Electric Drive Component Manufacturing Facilities

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U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

USDRIVE
DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY

The Problem

- **Component manufacturing costs are driven largely by production quantity, and to achieve high production volumes, low cost components are required**
- **Without high volume commitment from OEMs, component manufacturers are unwilling to invest in the equipment, tooling, and other supply chain costs to bring propulsion system prices down**
- **Without low cost propulsion systems, OEMs are unable to price vehicles at a level that will create consumer demand**

Project Overview

Focus Area: motors and power electronics (traction drive system)
➔ manufacturing

Objective

- This project aims to address the problem by making manufacturing investments to facilitate lower costs, and therefore, higher volumes within electrified vehicle markets

Addresses Targets

- UQM Technologies is focusing on two markets within this project by taking existing products and applying manufacturing disciplines and investments to bring costs down and volumes up
  - Automotive (100 to 135 kW)
  - Truck and Bus (150 to 220 kW)

Uniqueness and Impacts

- UQM's established technology and decades of vehicle electrification experience provide a solid foundation to apply manufacturing principles and disciplines

Description of Technology/Approach

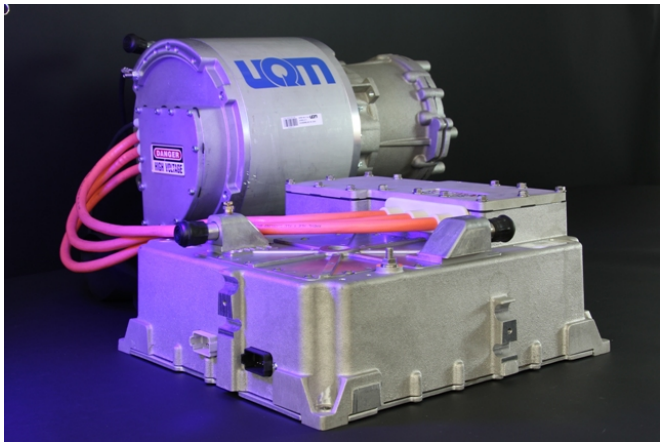
- Apply Design for Manufacturing and Assembly (DFM/DFA) principles to existing products to create low cost electric propulsion systems that can be manufactured in volume, following Advanced Product Quality Planning (APQP) and Control Plans, creating quality products that meet SAE Standards
- Create a manufacturing facility that supports high volume component manufacturing
- Set up production lines and systems to support an initial rate of at least 20,000 units a year on a single shift
- Establish multiple suppliers for key components to minimize timing and volume delivery risks
- Design manufacturing systems that are flexible enough to adapt to evolving technologies and product variants

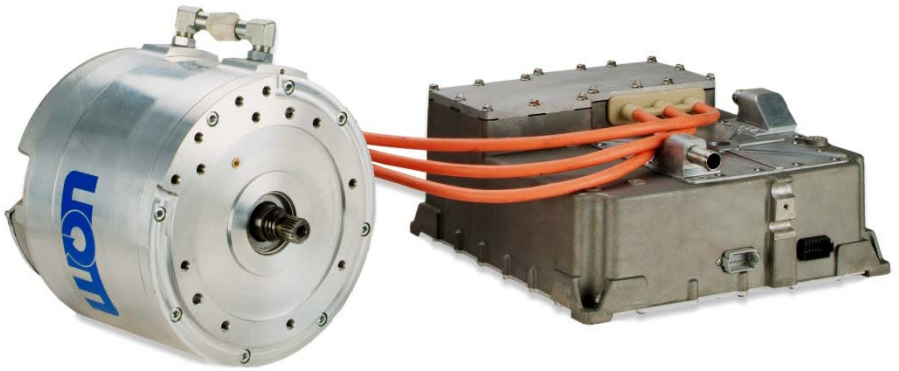
Accomplishments to Date

- **Relocated into a larger facility (13,000 square meters / 140,000 square feet) with sufficient manufacturing space in July 2010**
- **Established motor and controller production lines to support the objective volumes in June 2011**

Accomplishments to Date

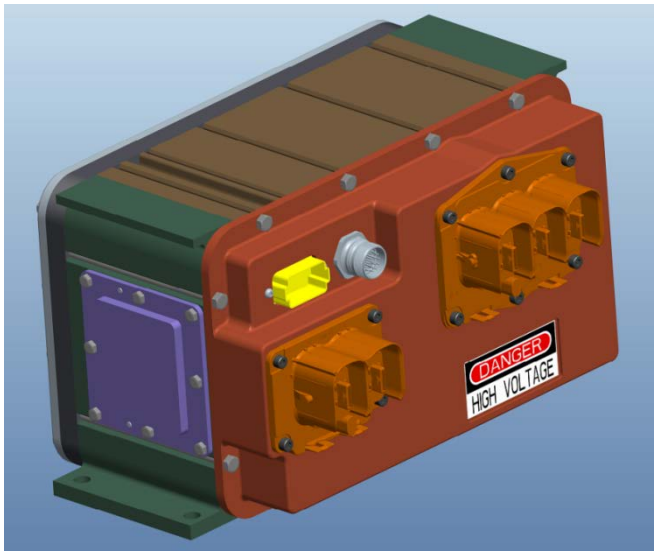
- **Completed the Production Part Approval Process (PPAP) for the automotive product (100 kW motor and controller)**
- **Design and process validation includes the following standards**
  - **Mechanical Vibration** Passed
  - **Mechanical Shock** Passed
  - **Humidity Cycle** Passed
  - **Salt Fog** Passed
  - **Thermal Cycle** Passed
  - **Water Immersion** Passed
  - **Liquid Contaminant Splash** Passed
  - **Pressure Wash** Passed
  - **Electrical System Qualification** Passed

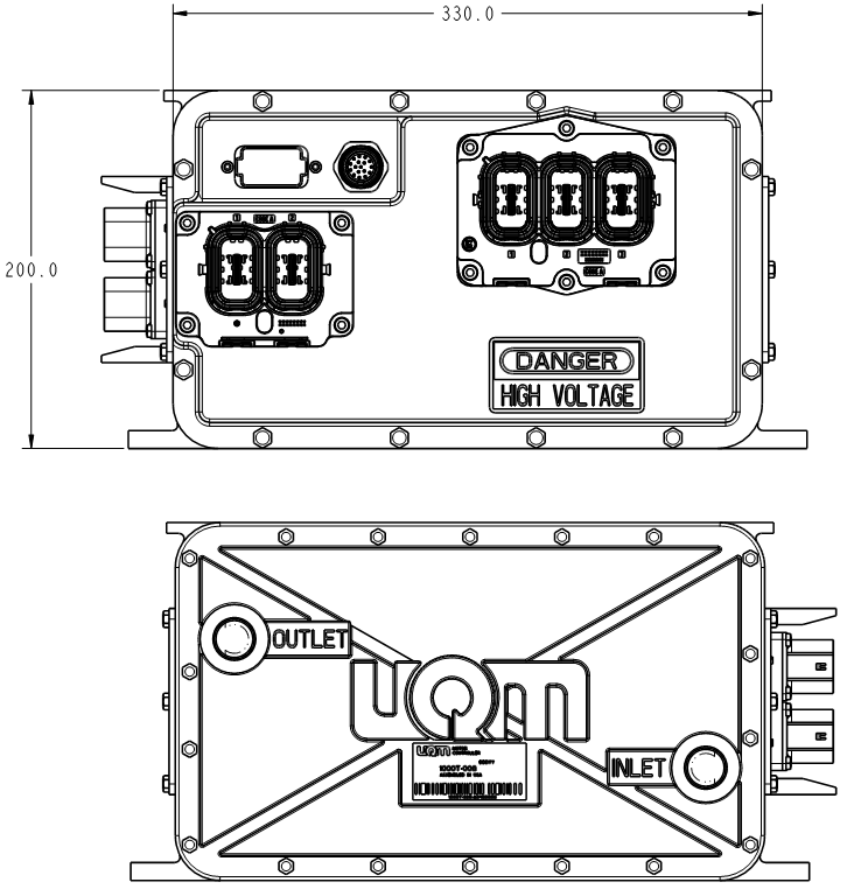




Accomplishments to Date

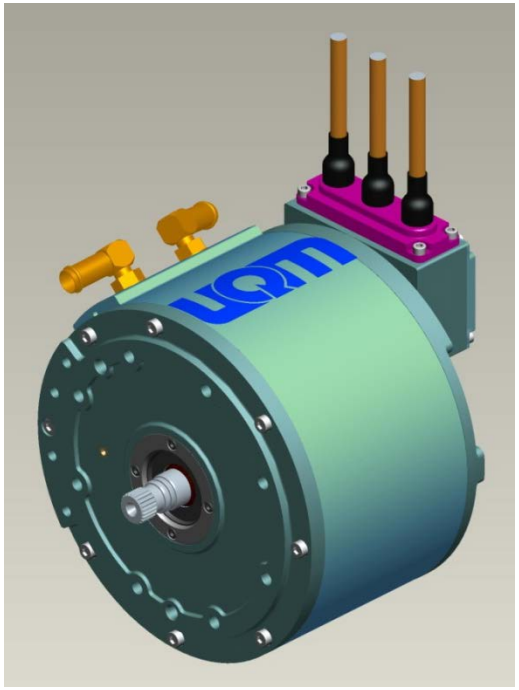
- **Second Generation reduced size automotive controller**
- **Preliminary Specifications include the following:**
  - **Support 100/135 kW peak power**
  - **Existing motor and next gen IPM motor**
  - **Controller is half the size of Gen 1**
  - **Reduced weight and cost**
  - **Testing occurring now**

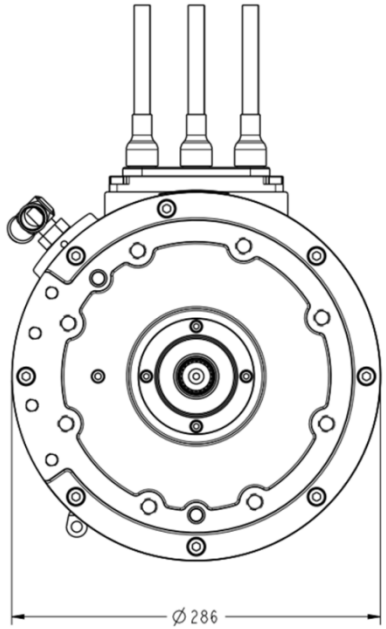


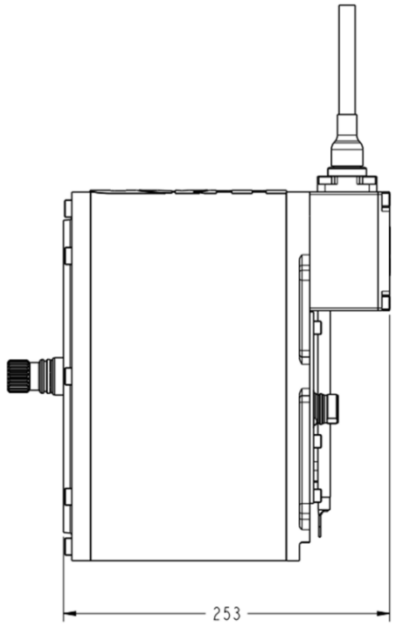


Accomplishments to Date

- **Second Generation interior permanent magnet (IPM) motor**
- **Preliminary Specifications include the following:**
  - **100 kW peak power in mid-speed range**
  - **80 kW peak power at top speed**
  - **10,000 RPM operational top speed**
  - **300 N-m peak torque**
  - **Motor build occurring now**

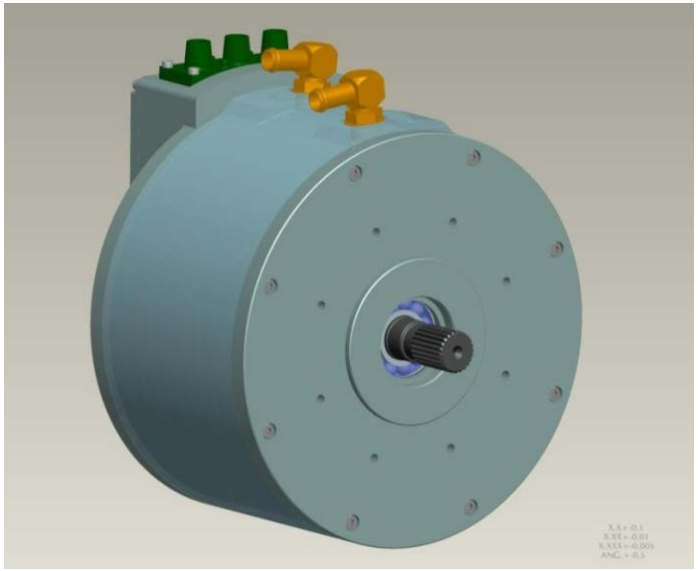


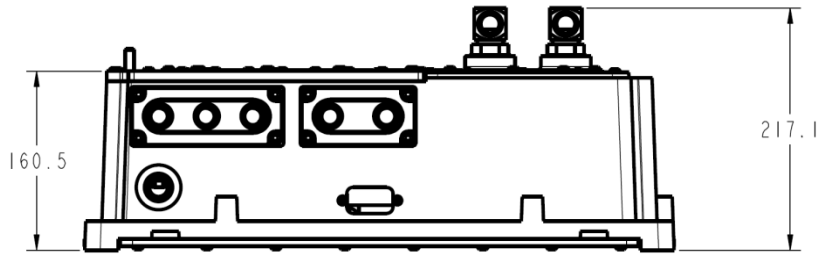


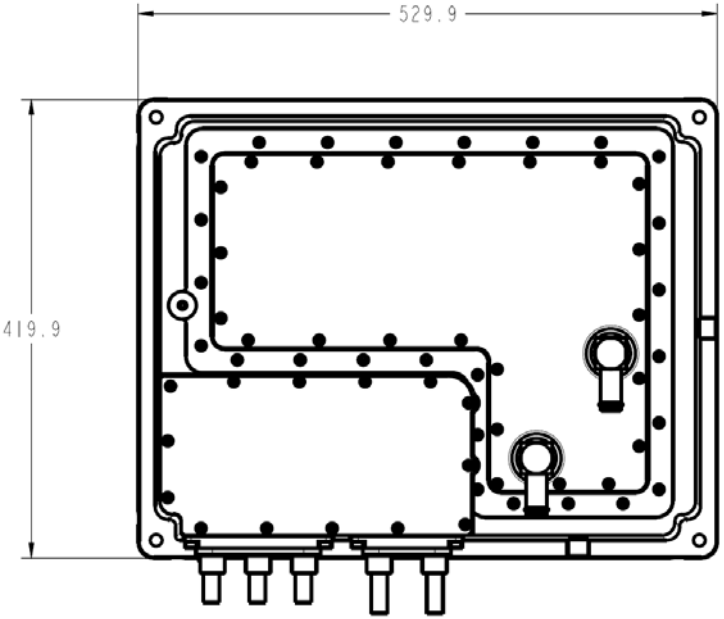


Accomplishments to Date

- **Launched bus/truck product (220 kW motor and controller)**
- **Specifications include the following:**
  - **220 kW Peak Power (295 hp)**
  - **120 kW Continuous Power (161 hp)**
  - **700 N-m Peak Torque (517 lb-ft)**
  - **6000 RPM Top Speed**
  - **360 VDC nominal voltage**
  - **DV complete (next slide)**







Accomplishments to Date

- **Completed Design Validation for the truck/bus product (220 kW motor and controller)**
- **Design validation includes the following tests**
  - **Mechanical Vibration** Passed
  - **Mechanical Shock** Passed
  - **Humidity Cycle** Passed
  - **Salt Fog** Passed
  - **Thermal Cycle** Passed
  - **Water Immersion** Passed
  - **Liquid Contaminant Splash** Passed
  - **Pressure Wash** Passed
  - **Electrical System Qualification** Passed

Accomplishments to Date

- High volume manufacturing facility is in place
- Automotive production system is complete
- Well over a thousand production 100 kW systems built on the production line

Accomplishments to Date

Adapted automotive motor production to accommodate heavy duty product

- **Mixed model assembly line**
- **Power levels up to 220 kW**

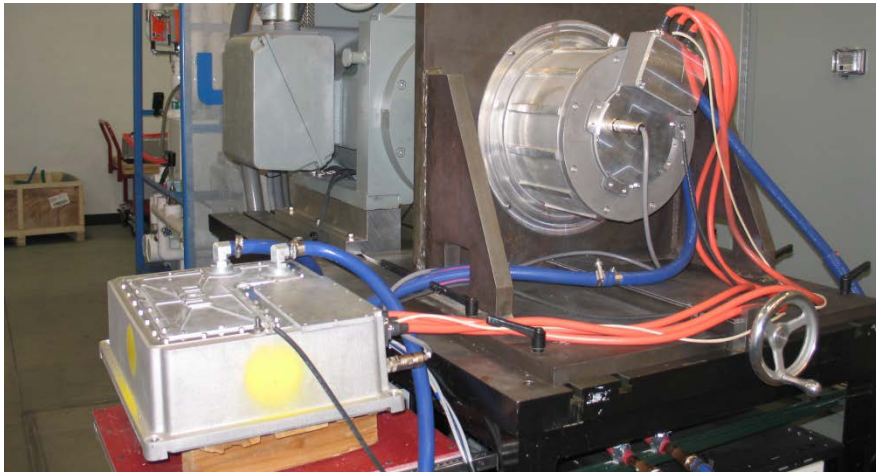
Accomplishments to Date Summary

- Completed PPAP for the first generation automotive propulsion system
- Automotive high volume production line is now in place
- Completed Design Validation for the bus/truck propulsion system
- Bus/Truck production line is now in place (part of mixed model line with the automotive system)
- Second generation automotive systems are in validation
  - Smaller controller to meet the requirements of some vehicle applications (dynamometer testing occurring now)
  - IPM motor for optimized automotive performance and efficiency (build is occurring now)
- No exclusivity agreements exist and these systems may be supplied to any customer with production programs

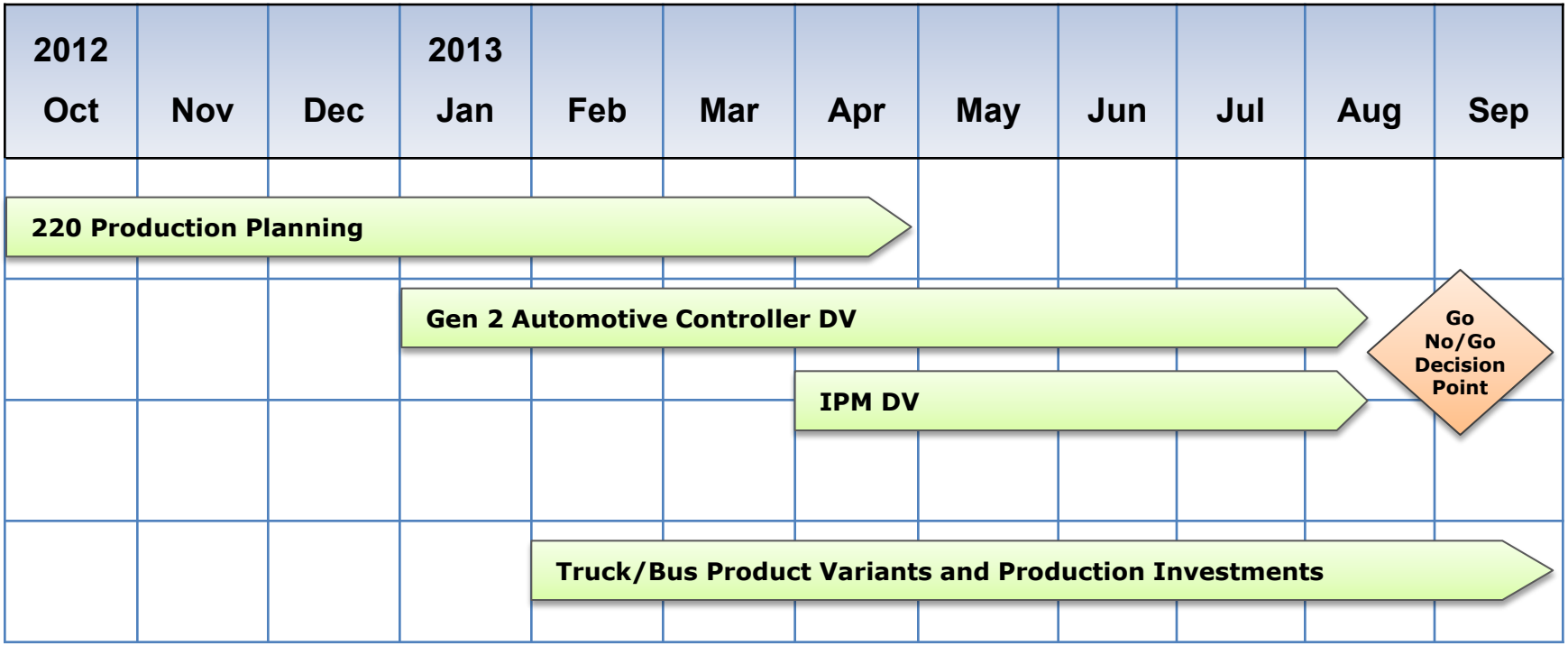
Future Work

Initiated two new heavy duty product variants to meet customer requirements

- **Higher torque, lower speed product**
  - **Optimized efficiency for parallel hybrids**
  - **“Engine replacement” programs**
- **Higher voltage variant**
  - **Targets 600-700 VDC based vehicles**
  - **Potential increase of current 220 kW peak power**
- **Programs launched this calendar year**



FY13 Approach and Challenges



Go No/Go Decision Point: Second Generation automotive system validation results will be used to generate new opportunities and production line investments will be made based upon demand

Challenges/Barriers: The electric vehicle market has moved slower than anticipated and the volume for these systems is difficult to plan

FY13 Approach Highlights

- The next generation versions of our automotive systems are in early Design Validation
  - Smaller second generation controller
  - IPM motor
- Product variants for our heavy duty systems will address additional vehicle applications
- Mixed model assembly line provides flexibility to adapt to changing market conditions – automotive versus truck/bus demand
- Continued planning for ISO26262 standard implementation
- This is a continuing project from FY11 and no changes in the scope have occurred