INNOVATIVE POWER SOLUTIONS INC.

SUMMARY

Innovative Power Solutions is a consulting engineering company specializing in power electronics. Innovative Power Solutions was founded by Dale Tardiff to provide power electronics expertise industrial and utility clients. Power Electronics is an enabling technology used extensively to increase productivity, reduce costs, & solve technical challenges for industrial applications. It is the application of innovative power conversion and control technologies to control electrical energy for your purposes. IPS offers 25 years industry & field experience offering power electronics solutions across industrial, transportation, communications, petroleum and renewable and remote power generation sectors.

About Dale Tardiff, President and Power Electronics Specialist

- ✓ Professional Engineer with 25 years engineering experience.
- ✓ Received MSc in Electrical Engineering from the University of Calgary (1990), specializing in power electronics.
- ✓ Industry experience includes transportation (railway and aerospace), chemical process, telecommunications, medical and instrumentation, remote power generation, alternative energy, and transient voltage surge suppression.
- ✓ Past Chair of IEEE Southern Alberta IAS/PES chapter.
- ✓ Member of CSA 22.2 No 107.1 (Power Conversion Equipment) Technical Subcommittee, and IEEE 1566 (Performance of Adjustable Speed AC Drives 375 kW and larger).

INNOVATIVE POWER SOLUTIONS DELIVERS:

1. Design for durability and reliability. 25 years of designing, building, testing and commissioning power electronics provides the knowledge and experience needed to avoid pitfalls and deliver a reliable, long lasting design.
2. Proven track record of performance for delivering successful, tested, documented solutions for difficult industrial applications.
3. Can bring other consultants to the table with expertise in controls, standards and regulatory compliance, etc.

Further details available at www.innovativepower.ca
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MOTOR DRIVE PROJECTS

400 kW DC traction motor drive for railway applications

Problem: Develop a reliable, high current DC chopper for a 500 hp railway traction drive application. Existing drive had a >20% failure rate and peak current of 1350A.

Solution: A new DC chopper was designed to meet the requirements. A thorough test plan was developed and implemented to fully validate the design for difficult conditions. Result was a 1200VDC, 1500A air cooled DC chopper. Thermal design considerations were critical to solve this problem and ensure a reliable product. Also, proper device selection (IGBT and fast recovery diode modules) and careful buss bar design were critical for the overall design integrity.

Results: A successful product was developed for a demanding application and the new design reduced failure to <5%. This project is an example of the results possible when power electronics are designed specifically for the application as opposed to using generic, off the shelf solutions. These drives entered service in 2009.

Device for mitigation of reflected waves in motor-drive applications

Problem: In many adjustable speed drive applications with long cables to the motor, voltage transients known as 'reflected waves' can develop at the motor, resulting in damage to the motor.

Solution: A device was developed and patented (Reflected Wave Trap, US Patent 5784236). This device used technologies from surge suppression to provide a voltage clamping device for the motor terminals that successfully mitigated reflected waves.

Results: Applications employing this device experienced a reduction in motor failures. The device was commercially available in 1998. Although the device and its technology are obsolete today, the research in developing this device provided much insight into the causes and effects of adjustable speed drive (ASD) related motor failures. This is 1 of several possible solutions to the reflected wave problem. As ASD technology advances, reflected waves paradoxically start developing in systems that were previously immune.

10 hp Motor Drive Inverter

Problem: Build an inverter capable of driving a 10 hp induction motor. The technology available at the time was bipolar junction transistors.

Solution: An inverter was build based on bipolar power Darlington transistors. Crucial design elements were transistor gate drives and snubber circuits. The snubber circuit was regenerative: power was recovered instead of being dissipated in resistors. This resulted in a 25% reduction in power losses in the inverter.

Results: The inverter is still operational 25 years after being put in service. This inverter was used by the power electronics group at the University of Calgary for many years in motor control research, being 'retired' when it was superseded by newer and better technology. Many of the fundamental design concepts (gate drives, regenerative snubber circuits) are still applicable with

modern power converter topologies.

INDUSTRIAL POWER SUPPLIES

22 kW power supply for locomotive applications

Problem: Replace an obsolete 12kW supply with a new design increasing the power output by 80% using the same physical envelope as the previous supply.

Solution: The redesigned supply used the latest power supply topologies and devices to meet the requirements. This allowed operation at a higher switching frequency permitting smaller magnetics to be used. Also, the control system was updated to use battery voltage and temperature feedback to properly charge the batteries.

Results: The supply went into service in 2012. Prior to this it was thoroughly tested on a locomotive with the 'worst case' scenario created. It met or exceeded all requirements.

2000VDC 100A SCR power supply

Problem: Build a high voltage variable output power supply for a test facility using existing rectifier controller and transformer.

Solution: Thyristors (SCRs) were selected for this power supply. A rectifier controller was already available to drive a 3 phase SCR bank. Development included SCR selection, heat sink and snubber design, and isolated gate trigger circuits for the SCRs. During commissioning voltage sense and control signals were examined and shielded where required to give reliable operation.

Results: Power supply has been in service since 2008. It is used regularly for manufacturing testing as well as R&D purposes.

RENEWABLE ENERGY PROJECTS

Electrical System Design for 100 kW Concentrated Solar Power (CSP) system

Problem: 100 kW CSP unit required electrical power, instrumentation and control wiring suitable for the application. The system would be deployed outdoors, often in desert conditions. The electrical system monitored instrumentation and powered the hydraulic motion control and tracker system.

Solution: Worked with mechanical design and manufacturing teams to design an electrical system to meet the environmental and utility requirements. The unit was a self-contained pedestal with combiner boxes and a grid interconnected inverter. Among the challenges was designing for outdoor use for a variety of conditions (UV exposure, temperature extremes, dust and possibly rain in some deployments.)

Results: This was a 100 kW CSP system capable of being manufactured in volume. This project showcased the client's new solar panel technology.

Electronic braking circuit for 1 kW wind turbines

Problem: Client had developed a 1 kW wind turbine. However, existing devices to provide braking were unreliable and did not meet agency approvals.

Solution: A prototype braking circuit was designed, built and tested successfully. A rectifier and SCR circuit was designed to safely load the generator during braking events. Detailed analysis was done to determine the requirements and ensure reliable operation in worst case conditions.

Results: The brake prototype was successfully tested by manufacturing and met their requirements. Unfortunately, the client went out of business before the devices could be deployed in commercial applications.

Electrical Design for Alberta Solar Showcase Solar Power System

Problem: To win a competitive bid for a demonstration solar project, and provide engineering support for the project.

Solution: Reviewed the tender and examined the site to determine requirements. Roof of the facility was new, so they did not want a system that involved any fixed to the roof. Worked with electrical contractor to propose an awning mount over the parking lot and create a successful bid. Provided engineering support and prepared the drawing package for the project.

Results: Project was successfully completed in 2007, and is in service at the Town of Westlock.

Troubleshooting of Resort Solar Power System

Problem: A recently installed solar PV system was experiencing unexpected shutdowns.

Solution: The electrical system for the resort was examined, and a single line diagram created. The system loads were compared to the capacity of the solar PV system. The system was monitored for several days in an attempt to capture voltage and current waveforms for suspect loads when there was a shutdown.

Results: There were 2 pumps that were suspected of causing the shutdowns. Further testing confirmed inrush current for 1 of the pumps was high enough to trigger a system shutdown. Steps were taken to mitigate the inrush current for the pump, greatly increasing system reliability.

Generator Instrumentation and Control Panel

Problem: 150 kW gas generator used new technology to significantly reduce emissions. To validate the early prototypes, a comprehensive instrumentation and control system was required.

Solution: Instrumentation and control electronics was specified and procured. A custom data acquisition and monitoring system was also obtained for the project. This project involved the design of an electrical interconnect system for the data acquisition, instrumentation and control electronics. The electrical system interconnected the instrumentation with the control and data acquisition electronics, and was designed for harsh environmental and service conditions.

Results: The new instrumentation and control system greatly simplified engine start up and allowed the engine developers to understand and monitor the system performance. It replaced the obsolete analog instrumentation from the original gensets.

POWER ELECTRONICS FOR SPECIAL APPLICATIONS

Magnetic Bearing Power Amplifier

Problem: A power amplifier was required for 72V, 8A high performance magnetic bearing system.

Solution: A power MOSFET based power amplifier was developed to interface with the clients existing control technology. A significant thermal challenge was cooling 40 power MOSFETs in the small enclosure. The control loop was very sensitive to noise; therefore careful layout and filtering were required to minimize noise in the feedback and power MOSFET drive circuits.

Results: Developed a highly reliable system that greatly exceeded the performance of existing technology. A significant improvement was that application engineers could commission the system in less than 1 hour vs. 1 – 2 days using off the shelf amplifier technology.

Spark ignition circuit for natural gas generators

Problem: A spark igniter was required for a Thermoelectric natural gas generator. Existing solution was an off the shelf ignitor that was being discontinued.

Solution: Magnetics design was a key aspect of this project. The spark was generated by a high voltage spark transformer, which was sourced from a specialist vendor. A capacitor on the spark transformer primary was discharged to provide the spark. This capacitor needed to be charged in steps, which required a pulse transformer and circuit to 'step' charge the capacitor. A unique technology used was a flame detection method used to inhibit sparking once the burner was lit.

Results: The circuit was designed and tested and shown to meet the requirements. This provided an in house solution for the client preventing potential supply disruptions.

OTHER PROJECTS

- Wiring and interconnect systems for cellular telecommunications enclosures. Multiple projects involving close collaboration with the enclosure design team. Particular requirements for these systems included outdoor operation in a variety of climates. The project also had to meet requirements of telecommunications electrical codes. Project deliverables included a comprehensive documentation package for manufacturing.

- Electrical enclosure for advanced router. Client incorporated new technology to create a high end telecommunications router. Project had a tight schedule to meet launch date. Worked with enclosure and cooling design team to design internal power distribution system and interconnect. Project successfully launched on time and went into production.

- Chemical Analyser electrical system design. Specified power supplies and designed

electrical interconnect for a laboratory chemical analyser. Unique requirements included design for use in many countries and modular design to allow a variety of versions to be built.

- Electrical design for a medical console. Designed wiring harnesses and specified power supplies and electrical components for a medical diagnostic console. A unique challenge of this project was the meeting the electrical product standards for Class 2 medical devices.

CLIENT TESTIMONIALS

"As a project manager at Sanmina-SCI, I contracted with Dale Tardiff of Innovative Power Solutions for his power supply electrical interconnect expertise. In one particular project, for a major telecommunications client, we designed an enclosure and power distribution system for one of their new products. This involved integrating a commercial power supply into a custom rack we designed for the client. Dale's knowledge of the power supplies and connector systems, as well as his ability to work smoothly with the client, the power supply vendor and our design and manufacturing teams were significant in the success of the project." Jamie Weir

"Dale has always delivered his contract electrical design services in a very professional manner. He is very knowledgeable about his subject area and as such, has been a key contributor on many electro-mechanical project development teams." Roger Helston

"I've worked with Dale at Sanmina-SCI for 5 years and he has a comprehensive understanding of electrical systems design. Operating as a consultant, Dale was extremely professional and always integrated well with our design teams. Dale used an organized and pragmatic approach and has consistently delivered sound designs on consumer and commercial electronics equipment, whether detailing individual components or large scale systems. "Kelly Pickrell, P. Eng.

"Dale Tardiff has been affiliated with Decentralised Energy Canada since 2004. He has provided competent expert advice on technical issues related to power electronics and decentralised energy systems. We have hired him on several occasions to analyse projects, review power electronics designs or trouble shoot power electronics challenges in projects.

In our most recent engagement Dale was tasked with troubleshooting unexpected shutdowns at a remote solar power system in northern BC that was utilising an innovative controller and power electronics package. After several electrical engineers had failed to resolve the issue, Dale was brought in to find the fault and the solution. He quickly performed several system diagnostics and was able to trace the source of the unexpected shutdowns. In addition, Dale was able to identify three addition system modifications that would improve the overall operation of the power system. In addition, Dale was effective at explaining complicated issues to the non-technical customers – this skill is impressive and extremely valuable in our industry.

Dale is a professional, reliable, and highly capable electrical engineer that has become one of Western Canada's most experienced power electronics specialists in the decentralised energy industry."

Anouk Kendall, President, Decentralised Energy Canada