INVENTIONS & INNOVATION

Project Fact Sheet

A DSP-Based Power Electronics Interface for Alternate/Renewable Energy Systems

Digital-signal-processor-based control provides grid-tied inverters with greater flexibility, speed, and reliability

Benefits

- Maintains stiffness of AC voltages at the point of common coupling, regardless of variation in the input DC bus voltage
- Faster response results in higher performance
- Uses fewer components
- Increases reliability
- Offers flexibility of control to upgrade or modify control algorithms to meet specific system requirements
- Costs less to implement than conventional technologies

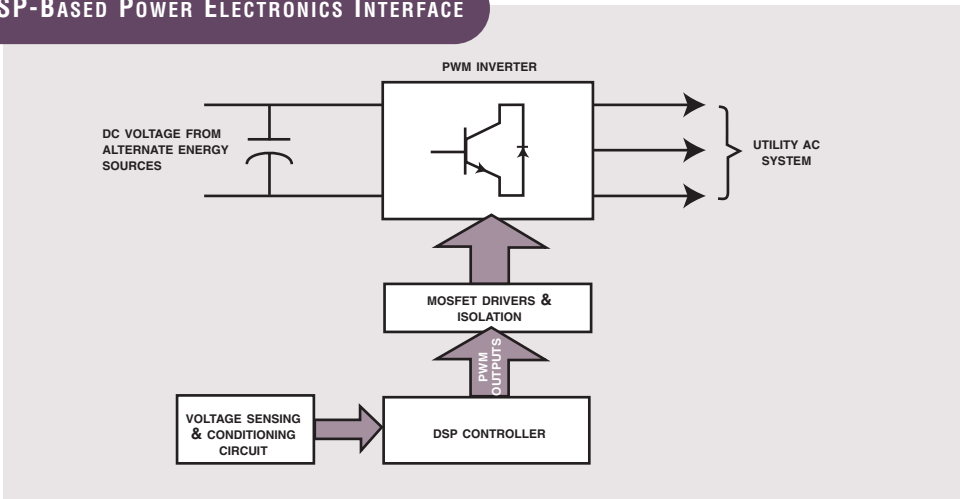
Applications

The DSP-based grid-tied inverter will have immediate applications in the renewable energy industry, where alternate energy systems, notably photovoltaics and wind, are being interconnected with the electric utility grid in the United States, Europe, and other industrialized countries.

An inverter converts direct current (DC) into alternating current (AC) by mechanical or electronic means and makes renewable resources and energy-storage systems utility interactive. Inverters are basic components on most small and large energy systems that convert low-voltage DC power generated from a renewable energy source into higher-voltage AC power required for many residential, commercial, and industrial applications. Grid-tied inverters are required in energy systems that produce or store electric energy in DC form and transfer that energy to or from an AC power system. Typical energy systems include solar photovoltaics (PV), wind turbines, batteries, and fuel cells. Grid-tied inverters were considered unreliable when they were first commercially introduced in the early 1980s. Their problems were attributed to the lack of quality control that comes from mass production.

A new grid-tied inverter technology is based on the use of a state-of-the-art Texas Instruments digital signal processor (DSP) controller and the inventor's proprietary software. The advantages expected from a DSP-based control algorithm include increased reliability, fast response resulting in high performance, low cost of implementation, and flexibility of control. In addition, the proposed control will be capable of maintaining stiffness of the AC voltages at the point of common coupling, regardless of variation in the input DC bus voltage, without any additional costs or components.

DSP-Based Power Electronics Interface



The DSP-based electronics interface can be upgraded or modified to meet system requirements without additional components.

Project Description

Goal: The project goal is to move the invention toward the creation of proprietary software and a laboratory prototype for further testing.

According to Trace Technologies Corporation, the largest domestic manufacturer of inverters for wind and PV systems above 50 kW, grid-tied inverter technology for industrial applications has evolved in three major areas since its inception. These areas are: 1) power semiconductors, such as insulated gate bipolar transistors; 2) magnetics, including transformers and inductors; and 3) embedded controls, in particular the DSP. While some products are still based on older, analog-type controls, Trace Technologies believes all inverter technology needs to move to DSP.

Most of the technology innovations in this decade have occurred in the first two areas, resulting in greater efficiencies and cost reductions. The industry's leading manufacturer has used the same basic DSP technology since the early 1990s and reports it is still performing well, but sharp reductions in DSP prices, along with much greater functionality, have caused this dominant inverter manufacturer to take another look at its DSP modules. The proposed DSP-based grid-tied inverter is an option to fill this company's need for state-of-the-art inverter controls. In particular, the new technology's design might be readily adapted to various system applications. The proposed DSP-based control promises flexibility, as well as higher efficiency and reliability, without adding cost.

The University of Houston is developing this technology with the help of a grant funded by the Inventions and Innovation Program in the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

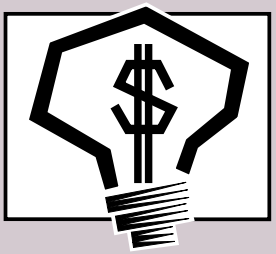
- The inventor has been working with technical staff at Texas Instruments, the DSP developer. Texas Instruments, in support of this technology-development program, has committed both hardware and software. TMS320F24XX, a fixed point DSP by Texas Instruments, is being used to implement the control algorithm.
- At the conclusion of the DOE project, software will be developed and a proof-of-concept laboratory prototype will be fabricated and optimized.
- Patent protection will be sought by the inventor at a future date.
- Project results will be disseminated at the Institute of Electrical and Electronics Engineers' (IEEE) conferences and through IEEE journals at the completion of the project.

Economics and Commercial Potential

According to industry representatives, unofficial estimates for the domestic market for grid-tied inverters is about $10 million to $19 million. However, the European market for utility-tied inverters is estimated to be five times as large as the U.S. market–approximately $50 million to $100 million–and while it is growing at a slower rate, its growth is more steady. The Asian market, Japan in particular, has the highest demand for grid-tied inverters, but production is almost exclusively consumed internally by government-supported solar electrification programs.

The Sacramento Municipal Utility District (SMUD) is the largest U.S.-based PV grid-tied residential project with 450 household installations, accounting for an estimated 90% of utility-tied residential system installations in the United States. BP Solar in Spain is installing grid-tied PV on its gas/convenience establishments and has recently placed 200 orders with the largest U.S. grid-tied inverter manufacturer. In both instances, grid-tied PV (and other renewable energy) programs are being implemented to capture distributed-generation benefits and test new business opportunities. The result is an acceleration of grid-tied commercialization opportunities.

While the commercial potential for grid-tied inverter technology is still relatively modest, research suggests that demand could grow exponentially in the next two decades if renewable energy resources become firmly established in the marketplace as an essential part of the domestic utility industry's fuel-source portfolio.



The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

Project Partners

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