Construction, Qualification, and Low Rate Production Start-up of a DC Bus Capacitor High Volume Manufacturing Facility with Capacity to Support 100,000 Electric Drive Vehicles

Ed Sawyer
SBE Inc.
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Overview

Timeline
- **Start date:** Dec 23, 2009
- **End date:** Dec 22, 2012
- **Percent complete:** 80%

Budget
- **Total project funding:** $18,186,367
- **DoE share:** 48.22391%
- **SBE Share:** 51.77609%

Barriers
- **Barriers addressed:**
  - Speed to full capacity
  - Scalability with market
  - Cost competitiveness
  - Automotive qualified

Partners
- **Interactions/collaborations:**
  - EF Wall and Associates, Inc. (EF Wall)
  - Active Precision, Inc. (API)
  - Oak Ridge National Labs (ORNL)
  - Steiner Films
  - Azure Dynamics

Project Lead
- **Ed Sawyer - SBE, Inc.**
  - Deputy Project Manager: Tom McBride
• Insufficient domestic capacity of critical EV components; i.e. DC link capacitors

• Need for critical components to be cost competitive

• Need to fulfill the Recovery Act’s purposes to stimulate the economy and to create and retain jobs.
Project Goals and Relevance

• Objective
The objective of this project is to construct and qualify a state of the art DC Bus Capacitor manufacturing facility which is capable of supplying capacitor products to support the manufacture of 100,000 Electric Drive Vehicles (EDVs) per year by 2012.

• Targets Addressed
  – Design and qualify custom manufacturing equipment and attain industry standard TS16949 certification
  – Scale proven production processes to provide cost competitive DC bus capacitors to the global market place.

• Relevance and Impacts
  – This project will create 80 jobs as part of the Recovery Act’s goal to stimulate the economy and to create and retain jobs
We will...

• Permit, design, and build a plant with capacity to produce DC link capacitors for 100,000 EV’s
• Obtain necessary industry and key customer approvals
• Achieve cost goals that compete favourably with off-shore competitors, but with greatly improved performance
• Provide quality data and product validation to DoE

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Month/Year</th>
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<tbody>
<tr>
<td>Local Building Permit Approval</td>
<td>November 2009</td>
</tr>
<tr>
<td>Building &amp; Plant Layout Design</td>
<td>March 2010</td>
</tr>
<tr>
<td>Finding-of-No-Significant-Impact</td>
<td>March 2010</td>
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<tr>
<td>Winder Design Completion</td>
<td>April 2010</td>
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<tr>
<td>Building Construction Start</td>
<td>April 2010</td>
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<tr>
<td>All Equipment Designed</td>
<td>September 2010</td>
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<tr>
<td>Plant Move – In</td>
<td>November 2010</td>
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<tr>
<td>First Line Set – Up</td>
<td>April 2011</td>
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<tr>
<td>First Line “Production Rate”</td>
<td>May 2011</td>
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<tr>
<td>TS-16949 Approval</td>
<td>December 2011</td>
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Approach/Strategy

• Permit, Design, and Build Plant with 100,000 Vehicle Capacity
  – Qualification of material and equipment
  – Production process and training development
  – Freeze design rules and procedures
  – Secure site and building certification
  – Construction of new facility
  – Hiring new plant workforce
  – Line Setup
  – Move
  – Ramp up to capacity
• Obtain Necessary Industry and Key Customer Approvals
  – Achieve TS16949 Certification
  – Design and product qualification dialogues and necessary associated activities
  – Develop Customer Test requirements and Quality Plans
  – Employ dedicated sales individual with automotive OEM experience to introduce customers to the Power Ring
  – Support the sales team with highly skilled and experienced electrical and mechanical engineers to develop application specific solutions based on customer needs
  – Demonstrate capacity ramp up plans
• Provide Quality Data and Product Validation to DoE
  – Open dialogues with materials and equipment vendors to assure specification compliance
  – Conduct ongoing electrical, mechanical, and life testing to assure product specification compliance
  – Work in conjunction with ORNL to define ESR, materials spec verification, and life testing methodologies for inclusion in DOE validation reports
  – Incorporate (yet to be defined) ORNL ESR testing methods into production flow for increased finished goods’ reliability and performance consistency
  – Implement item serial numbering and bar-coding to insure traceability
Areas of Accomplishment

- Building Design
- Permitting and Construction
- Material, Equipment, and Product Activities
- Customer Qualification Activities
Technical Accomplishments to Date

• Building Design
  – Preliminary civil and electrical engineering designs complete – Late August 2009
  – Building specifications finalized – Late February 2010
  – Ongoing energy efficiency design upgrade qualification – March 2010
  – Phone and internet service provider finalized and contract signed – March 2010
  – Office design and layout complete and finalized – Early April 2010
  – Office furniture contract signed – Early April 2010
  – Plant floor layout and process flow finalized – Early April 2010
  – Finalized facility needs and interior design elements – October 2010
Technical Accomplishments to Date

• Permitting and Construction
  – Preliminary site plan/civil engineering designs complete – Late August 2009
  – Permit ready for construction; all state and local land use, zoning, and subdivision permits approved – Mid November 2009
  – 10 Acre plot of land purchased – Early March 2010
  – Federal Environmental Assessment clears public review – March 24, 2010
  – Finding-Of-No-Significant-Impact (FONSI) issued – March 30, 2010
  – Site preparation and formal ground breaking – Early April 2010
  – Municipal road and utility extension completed – Early September 2010
  – Building fully enclosed – Mid September 2010
  – Fire safety and occupancy permits issued – Late September 2010
  – Construction completion – November 8, 2010
  – Formal ribbon cutting ceremony – December 6, 2010

DOE Annual Merit Review 2011
Technical Accomplishments to Date

• Material, Equipment, and Product Activities
  – New industry standard test equipment acquired to aid in product and material qualification
  – All necessary equipment vendors have been chosen
  – Custom co-engineered winder development contract signed with Active Precision, Inc.
  – Specifications for winder qualification have been finalized
  – Developing and base-lining material specifications
  – Class 10,000 clean room installed in new facility for winding consistency
  – Product architecture finalized with new production methods
  – All first article equipment orders have been placed
  – Ramp up plans developed
  – Equipment installation ongoing
  – New equipment 95% qualified at new production facility
Technical Accomplishments to Date
Customer Qualification Activities

- Design win for 4 automotive OEM EV inverter applications
- Design win for commercial truck electrification and auxiliary power application
- Design win for 2 Hybrid Bus/Truck Power train applications
- Design win for an electric motorcycle application
- Engaged with automotive/transportation OEM EV and HEV for capacitor use for inverter applications
  - 8 OEMs: Currently have their systems being tested by their customer; with the Power Ring designed in
  - 12 OEMs: Currently testing the Power Ring
  - 15 OEMs: SBE having program-specific technical dialogues
  - 20+ OEMs: SBE having dialogues
Collaborations

- **EF Wall** – Construction contract signed and initial site prep begun. Ongoing weekly materials and specifications meetings to ensure parity of information and progress
- **API** – Contract for continued design and delivery schedule signed for total of 9 custom winding machines. Proprietary winding technology is pivotal to Power Ring success
- **ORNL** – Federal lab contracted to provide supplemental engineering resources for the development of ESR test methodology, material validation, and life testing
- **Steiner** – Co-developing film processing technologies for improved reliability
- **Azure** – Hybrid/electric technology leader will be building a commercial vehicle sized inverter (75 – 100kw) for the purpose of exercising the Power Ring in drive profile environments
### FY11 Approach and Challenges

#### Go No/Go Decision Point:
- Not Associated

#### Challenges/Barriers:
1. Scaling of known processes
2. Fully defined customer requirements

<table>
<thead>
<tr>
<th>2010</th>
<th>2011</th>
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<tbody>
<tr>
<td>Oct</td>
<td>Nov</td>
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<td></td>
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<tr>
<td>Building Complete</td>
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FY11 Approach Highlights

• Demonstrate production capacity of DC link capacitors

• Cost competitive, yet long reliability product to the customer

• Full preparation for TS-16949 4th Quarter 2011 audit
Beyond FY11

- FY12
  - Phase II and III capacity expansion to reach 100,000 vehicles
  - TS-16949 qualification
  - Continued cost/reliability/performance optimization
Proposed Future Work

- **Possible doubling of capacity** – A possible phase II could add 47,200 ft² of space to our new facility bringing total square footage to 100,000 to accommodate increased market need
  - Pre-permitted for 100,000 ft²
  - Additional employment growth to accommodate future expansion

- **Continuous improvement of cost** – Employment of full-time supplier quality and purchasing engineers will work continually to source better and less costly materials. Further refinement of manufacturing processes to limit waste of time, resources, and materials.

- **Integrated designs with key customers** – For most volumetric, weight and cost efficiency, integrated inverter solutions for next generation EVs are planned
Summary Slide

• First year of $18 million project complete and on schedule
• Manufacturing milestones achieved:
  – Permits obtained
  – Site construction finished
  – Plant floor and office layout finalized
  – Qualification of material/equipment and product 95% complete
  – Hiring in progress
• Customer qualifications ahead of plan