DECLARATION OF DR. MARK EHSANI RE U.S. PATENT 7,626,349

1. My name is Dr. Mark Ehsani. I am over the age of twenty-one (21) years, of sound mind and capable of making the statements set forth in this Declaration. I am competent to testify to matters set forth herein. All the facts and statements contained herein are within my personal knowledge and they are, in all things, true and correct.

2. My experience and education are detailed in my curriculum vitae, which is attached as Appendix 1 to this report.

3. I hold BS and MS degrees in electrical engineering from The University of Texas at Austin and a Ph.D. in Electrical Engineering from University of Wisconsin-Madison.

4. I am currently a tenured Professor in the Department of Electrical and Computer Engineering and the director of the Power Electronics and Motor Drives Laboratory and Advanced Vehicle Systems Research Program at Texas A&M University. I am also the director of the National Science Foundation Efficient Vehicles and Sustainable Transportation Systems (EV-STS) Center. Prior to my position at A&M, I held professional research engineering positions at Argonn National Lab, in Chicago Illinois and the Fusion Research Center at the University of Texas at Austin. I have published over 370 papers in refereed conferences, and

journals in the areas of energy systems, power electronics, motor drives, and electric and hybrid electric vehicles, and other areas of control, storage, and use of electric power and energy systems. I am also the co-author of 17 books on the above topics. During my over 33 years of employment at A&M, I have originated and taught over eight different undergraduate and graduate electrical engineering courses on a variety of topics including power electronics, motor drives, dc power systems, electric and hybrid electric vehicles, sustainable energy and transportation systems, and industrial practice of electrical and computer engineering.

5. As detailed in my curriculum vitae, I have received, among other awards, the "Avant Guard Award" from the Vehicular Technology Society of Institute of Electrical and Electronics Engineers (IEEE), the IEEE Undergraduate Teaching Award and have received several distinguished research paper awards, in the area of power electronics and motor drives. I have been elected as a Fellow if Institute of Electrical and Electronics Engineers as well as a Fellow of Society of Automotive Engineers (SAE) for my original contributions the advancement the art in the above technical fields.

6. I have presented many invited short courses on the advanced control of AC permanent magnet motor drives, including AC vector control technologies at the international conferences of Institute of Electrical and Electronics Engineers,

IEEE, conferences, and other forums. These include an Invited Seminar to the Local Chapter of IEEE in Istanbul, Turkey on "State of the Art in Power Electronics and Motor Drives," August 27, 1998; Invited Short Course in IEEE Applied Power Electronics Conference and Exposition, Dallas, Texas, March 1995: "Electric Drives in Electric and Hybrid Vehicles"; Invited Short Course at GM Proving Grounds in Milford, MI and Mesa, AZ, September/October, 1995: "Electric Drives in Electric and Hybrid Vehicles"; Invited Short Course at Hanyang University, Seoul, Korea, June 26, 2000: "State of the Art of Brushless DC Motor and Switched Reluctance Motor Drives"; Sensorless Brushless DC Motor Drives for Integrated in-line automotive Pump Applications, Short course given at EMP Corp. Escenaba, Michigan, August, 2004; "Control of BLDC Machines with Improved Performance", U.S. Army Vetronics Institute 3rd Annual Winter Workshop, Jan 13, 2004, U.S. Army Tank-Automotive RD&E Center Warren, MI; "Control of the BLDC machine with improved performance", Short Course, June 2004, Tel Aviv University, Israel; and " Short Course on Advanced Controls for Brushless DC Motor Drivres," IEEE Applied Power Electroncis Conference, Dallas, Texas, March, 2006.

7. I am familiar with the knowledge and capabilities one of ordinary skill in the art of motor control. Specifically, I am familiar with the understandings of

one of ordinary skill in the art in the period of the invention of U.S. Patent No. 7,626,349 (hereinafter "the '349 Patent") and my testimony herein when referring to one of ordinary skill refers to that period.

8. In my opinion, a person of ordinary skill would have had at least a Master's degree in electrical engineering, some specialization in electric motor drives or a Bachelor's Degree in electrical engineering and approximately two years of academic or industry experience in electric motor drives including experience concerning power electronics, motor drives, and controls.

9. I am being compensated by the petitioner of the *Inter Partes* Review (IPR) of the '349 Patent for my assistance with its and, specifically, for my time spent reviewing documents in association with the IPR and in preparing my testimony.

State of the Art

10. By the mid-1990s, about a decade before the provisional application to which the '349 Patent claims priority was filed, permanent magnet synchronous motors ("PM Motors") were well understood and widely used in virtually every motor application. For example, PM Motors were used in applications ranging from hard disk drives to a variety of industrial and military uses.[1]

[1] *See* e.g. Duane C. Hanselman, Brushless Permanent-Magnet Motor Design, at Preface (McGraw-Hill 1994). Ex. 100X.

11. PM Motors are electronically commutated, meaning that the windings of the motor are energized electronically based on the position of the rotor, rather than by using brushes (as in a DC motor). By 2007, the control of PM Motors had been well studied and widely understood. For example, in 1985 I developed a graduate course, named Motor Drive Dynamics, as part of my electronic motor drives curriculum at Texas A&M University. This course included the control of PM Motor drives, including AC permanent magnet and hybrid AC permanent magnet motor drives, using vector control and sinusoidal commutation techniques, as well as others. This course has been in continual teaching at Texas A&M up to the present and is part of the catalogue of the graduate courses at Texas A&M.

12. One method of controlling PM Motors is called vector control, which uses a rotating frame of reference. The rotating frame of reference simplifies the mathematical representation of the motor control and allows for precise control of the motor. Vector control was well developed to the level of being present in many textbooks and university courses and has existed for over 25 years.

13. The concept of vector control, which typically uses d and q current components, arises from the following simple principle. In every electric motor torque arrives from the interaction of two magnetic fields, one originating from the stator and one originating from the rotor. Under ideal conditions these two

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