keep accelerating, the inverter must push electricity into the motor with a voltage higher than this Back EMF. If the battery's standard voltage isn't high enough, the motor hits a "speed wall." A Boost converter raises the voltage (e.g., from 300V to 500V) to push past this limit, allowing for higher top speeds and stronger acceleration.

67. Regenerative braking: Regenerative braking is an energy recovery mechanism that slows down a moving vehicle or object by converting its kinetic energy into a form that can be either used immediately or stored until needed. In electric vehicles (EVs), the electric motor acts as a generator to recover this energy. The key to regenerative braking is that electric motors are reversible machines.

> **Motor Mode:** When you supply electricity to the machine, it spins and creates torque to drive the wheels. Energy flow: Battery → Inverter → Motor → Wheels (Kinetic Energy increases)
>
> **Generator Mode:** When the wheels spin the machine (due to the vehicle's momentum), it acts as a generator, creating resistance (drag) and producing electricity. Energy flow: Wheels (Kinetic Energy) → Motor (now Generator) → Inverter (Rectifier) → Battery (Chemical Energy increases)

68. Electric machines exhibit distinct efficiency maps for motoring (traction) and generating (regenerative) modes. An example of such an efficiency map is illustrated in the

figure below, where negative torque values denote the regenerative braking region. As shown, machine efficiency is a dynamic variable that depends heavily on both rotational speed and torque. By selecting the optimal operating mode and utilizing the appropriate transmission gear, the electric motor can be maintained within its peak efficiency zone across various driving conditions.



69. If the battery is 100% charged, it cannot accept more energy, so regenerative braking is disabled or limited. As the car comes to a stop, the motor generates less and less voltage. Below a certain speed (e.g., 5 mph), regeneration isn't effective, and friction brakes take over to hold the car still.

D. Energy Storages / Batteries for Electric and Hybrid Electric Vehicles

70. The materials in this section are based on Chapter 12 of EX1011 (Ehsani, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles").

71. "Energy storages" are defined as devices that store energy, deliver energy outside (discharge), and accept energy from outside (charge). There are several types of energy storages that have been proposed for EV and HEV applications. These energy storages, so far, mainly include chemical batteries, ultracapacitors or supercapacitors, and ultra-high-speed flywheels.

72. Battery and ultracapacitor characteristics are shown in Tables 12.2 and 12.3 for sample automotive batteries:

TABLE 12.2
Status of Battery System for Automotive Application

System	Specific Energy (Wh/kg)	Peak Power (V/kg)	Energy Efficiency (%)	Cycle Life	Self-Discharge (% per 48 h)	Cost (US$/kWh)
Acidic Aqueous Solution						
Lead/acid	35–50	150–400	>80	500–1000	0.6	120–150
Alkaline Aqueous Solution						
Nickel/cadmium	50–60	80–150	75	800	1	250–350
Nickel/iron	50–60	80–150	75	1500–2000	3	200–400
Nickel/zinc	55–75	170–260	65	300	1.6	100–300
Ni–MH	70–95	200–300	70	750–1200+	6	200–350
Aluminum/air	200–300	160	<50	?	?	?
Iron/air	80–120	90	60	500+	?	50
Zinc/air	100–220	30–80	60	600+	?	90–120
Flow						
Zinc/bromine	70–85	90–110	65–70	500–2000	?	200–250
Vanadium redox	20–30	110	75–85	–	–	400–450
Molten Salt						
Sodium/sulfur	150–240	230	80	800+	0[a]	250–450
Sodium/nickel chloride	90–120	130–160	80	1200+	0[a]	230–345
Lithium/iron sulfide (FeS)	100–130	150–250	80	1000+	?	110
Organic/Lithium						
Li–I	80–130	200–300	>95	1000+	0.7	200

[a] No self-discharge, but some energy loss by cooling.

TABLE 12.3

Technical Specifications of Maxwell Technologies Ultracapacitor Cell and Integrated Modules[7]

	BCA P0010 (Cell)	BMOD0115 (Module)	BMOD0117 (Module)
Capacitance (farads, −20%/+20%)	2600	145	435
Maximum series resistance ESR at 25°C (mΩ)	0.7	10	4
Voltage (V): continuous (peak)	2.5 (2.8)	42 (50)	14 (17)
Specific power at rated voltage (W/kg)	4300	2900	1900
Specific energy at rated voltage (Wh/kg)	4.3	2.22	1.82
Maximum current (A)	600	600	600
Dimensions (mm) (reference only)	60 × 172 (cylinder)	195 × 165 × 415 (box)	195 × 265 × 145 (box)
Weight (kg)	0.525	16	6.5
Volume (L)	0.42	22	7.5
Operating temperature[a] (°C)	−35 to +65	−35 to +65	−35 to +65
Storage temperature (°C)	−35 to +65	−35 to +65	−35 to +65
Leakage current (mA) 12 h, 25°C	5	10	10

[a] Steady-state case temperature.

73. Ultracapacitors: Because of the frequent stop-and-go operation of EVs and HEVs, the discharging and charging profile of the energy storage is highly varied. The average power required from the energy storage is much lower than the peak power for acceleration and hill climbing in a relatively short duration. The ratio of peak power to average power can reach over 10:1.

74. Based on present battery technology, battery design has to carry out the trade-off among specific energy, specific power, and cycle life. The difficulty in simultaneously obtaining high values of specific energy, specific power, and cycle life has led to some suggestions that the energy storage system of EV and HEV should be a hybridization of an energy source and a power source. The energy source, mainly batteries and fuel cells, has

high specific energy, whereas the power source has high specific power. Power sources can be recharged from the energy source during less demanding driving or regenerative braking. The power source that has received wide attention is the ultracapacitor.

75. Nevertheless, there are a number of advantages that can result from using the ultracapacitor as an auxiliary power source. One promising application is the so-called battery and ultracapacitor hybrid energy storage system for EVs and HEVs. Specific energy and specific power requirements can be decoupled, thus affording an opportunity to design a battery that is optimized for specific energy and cycle life with little attention being paid to specific power. Due to the load leveling effect of the ultracapacitor, the high current discharging from the battery and the high current charging to the battery by regenerative braking are minimized so that available energy, endurance, and life of the battery can be significantly increased.

76. Hybridization of Energy Storages: The hybridization of energy storage involves to combining two or more energy storages together so that the advantages of each can be brought out and the disadvantages can be compensated by others. For instance, the hybridization of a chemical battery with an ultracapacitor can overcome problems such as the low specific power of chemical batteries and low specific energy of ultracapacitors, thus achieving high specific energy and high specific power. Basically, the hybridized energy storage consists of two basic energy storages, one with high specific energy and the other with high specific power.

77. The basic operation of this system is illustrated in Figure 12.18. In high-power demand operation, such as acceleration and hill climbing, both basic energy storages deliver their power to the load as shown in Figure 12.18a. On the other hand, in low-power demand operation, such as constant-speed cruising operation, the high specific energy storage will deliver its power to the load and charge the high specific power storage to recover its charge lost during high-power demand operation, as shown in Figure 12.18b. In regenerative braking operation, the peak power will be absorbed by the high specific power storage, and only a limited part is absorbed by the high specific energy storage. In this way, the whole system would be much smaller in weight and size than if any one of them alone was the energy storage.

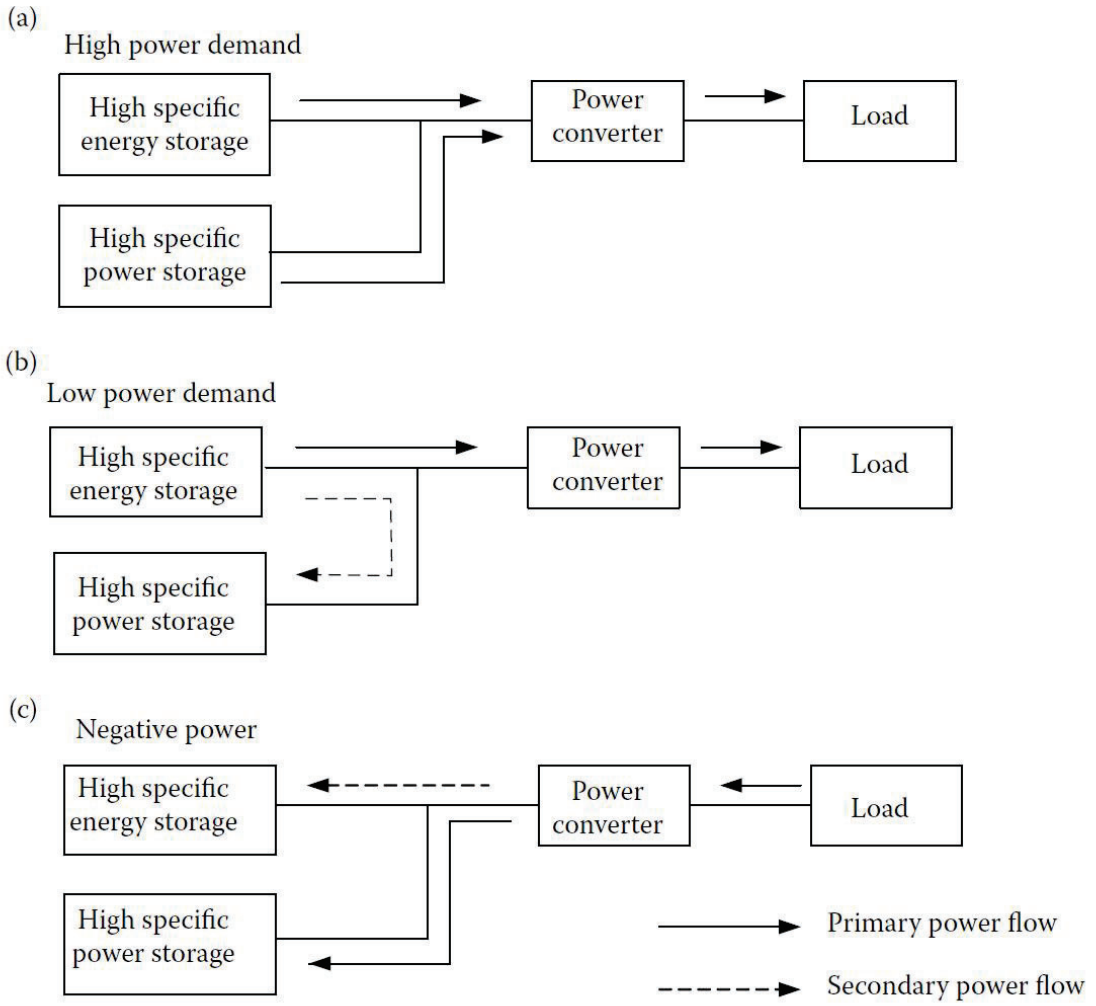


FIGURE 12.18 Concept of a hybrid energy storage operation. (a) Hybrid powering, (b) power split, and (c) hybrid charging.

78. Hybrid Energy Storage with Battery and Ultracapacitor: Based on the available technologies of various energy storages, there are several viable hybridization schemes for EVs and HEVs—typically, battery and battery hybrids, and battery and ultracapacitor hybrids. The latter is more natural because the ultracapacitor can offer a much higher power than batteries, and it collaborates with various batteries to form the battery and ultracapacitor hybrids. During the hybridization, the simplest way is to directly and parallelly connect the ultracapacitors to the batteries as shown in Figure 12.19.

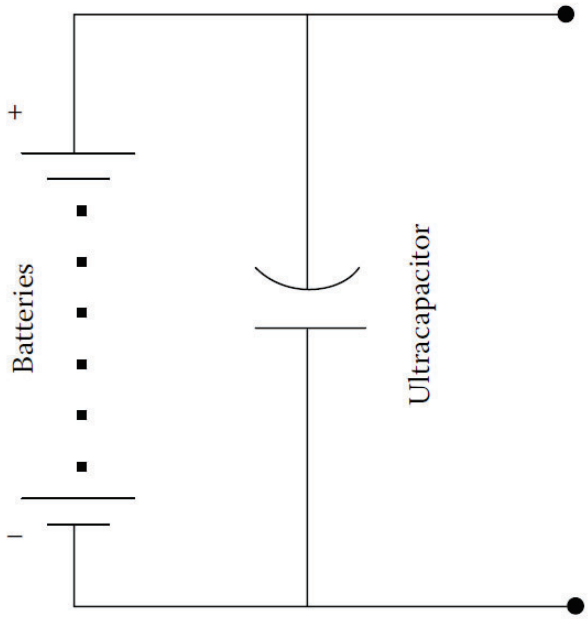


FIGURE 12.19 Direct and parallel connection of batteries and ultracapacitors.

79. In this configuration, the ultracapacitors simply act as a current filter, which can significantly level the peak current of the batteries and reduce the battery voltage drop as shown in Figures 12.20 and 12.21.

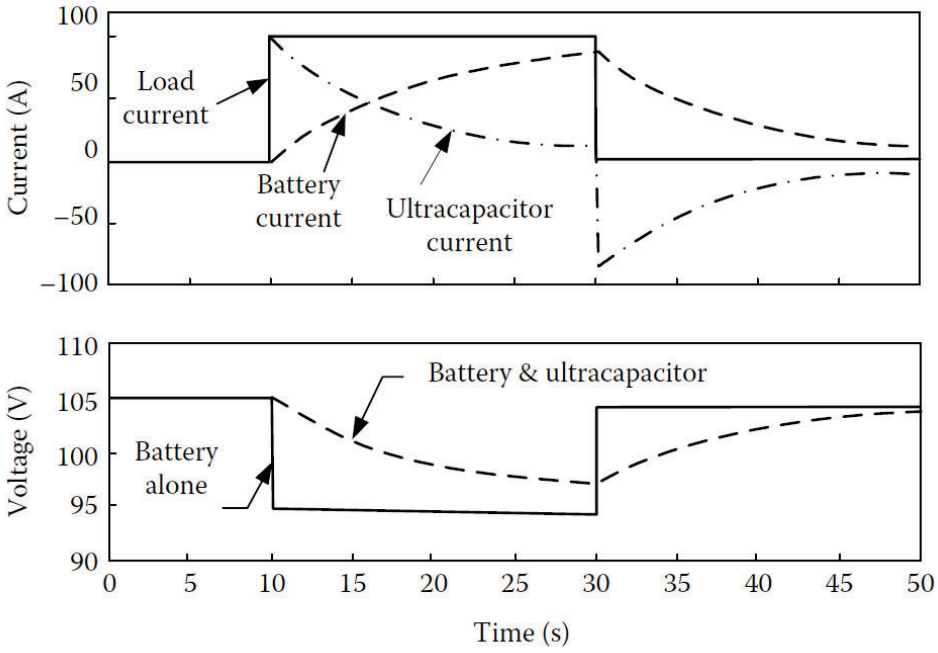


FIGURE 12.20 Variation of battery and ultracapacitor currents and voltages with a step current output change.

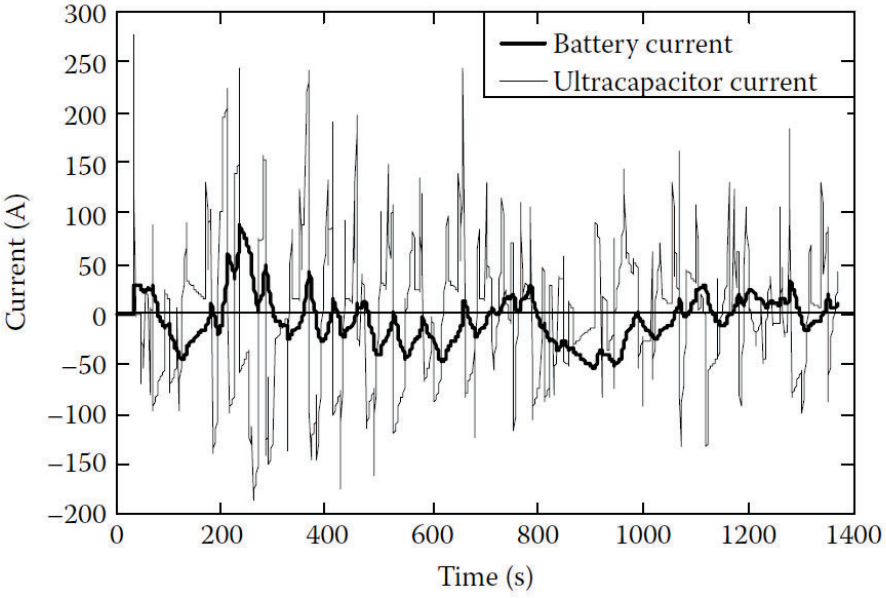


FIGURE 12.21 Battery and ultracapacitor currents during operation of HEV in an FTP75 urban drive cycle.

V. THE '508 PATENT

A. Overview of the '508 Patent

80. The '508 Patent generally describes an electric drive system with an energy storage system (ESS), a power conversion system, and an alternating current (AC) traction system. EX1001, abstract. The '508 Patent's overall system also includes an energy management system (EMS) that manages the flow of energy among the overall system's components. *Id.*

81. The AC traction system includes a first electric motor and a second electric motor, both of which are coupled to the power conversion system and ultimately to the ESS. EX1001, *id.*, claim 1. The ESS may include a plurality of energy storage units, such as a battery and an ultra-capacitor. EX1001, abstract. The '508 Patent's Fig. 1 is annotated below in color to highlight the key components:

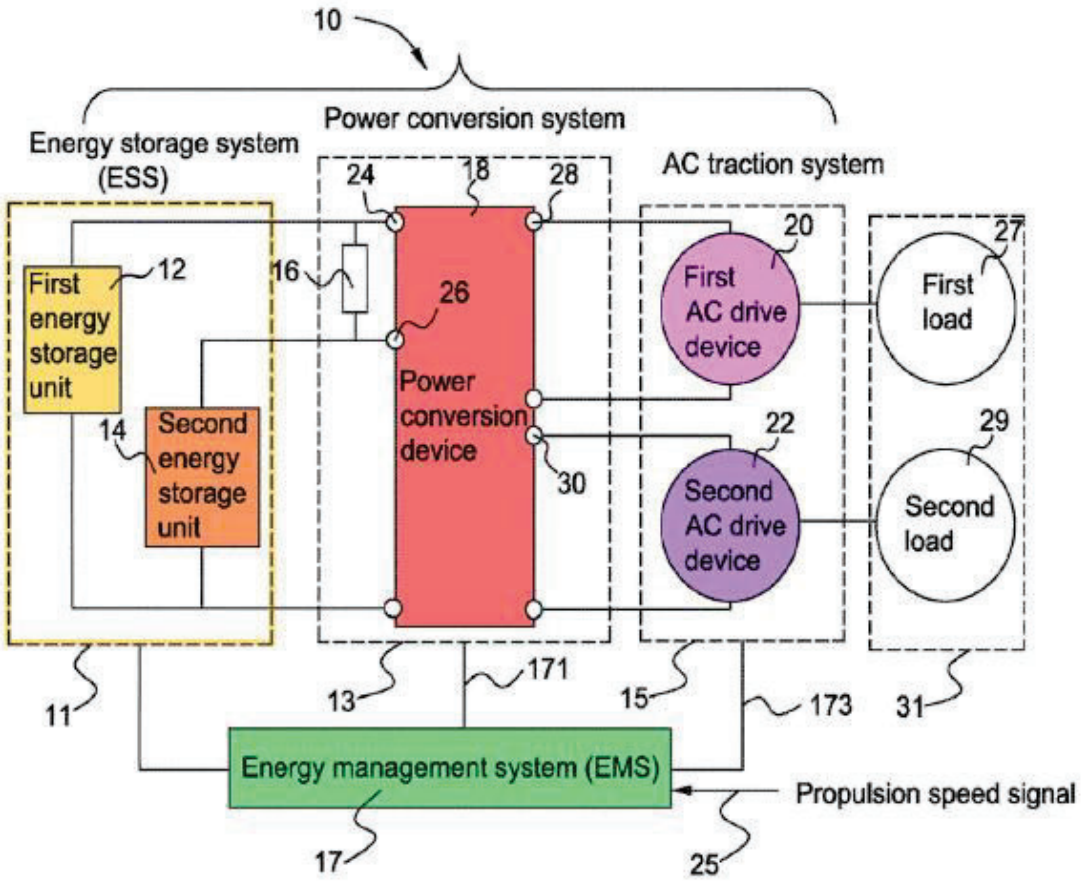


FIG. 1

82. The '508 Patent also discloses designs where, instead of two separate loads as shown in Fig. 1, there is only a single load that is driven through a power split device connected to both motors (potentially via an additional transmission device). This is shown in Fig. 2, annotated in color below:

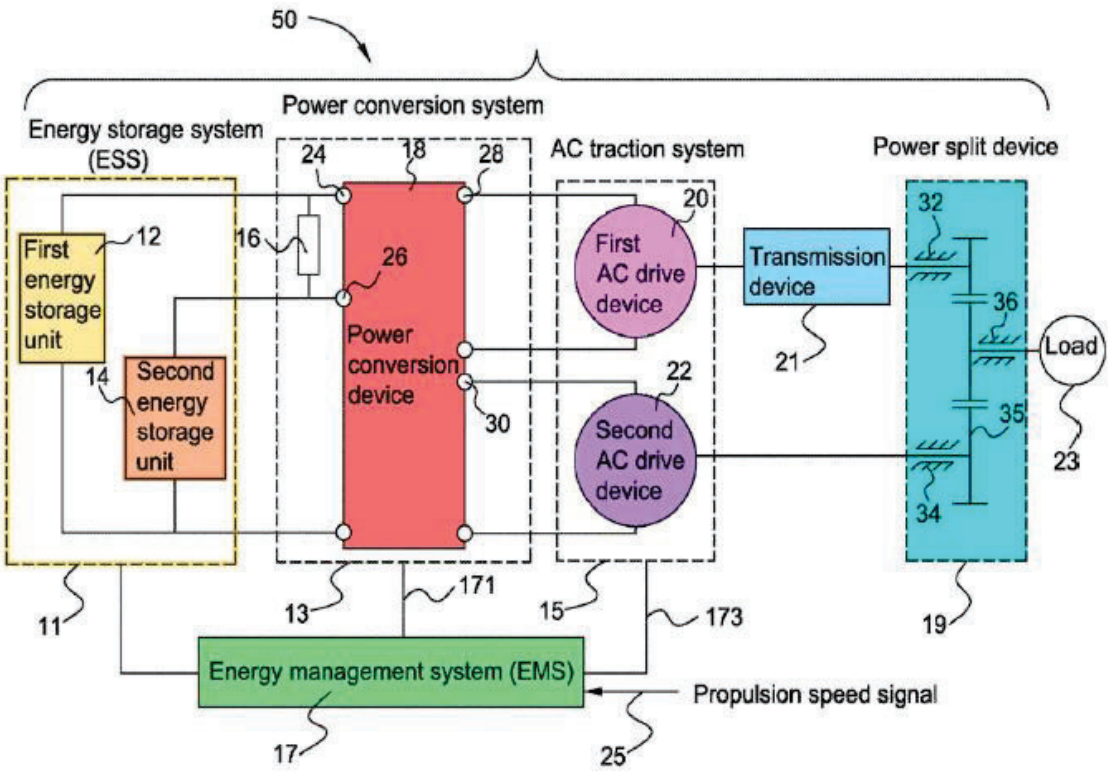


FIG. 2

83. The system's EMS enables and manages multiple modes of operation. EX1001, 8:54-63, 11:7-41. In some modes, only the first electric motor operates to drive the vehicle. *Id.* In other modes, both the first and second electric motors operate to drive the vehicle. *Id.* For example, when the vehicle is starting from a stop or cruising, only one of the motors may be active. *Id.* at 11:16-24, 31-36. On the other hand, when the vehicle is accelerating or going uphill, both motors may be active. *Id.* at 11:25-30.

B. Prosecution History of the '508 Patent

84. The '508 Patent issued on June 28, 2022, from U.S. Patent Application No. 16/866,028, filed May 4, 2020. EX1001, cover. The patent ultimately claims priority to application No. 14/094,086, filed on December 2, 2013. *Id*. It further claims foreign priority to Chinese Application No. 2012-10509493.2, filed on December 3, 2012. *Id.*

85. I understand the none of the references relied on in this Declaration were before the USPTO during prosecution of the '508 Patent.

86. I understand that on December 24, 2021, the pending claims were rejected for obviousness-type double patenting. EX1002 at 218-222. Pending claims 1-4, 7-9, and 12-15 were also rejected as obvious over Iida (US 2009/0115375) in view of Shimizu (US 2005/0070401). *Id.* at 222-223. Pending claims 5, 10, and 16 were rejected as obvious over Iida in view of Shimizu and King (US 7,595,597). *Id.* at 224. Pending claims 6, 11, and 17 were rejected as obvious over Iida in view of Shimizu and Aizawa (US 2005/0082992). *Id.*

87. On February 4, 2022, the applicant amended the claims to require that "only" the first electric motor operate to drive the vehicle when the vehicle is cruising. *Id.* at 278-282. The applicant argued that none of the cited prior art references disclosed something that satisfied the claims as amended. *Id.* at 283-286.

88. On February 18, 2022, the Examiner issued a final rejection maintaining the existing obviousness rejections. *Id.* at 301-303. In response to

applicant's arguments, the Examiner noted that Shimizu teaches that only a single motor is driven when the vehicle is cruising. *Id.* at 303-304.

89. On April 8, 2022, the applicant filed a Request for Continued Examination (RCE) and further amended the claims to include a new limitation requiring that only the first electric motor operate to drive the vehicle "when the vehicle is starting." *Id.* at 328-333. The applicant distinguished Shimizu by pointing out that Shimizu requires that both a first motor and a second motor (not the first motor only) drive the vehicle when the vehicle is starting. *Id.* at 337-339.

90. I understand that the USPTO issued a Notice of Allowance for the '508 Patent on May 13, 2022. *Id.* at 409. The '508 Patent issued on June 28, 2022.

91. As such, I understand that this Declaration presents new prior art and substantially new arguments that were not previously considered during prosecution at the USPTO.

VI. OVERVIEW OF PRIOR ART CONSIDERED

92. The prior art references I reviewed confirm that each limitation of the '508 Patent claims was known before the patent's priority date of December 3, 2012.

A. Tsuzuki

93. Tsuzuki was published on February 18, 2010. EX1005, cover page. Therefore, Tsuzuki was published more than one year before the priority date of the '508 Patent.

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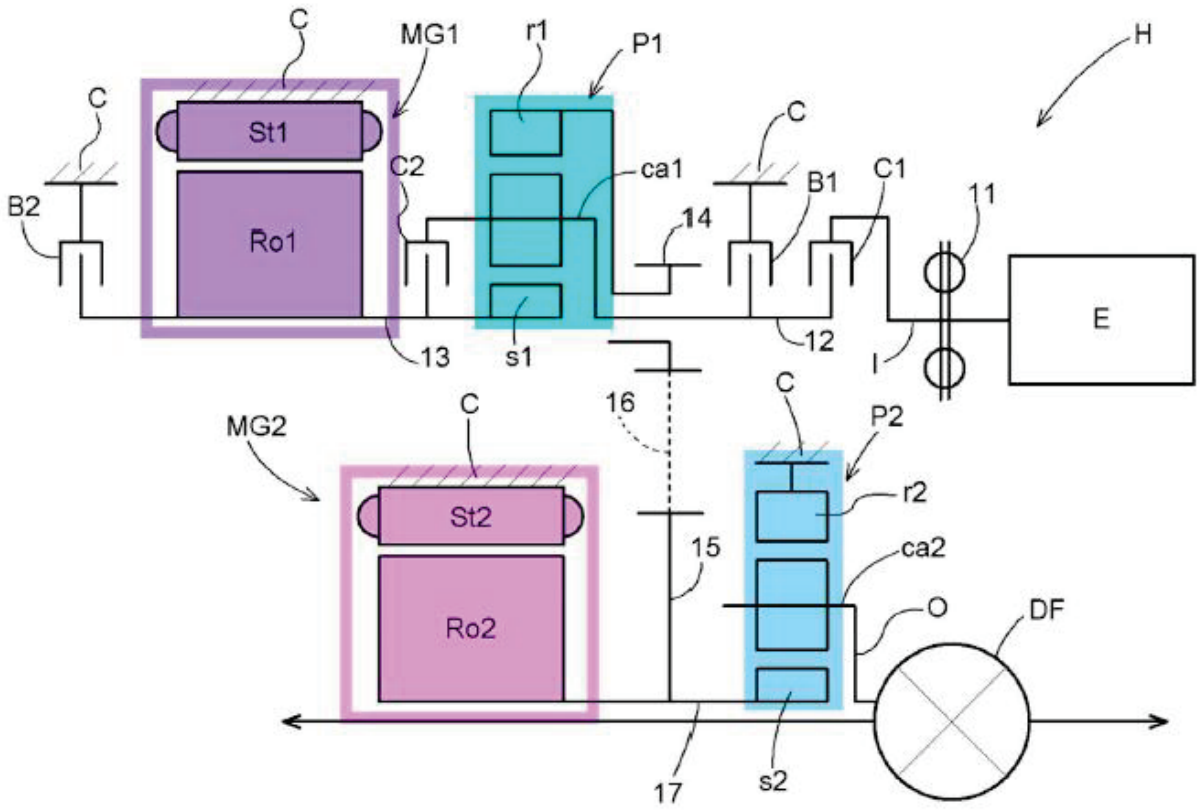
94. Tsuzuki generally discloses a hybrid driving apparatus. EX1005, title. The system includes an engine and two electric motor/generators that provide driving force to a vehicle. *Id.*, abstract. A battery or other power storage system supplies power to the electric motors by way of inverters. *Id.*, [0050]. One electric motor (MG2) provides power to the vehicle's wheels by way of a planetary gear unit that functions as a reduction gear. *Id.*, [0056]. The other electric motor (MG1) is connected to a separate planetary gear unit that is also connected to the engine. *Id.*, [0053]. This separate planetary gear unit functions as a power split device, and is further connected to the first electric motor (MG2) by way of a transmission chain. *Id.*, [0057]. This overall structure is shown in Tsuzuki's Fig. 1, annotated below:

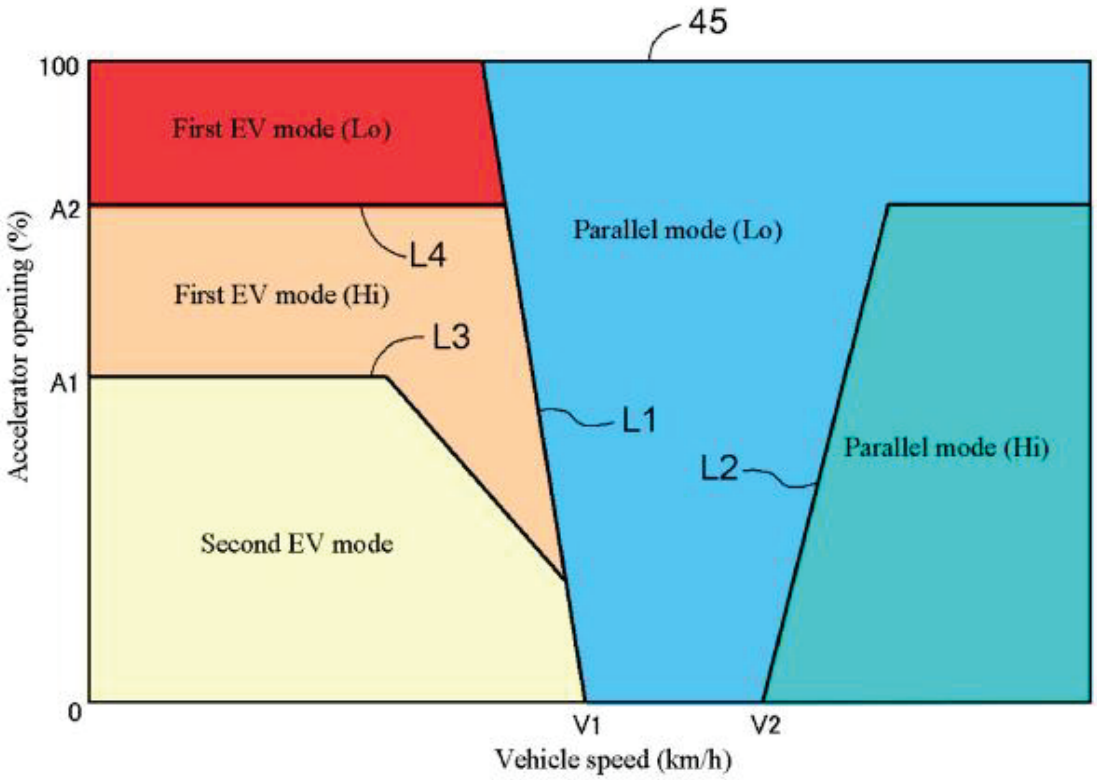
[FIG. 1]



95. Tsuzuki further discloses that its hybrid drive system can operate under different modes. *Id.*, [0063]. Some of these modes involve using only one of the electric motors to drive the vehicle, while other modes involve using both electric motors to drive the vehicle. *Id.* For example, Tsuzuki discloses a "second EV mode" where only MG2 drives the vehicle. *Id.*, [0089]. Tsuzuki also discloses a "first EV mode" where both MG2 and MG1 together may drive the vehicle. *Id.*, [0080]. Tsuzuki discloses that when starting the vehicle or traveling at a moderate speed with a relatively low accelerator opening, the vehicle operates in the second EV mode, such that only MG2 drives the vehicle. *Id.*, [0063], Fig. 3. However, when

the accelerator is depressed further (relatively higher accelerator opening), the vehicle enters the first EV mode, which may require that both MG1 and MG2 drive the vehicle. *Id.* This is shown conceptually in Tsuzuki's Fig. 3, annotated below:

[FIG. 3]



B. Imai

96. Imai was published on October 7, 2010. EX1006, cover page. Therefore, Imai was published more than one year before the priority date of the '508 Patent.

97. Imai discloses a control device for a vehicle driving device. Imai, abstract. Imai's vehicle driving device includes an engine and an electric differential unit having a first electric motor, a second electric motor, and a differential

mechanism, ensuring driving torque and reducing energy loss. *Id.* Imai discloses that when a high driving torque needs to be maintained when an EV switch is turned on or when there is an input restriction on the system's power storage device (*e.g.*, battery), both electric motors are used in combination to power the vehicle. *Id.* Conversely, when the second electric motor can alone provide sufficient drive torque, only the second electric motor is used to power the vehicle (without any assistance from the first electric motor). *Id.*

C. Zing

98. Zing issued based on an application filed on July 20, 2011. EX1007, cover page. Therefore, Zing was filed before the priority date of the '508 Patent.

99. Zing discloses a system, architecture, and method for minimizing power consumption and increasing performance in electric vehicles. EX1007, abstract. In particular, Zing discloses an electric vehicle with two electric motor/generators, where one of the electric motor/generators operates as a motor and the other electric motor/generator operates as a generator at the same time. *Id.* at 13:62-14:19. In this regard, Zing teaches a "power and regenerate feature" where "one motor provides power at a high power output level, such as at 100% output, where it is more efficient than at a lower level" and "[t]he second motor can be operating in a regenerating mode such that it works as a generator, which presents as a load to the first motor." *Id.*

D. Ashtiani

100. Ashtiani was published on May 11, 2006. EX1008, cover page. Therefore, Ashtiani was published more than one year before the priority date of the '508 Patent.

101. Ashtiani discloses an energy storage system with an ultracapacitor and a switched battery. EX1008, abstract. In particular, Ashtiani's energy storage system includes an ultracapacitor that is electrically coupled in parallel with a battery through a diode connected in series with the battery. *Id.* The ultracapacitor delivers the energy required for all high current surges that occur during engine start, acceleration, and regeneration. *Id.* The battery is used only to assist with longer duration, high energy loads, such as accessory loads when an engine of the vehicle is not running. *Id.* In other words, the battery conducts only during longer and less-frequent pulses and, therefore, does not have to withstand high-power pulses. *Id.*

E. Satoru

102. Satoru was published on August 10, 2001. EX1009, cover page. Therefore, Satoru was published more than one year before the priority date of the '508 Patent.

103. Satoru discloses an electric storage device that can be used with a battery mounted on an electric vehicle. EX1009, [0001]. In particular, Satoru describes a battery storage group 11 and a capacitor group 12 with a "pre-charging circuit 40 which constitutes a closed circuit with the storage battery bank 11 and the

capacitor bank 12 and has pre-charging switches 51, 52, 53 for electrically connecting or disconnecting the storage battery bank 11 and the capacitor bank 12…." *Id.*, [0004]. Satoru teaches that "when the power supply is turned on, the control circuit 14 closes the pre-charging switches 51, 52, 53 while maintaining a non-connected mode. As a result, the storage battery bank 11 and the capacitor bank 12 are electrically connected, and the pre-charging circuit 40 thereby becomes a closed circuit, so that the charge is filled approximately equally to each capacitor 12a to 12e, and the potential difference between each storage battery 11a to 11e and each capacitor 12a to 12e becomes extremely small." *Id.*, [0005].

F. Reynolds

104. Reynolds was filed on October 5, 2012. EX1010, cover page. Therefore, Reynolds was filed before the priority date of the '508 Patent.

105. Reynolds discloses a system for controlling an electric machine in an electric vehicle and includes a generator and a motor that are each electrically powered through separate inverters. Electrical power is stored in a battery and sent through a DC/DC converter to modify the vehicle voltage level according to the devices being powered. EX1010, ¶ [0013]; *see also* Fig. 1.

VII. Ground 1: Claims 1, 2, 4, 7, 8, 12, 13, and 15 Are Anticipated by Tsuzuki

106. It is my opinion that claims 1, 2, 4, 7, 8, 12, 13, and 15 are anticipated by Tsuzuki.

B. Independent Claim 1

Limitation [1.0]: A drive system for a vehicle, comprising:

107. Tsuzuki discloses a drive system for a vehicle. For example, Tsuzuki discloses that "[t]he present invention relates to a hybrid drive device comprising of an input member connected to an engine, an output member connected to wheels, a first rotating electrical machine, a second rotating electrical machine, and a differential gear device having three rotating elements…." EX1005, [0001]. Further, "[a]ccording to this characteristic configuration, by switching between the continuously variable transmission mode and the first rotating electrical machine drive mode, as well as the two gears provided in the first rotating electrical machine drive mode, depending on the vehicle's driving condition and vehicle speed range, it is possible to drive the vehicle with high energy efficiency while outputting sufficient driving force in a variety of vehicle driving conditions and vehicle speed ranges." *Id.*, [0009].

108. Therefore, limitation [1.0] is disclosed by Tsuzuki.

Limitation [1.1]: an energy storage system (ESS);

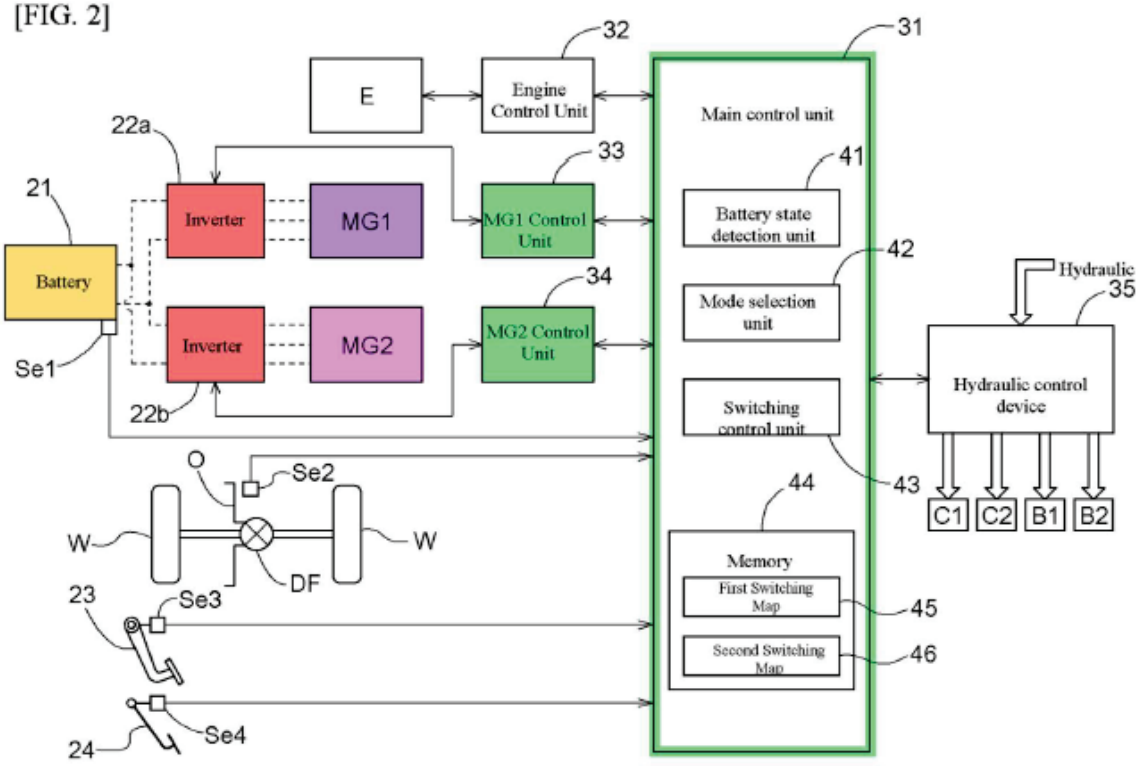
109. Tsuzuki discloses an energy storage system (ESS). For example, Tsuzuki discloses a "battery 21 that supplies power to the first motor generator MG1 and the second motor generator MG2." *Id.*, [0051]. A POSITA would have understood that a battery is an "energy storage system."

110. Therefore, limitation [1.1] is disclosed by Tsuzuki.

Limitation [1.2]: a power conversion device coupled to the ESS;

111. Tsuzuki discloses a power conversion device coupled to the ESS. For example, Tsuzuki discloses that MG1 and MG2 are connected to the battery 21 "via inverters 22a and 22b, respectively." *Id.*, [0050]. This is shown in Fig. 2, annotated below:

[FIG. 2]



112. A POSITA would have understood that an inverter or group of inverters is a "power conversion device." In Tsuzuki, inverter 22a and inverter 22b collectively form a "power conversion device." In this regard, a POSITA would have understood that Tsuzuki's power conversion device converts the DC power supplied by battery 21 into AC power that MG1 and MG2 can use. Indeed, the fact

that the claimed power conversion device is coupled to both the ESS (which supplies DC power) and the first and second electric motors (which need AC power) indicates that the power conversion device can be (and here, is) made up of inverters.

113. Therefore, limitation [1.2] is disclosed by Tsuzuki.

Limitation [1.3]: a first electric motor coupled to the power conversion device;

114. Tsuzuki discloses a first electric motor coupled to the power conversion device. For example, Tsuzuki discloses "motor-generator MG2" that can function as a motor. *Id.*, [0052]. MG2 is coupled to the power conversion device (group of inverters 22a and 22b collectively), as shown in Fig. 2. *Id.*, [0050].

115. Therefore, limitation [1.3] is disclosed by Tsuzuki.

Limitation [1.4]: a second electric motor coupled to the power conversion device;

116. Tsuzuki discloses a second electric motor coupled to the power conversion device. For example, Tsuzuki discloses "motor-generator MG1" that can function as a motor. *Id.*, [0052]. MG1 is coupled to the power conversion device (group of inverters 22a and 22b collectively), as shown in Fig. 2. *Id.*, [0050].

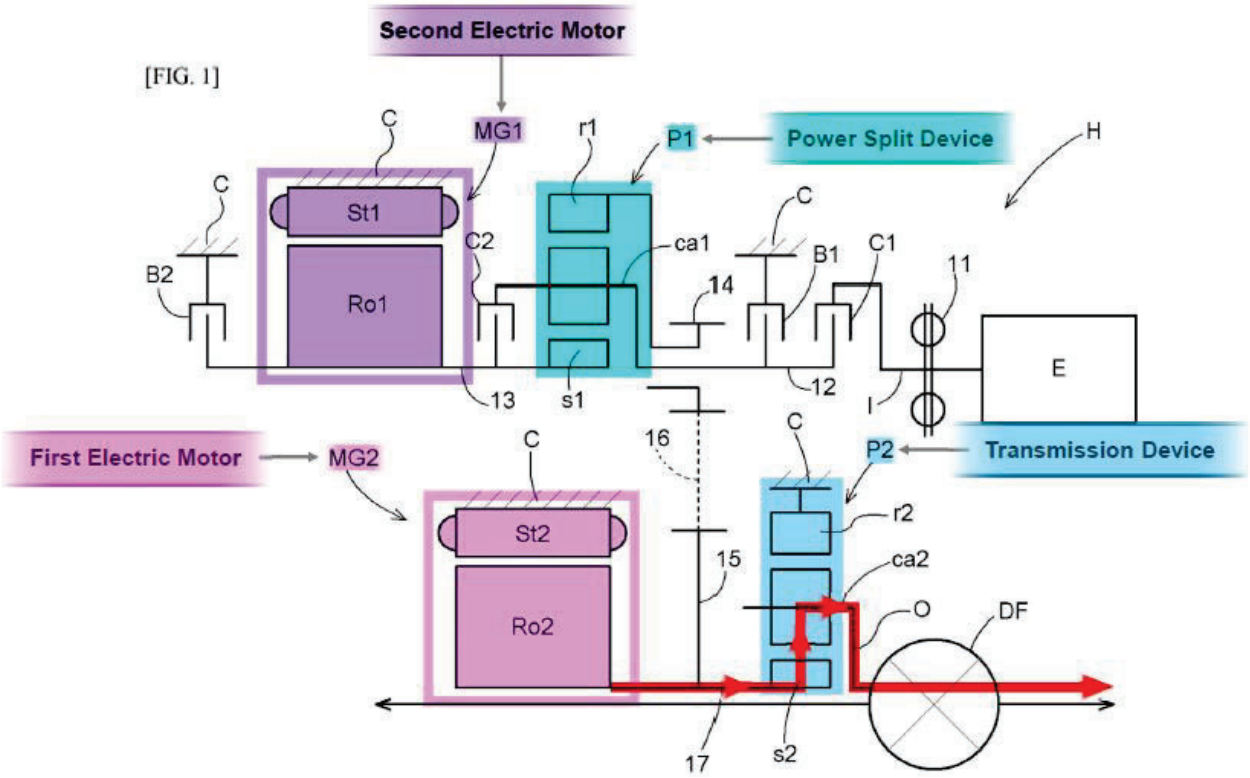
117. Therefore, limitation [1.4] is disclosed by Tsuzuki.

Limitation [1.5]: a transmission device coupled to the first electric motor;

118. Tsuzuki discloses a transmission device coupled to the first electric motor. For example, Tsuzuki discloses:

> The **second planetary gear device P2** is a single-pinion planetary gear mechanism that is arranged coaxially with the output member O. That is, the second planetary gear device P2 has, as rotating elements, a carrier ca2 that supports a plurality of pinion gears, and a sun gear s2 and a ring gear r2 that mesh with the pinion gears, respectively. The sun gear s2 is connected to rotate integrally with a second rotor shaft 17, which is the rotation shaft of the rotor Ro2 of the second motor-generator MG2. The carrier ca2 is connected to the output member O and the differential case of the output differential gear device DF so as to rotate integrally with them. The ring gear r2 is fixed to the case C. As a result, **the second planetary gear device P2 functions as a reduction device that reduces the rotation speed of the second rotor shaft 17 at a constant reduction ratio, outputs it from the carrier ca2, and transmits it to the output member O and the differential case of the output differential gear device DF**.

Id., [0056] (emphasis added). A POSITA would have understood that the second planetary gear device P2 is a "transmission device" because it transmits power between MG2 and the output differential gear device DF. MG2 is ON and provides power to the wheels via the transmission device in multiple modes of operation, such as split mode, first EV mode and second EV mode. For instance, during the second EV mode, power from MG2 is transferred to the transmission device since rotor shaft 17 is mechanically coupled to the sun gear of P2 planetary gear set (i.e., transmission device). The planetary carrier ca2 of the transmission device is mechanically coupled to the output shaft O and differential DF; thus, power from MG2 is transferred to wheels. This is shown in Fig. 1:



119. Therefore, limitation [1.5] is disclosed by Tsuzuki.

Limitation [1.6]: a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets; and

120. Tsuzuki discloses a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets. For example, Tsuzuki discloses:

> [T]he first planetary gear device P1 is a single-pinion planetary gear mechanism that is arranged coaxially with the input shaft I. That is, the first planetary gear device P1 has, as rotating elements, a carrier ca1 that supports a plurality of pinion gears, and a sun gear s1 and a ring gear r1 that mesh with the pinion gears, respectively. The sun gear s1 is connected to rotate integrally with a first rotor shaft 13, which is the rotation shaft of the rotor Ro1 of the first motor-generator MG1. The carrier ca1 is connected

> to the intermediate shaft 12 so as to rotate integrally with the intermediate shaft 12. The ring gear r1 is connected to the drive gear 14 so as to rotate integrally with it. In this way, the first planetary gear device P1 as a differential gear device has three rotating elements, and in this embodiment, the sun gear s1, carrier ca1, and ring gear r1 correspond to "the first rotating element", "the second rotating element", and "the third rotating element" in the present invention, respectively. In the first planetary gear device P1, the three rotating elements, in order of rotation speed, are a sun gear s1 (the first rotating element), a carrier ca1 (the second rotating element), and a ring gear r1 (the third rotating element).

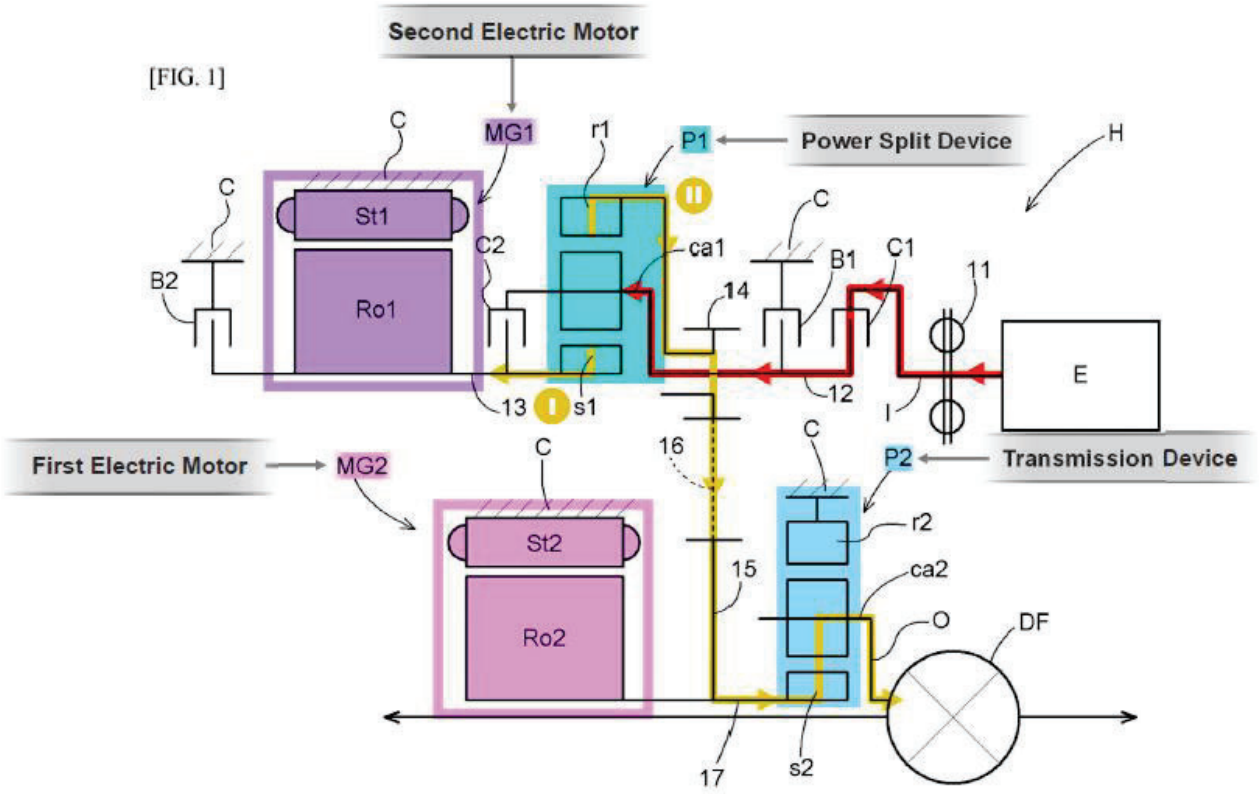
Id., [0053]. A POSITA would have understood that the first planetary gear device P1 is a "power split device" because it splits power among the engine and MG1. In particular, MG1 is connected to P1's sun gear, the engine is connected to P1's carrier via the intermediate shaft 12, and MG2 is connected to P1's ring gear via the drive gear 14, transmission chain 16, and driven gear 15. *Id.*, [0053], [0057], Fig. 1.

121. Tsuzuki also discloses "In the *split mode*, the first planetary gear device P1 operates to *distribute the rotational driving force* of the engine E to the output member O and the first motor-generator MG1. That is, as shown in FIG. 6, in the first planetary gear device P1, the carrier ca1, which is intermediate in the order of rotation speed, rotates integrally with the engine E. The rotation of the carrier ca1 is distributed to the sun gear s1, which is at one end in the order of rotation speed, and the ring gear r1, which is at the other end in the order of rotation speed." *Id.*, [0068] Thus, the planetary gear device P1 is a power split device to split (distribute) engine power to MG1 and output member O.

122. Moreover, P1 is coupled to the transmission device (P2) by way of the drive gear 14 and transmission chain 16:

> Meanwhile, the driven gear 15 is fixed to the second rotor shaft 17 so as to rotate integrally therewith. A transmission chain 16 is wound around the driven gear 15 to connect the drive gear 14, which rotates integrally with the ring gear r1 of the first planetary gear device P1, to the driven gear 15. As a result, the drive gear 14 and the driven gear 15 are connected via the transmission chain 16 so that a driving force can be transmitted. Here, the driven gear 15 has a larger diameter than the drive gear 14. Therefore, the rotation of the ring gear r1 of the first planetary gear device P1 and the drive gear 14 is reduced in speed and transmitted to the second rotor shaft 17 via the drive gear 14, the transmission chain 16, and the driven gear 15. In other words, the rotation of the sun gear s2 of the second planetary gear device P2, the rotor Ro2 of the second motor-generator MG2, and the second rotor shaft 17 is accelerated via the driven gear 15, the transmission chain 16, and the drive gear 14 and transmitted to the ring gear r1 of the first planetary gear device P1.

Id., [0057]. This is also shown in the following annotated Fig. 1, which illustrates that the engine power is split between paths I and II.



123. Finally, P1 is further connected to the second electric motor (MG1), as described at [0053] and shown in Fig. 1.

124. Therefore, limitation [1.6] is disclosed by Tsuzuki.

Limitation [1.7]: an energy management system (EMS) configured to:

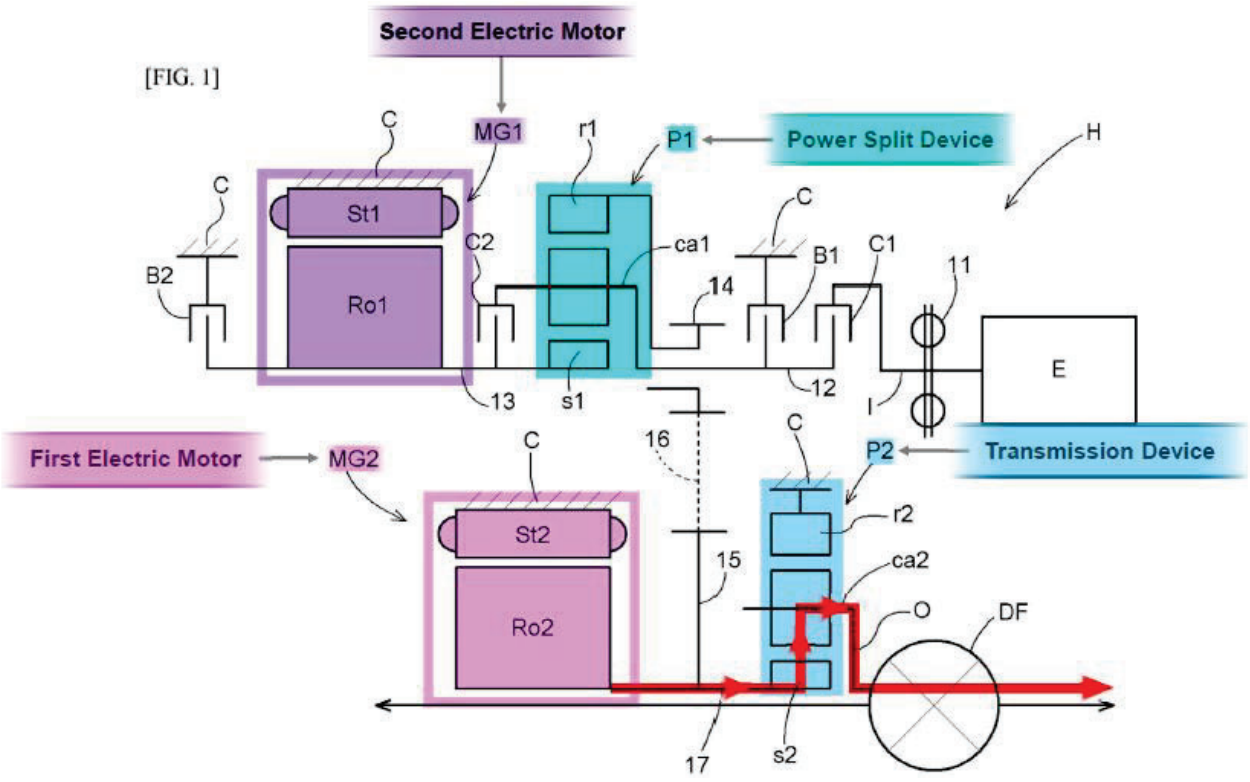
125. Tsuzuki discloses an energy management system (EMS). For example, Tsuzuki teaches that "the hybrid drive device H includes a main control unit 31 for controlling each part of the system." *Id.*, [0058]. "The main control unit 31 is connected to an engine control unit 32, an MG1 control unit 33, an MG2 control unit 34, and a hydraulic control device 35 in a state where information can be exchanged between them." *Id.* A POSITA would have understood that Tsuzuki's "main control

unit" and other subsidiary control units together comprise "an energy management system."

126. Therefore, limitation [1.7] is disclosed by Tsuzuki.

Limitation [1.8]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising;

127. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising. As noted above, in the "second EV mode," only MG2—not MG1—operates as a motor to drive the vehicle.



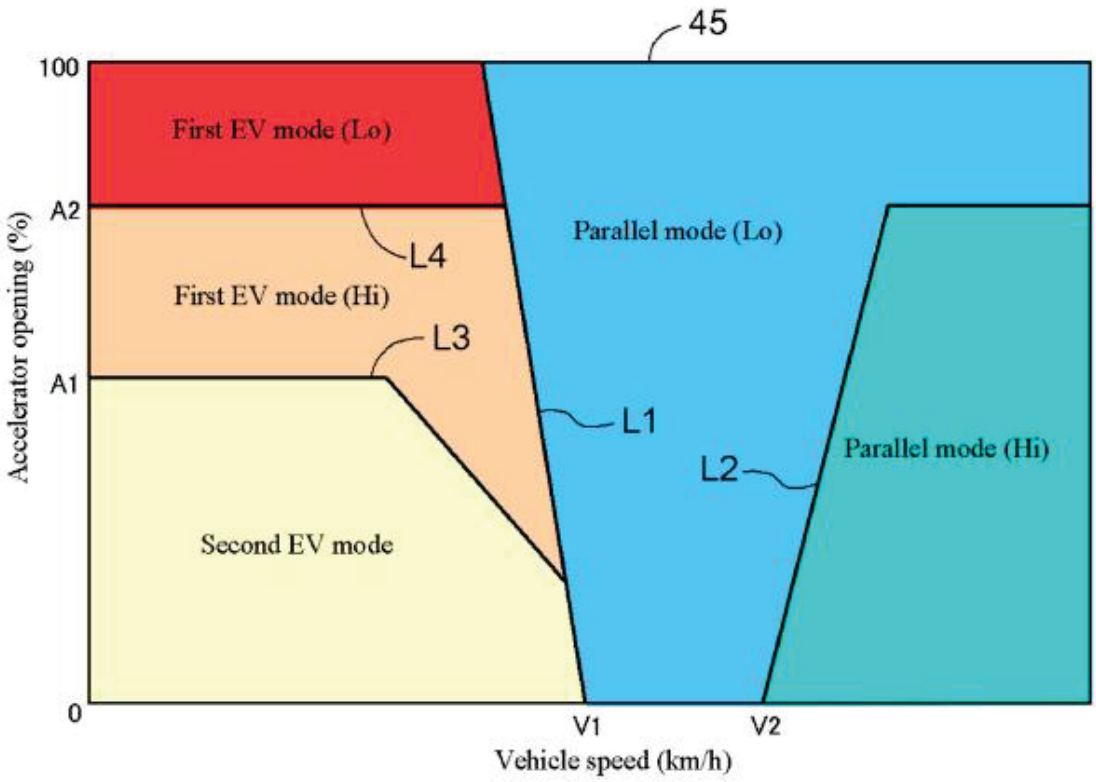
128. For example, Tsuzuki discloses:

> Finally, the operating state of the hybrid drive device H in the second EV mode will be described. **The second EV mode is a mode in which the first motor-generator MG1 is in a non-driving state and the rotational driving force of the second motor-generator MG2 is transmitted to the output member O**. … This second EV mode is a mode in which the vehicle operates as an EV (Electric Vehicle) by consuming power from the battery 21 and running solely on the rotational driving force of the second motor-generator MG2.

Id., [0089] (emphasis added). Because Tsuzuki states that MG1 "is in a non-driving state" but that "the rotational driving force of the second motor-generator MG2 is transmitted to the output member O," it is clear that only the first electric motor (MG2) operates as a motor to drive the vehicle—without any assistance from the second electric motor (MG1)—when the vehicle is in the second EV mode.

129. And Tsuzuki discloses that the vehicle will employ the "second EV mode" in conditions when the vehicle is traveling at a speed between 0 and V1 (or slightly below V1) and the accelerator is depressed relatively lightly (accelerator opening is relatively low). This is shown in Fig. 3:

[FIG. 3]



130. As Tsuzuki describes:

> [A]s shown in FIG. 3, the second EV mode is used in the low vehicle speed range where the vehicle speed is low. In the illustrated example, as described above, the first EV mode and the second EV mode are used in the range lower than the first boundary line L1, where the vehicle speed is V1 when the accelerator pedal depression is 0% and the vehicle speed decreases as the accelerator pedal depression increases. The second EV mode can output less driving force than the first EV mode, **so it is used in areas where the accelerator opening is lower than in the first EV mode (where the required driving force is relatively small).** In the illustrated example, the second EV mode is used on the side of the accelerator opening that is smaller than the third boundary line L3.

Id., [0092] (emphasis added). As shown, when the vehicle is traveling at a steady speed greater than 0 and less than V1 (or slightly below V1) and not accelerating (required driving force is relatively small), the vehicle is "cruising" in the second EV mode. This is consistent with the meaning of "cruising" in the '508 patent. *See* EX1001 at 11:31-33 ("At branch 706, the EV system is operated in a cruising mode 715 when V_{speed} fluctuates within a scope of a small range."). Under the '508 patent's understanding of "cruising," a vehicle is "cruising" when its speed is relatively constant (V_{speed} fluctuating within a small range). Thus, a vehicle would be "cruising" when traveling at a constant positive speed less than V1.

131. During cruising, a vehicle no longer needs to generate force to increase its speed; it only needs enough force to sustain it. The acceleration variable becomes zero. The vehicle propulsion system only needs to cancel out the resistive forces to keep the forces in equilibrium. During cruising on a flat road, the resistive forces are aerodynamic drag force (F_{w}) and rolling resistance force (F_{ro}). These two forces depend strongly on the vehicle speed, $F_w = f(V^2)$, $F_{ro} = g(V^{2.5})$. As a result, these two resistive forces are substantially smaller at low speeds (i.e., $V < V_1$ in Fig. 3), compared to those at high vehicle speeds (i.e., $V > V_2$ in Fig. 3). Thus, when cruising at low speeds ($V < V_1$) on a flat road, the vehicle is expected to engage the Second EV mode.

132. Examples of low-speed cruising include driving through scenic parks, construction zones, or school zones where speed limits are strictly enforced. During

these conditions, the vehicle operation is likely to engage Second EV mode in Fig. 3, provided the battery state of charge (SOC) is high enough to support EV operation.

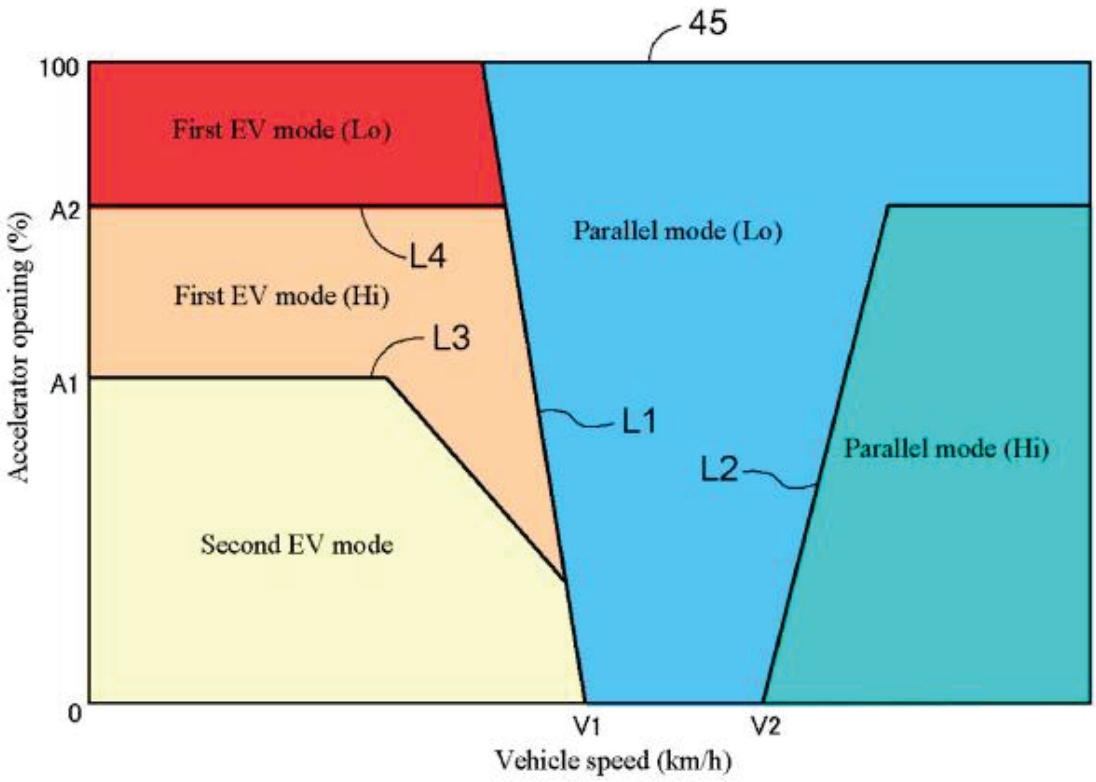
133. During cruising at a speed less than V_1, the accelerator opening is relatively low (a percentage value below A1%). This corresponds to the "second EV mode" area of Tsuzuki's Fig. 3, where only MG2 is operative. Thus, Tsuzuki discloses that only the first electric motor (MG2) operates as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising.

134. Therefore, limitation [1.8] is disclosed by Tsuzuki.

Limitation [1.9]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting; and

135. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting. As discussed above, in the second EV mode, only MG2 operates to drive the vehicle. *See id.*, [0089]. And as shown in Fig. 3, the vehicle operates in the second EV mode when the vehicle starts moving from a stopped position (vehicle speed = 0) and the accelerator opening is relatively low (less than A1%):

[FIG. 3]



136. As Tsuzuki describes:

> **[A]s shown in FIG. 3, the second EV mode is used in the low vehicle speed range where the vehicle speed is low.** In the illustrated example, as described above, the first EV mode and the second EV mode are used in the range lower than the first boundary line L1, where the vehicle speed is V1 when the accelerator pedal depression is 0% and the vehicle speed decreases as the accelerator pedal depression increases. The second EV mode can output less driving force than the first EV mode, so it is used in areas where the accelerator opening is lower than in the first EV mode (where the required driving force is relatively small). In the illustrated example, the second EV mode is used on the side of the accelerator opening that is smaller than the third boundary line L3.

Id., [0092]. As shown, when the vehicle is traveling from a stopped position with the accelerator opening relatively low, the vehicle is "starting" in the second EV mode. This is consistent with the meaning of "starting" in the '508 patent. *See* EX1001 at 11:16-17 ("At branch 702, the EV system is operated in a starting mode 711 when V_{speed} increases from about 0."). Under the '508 patent's understanding of "starting," a vehicle is "starting" when its speed increases from about 0. This is what a vehicle would be doing if the vehicle is starting to move from a stopped position and the accelerator opening is relatively low (a percentage value below A1%). This corresponds to the "second EV mode" area of Tsuzuki's Fig. 3, where only MG2 is operative. Thus, Tsuzuki discloses that only the first electric motor (MG2) operates as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting.

137. Notably, Tsuzuki also discloses that a vehicle can start in the first EV mode (rather than the second EV mode) if the accelerator opening is relatively high. *See* EX1005, Fig. 3. However, this does not detract from the fact that Tsuzuki's second EV mode corresponds to "a second mode of operation when the vehicle is starting," as required by claim element [1.9]. For example, Tsuzuki's first EV mode corresponds to "another mode of operation when the vehicle is starting"—which operates in the case when the accelerator opening is relatively high—but that additional disclosure does nothing to undermine Tsuzuki's disclosure of the second

EV mode, which operates when the vehicle is starting and the accelerator opening is relatively low.

138. Therefore, limitation [1.9] is disclosed by Tsuzuki.

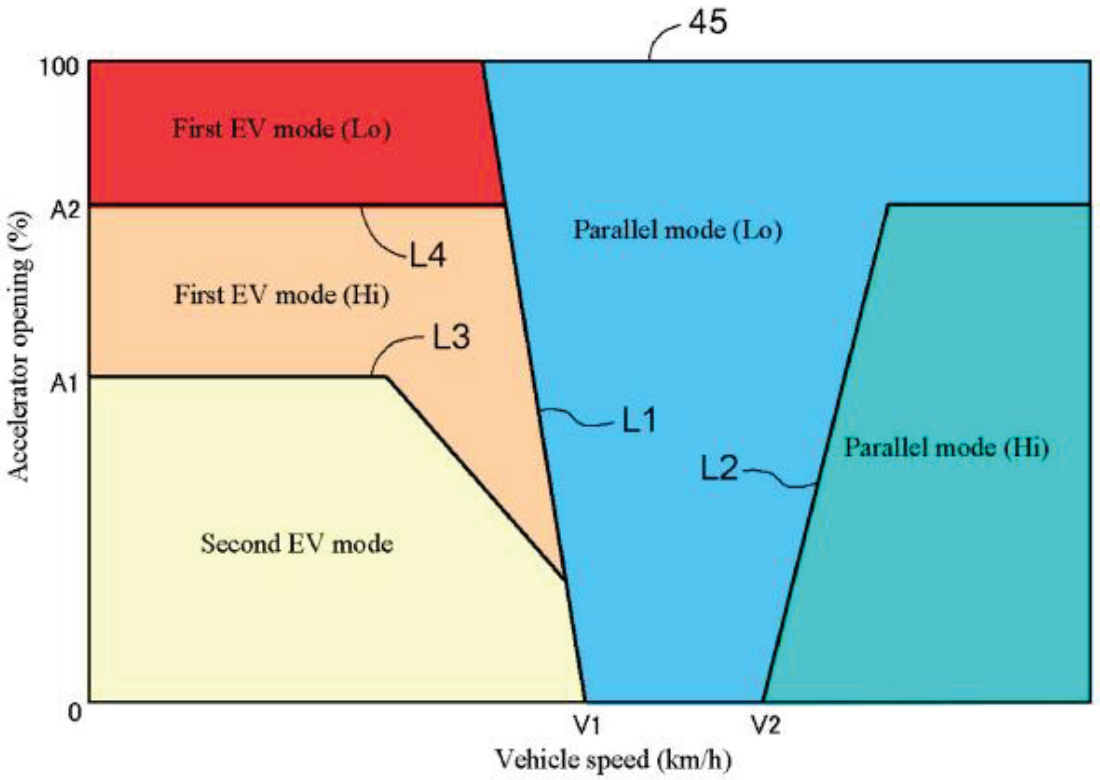
Limitation [1.10]: enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is accelerating.

139. Tsuzuki discloses that its EMS is configured to enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is accelerating. As noted above, in the "first EV mode," both MG2 and MG1 can operate as motors to drive the vehicle. For example, Tsuzuki discloses:

> The first EV mode is a mode in which the rotational driving force of the first motor-generator MG1 is transmitted to the output member O, and is a mode in which two gear stages with different gear ratios can be switched when transmitting the rotation of the first motor-generator MG1 to the output member O by switching the rotational states of the three rotating elements of the first planetary gear device P1. The first EV mode corresponds to the first rotating electrical machine drive mode in the present invention. In the first EV mode, as will be described below, the vehicle can be driven solely by the rotational driving force of the first motor-generator MG1. ***However, in this embodiment, the rotational driving force of the second motor-generator MG2 is transmitted to the output member O as needed, thereby supplementing the rotational driving force of the first motor-generator MG1 transmitted to the output member O.***

EX1005, [0080] (emphasis added). And Tsuzuki discloses that the vehicle will employ the "first EV mode" in conditions when the vehicle is traveling at a speed between 0 and V1 (or slightly below V1) and the accelerator is depressed relatively firmly (accelerator opening relatively high). This is shown in Fig. 3:

[FIG. 3]



140. An example of vehicle operation to engage the first EV mode could be when a vehicle is accelerating during uphill driving (typically low speeds). In this condition, the propulsion system needs to provide high power (torque) to overcome high resistive forces. Thus, the vehicle is expected to operate in the first EV mode by using power from both MG1 and MG2 to support the required acceleration during

uphill driving. Another example could be when the vehicle is accelerating on a flat road, while towing a heavy load, such as a boat.

141. As Tsuzuki describes:

> [A]s shown in FIG. 3, the first EV mode is used in the low vehicle speed range where the vehicle speed is low. In the illustrated example, two EV modes, namely the first EV mode and the second EV mode, are used in the range lower than the first boundary line L1, where the vehicle speed is V1 when the accelerator opening is 0% and the vehicle speed decreases as the accelerator opening increases. As described above, the first EV mode can output a greater driving force than the second EV mode, and is therefore used in a range where the accelerator opening is greater than in the second EV mode (where a relatively greater driving force is required). In the illustrated example, the first EV mode is used when the accelerator opening is higher than the third boundary line L3, which is a line that follows the accelerator opening A1 in areas where the vehicle speed is relatively low, and a line that decreases the accelerator opening as the vehicle speed increases in areas where the vehicle speed is higher.

Id., [0088]. As shown and described, when the vehicle is accelerating (relatively high accelerator opening) at a speed greater than 0 and less than V1, the vehicle is "accelerating" in the first EV mode. Thus, Tsuzuki discloses that the first electric motor (MG2) operates as a motor to drive the vehicle through the transmission device and the second electric motor (MG1) operates as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is accelerating.

142. Therefore, limitation [1.10] is disclosed by Tsuzuki.

C. Dependent Claim 2

2. The drive system of claim 1, wherein the ESS comprises a first energy storage unit and a second energy storage unit.

143. Use of two energy storage units in electric vehicles (EVs) was common among road-legal EVs produced before 2012. These EVs featured two distinct batteries: a standard 12-volt lead-acid battery for accessories (lights, radio, wipers) and a high-voltage traction battery for the motor. Some examples of these EVs include: GM EV1 (1996–1999), Tesla Roadster (2008–2012), Nissan LEAF (2010–2012), and Mitsubishi i-MiEV (2009–2012).

144. Tsuzuki discloses that the ESS comprises a first energy storage unit and a second energy storage unit. For example, Tsuzuki discloses that "[t]he battery 21 is an example of a power storage means, and other power storage means such as a capacitor may be used, ***or a plurality of types of power storage means may be used in combination***." EX1005, [0051] (emphasis added). A POSITA would have understood that if "a plurality of types of power storage means" are "used in combination," that means that there is a "first energy storage unit" and a "second energy storage unit."

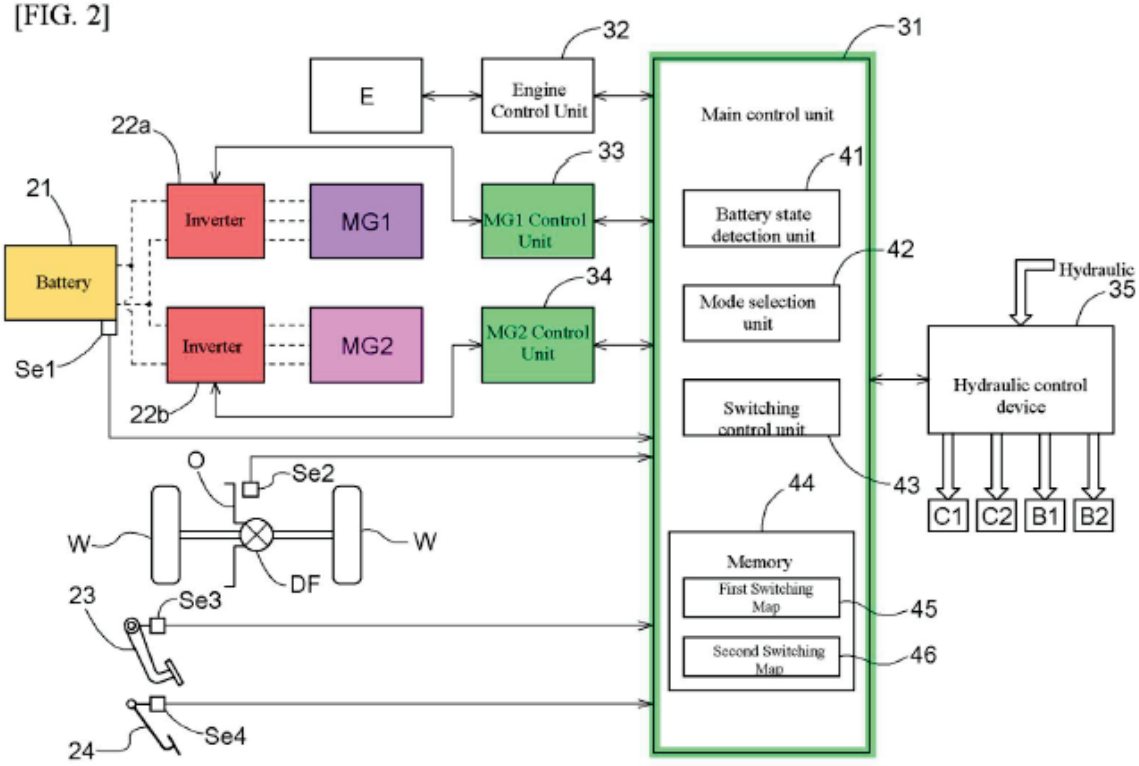
145. Therefore, the limitations of claim 2 are disclosed by Tsuzuki.

D. Dependent Claim 4

4. The drive system of claim 1, further comprising a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor.

146. Tsuzuki discloses a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor. For example, Tsuzuki discloses that MG1 and MG2 are connected to the battery 21 "via inverters 22a and 22b, respectively." *Id.*, [0050]. This is shown in Fig. 2, annotated below:

[FIG. 2]



147. Accordingly, a first inverter (inverter 22b) is coupled between the ESS (battery 21) and the first electric motor (MG2). And a second inverter (inverter 22a) is coupled between the ESS (battery 21) and the second electric motor (MG1).

148. Therefore, the limitations of claim 4 are disclosed by Tsuzuki.

E. Independent Claim 7

Limitation [7.0]: An electric drive system for a vehicle, comprising:

149. Tsuzuki discloses an electric drive system for a vehicle. *See* claim element [1.0], *supra*. A POSITA would have understood that Tsuzuki's hybrid drive device is an "electric drive system" because it relies on electric motor/generators (MG1/MG2) to drive the vehicle. In particular, in the "first EV mode" and "second EV mode," these electric motor/generators exclusively drive the vehicle (without assistance from the engine). EX1005, [0080], [0089].

150. Therefore, limitation [7.0] is disclosed by Tsuzuki.

Limitation [7.1]: an energy storage system (ESS);

151. Tsuzuki discloses an energy storage system (ESS). *See* claim element [1.1], *supra*.

152. Therefore, limitation [7.1] is disclosed by Tsuzuki.

Limitation [7.2]: a power conversion device coupled to the ESS;

153. Tsuzuki discloses a power conversion device coupled to the ESS. *See* claim element [1.2], *supra*.

154. Therefore, limitation [7.2] is disclosed by Tsuzuki.

Limitation [7.3]: a first inverter coupled to the power conversion device;

155. Tsuzuki discloses a first inverter coupled to the power conversion device. *See* claim 4, *supra*. The first inverter (inverter 22b) is part of Tsuzuki's "power conversion device" and is thus coupled to the power conversion device.

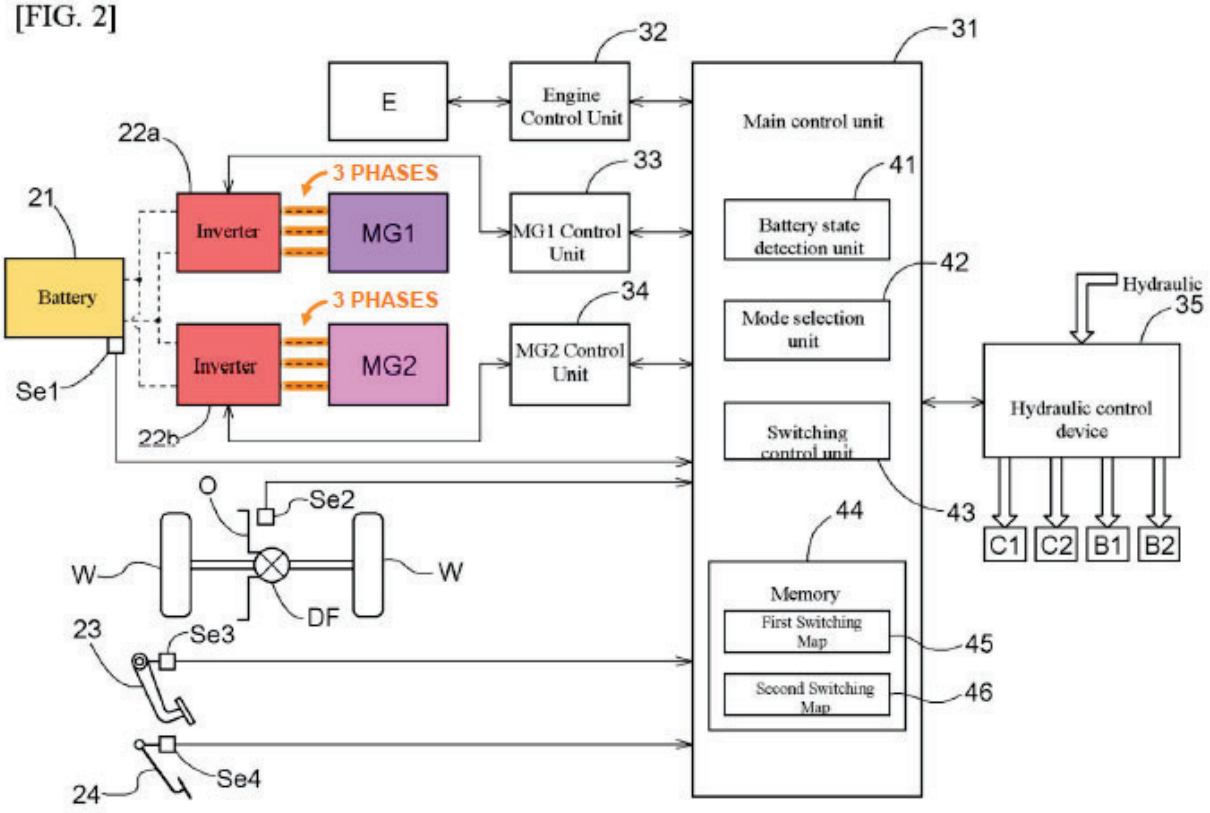
156. Therefore, limitation [7.3] is disclosed by Tsuzuki.

Limitation [7.4]: a first AC motor coupled to the first inverter;

157. Tsuzuki discloses a first AC motor coupled to the first inverter. *See* claim element [1.3] and claim 4, *supra*. A POSITA would have understood that MG2 is a "first AC motor" because it is an electric motor attached to a DC power source (battery) via an inverter. An inverter is "The Current Type Changer" and its job is to invert Direct Current (DC) into Alternating Current (AC).

158. Figure 2 shows "a schematic diagram showing the system configuration of the hybrid drive H" EX1005 [0046]. "In FIG. 2, solid arrows indicate transmission paths for various types of information, *dashed arrows indicate transmission paths for power*, and hollow arrows indicate transmission paths for hydraulic pressure. EX1005 [0046]. MG1 is connected via three wires to the inverter 22a and MG2 is connected via three wires to the inverter 22b (see annotated Fig. 2 below). A POSITA would have understood that both MG1 and MG2 are "three-phase" motors.

[FIG. 2]



159. Since MG1 and MG2 are “three-phase” motors, they are inherently an AC motor. Direct Current (DC) is a flat, constant line of voltage, it does not have frequency or "phases." Therefore, one cannot have a “three-phase” DC motor. Examples of 3-Phase AC motors are Induction Motor and Permanent Magnet Synchronous Motor (PMSM).

160. Therefore, limitation [7.4] is disclosed by Tsuzuki.

Limitation [7.5]: a second inverter coupled to the power conversion device;

161. Tsuzuki discloses a second inverter coupled to the power conversion device. *See* claim 4, *supra*. The second inverter (inverter 22a) is part of Tsuzuki's "power conversion device" and is thus coupled to the power conversion device.

162. Therefore, limitation [7.5] is disclosed by Tsuzuki.

Limitation [7.6]: a second AC motor coupled to the second inverter;

163. Tsuzuki discloses a second AC motor coupled to the second inverter. *See* claim element [1.4] and claim 4, *supra*. A POSITA would have understood that MG1 is a "second AC motor" because it is an electric motor attached to a DC power source (battery) via an inverter. For additional details, see my discussion of Limitation [7.4] above.

164. Therefore, limitation [7.6] is disclosed by Tsuzuki.

Limitation [7.7]: a transmission device coupled to the first AC motor;

165. Tsuzuki discloses a transmission device coupled to the first AC motor. *See* claim element [1.5], *supra*.

166. Therefore, limitation [7.7] is disclosed by Tsuzuki.

Limitation [7.8]: a power split device coupled to the transmission device and the second AC motor, the power split device comprising one or more planetary sets; and

167. Tsuzuki discloses a power split device coupled to the transmission device and the second AC motor, the power split device comprising one or more planetary sets. *See* claim element [1.6], *supra*.

168. Therefore, limitation [7.8] is disclosed by Tsuzuki.

Limitation [7.9]: an energy management system (EMS) configured to selectively:

169. Tsuzuki discloses an energy management system (EMS). *See* claim element [1.7], *supra*.

170. Therefore, limitation [7.9] is disclosed by Tsuzuki.

Limitation [7.10]: enable only the first AC motor of the first and second AC motors to operate as a motor to drive the vehicle through the transmission device when the vehicle is cruising;

171. Tsuzuki discloses that its EMS is configured to enable only the first AC motor of the first and second AC motors to operate as a motor to drive the vehicle through the transmission device when the vehicle is cruising. *See* claim element [1.8], *supra*.

172. Therefore, limitation [7.10] is disclosed by Tsuzuki.

Limitation [7.11]: enable only the first AC motor of the first and second AC motors to operate as a motor to drive the vehicle through the transmission device when the vehicle is starting; and

173. Tsuzuki discloses that its EMS is configured to enable only the first AC motor of the first and second AC motors to operate as a motor to drive the vehicle through the transmission device when the vehicle is starting. *See* claim element [1.9], *supra*.

174. Therefore, limitation [7.11] is disclosed by Tsuzuki.

Limitation [7.12]: enable the first AC motor to operate as a motor to drive the vehicle through the transmission device and enable the second AC motor to operate as a motor to drive the vehicle through the power split device when the vehicle is accelerating.

175. Tsuzuki discloses that its EMS is configured to enable the first AC motor to operate as a motor to drive the vehicle through the transmission device and enable the second AC motor to operate as a motor to drive the vehicle through the power split device when the vehicle is accelerating. *See* claim element [1.10], *supra*.

176. Therefore, limitation [7.12] is disclosed by Tsuzuki.

F. Dependent Claim 8

8. The electric drive system of claim 7, wherein the ESS comprises a first energy storage unit and a second energy storage unit.

177. Tsuzuki discloses that the ESS comprises a first energy storage unit and a second energy storage unit. *See* claim 2, *supra*.

178. Therefore, the limitations of claim 8 are disclosed by Tsuzuki.

G. Independent Claim 12

Limitation [12.0]: A drive system for a vehicle, comprising:

179. Tsuzuki discloses a drive system for a vehicle. *See* claim element [1.0], *supra*.

180. Therefore, limitation [12.0] is disclosed by Tsuzuki.

Limitation [12.1]: an energy storage system (ESS);

181. Tsuzuki discloses an energy storage system (ESS). *See* claim element [1.1], *supra*.

182. Therefore, limitation [12.1] is disclosed by Tsuzuki.

Limitation [12.2]: a power conversion device coupled to the ESS;

183. Tsuzuki discloses a power conversion device (*i.e.*, an inverter or group of inverters) coupled to the ESS. *See* claim element [1.2], *supra*.

184. Therefore, limitation [12.2] is disclosed by Tsuzuki.

Limitation [12.3]: a first electric motor coupled to the power conversion device;

185. Tsuzuki discloses a first electric motor coupled to the power conversion device. *See* claim element [1.3], *supra*.

186. Therefore, limitation [12.3] is disclosed by Tsuzuki.

Limitation [12.4]: a second electric motor coupled to the power conversion device;

187. Tsuzuki discloses a second electric motor coupled to the power conversion device. *See* claim element [1.4], *supra*.

188. Therefore, limitation [12.4] is disclosed by Tsuzuki.

Limitation [12.5]: a transmission device coupled to the first electric motor;

189. Tsuzuki discloses a transmission device coupled to the first electric motor. *See* claim element [1.5], *supra*.

190. Therefore, limitation [12.5] is disclosed by Tsuzuki.

Limitation [12.6]: a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets; and

191. Tsuzuki discloses a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets. *See* claim element [1.6], *supra*.

192. Therefore, limitation [12.6] is disclosed by Tsuzuki.

Limitation [12.7]: an energy management system (EMS) configured to:

193. Tsuzuki discloses an energy management system (EMS). *See* claim element [1.7], *supra*.

194. Therefore, limitation [12.7] is disclosed by Tsuzuki.

Limitation [12.8]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising;

195. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising. *See* claim element [1.8], *supra*.

196. Therefore, limitation [12.8] is disclosed by Tsuzuki.

Limitation [12.9]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the

transmission device in a second mode of operation when the vehicle is starting; and

197. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting. *See* claim element [1.9], *supra*.

198. Therefore, limitation [12.9] is disclosed by Tsuzuki.

Limitation [12.10]: enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode.

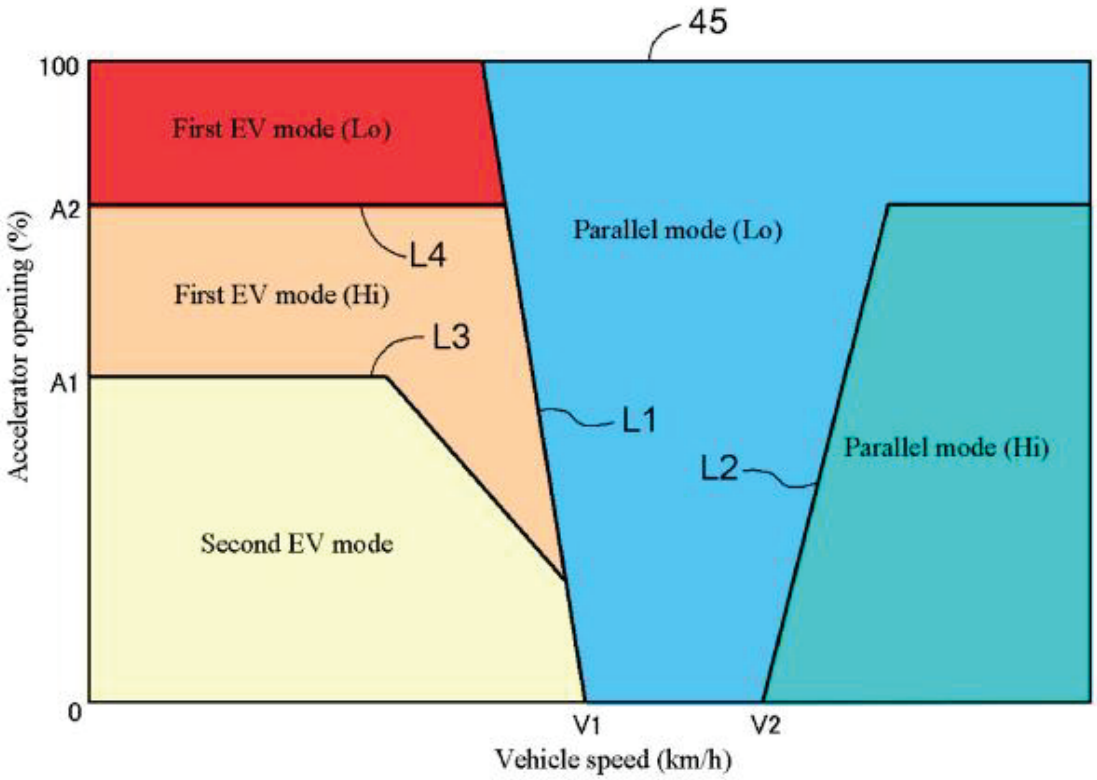
199. Tsuzuki discloses that its EMS is configured to enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode. As noted above with respect to claim element [1.10], in the "first EV mode," both MG2 and MG1 can operate as motors to drive the vehicle. For example, Tsuzuki discloses:

> The first EV mode is a mode in which the rotational driving force of the first motor-generator MG1 is transmitted to the output member O, and is a mode in which two gear stages with different gear ratios can be switched when transmitting the rotation of the first motor-generator MG1 to the output member O by switching the rotational states of the three rotating elements of the first planetary gear device P1. The first EV mode corresponds to the first rotating electrical machine drive mode in the

> present invention. In the first EV mode, as will be described below, the vehicle can be driven solely by the rotational driving force of the first motor-generator MG1. ***However, in this embodiment, the rotational driving force of the second motor-generator MG2 is transmitted to the output member O as needed, thereby supplementing the rotational driving force of the first motor-generator MG1 transmitted to the output member O.***

EX1005, [0080] (emphasis added). And Tsuzuki discloses that the vehicle will employ "first EV mode" in conditions when the vehicle is traveling at a speed between 0 and V1 (or slightly below V1) and the accelerator is depressed relatively firmly (relatively high accelerator opening). This is shown in Fig. 3:

[FIG. 3]



200. As Tsuzuki describes:

> **[A]s shown in FIG. 3, the first EV mode is used in the low vehicle speed range where the vehicle speed is low.** In the illustrated example, two EV modes, namely the first EV mode and the second EV mode, are used in the range lower than the first boundary line L1, where the vehicle speed is V1 when the accelerator opening is 0% and the vehicle speed decreases as the accelerator opening increases. As described above, the first EV mode can output a greater driving force than the second EV mode, and is therefore used in a range where the accelerator opening is greater than in the second EV mode (where a relatively greater driving force is required). In the illustrated example, the first EV mode is used when the accelerator opening is higher than the third boundary line L3, which is a line that follows the accelerator opening A1 in areas where the vehicle speed is relatively low, and a line that decreases the accelerator opening as the vehicle speed increases in areas where the vehicle speed is higher.

Id., [0088] (emphasis added). As shown and described, when the vehicle has a relatively greater accelerator opening because "a relatively greater driving force is required" at a speed greater than 0 and less than V1, the vehicle is in the first EV mode. A POSITA would have understood that a relatively greater driving force is required when driving uphill, and that there would thus be a relatively greater accelerator opening when the vehicle is driving uphill. Accordingly, based on Tsuzuki's disclosure, the vehicle would be operating in the first EV mode (where both MG1 and MG2 may drive the vehicle) when going uphill at a relatively low speed. Thus, Tsuzuki discloses that the first electric motor (MG2) operates as a motor to drive the vehicle through the transmission device and the second electric

motor (MG1) operates as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode.

201. Therefore, limitation [12.10] is disclosed by Tsuzuki.

H. Dependent Claim 13

13. The drive system of claim 12, wherein the ESS comprises a first energy storage unit and a second energy storage unit.

202. Tsuzuki discloses that the ESS comprises a first energy storage unit and a second energy storage unit. *See* claim 2, *supra*.

203. Therefore, the limitations of claim 13 are disclosed by Tsuzuki.

I. Dependent Claim 15

15. The drive system of claim 12, further comprising a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor.

204. Tsuzuki discloses a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor. *See* claim 4, *supra*.

205. Therefore, the limitations of claim 15 are disclosed by Tsuzuki.

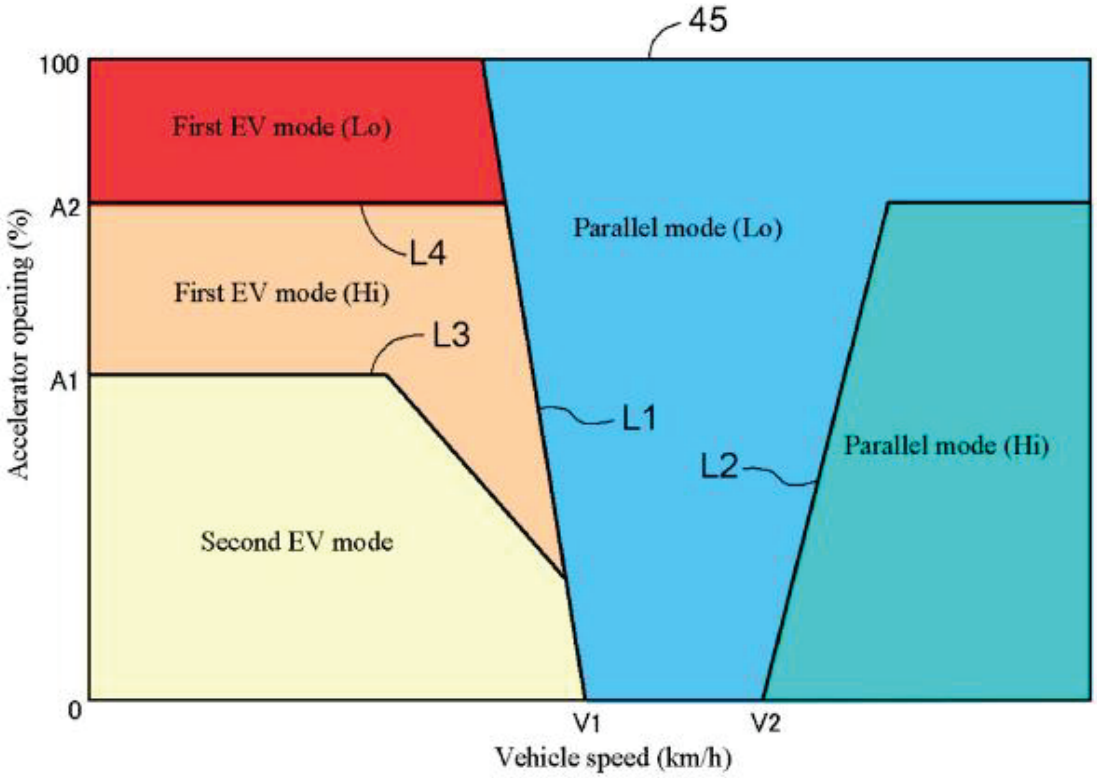
VIII. Ground 2: Claims 1, 2, 4, 7, 8, 12, 13, and 15 Are Obvious Over Tsuzuki

206. It is my opinion that the subject matter of claims 1, 2, 4, 7, 8, 12, 13, and 15 would have been obvious to a POSITA based on the teachings of Tsuzuki.

207. Ground 1 above is incorporated here by reference. Further, to the extent that Tsuzuki is found not to disclose claim elements [1.9], [7.11], or [12.9], claims 1, 2, 4, 7, 8, 12, 13, and 15 would still have been obvious over Tsuzuki. As shown

in Fig. 3, Tsuzuki discloses operating in the second EV mode when the speed and accelerator opening are relatively low:

[FIG. 3]



208. To the extent that this disclosure is found not to expressly or inherently cover a condition "when the vehicle is starting," a POSITA would have found it obvious to employ the second EV mode when the vehicle is starting. In the context of the '508 Patent, "starting" the vehicle simply means moving the vehicle from a stopped position. *See* EX1001, 11:16-17 ("At branch 702, the EV system is operated in a starting mode 711 when Vspeed increases from about 0."). Based on Tsuzuki's Fig. 3 and related discussion, the second EV mode is employed at low speeds when the accelerator opening is relatively low. A speed of zero (*i.e.*, a stopped position)

is the lowest possible speed, and thus a POSITA would have found it obvious to employ Tsuzuki's second EV mode when starting to move from a stopped position. In this regard, there is no disclosure or suggestion in Tsuzuki of using any electric-only mode other than the second EV mode when starting with a relatively low accelerator opening, so a POSITA would not be dissuaded from following Tsuzuki's suggestion of using the second EV mode at low speeds and low accelerator opening to its obvious conclusion, *i.e.*, using the second EV mode at the lowest possible speed: when starting. Accordingly, it would have been obvious to employ the second EV mode and thus enable only the first electric motor (MG2) of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting.

209. Thus, independent claims 1, 7, and 12—and dependent claims 2, 4, 8, 13, and 15—would have been obvious over Tsuzuki.

IX. Ground 3: Claims 1, 2, 4, 7, 8, 12, 13, and 15 Are Obvious Over Tsuzuki in view of Reynolds

210. As discussed above in Grounds 1 and 2, I believe that claims 1, 2, 4, 7, 8, 12, 13, and 15 are anticipated by, or obvious over, Tsuzuki. However, it is also my opinion that the subject matter of claims 1, 2, 4, 7, 8, 12, 13, and 15 would have been obvious to a POSITA based on the teachings of Tsuzuki and Reynolds.

211. Ground 1 above is incorporated here by reference. Further, to the extent that Tsuzuki's "power conversion device" is narrowly construed so as not to

encompass an inverter or group of inverters or Tsuzuki is found not to disclose claim elements [7.3] or [7.5], claims 1, 2, 4, 7, 8, 12, 13, and 15 would still have been obvious over Tsuzuki in view of Reynolds. In particular, it would have been obvious to a POSITA to incorporate the DC-DC converter taught by Reynolds (denoted as VVC 82) into the powertrain disclosed in Tsuzuki. A POSITA would have been motivated to make this combination to achieve the benefits explicitly described in Reynolds, namely boosting the battery "voltage to a higher level voltage in an HEV drivetrain system for multi-purposes such as, but not limited to, torque capability optimizations for electric machines, system loss optimization, and so on." EX1010, ¶ 0024.

212. In particular, if the "power conversion device" is construed as needing to be something other than an inverter or group of inverters, then the "power conversion device" corresponds to a DC-DC converter as disclosed in Reynolds. Tsuzuki's inverters would then be separate and distinct from the power conversion device in the combined system. And the power conversion device would be coupled to the first and second electric motors (via Tsuzuki's inverters) and the ESS, as required by claims 1 and 12. Thus, independent claims 1 and 12 would have been obvious over Tsuzuki and Reynolds.

213. Moreover, if the "first inverter" and/or "second inverter" are construed as needing to be separate from the "power conversion device" (which they should not), then the "power conversion device" can be mapped to a DC/DC converter as

disclosed in Reynolds. Tsuzuki's inverters would then be separate and distinct from the power conversion device in the combined system.

214. A POSITA would have found it obvious to combine Tsuzuki and Reynolds. In particular, both references are in the same technical field. Thus, Tsuzuki and Reynolds are analogous references, and a POSITA would have found combining these references to be one of a finite number of identified means for transferring energy between multiple energy storage devices and electromechanical devices in EV and HEV vehicles, and further, would have had a reasonable expectation of success in combining their teachings.

215. Reynolds discloses a DC/DC converter coupled to an energy storage device. "Electrical power stored in battery 46 is sent through a DC-DC voltage converter to modify the vehicle voltage level according to the devices being powered. The variable voltage control (VVC) 48 converts the DC voltage level of battery 46 to the DC desired voltage level of high-voltage electrical bus 50." EX1010, ¶ 0013; *see also* Fig. 1.

216. It would have been obvious to a POSITA to incorporate Reynolds' DC/DC converter into Tsuzuki. A DC-DC converter is a standard device for converting direct current from one voltage to another. For hybrid and electric vehicles, it was well known in December 2012 that a DC-DC converter could be used to manage power flow between a battery and other systems. *Id.* For example, a DC-DC converter can step-down (buck) high voltage (*e.g.*, 250 V) from a battery to

a lower voltage (*e.g.*, 12 V) for powering onboard devices such as lights, infotainment systems, or other accessories. *Id.* A DC-DC converter can also step-up (boost) voltage, *e.g.*, from 250 V to 650 V to supply high power to electric motors via an inverter when it is necessary (*e.g.*, during heavy accelerations). This will allow an automotive manufacturer to use a smaller, lighter physical battery pack while still achieving high-performance motor output. A POSITA would have at least been motivated by Reynolds to incorporate a DC-DC converter using variable voltage control (VVC) into the powertrain of Tsuzuki to buck or boost voltage to/from the vehicle battery as needed, as shown by Reynolds' teaching that "battery 46 further includes a two-way electrical connection, such that it can also receive and store energy provided through regenerative braking, for example, and then supply the energy to an electric machine." EX1010, ¶ 0017. Accordingly, it would have been obvious to a POSITA to include the DC-DC converter taught by Reynolds in the powertrain disclosed in Tsuzuki to power onboard devices as well as turn braking energy back into electricity for charging the battery.

217. Accordingly, in a scenario where the "power conversion device" is construed as needing to be something other than an inverter or group of inverters and/or the "first inverter" and/or the "second inverter" recited in claim 7 are required to be separate from the "power conversion device," the "power conversion device" corresponds to the DC-DC converter of Reynolds as combined with Tsuzuki.

218. Thus, claims 1, 2, 4, 7, 8, 12, 13, and 15 would have been obvious over Tsuzuki and Reynolds.

X. Ground 4/4a: Claims 12, 13, and 15 Are Obvious Over Tsuzuki in view of Imai (or Tsuzuki in view of Reynolds and Imai)

219. It is my opinion that the subject matter of claims 12, 13, and 15 would have been obvious to a POSITA based on the teachings of Tsuzuki in view of the teachings of Imai.

220. A POSITA would have been motivated to combine the teachings of Tsuzuki with the teachings of Imai—and would have had a reasonable expectation of success in making the combination—for a number of reasons.

221. Both of these references are directed to hybrid electric vehicle systems with an engine and two electric motors. *See, e.g.*, EX1005, abstract, EX1006, abstract. Accordingly, the references are in the same field of endeavor, and POSITAs would naturally have looked to them in their work. Moreover, a POSITA would have understood that the teachings of Tsuzuki would have been compatible and operable in combination with the teachings of Imai.

222. For example, a POSITA would have recognized that Imai describes how its system of only using both electric motors to drive the vehicle when necessary (such as on a steep climb)—and not using both motors when not necessary—ensures adequate driving torque under all conditions and reduces energy loss. EX1006, abstract, [0101]. These benefits are consistent with the efficiency goals described in

Tsuzuki. Accordingly, a POSITA looking to improve efficiency while ensuring adequate driving torque under all conditions would have incorporated Imai's guidance regarding using both motors for steep uphill driving into Tsuzuki's system (to the extent that this is not already implicit or inherent in Tsuzuki). A POSITA would have been motivated to take advantage of these benefits by combining Imai's disclosures with those of Tsuzuki.

223. Imai discloses the conditions under which the use of an EV operating mode will be beneficial. For example, Imai discloses: "… when there is an input limit Win for the power storage device 70, the first electric motor MG1 and the second electric motor MG2 are used together to perform motor running, limited to where necessary in order to secure high driving torque (accelerator pedal opening degree ≧ θ1) during motor running, and the securing of driving torque and reduction of energy loss are achieved by not using the first electric motor MG1 within the range that running solely by the second electric motor MG2 is possible (the range until the driving torque reaches the upper limit torque of the second electric motor MG2)." EX1006, abstract. On the other hand, Tsuzuki does not specifically disclose a condition where an input limit (W_{in}) is imposed on the power storage device. A POSITA would understand, however, that this limit typically arises when the energy storage device (e.g., a battery) is fully charged or at a high State of Charge (SOC). In such a scenario, prioritizing the electric motors consumes stored power, thereby creating capacity to absorb subsequent regenerative braking energy. This strategy

effectively reduces overall vehicle energy consumption. Therefore, a POSITA would have incorporated Imai's teachings into Tsuzuki to enhance energy efficiency, specifically by utilizing an EV operating mode—using either one or two motors depending on torque demand—to manage high SOC conditions.

224. Ultimately, a POSITA would have been motivated to combine the teachings of Tsuzuki with those of Imai, and would have recognized that combining these teachings would have produced predictable and operable results.

A. Independent Claim 12

Limitation [12.0]: A drive system for a vehicle, comprising:

225. Tsuzuki discloses a drive system for a vehicle. *See* Ground 1, *supra*.

Limitation [12.1]: an energy storage system (ESS);

226. Tsuzuki discloses an energy storage system (ESS). *See* Ground 1, *supra*.

Limitation [12.2]: a power conversion device coupled to the ESS;

227. Tsuzuki discloses a power conversion device coupled to the ESS. *See* Ground 1, *supra*.

Limitation [12.3]: a first electric motor coupled to the power conversion device;

228. Tsuzuki discloses a first electric motor coupled to the power conversion device. *See* Ground 1, *supra*.

Limitation [12.4]: a second electric motor coupled to the power conversion device;

229. Tsuzuki discloses a second electric motor coupled to the power conversion device. *See* Ground 1, *supra*.

Limitation [12.5]: a transmission device coupled to the first electric motor;

230. Tsuzuki discloses a transmission device coupled to the first electric motor. *See* Ground 1, *supra*.

Limitation [12.6]: a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets; and

231. Tsuzuki discloses a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets. *See* Ground 1, *supra*.

Limitation [12.7]: an energy management system (EMS) configured to:

232. Tsuzuki discloses an energy management system (EMS). *See* Ground 1, *supra*.

Limitation [12.8]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising;

233. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising. *See* Ground 1, *supra*.

Limitation [12.9]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting; and

234. Tsuzuki discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting. *See* Ground 1, *supra*.

Limitation [12.10]: enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode.

235. As discussed above in Ground 1, Tsuzuki discloses that its EMS is configured to enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode. However, to the extent that this limitation is found not to be disclosed in Tsuzuki, Imai expressly discloses it, and it would have been obvious to combine Tsuzuki with Imai (as described above). For example, Imai discloses:

> Here, even when the EV switch is OFF (the determination result in step ST101 is negative), if there is an input limitation Win on the battery device 70, the region where driving by the engine is possible and the available drive torque become limited, and therefore ***running using both the first electric motor MG1 and the second electric motor MG2 (combined running) may be necessary***. That

> is, when the input limitation Win is present, the engine 10 cannot be started, and therefore, for example ***during steep uphill driving***, it may become necessary to secure drive torque by motor running.

EX1006, [0101] (emphasis added). Accordingly, Imai expressly teaches that both electric motors operate as motors to drive the vehicle when the vehicle is in an uphill mode, *i.e.*, during "steep uphill driving." *Id.*

236. Therefore, limitation [12.10] is disclosed by Tsuzuki and Imai. Claim 12 would have been obvious over Tsuzuki in view of Imai. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 12 would have been obvious over Tsuzuki in view of Reynolds and Imai. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with claim 12.

B. Dependent Claim 13

13. The drive system of claim 12, wherein the ESS comprises a first energy storage unit and a second energy storage unit.

237. Tsuzuki discloses that the ESS comprises a first energy storage unit and a second energy storage unit. *See* Ground 1, *supra*.

238. Therefore, the limitations of claim 13 are disclosed by Tsuzuki. Claim 13 would have been obvious over Tsuzuki in view of Imai. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 13 would have been obvious over Tsuzuki in view of Reynolds and Imai. See

Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with claim 12 (from which claim 13 depends).

C. Dependent Claim 15

15. The drive system of claim 12, further comprising a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor.

239. Tsuzuki discloses a first inverter coupled between the ESS and the first electric motor and a second inverter coupled between the ESS and the second electric motor. *See* Ground 1, *supra*.

240. Therefore, the limitations of claim 15 are disclosed by Tsuzuki. Claim 15 would have been obvious over Tsuzuki in view of Imai. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 15 would have been obvious over Tsuzuki in view of Reynolds and Imai. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with claim 12 (from which claim 15 depends).

XI. Ground 5/5a: Claims 3, 9, and 14 Are Obvious Over Tsuzuki in view of Ashtiani (or Tsuzuki in view of Reynolds and Ashtiani)

241. It is my opinion that the subject matter of claims 3, 9, and 14 would have been obvious to a POSITA based on the teachings of Tsuzuki in view of the teachings of Ashtiani.

242. A POSITA would have been motivated to combine the teachings of Tsuzuki with the teachings of Ashtiani—and would have had a reasonable expectation of success in making the combination—for a number of reasons.

243. Both of these references are directed to hybrid electric vehicle systems. *See, e.g.*, EX1005, abstract, EX1008, [0002]. Accordingly, the references are in the same field of endeavor, and a POSITA would naturally have looked to them in their work. Moreover, a POSITA would have understood that the teachings of Tsuzuki would have been compatible and operable in combination with the teachings of Ashtiani.

244. For example, Tsuzuki teaches that "[t]he battery 21 is an ***example*** of a power storage means, and other power storage means ***such as a capacitor*** may be used, or a plurality of types of power storage means may be used in combination." EX1005, [0051] (emphasis added). Thus, Tsuzuki already contemplates that a capacitor may be used in place of, or in addition to, a traditional battery in a hybrid vehicle system. Ashtiani explains the benefits of using an ultracapacitor along with a battery in this context: the battery "does not have to withstand high-power pulses" because the ultracapacitor "delivers the energy required for all high current surges that occur during engine start, acceleration, and regeneration." EX1008, abstract. This would reduce wear on the battery and allow for a less expensive and more efficient overall design. A POSITA would thus have recognized the benefits of using Ashtiani's ultracapacitor with Tsuzuki's hybrid drive device.

245. Ultimately, a POSITA would have been motivated to combine the teachings of Tsuzuki with those of Ashtiani, and would have recognized that combining these teachings would have produced predictable and operable results.

A. Dependent Claim 3

3. The drive system of claim 2, wherein the first energy storage unit comprises a battery and the second energy storage unit comprises an ultra-capacitor.

246. Tsuzuki does not expressly disclose that the second energy storage unit comprises an ultra-capacitor. However, Ashtiani discloses this limitation. For example, Ashtiani discloses "an energy storage system for a hybrid electric vehicle comprising: an ultracapacitor having a maximum operable voltage" along with a battery. *See* EX1008, cl. 1. As discussed above, it would have been obvious to combine Ashtiani's disclosure in this regard with Tsuzuki's system. In Tsuzuki's system as modified based on Ashtiani, the first energy storage unit comprises a battery and the second energy storage unit comprises an ultra-capacitor. Accordingly, claim 3 would have been obvious to a POSITA based on Tsuzuki in view of Ashtiani. Further, in a scenario where the "power conversion device" of claim 1 is construed as excluding inverters, claim 3 would have been obvious over Tsuzuki in view of Reynolds and Ashtiani. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 1 (from which claim 3 depends).

247. Therefore, the limitations of claim 3 are disclosed by Ashtiani. Claim 3 would have been obvious over Tsuzuki in view of Ashtiani.

B. Dependent Claim 9

9. The drive system of claim 8, wherein the first energy storage unit comprises a battery and the second energy storage unit comprises an ultra-capacitor.

248. *See* discussion of claim 3, *supra*. Claim 9 would have been obvious over Tsuzuki in view of Ashtiani. Further, in a scenario where the "first inverter" and/or the "second inverter" are required to be separate from the "power conversion device" recited in claim 7, claim 9 would have been obvious over Tsuzuki in view of Reynolds and Ashtiani. See Ground 3, *supra* for my discussion of combining Tsuzuki and Reynolds in connection with independent claim 7 (from which claim 9 depends).

C. Dependent Claim 14

14. The drive system of claim 13, wherein the first energy storage unit comprises a battery and the second energy storage unit comprises an ultra-capacitor.

249. *See* discussion of claim 3, *supra*. Claim 14 would have been obvious over Tsuzuki in view of Ashtiani. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 14 would have been obvious over Tsuzuki in view of Reynolds and Ashtiani. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 12 (from which claim 14 depends).

XII. Ground 6/6a: Claims 5, 10 and 16 Are Obvious Over Tsuzuki in view of Satoru (or Tsuzuki in view of Reynolds and Satoru)

250. It is my opinion that the subject matter of claims 5, 10, and 16 would have been obvious to a POSITA based on the teachings of Tsuzuki in view of the teachings of Satoru.

251. A POSITA would have been motivated to combine the teachings of Tsuzuki with the teachings of Satoru—and would have had a reasonable expectation of success in making the combination—for a number of reasons.

252. Both of these references relate to energy storage devices for use in hybrid or electric vehicles. *See, e.g.*, EX1005, [0051], EX1009, [0001]. Accordingly, the references are in the same field of endeavor, and POSITAs would naturally have looked to them in their work. Moreover, a POSITA would have understood that the teachings of Tsuzuki would have been compatible and operable in combination with the teachings of Satoru.

253. For example, Tsuzuki teaches that "[t]he battery 21 is an example of a power storage means, and other power storage means such as a capacitor may be used, ***or a plurality of types of power storage means may be used in combination***." EX1005, [0051] (emphasis added). Thus, Tsuzuki already contemplates that multiples types of power storage means—such as a battery and a capacitor—may be used in combination.

254. In an Electric Vehicle (EV) with multiple energy storage systems (e.g., a battery hybridizing with a supercapacitor, or multiple battery packs in parallel), the problem of "inrush current" can occur. The "inrush current" acts almost like a short circuit and can be thousands of amps. This surge can weld the main contactors shut or damage the battery cells. The "inrush current" can happen when one tries to connect two energy sources in parallel that are at different voltage levels. Another example is when a car is driving using only the main battery and the secondary source (e.g., a supercapacitor) is sitting idle and disconnected. When high power is needed (e.g., acceleration) or to capture energy (e.g., regenerative braking), the vehicle controller decides it needs the secondary source and closes its switch. If the supercapacitor is empty (0 V) and connects to the live e.g., 400 V bus, it looks like a short circuit to the main battery. Conversely, if the supercapacitor is fully charged (400 V) and connects to a bus that has sagged to 350 V under load, the capacitor will dump its energy instantly into the bus. The problem/risk of "inrush current" has been known to POSITA for an EV with multiple energy storage systems. Thus, POSITA should have been motivated to find solutions to protect the vehicle energy storage system from the risk of "inrush current."

255. Satoru also mentions the inrush current problem: "there is a risk that the power semiconductor relay (connection switching means) may be damaged due to the large *inrush current* at the starting of the device. This damage can occur when

the power storage device is activated when the capacitor is uncharged or when the capacitor is discharged due to leakage current." EX1009, [0003] (emphasis added).

256. Satoru introduces a pre-charging switching device to prevent damage from sudden power surges. "... further comprising a pre-charging circuit 40 which constitutes a closed circuit with the storage battery bank 11 and the capacitor bank 12 and has *pre-charging switches 51, 52, 53* for electrically connecting or disconnecting the storage battery bank 11 and the capacitor bank 12; and is characterized in that, when the power is turned on and the non-connection mode is switched by the connection switching means 13, the control circuit 14 controls the pre-charging circuit 40 to electrically connect the storage battery bank 11 and the capacitor bank 12. In the power storage device described in Claim 1, when the power supply is turned on, the control circuit 14 closes the pre-charging switches 51, 52, and 53 while maintaining a non-connected mode. As a result, the storage battery bank 11 and the capacitor bank 12 are electrically connected, and the pre-charging circuit 40 thereby becomes a closed circuit, so that the charge is filled approximately equally to each capacitor 12a to 12e, and the *potential difference between each storage battery 11a to 11e and each capacitor 12a to 12e becomes extremely small*." EX1009, [0004]-[0005] (emphasis added). A POSITA would thus have recognized the benefits of using Satoru's pre-charging switching device with Tsuzuki's hybrid drive device.

257. Ultimately, a POSITA would have been motivated to combine the teachings of Tsuzuki with those of Satoru, and would have recognized that combining these teachings would have produced predictable and operable results.

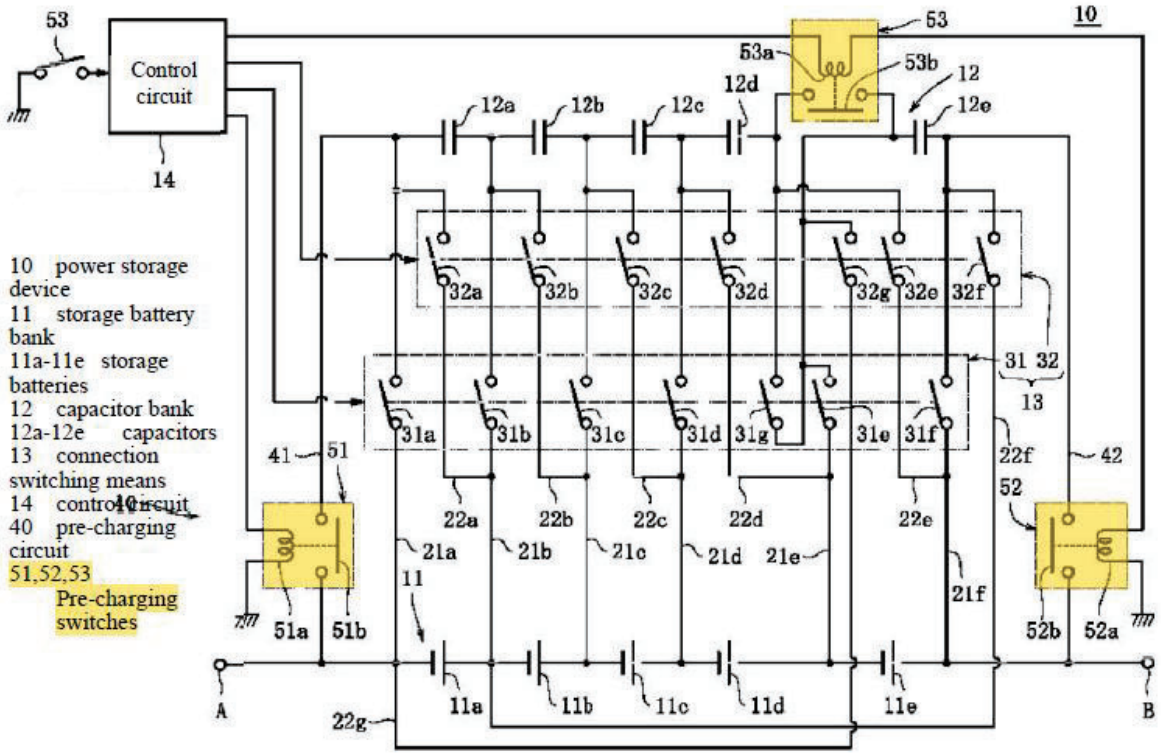
A. Dependent Claim 5

5. The drive system of claim 1, further comprising a pre-charging switching device.

258. Tsuzuki does not expressly disclose a pre-charging switching device. However, Satoru discloses this limitation. For example, Satoru discloses "pre-charging circuit 40 which constitutes a closed circuit with the storage battery bank 11 and the capacitor bank 12 and has *pre-charging* switches 51, 52, 53 for electrically connecting or disconnecting the storage battery bank 11 and the capacitor bank 12…." EX1009, [0004] (emphasis added). Satoru further discloses "as shown in Figure 1, the control circuit 14 is configured to control the pre-charging circuit 40 in a state constituting a closed circuit, electrically disconnect the storage battery bank 11 and the capacitor bank 12, and then control the connection switching means 13 to switch to the first or second connection mode. In the power storage device described in Claim 2, when the power supply is turned on, the control circuit 14 closes the pre-charging switches 51, 52, and 53 while maintaining a non-connected mode. As a result, the storage battery bank 11 and the capacitor bank 12 are electrically connected, and the pre-charging circuit 40 thereby becomes a closed circuit, so that the charge is filled approximately equally to each capacitor 12a to

12e, and the potential difference between each storage battery 11a to 11e and each capacitor 12a to 12e becomes extremely small. In this state, the control circuit 14 repeatedly switches between the first and second connection modes after opening the pre-charging switch 40. Since the switching between the first and second connection modes is performed after *the potential difference between the storage batteries 11a-11e and capacitors 12a-12e has become extremely small in this way, the* ***inrush current becomes extremely small***. EX1009, [0006] (emphasis added). Figure 1 is shown below:

[Figure 1]



259. As discussed above, it would have been obvious to combine Satoru's disclosure in this regard with Tsuzuki's system to limit the flow of electricity and

prevent damage from sudden power surges. In Tsuzuki's system as modified based on Satoru, the drive system would further comprise a pre-charging switching device. Accordingly, claim 5 would have been obvious to a POSITA based on Tsuzuki in view of Satoru.

260. Therefore, the limitations of claim 5 are disclosed by Satoru. Claim 5 would have been obvious over Tsuzuki in view of Satoru. Further, in a scenario where the "power conversion device" of claim 1 is construed as excluding inverters, claim 5 would have been obvious over Tsuzuki in view of Reynolds and Satoru. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 1 (from which claim 5 depends).

B. Dependent Claim 10

10. The electric drive system of claim 7, further comprising a pre-charging switching device.

261. *See* discussion of claim 5, *supra*. Claim 10 would have been obvious over Tsuzuki in view of Satoru. Further, in a scenario where the "first inverter" and/or the "second inverter" are required to be separate from the "power conversion device" recited in claim 7, claim 10 would have been obvious over Tsuzuki in view of Reynolds and Satoru. See Ground 3, *supra* for my discussion of combining Tsuzuki and Reynolds in connection with independent claim 7 (from which claim 10 depends).

C. Dependent Claim 16

16. The drive system of claim 12, further comprising a pre-charging switching device.

262. *See* discussion of claim 5, *supra*. Claim 16 would have been obvious over Tsuzuki in view of Satoru. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 16 would have been obvious over Tsuzuki in view of Reynolds and Satoru. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 12 (from which claim 16 depends).

XIII. Ground 7/7a: Claims 6, 11, and 17 Are Obvious Over Tsuzuki in view of Zing (or Tsuzuki in view of Reynolds and Zing)

263. It is my opinion that the subject matter of claims 6, 11, and 17 would have been obvious to a POSITA based on the teachings of Tsuzuki in view of the teachings of Zing.

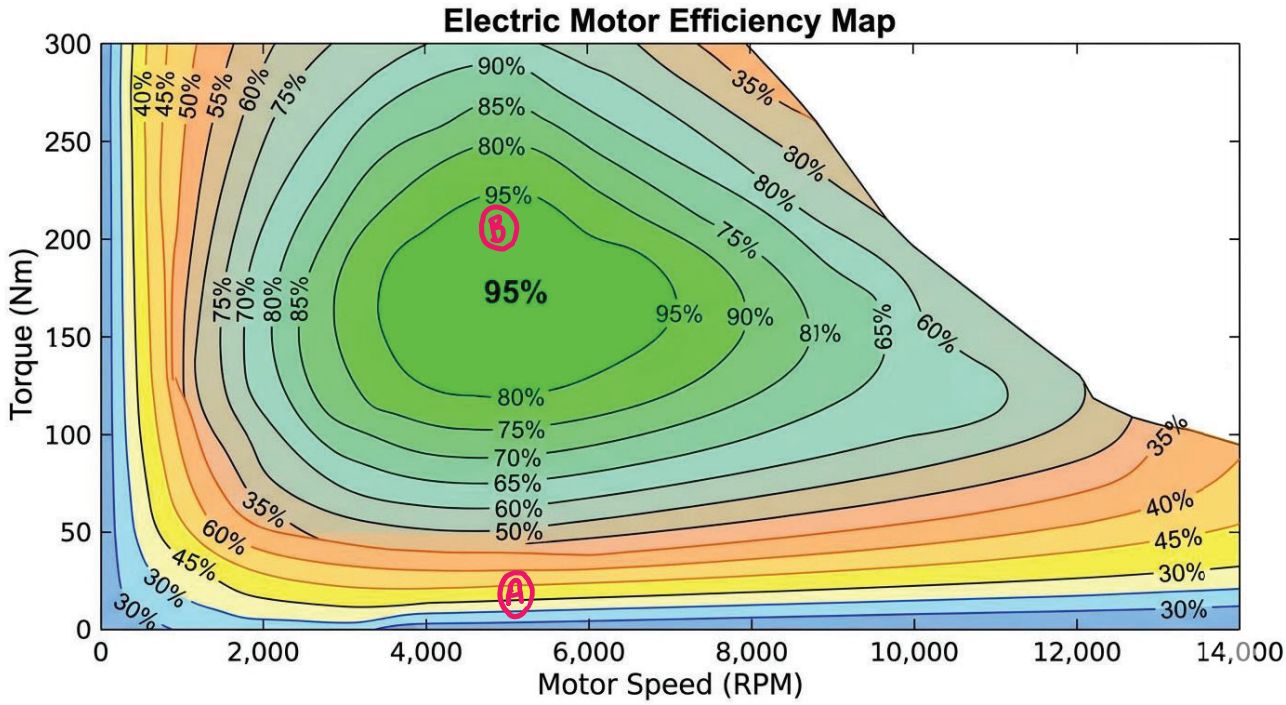
264. A POSITA would have been motivated to combine the teachings of Tsuzuki with the teachings of Zing—and would have had a reasonable expectation of success in making the combination—for a number of reasons.

265. Both of these references are directed to vehicle drive systems with at least two electric motors. *See, e.g.*, EX1005, abstract, EX1007, abstract. Accordingly, the references are in the same field of endeavor, and POSITAs would naturally have looked to them in their work. Moreover, a POSITA would have understood that the teachings of Tsuzuki would have been compatible and operable in combination with the teachings of Zing.

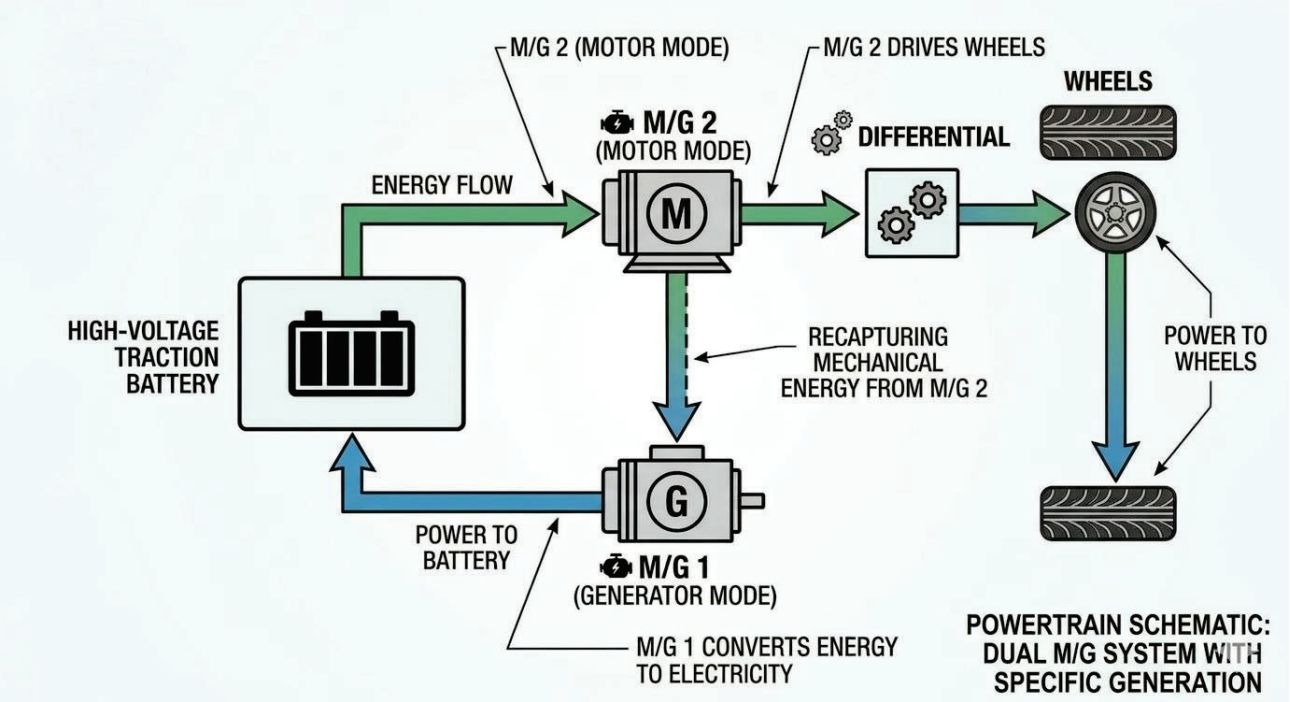
266. For example, a POSITA would have recognized that Tsuzuki values providing sufficient driving force over a wide speed range while also increasing energy efficiency. Tsuzuki, abstract. Zing specifically teaches a method of improving energy efficiency in a two-motor system by running one electric motor/generator at high output level where that motor/generator operates more efficiently, even at times when high output level is not needed, such as during cruising. EX1007, 13:62-14:19. Zing's method involves using the second electric motor/generator as a generator while the first motor/generator operates at a higher output level than necessary to drive the vehicle. *Id.* With Zing's method, the second motor/generator presents as a load to the first motor/generator and serves to recapture the excess energy from the first motor/generator that is not needed for purposes of driving the vehicle in that moment. *Id.* This allows the first motor/generator to run at a high output level (where it is most efficient) at all times.

267. As previously discussed in Section IV, each electric motor has a distinct characteristic map for its motoring and generating modes. An electric motor's efficiency map is a topographical graph that shows how efficiently a motor operates across its entire range of speeds and torques. The shape and contours of this map are shaped by several dynamic factors and losses within the motor. An electric motor's efficiency map depends on motor design and type, the inverter and control strategy, and also the types of motor losses. Several schematics are included here to better illustrate Zing's method. An example of an electric motor efficiency map is shown

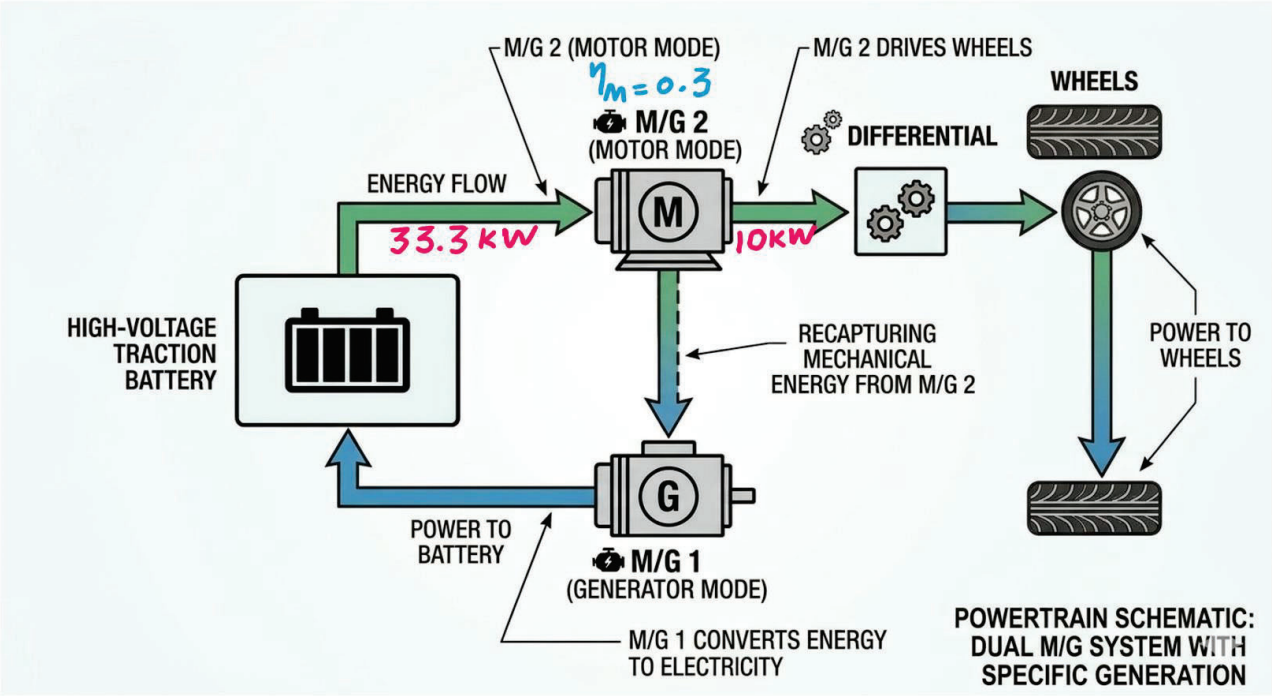
below. In this example, if the motor runs at low load (e.g., point A at 20 N.m), the motor efficiency can be as low as 30%, while if the motor runs at a higher load (e.g. 200 N.m), the motor efficiency will be 95%.



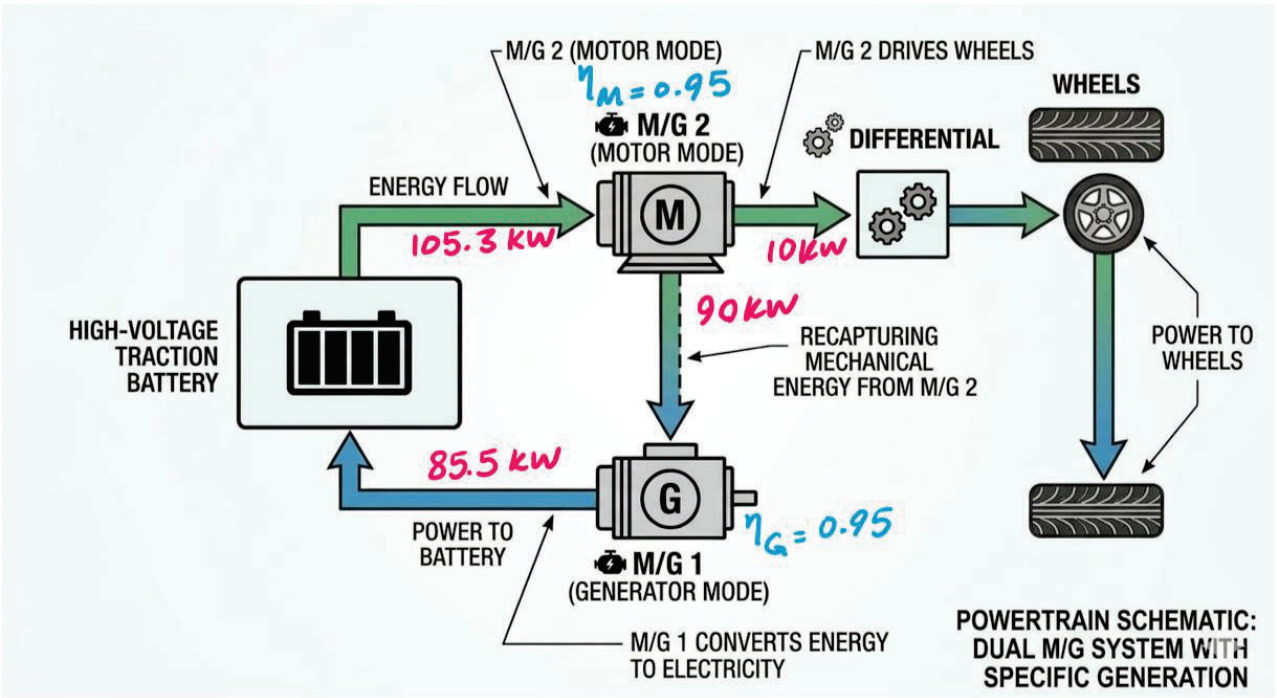
268. Zing's method discloses a "power and regenerate feature" in which the vehicle controller (ECU) runs the motor at higher load with peak efficiency, i.e., point A instead of running at point B with low efficiency. The excess mechanical power from the traction motor (e.g., M/G 2) is then transferred to the generator (e.g., M/G 1), which converts it into electrical energy to be stored in the battery. This process is illustrated in the following image:



269. Then Zing discloses an example to explain why the overall efficiency will be higher by using the "power and regenerate feature." Here, I illustrated two examples based on Zing's numbers that assume 95% efficiency for M/G 1 and M/G 2. As shown in the following figures, the overall efficiency in case B (i.e., power and regenerate feature) is 50%, while the efficiency in case A is 30%. Therefore, utilizing the "power and regenerate" feature improves overall efficiency from 30% to 50%—a 1.67-fold increase.



(A) Overall efficiency: $\frac{\text{Power delivered}}{\text{Net power taken from battery}} = \frac{10\ \text{kW}}{33.3\ \text{kW}} \times 100 = 30\%$



(B) Overall efficiency: $\frac{\text{Power delivered}}{\text{Net power taken from battery}} = \frac{10\ \text{kW}}{(105.3-85.5)\text{kW}} \times 100 = 50\%$

270. The values of efficiency and shape of contours in the efficiency map differ from one electric motor to another. In addition, the amount of losses for different components of the electric drive system will vary from one vehicle to another. However, the concept presented by the "power and regenerate feature" can be utilized whenever it provides energy savings.

271. Accordingly, a POSITA looking to improve efficiency while ensuring adequate driving torque under all conditions would have incorporated Zing's guidance regarding using one of the motor/generators as a generator when the full output level of the other motor/generator is not needed (*e.g.*, during cruising) into Tsuzuki's system. A POSITA would have been motivated to take advantage of these benefits by combining Zing's disclosures with those of Tsuzuki.

272. Ultimately, a POSITA would have been motivated to combine the teachings of Tsuzuki with those of Zing, and would have recognized that combining these teachings would have produced predictable and operable results.

A. Dependent Claim 6

6. The drive system of claim 1, wherein the EMS is further configured to enable the second electric motor to operate as a generator in the first mode of operation when the vehicle is cruising.

273. Tsuzuki does not expressly disclose that the EMS is further configured to enable the second electric motor to operate as a generator in the first mode of

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operation when the vehicle is cruising. However, Zing discloses this limitation. For example, Zing teaches:

> When a motor is used to deliver 10% or 20% of its rated output power level, the operation is not energy efficient. The efficiency can be as poor as 30%, versus an improved efficiency of 95% when the motor is running at a power level over about 60% of its designed load. In any of the embodiments described herein (i.e., those arranged serially or in parallel), operation using two motors can be used to improve efficiency, under a power and regenerate feature, described below.
>
> More particularly, the control logic 30 can be configured to control the multiple motors in such a way that one motor provides power at a high power output level, such as at 100% output, where it is more efficient than at a lower level. The second motor can be operating in a regenerating mode such that it works as a generator, which presents as a load to the first motor. The second motor "generator" (electrical) output can be captured and stored in an energy storage mechanism, such as a rechargeable battery (not shown). If the second motor absorbs, for example, 90% of the mechanical output from the first motor, then 10% of the mechanical output of the first motor is delivered to the output drive shaft 36. Accordingly, while only 10% of the first motor's mechanical output is delivered to the drive shaft, it is still operating (producing) at 100% of its mechanical output. Accordingly, energy is not being wasted.

EX1007, 13:62-14:19. Thus, Zing expressly teaches the concept of having one of two motor/generators operate as a motor and the other motor/generator operate as a generator when the full power of the first motor/generator is not needed. A POSITA would have understood that one situation where the full power of the first motor/generator is not needed is during cruising, *e.g.*, when Tsuzuki's system is

operating in the "second EV mode," as shown in Tsuzuki's Fig. 3. EX1005, Fig. 3. As discussed above, it would have been obvious to combine Zing's disclosure in this regard with Tsuzuki's system. In Tsuzuki's system as modified based on Zing, MG1 (the second electric motor) would operate as a generator in the first mode of operation when the vehicle is cruising. Accordingly, claim 6 would have been obvious to a POSITA based on Tsuzuki in view of Zing.

274. Therefore, the limitations of claim 6 are disclosed by Zing. Claim 6 would have been obvious over Tsuzuki in view of Zing. Further, in a scenario where the "power conversion device" of claim 1 is construed as excluding inverters, claim 6 would have been obvious over Tsuzuki in view of Reynolds and Zing. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 1 (from which claim 6 depends).

B. Dependent Claim 11

11. The electric drive system of claim 7, wherein the EMS is further configured to enable the second AC motor to operate as a generator when the vehicle is cruising.

275. *See* discussion of claim 6, *supra*. Claim 11 would have been obvious over Tsuzuki in view of Zing. Further, in a scenario where the "first inverter" and/or the "second inverter" are required to be separate from the "power conversion device" recited in claim 7, claim 11 would have been obvious over Tsuzuki in view of Reynolds and Zing. See Ground 3, *supra* for my discussion of combining Tsuzuki

and Reynolds in connection with independent claim 7 (from which claim 11 depends).

C. Dependent Claim 17

17. The drive system of claim 12, wherein the EMS is further configured to enable the second electric motor to operate as a generator in the first mode of operation when the vehicle is cruising.

276. *See* discussion of claim 6, *supra*. Claim 17 would have been obvious over Tsuzuki in view of Zing. Further, in a scenario where the "power conversion device" of claim 12 is construed as excluding inverters, claim 17 would have been obvious over Tsuzuki in view of Reynolds and Zing. See Ground 3, *supra* regarding combining Tsuzuki and Reynolds in connection with independent claim 12 (from which claim 17 depends).

XIV. Ground 8: Claims 1 and 12 Are Anticipated by Imai

277. It is my opinion that claims 1 and 12 are anticipated by Imai.

A. Independent Claim 1

Limitation [1.0]: A drive system for a vehicle, comprising:

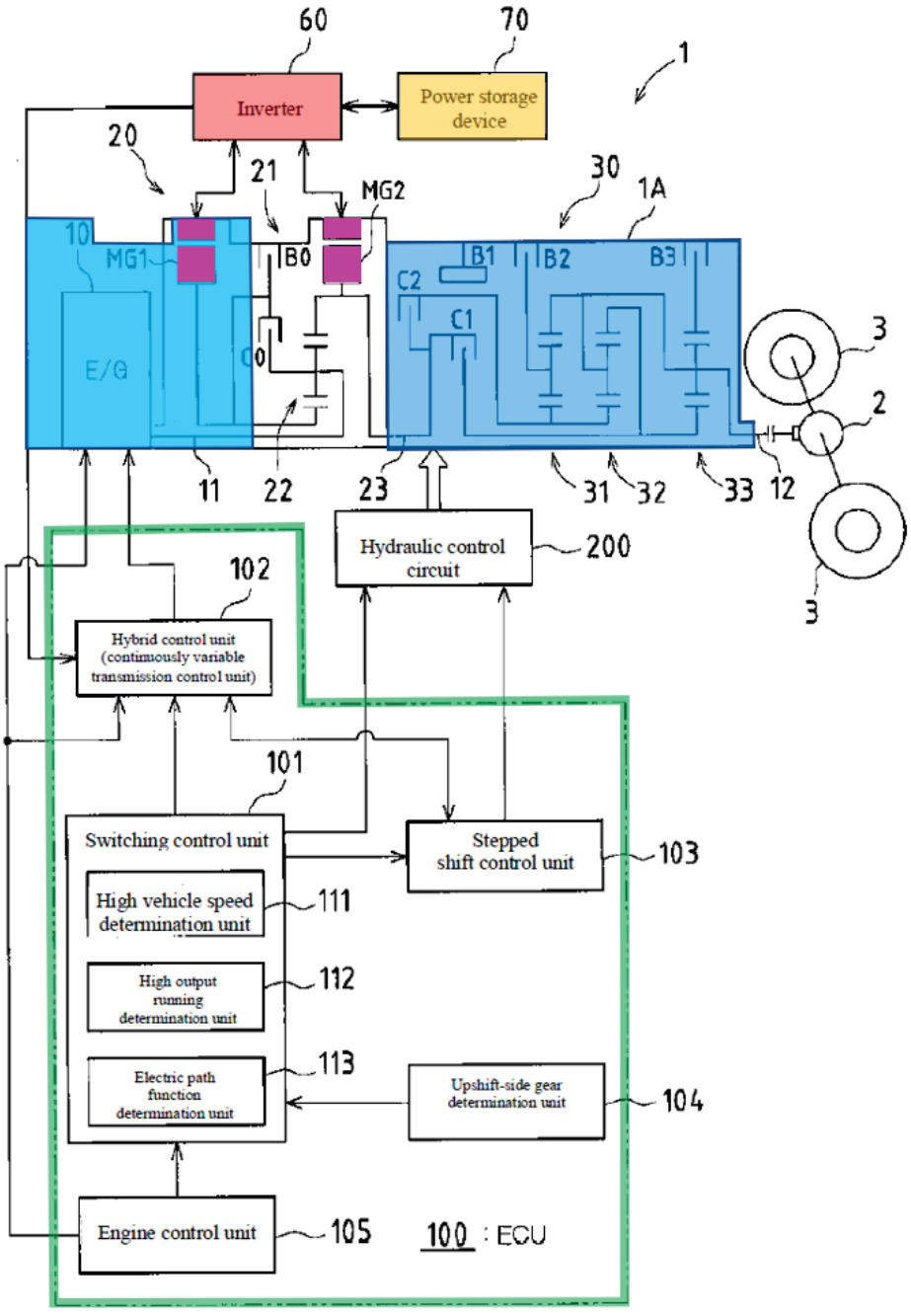
278. Imai discloses a drive system for a vehicle. For example, Imai discloses "a control device for a *vehicle drive device* comprised of an electric differential unit including a first electric motor, a second electric motor, and a differential mechanism…." EX1006, [0010] (emphasis added).

279. Therefore, limitation [1.0] is disclosed by Imai.

Limitation [1.1]: an energy storage system (ESS);

280. Imai discloses an energy storage system (ESS). For example, Imai discloses a "power storage device 70 (for example, a battery)." *Id.*, [0023]. This is shown in Imai's Fig. 5, annotated below:

[FIG. 5]



281. Therefore, limitation [1.1] is disclosed by Imai.

Limitation [1.2]: a power conversion device coupled to the ESS;

282. Imai discloses a power conversion device coupled to the ESS. For example, Imai discloses an inverter 60 coupled to the power storage device 70 in Fig. 5. *Id.*, [0063], [0077].

283. Therefore, limitation [1.2] is disclosed by Imai.

Limitation [1.3]: a first electric motor coupled to the power conversion device;

284. Imai discloses a first electric motor coupled to the power conversion device. For example, Imai discloses "second electric motor MG2" that can function as a motor. *Id.*, [0012]. MG2 is coupled to the power conversion device (inverter 60), as shown in Fig. 5.

285. Therefore, limitation [1.3] is disclosed by Imai.

Limitation [1.4]: a second electric motor coupled to the power conversion device;

286. Imai discloses a second electric motor coupled to the power conversion device. For example, Imai discloses "first electric motor MG1" that can function as a motor. *Id.*, [0012]. MG1 is coupled to the power conversion device (inverter), as shown in Fig. 5.

287. Therefore, limitation [1.4] is disclosed by Imai.

Limitation [1.5]: a transmission device coupled to the first electric motor;

288. Imai discloses a transmission device coupled to the first electric motor. For example, Imai discloses a transmission shaft 23 and mechanical transmission

unit 30 that are coupled to the first electric motor (MG2), as shown in Fig. 5. *Id.*, [0019].

289. Therefore, limitation [1.5] is disclosed by Imai.

Limitation [1.6]: a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets; and

290. Imai discloses a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets. For example, Imai discloses a power distribution mechanism 21 that is coupled to the transmission device 30 and second electric motor (MG1) and is comprised of one planetary set. *See* EX1006, Fig. 5, [0020]-[0022]. Imai also discloses "the power split mechanism 21 of the electric differential unit 20 is constituted by one set of planetary gear devices, however, the present invention is not limited thereto, and the power split mechanism of the electric differential unit *may be constituted by two or more sets of planetary gear devices…*". EX1006, [0135] (emphasis added).

291. Therefore, limitation [1.6] is disclosed by Imai.

Limitation [1.7]: an energy management system (EMS) configured to:

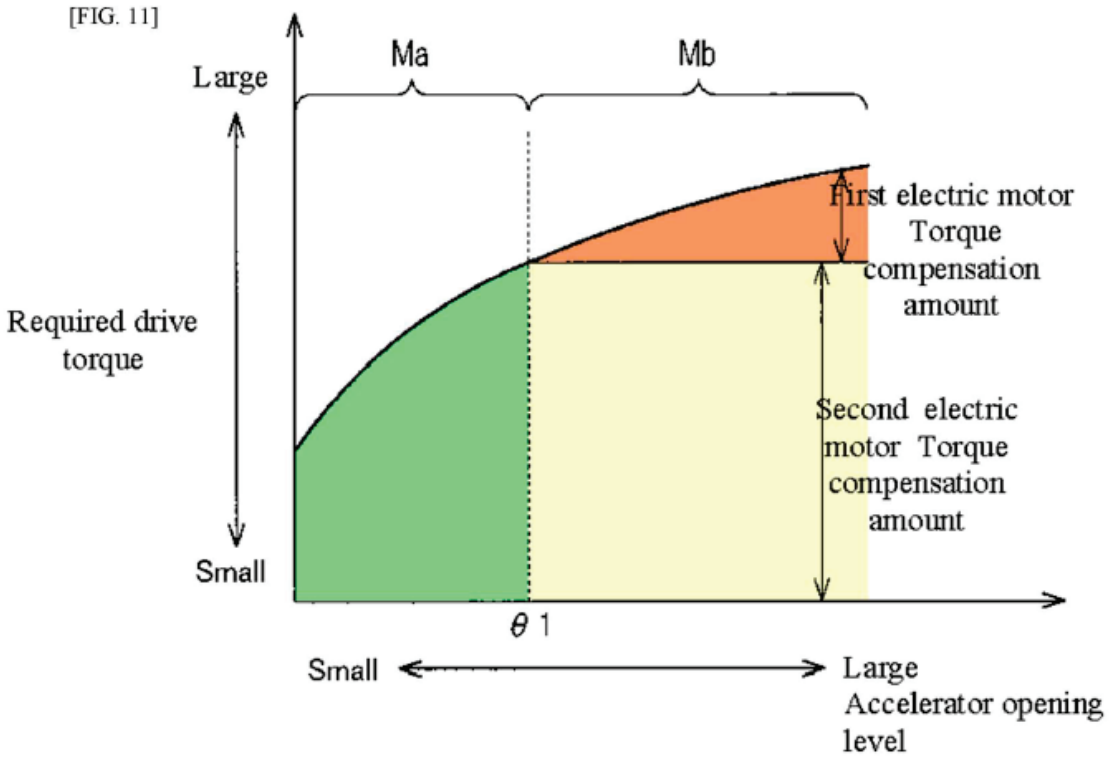
292. Imai discloses an "Electronic Control Unit," which corresponds to the claimed energy management system (EMS). For example, Imai teaches that "[t]he drive device 1 described above is controlled by **an ECU (Electronic Control Unit) 100** … The ECU 100 is provided with a CPU, a ROM, a RAM, a backup RAM, and

an input/output interface, etc., and executes the drive control of the engine 10, the first electric motor MG1, and the second electric motor MG2…" EX1006, [0051]-[0052] (emphasis added).

293. Therefore, limitation [1.7] is disclosed by Imai.

Limitation [1.8]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising;

294. Imai discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising. For example, Imai discloses that "in the region where running using only the second electric motor MG2 is possible (the region in which the drive torque does not exceed the upper limit torque of the second electric motor MG2), the first electric motor MG1 is not used, such that most of the motor running region can be motor running through the use of only the second electric motor MG2." EX1006, [0108]. This shown as region Ma in Imai's Fig. 11, annotated below:



Imai teaches that this region where only MG2 is used is a "low output region." *Id.*, [0007]. Imai further discloses that "only the second electric motor is used when the accelerator pedal opening degree is lower than the predetermined value." *Id.*, [0012], [0093]-[0095]. A POSITA would have understood that "cruising" is a relatively "low output region" that involves a relatively low accelerator pedal opening. Accordingly, a POSITA would have understood that Imai inherently discloses using only MG2 to drive the vehicle through the transmission device when the vehicle is cruising.

295. Therefore, limitation [1.8] is disclosed by Imai.

Limitation [1.9]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the

transmission device in a second mode of operation when the vehicle is starting; and

296. Imai discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting. As discussed above, Imai discloses using only MG2 to drive the vehicle in a "low output region," as shown in, *e.g.*, Fig. 11. A POSITA would have understood that "starting" could be located in a "low output region" that involves a relatively low accelerator pedal opening. For instance, consider a vehicle with a single occupant and no cargo starting on a flat road; the initial torque requirement is low. Accordingly, a POSITA would have understood that Imai inherently discloses using only MG2 to drive the vehicle through the transmission device when the vehicle is starting.

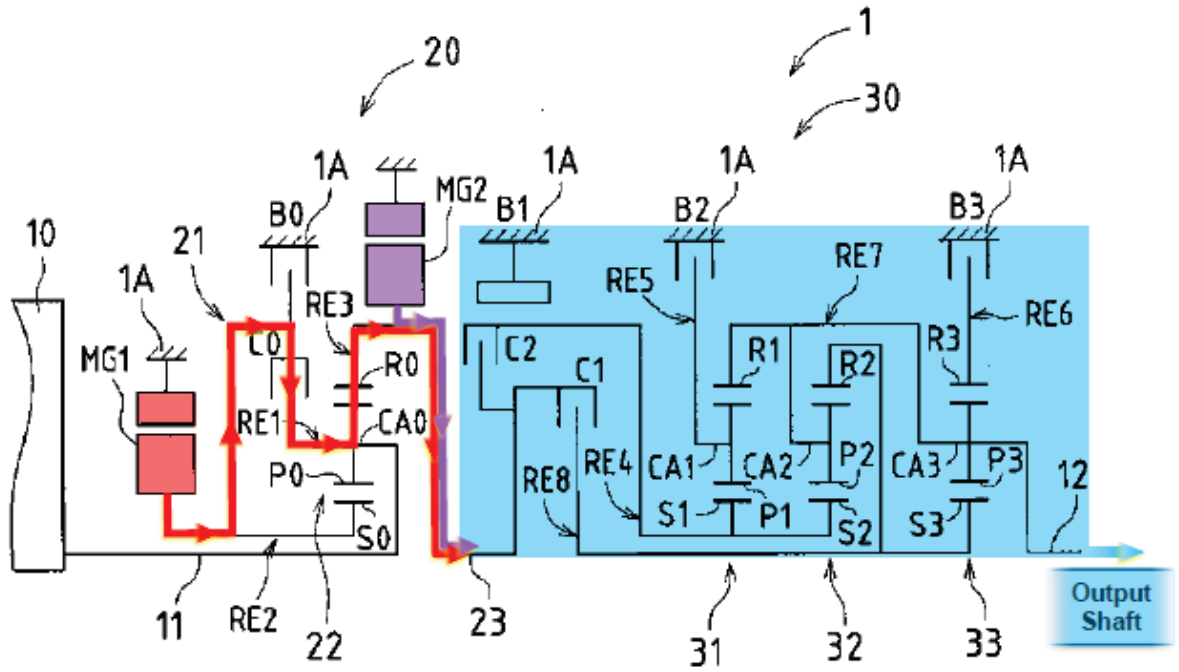
297. Therefore, limitation [1.9] is disclosed by Imai.

Limitation [1.10]: enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is accelerating.

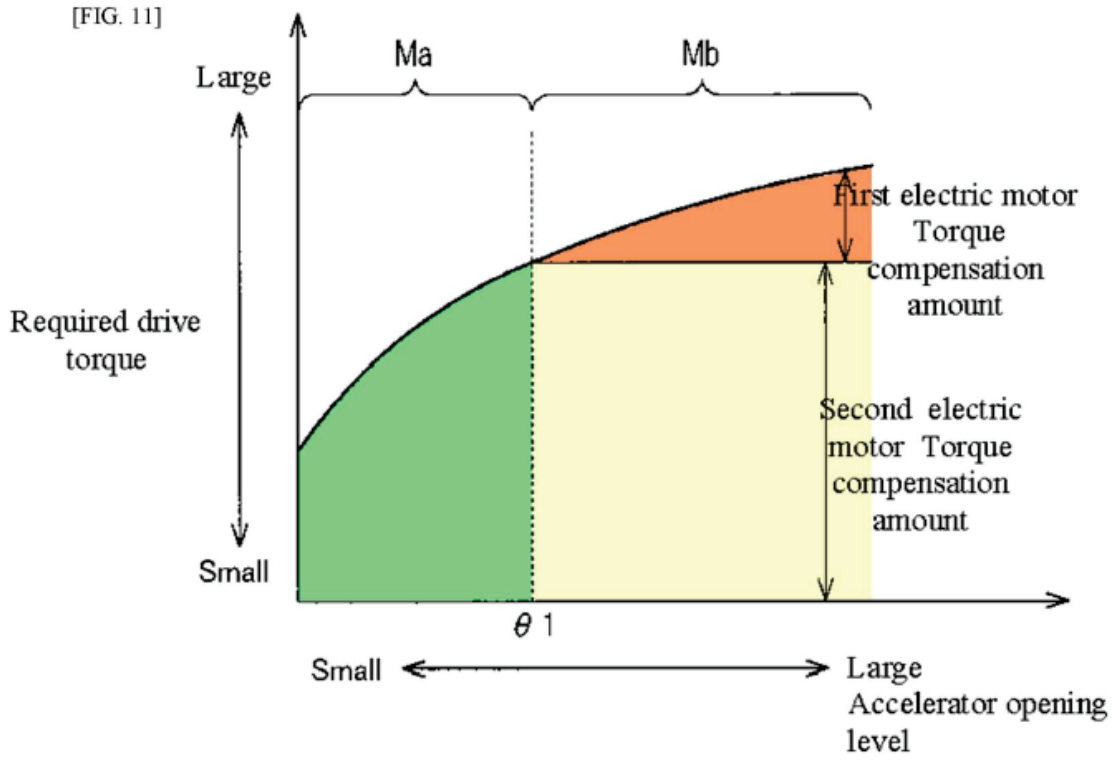
298. Imai discloses the conditions that both first and second electric motors act in motoring mode to propel the vehicle. "By engaging the clutch C0 in this manner, the sun gear S0, the carrier CA0, and the ring gear R0 rotate integrally, enabling motor running through the *use of both the first electric motor MG1 and the second electric motor MG2*." EX1006, [0099] (emphasis added). As shown in the

following annotated Figure 1, the power from the first electric motor (MG2) is transferred to the shaft 23 to go through the transmission device to propel the vehicle. The power from the second electric motor (MG1) goes through carrier CA0 to the power split device 21 that transfers the power to the output shaft 23 via the ring gear R0. The power from shaft 23 is transferred to wheels according to "the engagement operation table in FIG. 2, through the selective engagement of the switching clutch C0, the first clutch C1, the second clutch C2, the switching brake B0, the first brake B1, the second brake B2, and the third brake B3, any one of the gear stages from a first speed gear stage 1st (first gear stage) to a fifth speed gear stage 5th (fifth gear stage) is selectively engaged…". [EX1006], [0036].

[FIG. 1]



299. Imai discloses that its EMS is configured to enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is accelerating. For example, Imai discloses "the map Mb for the case where the first electric motor MG1 and the second electric motor MG2 are used is employed, and based on the accelerator opening level obtained from the output signal of the accelerator opening sensor 201 (FIG. 4), the map Mb is referenced to calculate the required drive torque, and the torque of the first electric motor MG1 is increased based on the calculated required drive torque (i.e., ***the first electric motor MG1 and the second electric motor MG2 are used in combination***), thereby ensuring a high drive torque that corresponds to the high torque demand caused by the depression of the accelerator pedal." [EX1006], [0100] (emphasis added). This is shown in Fig. 11:



300. Therefore, limitation [1.10] is disclosed by Imai.

B. Independent Claim 12

Limitation [12.0]: A drive system for a vehicle, comprising:

301. Imai discloses a drive system for a vehicle. *See* claim element [1.0], *supra*.

302. Therefore, limitation [12.0] is disclosed by Imai.

Limitation [12.1]: an energy storage system (ESS);

303. Imai discloses an energy storage system (ESS). *See* claim element [1.1], *supra*.

304. Therefore, limitation [12.1] is disclosed by Imai.

Limitation [12.2]: a power conversion device coupled to the ESS;

305. Imai discloses a power conversion device coupled to the ESS. *See* claim element [1.2], *supra*.

306. Therefore, limitation [12.2] is disclosed by Imai.

Limitation [12.3]: a first electric motor coupled to the power conversion device;

307. Imai discloses a first electric motor coupled to the power conversion device. *See* claim element [1.3], *supra*.

308. Therefore, limitation [12.3] is disclosed by Imai.

Limitation [12.4]: a second electric motor coupled to the power conversion device;

309. Imai discloses a second electric motor coupled to the power conversion device. *See* claim element [1.4], *supra*.

310. Therefore, limitation [12.4] is disclosed by Imai.

Limitation [12.5]: a transmission device coupled to the first electric motor;

311. Imai discloses a transmission device coupled to the first electric motor. *See* claim element [1.5], *supra*.

312. Therefore, limitation [12.5] is disclosed by Imai.

Limitation [12.6]: a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets; and

313. Imai discloses a power split device coupled to the transmission device and the second electric motor, the power split device comprising one or more planetary sets. *See* claim element [1.6], *supra*.

314. Therefore, limitation [12.6] is disclosed by Imai.

Limitation [12.7]: an energy management system (EMS) configured to:

315. Imai discloses an energy management system (EMS). *See* claim element [1.7], *supra*.

316. Therefore, limitation [12.7] is disclosed by Imai.

Limitation [12.8]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising;

317. Imai discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a first mode of operation when the vehicle is cruising. *See* claim element [1.8], *supra*.

318. Therefore, limitation [12.8] is disclosed by Imai.

Limitation [12.9]: enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the

transmission device in a second mode of operation when the vehicle is starting; and

319. Imai discloses that its EMS is configured to enable only the first electric motor of the first and second electric motors to operate as a motor to drive the vehicle through the transmission device in a second mode of operation when the vehicle is starting. *See* claim element [1.9], *supra*.

320. Therefore, limitation [12.9] is disclosed by Imai.

Limitation [12.10]: enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode.

321. Imai discloses that its EMS is configured to enable the first electric motor to operate as a motor to drive the vehicle through the transmission device and enable the second electric motor to operate as a motor to drive the vehicle through the power split device in a third mode of operation when the vehicle is in an uphill mode. *See* claim element [1.10], *supra*. Also, Imai discloses:

> Here, even when the EV switch is OFF (the determination result in step ST101 is negative), if there is an input limitation Win on the battery device 70, the region where driving by the engine is possible and the available drive torque become limited, and therefore ***running using both the first electric motor MG1 and the second electric motor MG2 (combined running) may be necessary***. That is, when the input limitation Win is present, the engine 10 cannot be started, and therefore, for example ***during steep uphill driving***, it may become necessary to secure drive torque by motor running.

EX1006, [0101] (emphasis added). Accordingly, Imai expressly teaches that both electric motors operate as motors to drive the vehicle when the vehicle is in an uphill mode, *i.e.*, during "steep uphill driving." *Id.*

322. Therefore, limitation [12.10] is disclosed by Imai.

XV. Ground 9: Claims 1 and 12 Are Obvious Over Imai in view of Reynolds

323. As discussed above in Ground 8, I believe that claims 1 and 12 are anticipated by Imai. However, it is also my opinion that the subject matter of claims 1 and 12 would have been obvious to a POSITA based on the teachings of Imai and Reynolds.

324. Ground 8 above is incorporated here by reference. Further, to the extent that the claimed "power conversion device" is narrowly construed so as not to encompass an inverter, claims 1 and 12 would still have been obvious over Imai in view of Reynolds. In particular, it would have been obvious to a POSITA to incorporate the DC-DC converter taught by Reynolds (denoted as VVC 82) into the powertrain disclosed in Imai. A POSITA would have been motivated to make this combination to achieve the benefits explicitly described in Reynolds, namely boosting the battery "voltage to a higher level voltage in an HEV drivetrain system for multi-purposes such as, but not limited to, torque capability optimizations for electric machines, system loss optimization, and so on." EX1010, ¶ 0024.

325. In particular, if the "power conversion device" is construed as needing to be something other than an inverter, then the "power conversion device"

corresponds to a DC-DC converter as disclosed in Reynolds. Imai's inverter would then be separate and distinct from the power conversion device in the combined system. And the power conversion device would be coupled to the first and second electric motors (via Imai's inverter) and the ESS, as required by claims 1 and 12. Thus, independent claims 1 and 12 would have been obvious over Imai and Reynolds.

326. A POSITA would have found it obvious to combine Imai and Reynolds. In particular, both references are in the same technical field. Thus, Imai and Reynolds are analogous references, and a POSITA would have found combining these references to be one of a finite number of identified means for transferring energy between multiple energy storage devices and electromechanical devices in EV and HEV vehicles, and further, would have had a reasonable expectation of success in combining their teachings.

327. Reynolds discloses a DC-DC converter coupled to an energy storage device. "Electrical power stored in battery 46 is sent through a DC-DC voltage converter to modify the vehicle voltage level according to the devices being powered. The variable voltage control (VVC) 48 converts the DC voltage level of battery 46 to the DC desired voltage level of high-voltage electrical bus 50." EX1010, ¶ 0013; *see also* Fig. 1.

328. It would have been obvious to a POSITA to incorporate Reynolds's D-DC converter into Imai. A DC-DC converter is a standard device for converting direct current from one voltage to another. For hybrid and electric vehicles, it was

well known in December 2012 that a DC-DC converter could be used to manage power flow between a battery and other systems. *Id.* For example, a DC-DC converter can step-down (buck) high voltage (*e.g.*, 250 V) from a battery to a lower voltage (*e.g.*, 12 V) for powering onboard devices such as lights, infotainment systems, or other accessories. *Id.* A DC-DC converter can also step-up (boost) voltage, *e.g.*, from 250 V to 650 V to supply high power to electric motors via an inverter when it is necessary (*e.g.*, during heavy accelerations). This will allow an automotive manufacturer to use a smaller, lighter physical battery pack while still achieving high-performance motor output. A POSITA would have at least been motivated by Reynolds to incorporate a DC-DC converter using variable voltage control (VVC) into the powertrain of Imai to buck or boost voltage to/from the vehicle battery as needed, as shown by Reynolds's teaching that "battery 46 further includes a two-way electrical connection, such that it can also receive and store energy provided through regenerative braking, for example, and then supply the energy to an electric machine." EX1010, ¶ 0017. Figure 5 of Imai also shows a two-way electrical connection between energy storage device (battery) 70 and inverter 60. Accordingly, it would have been obvious to a POSITA to include the DC-DC converter taught by Reynolds in the powertrain disclosed in Imai to power onboard devices as well as turn braking energy back into electricity for charging the battery.

329. Accordingly, in a scenario where the "power conversion device" is construed as needing to be something other than an inverter, the "power conversion device" corresponds to the DC-DC converter of Reynolds as combined with Tsuzuki.

330. Thus, claims 1 and 12 would have been obvious over Imai and Reynolds.

XVI. CONCLUSION

331. For the reasons set forth above, claims 1-17 of the '508 Patent are unpatentable in view of the prior art.

332. In signing this declaration, I recognize that it will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the USPTO. I also recognize that I may be subject to cross-examination in the case. If cross-examination is required of me, I will appear at the allotted time.

333. I reserve the right to supplement my opinions in the future to respond to any arguments that the Patent Owner raises and to consider new information as it becomes available to me.

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

Date: April 6, 2026

M. Shahbakhti

Mahdi Shahbakhti, Ph.D.