



U.S. Based HEV and PHEV Transaxle Program
HF35

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Ford Motor Company
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Project ID: ARRAVT024



Timeline

Start: October 1, 2009
Finish: September 30, 2012

Risks and Barriers

Functional
Financial
Marketing
Purchasing

Budget

Total Project Funding
DOE: \$62.5M
Ford: \$62.5M
Funding received in FY09 = \$6M
Funding for FY10 = \$56.5M

Partners

No official partners identified in grant

Program Objective:

Accelerate the launch and commercialization of hybrid and plug-in hybrid (HEV/PHEVs) electric vehicles by localizing the design and production of a world-class HEV/PHEV transaxle system.

Product Engineering Enablers:

- Leverage Ford's global platforms to further reduce transaxle and hybrid vehicle costs
- Leverage engineering efficiencies of a known hybrid transaxle architecture
- Reduce the HF35 transaxle cost by 20% and eliminate constrained supply of this critical electric drive vehicle component

Manufacturing Engineering and Production Enablers:

- Produce the HF35 transaxle in an existing state-of-the-art SE Michigan Ford transmission facility to minimize facility cost, lower project risk, and accelerate product launch

Hybrid Electric Vehicle (HEV)

- Combines an internal combustion engine with an electric motor and battery
- Electric power is used for vehicle launch and lower-speed operation
- Internal combustion engine takes over for higher demand operation and charges the battery

Plug-in Hybrid Electric Vehicle (PHEV)

- Combines HEV technology with a high-voltage storage battery like that used in a Battery Electric Vehicle (BEV)
- Ford's PHEV is a blended PHEV – optimally first using the battery charge and then operating in regular hybrid mode
- Offers consumers the best possible fuel economy, smallest battery and most affordable solution.

Relevance – Fuel Economy Leadership



“Ford is the second-largest producer of full HEV’s in the world”

HEV volume has doubled with the introduction of 2010 Fusion/Milan

Additional All-New HEV, PHEV and BEV vehicles coming soon

ESCAPE / MARINER HEV

FUSION / MILAN HEV

Most Fuel Efficient SUV on the Planet

Most Fuel Efficient Mid Size Sedan in North America

CITY MPG

Fuel Economy
Information

HIGHWAY MPG

CITY MPG

Fuel Economy
Information

HIGHWAY MPG

34



31

41

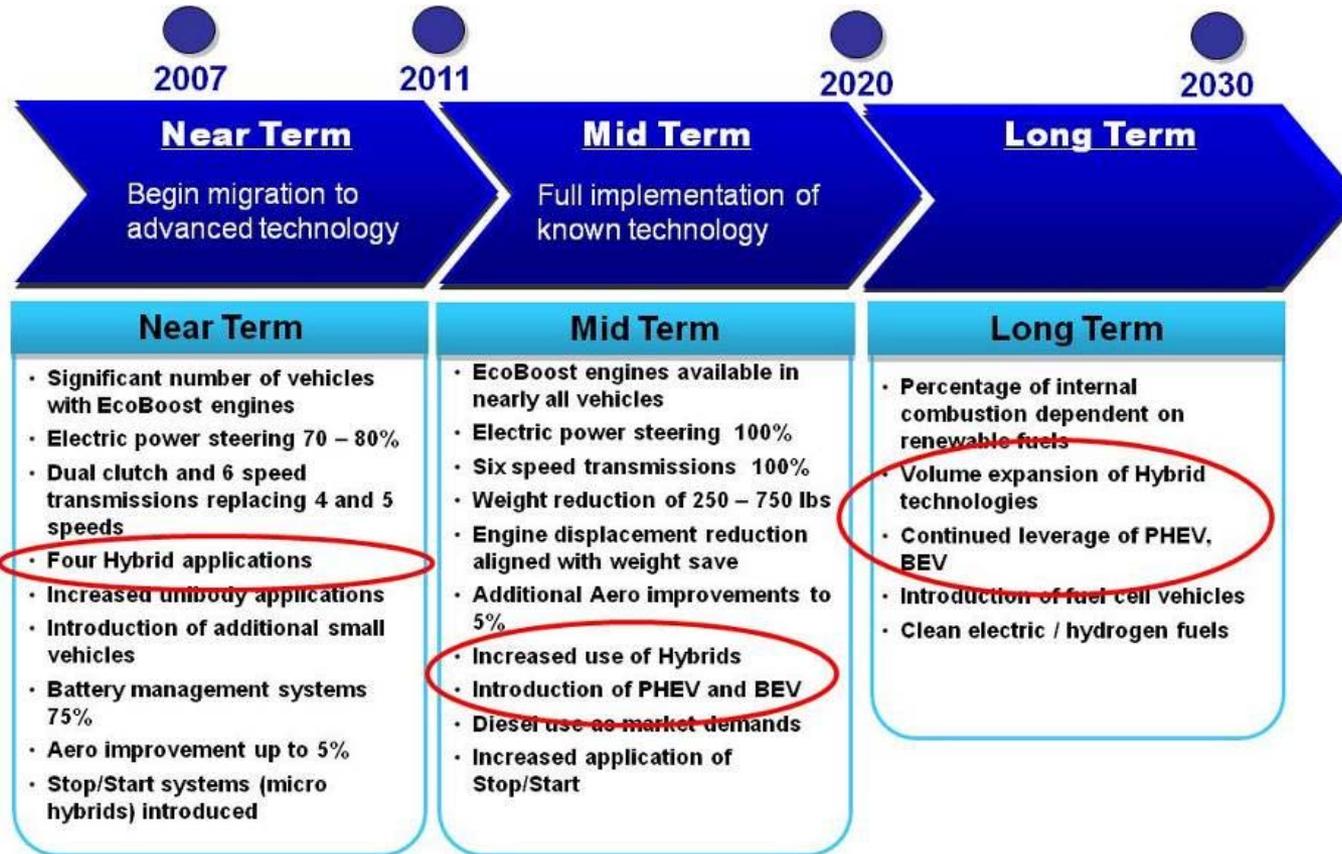


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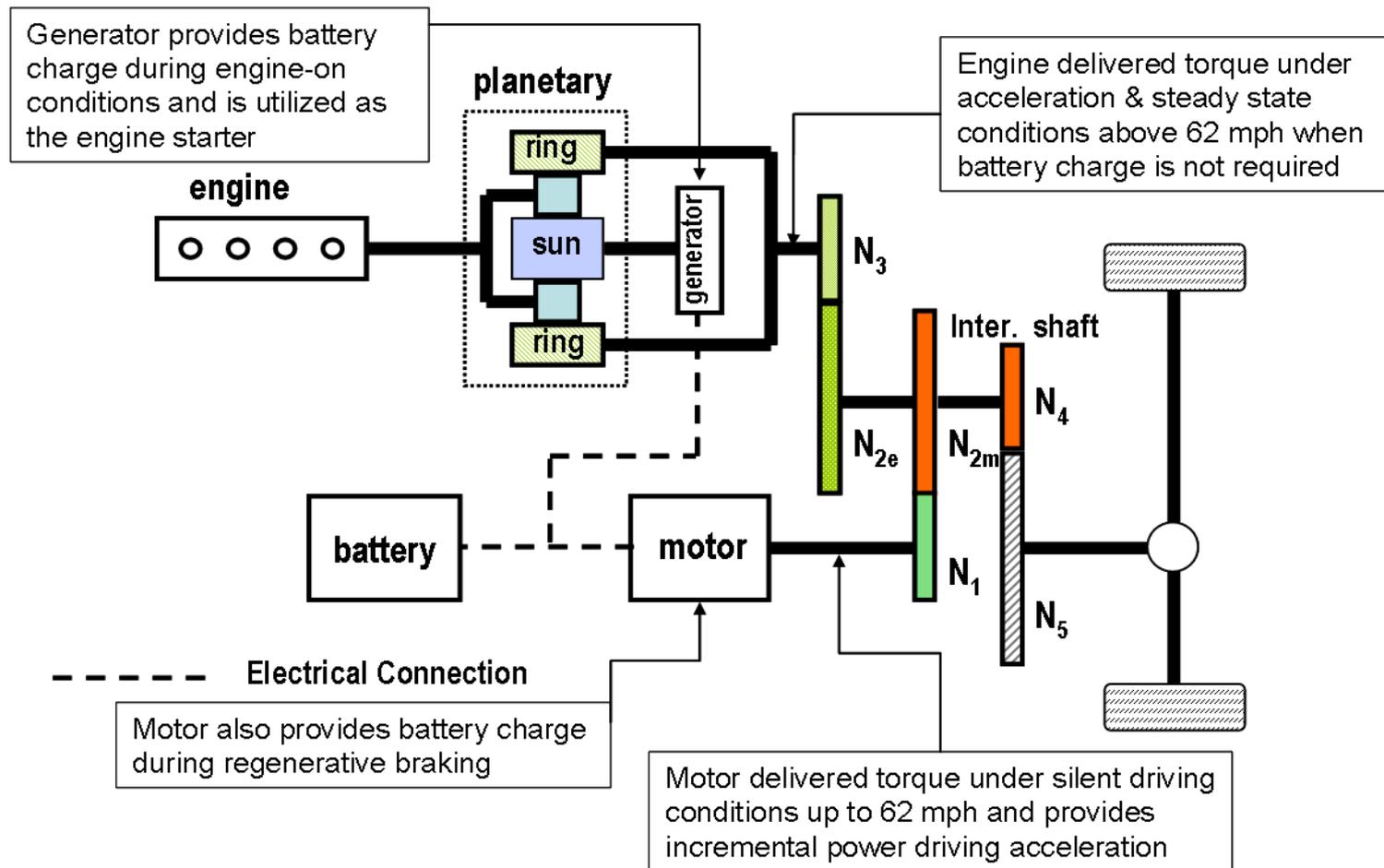
The HF35 is a key contributor to Ford’s Fuel Economy Leadership going forward





As part of our overall transformation, Ford Motor Company is committed to bringing hybrid and plug-in hybrid vehicles to market quickly and affordably. The HF35 transaxle program is a major catalyst in support of this strategy.

Approach – Powersplit Architecture

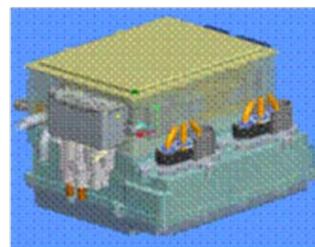
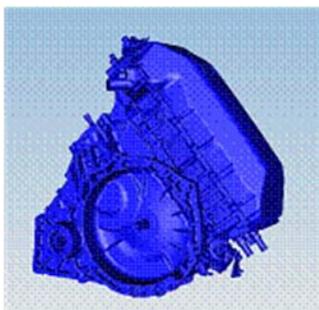


The HF35 Strategy takes advantage of a known, robust transaxle design

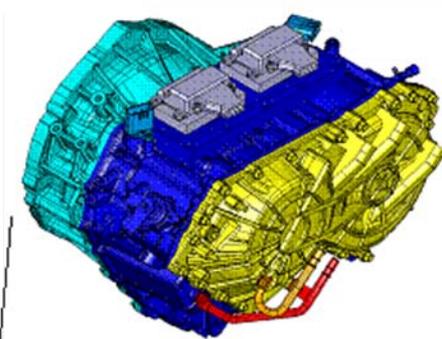
Approach – Architecture Evolution

	2004 – 2011 Gen I	2008 – 2012 Gen II	2012+ HF35
Engine	2.3 L / 2.5 L Atkinson	2.5 L Atkinson	2.0 L Atkinson
Transmission	• AW PowerSplit Trans	• AW PowerSplit Trans	• HF35 Transmission
	• AW Controls	• AW Controls	• Ford Controls & Calibration
	• Integrated Power Electronics	• Integrated Power Electronics with Variable Voltage Control	• Remote Power Electronics with Variable Voltage Control
Battery	• 250 Cell NiMH	• 208 Cell NiMH	• Li Ion

Gen I & Gen II

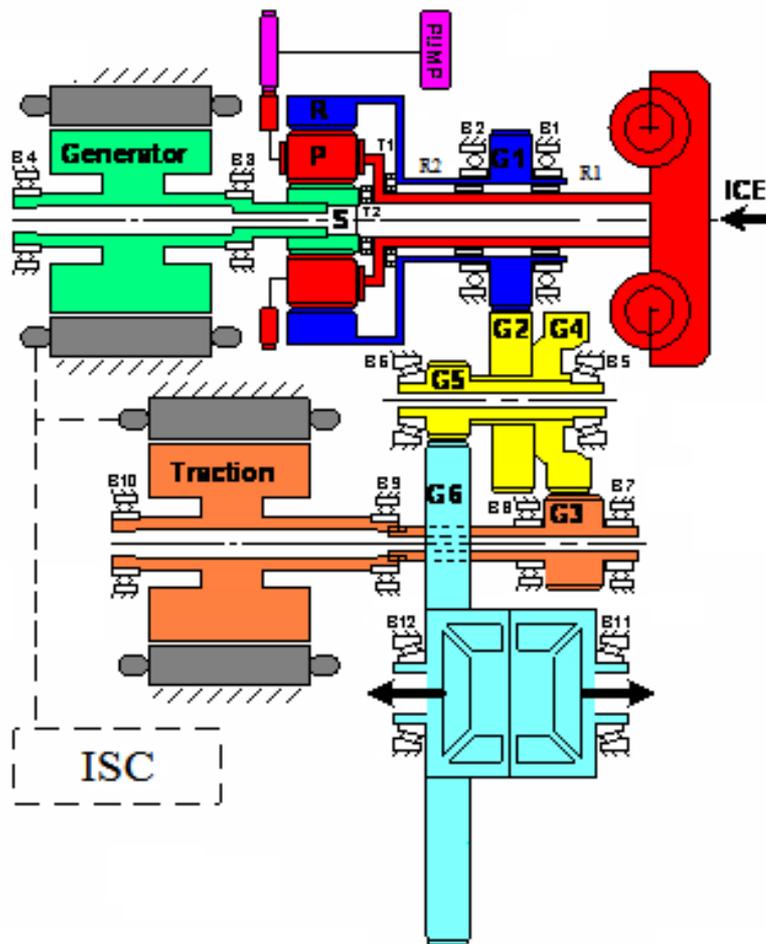


HF35



Separate power electronics from trans hardware & motors

The HF35 is Ford's third generation Powersplit transaxle, and the 1st internally manufactured – taking advantage of evolutionary design of a robust product



HF35 Major Components

- Motor/Generator Set
- Planetary Gearset
- Transfer Gears
- Final Drive Differential
- Shafts
- Bearings
- Pump/Filter
- Flywheel/Damper Assy

Components not shown

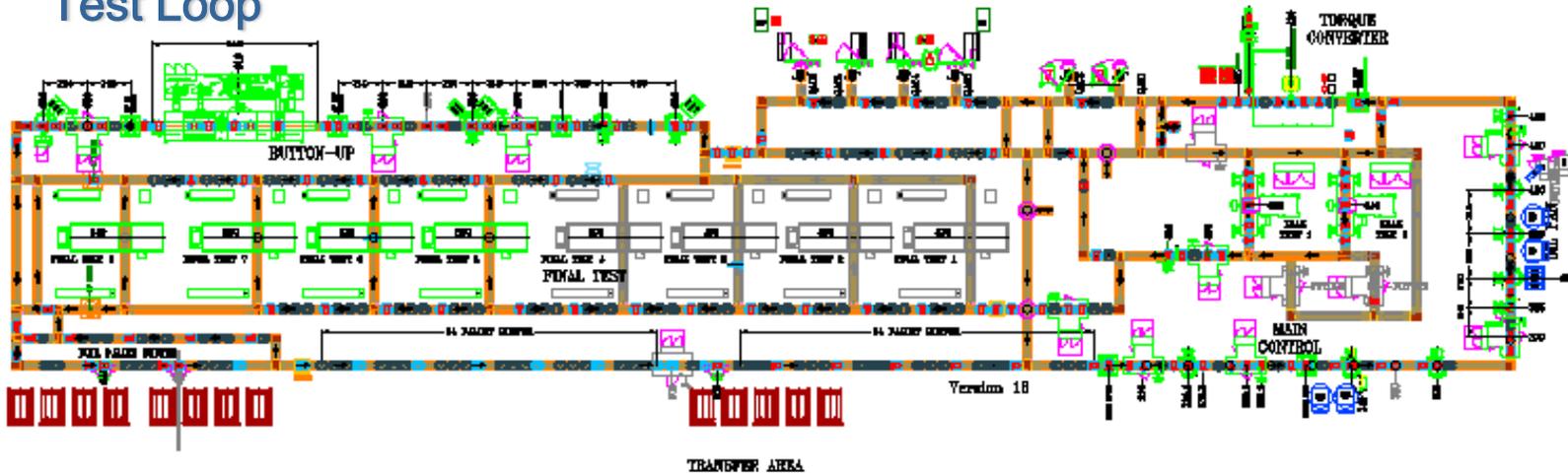
- Park System
- Electrical wiring/sensors
- Case and Bell Housing

134 New Parts
43 Carryover parts

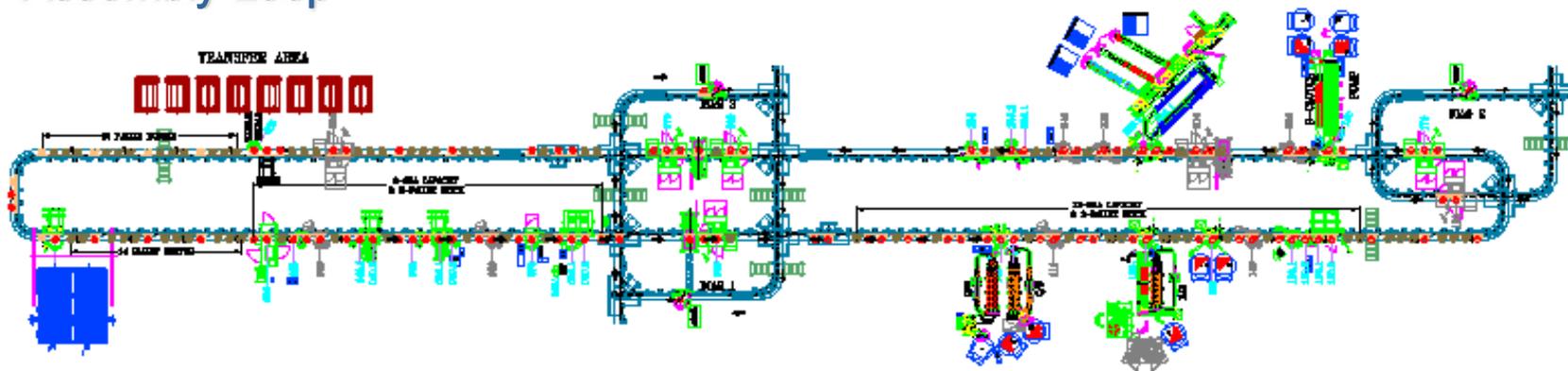
The cost of the HF35 is mitigated with the utilization of components common with other Ford transaxle products.

Approach – Flexible Assembly

Test Loop



Assembly Loop



Ford's 1st flexible transaxle assembly process for gas and hybrid models enables nimble response to customer demand fluctuations

Milestones Completed in Phase I (Period ending September 2009):

- ✓ <Unit PTC> Program Target Compatibility GPDS Milestone – September 2009 (Go / No Go Decision Point)
- ✓ Long Lead Funding Approved – September 2009
- ✓ Component Sourcing Agreements Signed – September 2009
- ✓ First Phase I (X0) Transaxle Available – September 2009

✓ = Completed

The objective of Phase I is to finalize the initial design and deliver the first functional prototype transaxle for testing.

Milestones Occurring in Phase II (Period ending May 2010):

- ✓ Phase II (M1) Level Design Freeze – October 2009
- ✓ Production Equipment Design Orders Initiated – October 2009
- ✓ <Unit PA> Program Approval GPDS Milestone – February 2010 (Go / No Go Decision Point)
- ✓ Component Commercial Pricing Agreements Signed – February 2010
- ✓ First Phase II (M1) Transaxle Available (Internal) – February 2010
- ✓ Production Equipment Build Orders Initiated – February 2010
- ✓ First Phase II (M1) Transaxle Available (External shipped to build site) – May 2010

✓ = Completed

The objective of Phase II is to refine the Phase I design and address any failure modes found during Phase I testing.

Milestones Occurring in Phase III (Period ending May 2011):

- Machine Tryout Parts Ordered – June 2010
- Phase III (VP) Level Design Freeze – July 2010
- Production Equipment Run-off's Initiated – November 2010
- <FDJ> Final Data Judgment GPDS Milestone – December 2010
(Go / No Go Decision Point)
- First Phase III (VP) Transaxle Available (Internal) – January 2011
- Production Equipment Delivery Completed – February 2011
- First Phase III (VP) Transaxle Available (External) – May 2011

✓ = Completed

The objective of Phase III is finalize design refinements and build confirmation prototypes

Milestones Occurring in Phase IV (Period ending June 2012):

- Production Equipment In-Plant Runoffs Completed – June 2011
- 1st Production HF35 Build at Transaxle Assembly Plant – September 2011
- 1st Production HF35 Build at Vehicle Assembly Plant – December 2011
- <FEC> Final Engineering Confirmation GPDS Milestone – December 2011 (Go / No Go Decision Point)
- HF35 Production Validation (PV) Testing Sign-off – January 2012
- Transaxle OK-to-Buy – April 2012
- <MP1> Mass Production 1 GPDS Milestone – June 2012

✓ = Completed

The objective of Phase IV is to deliver production level transaxles to the vehicle assembly plant and complete product launch

First HF35 Prototype Build Completed!

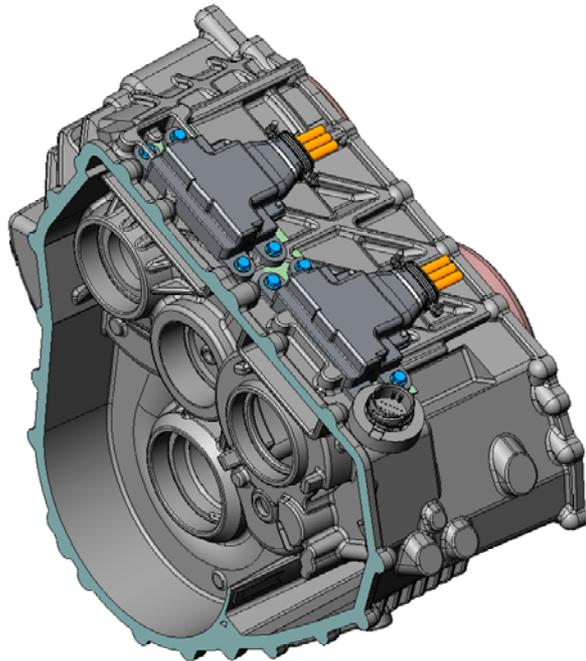
Build Complete:
August 11, 2009

Test Start:
(Pictured)
August 12, 2009

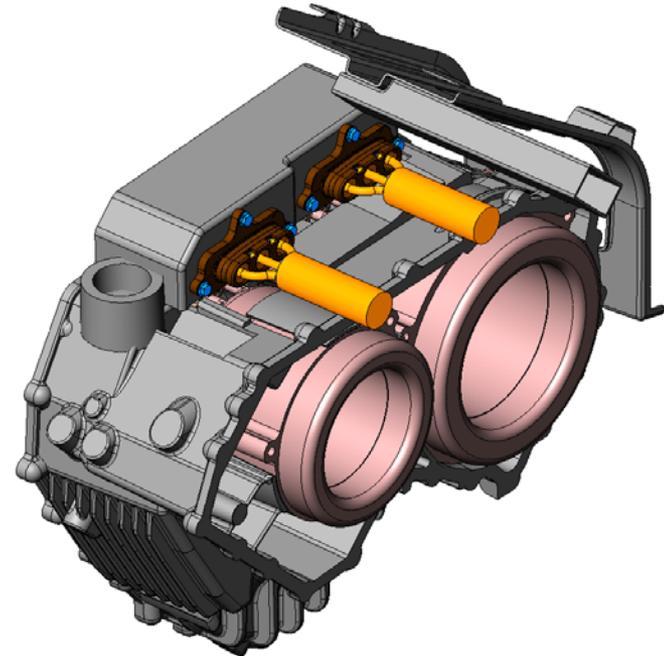


High Voltage Harness Design for High Volume Production

Phase I Design

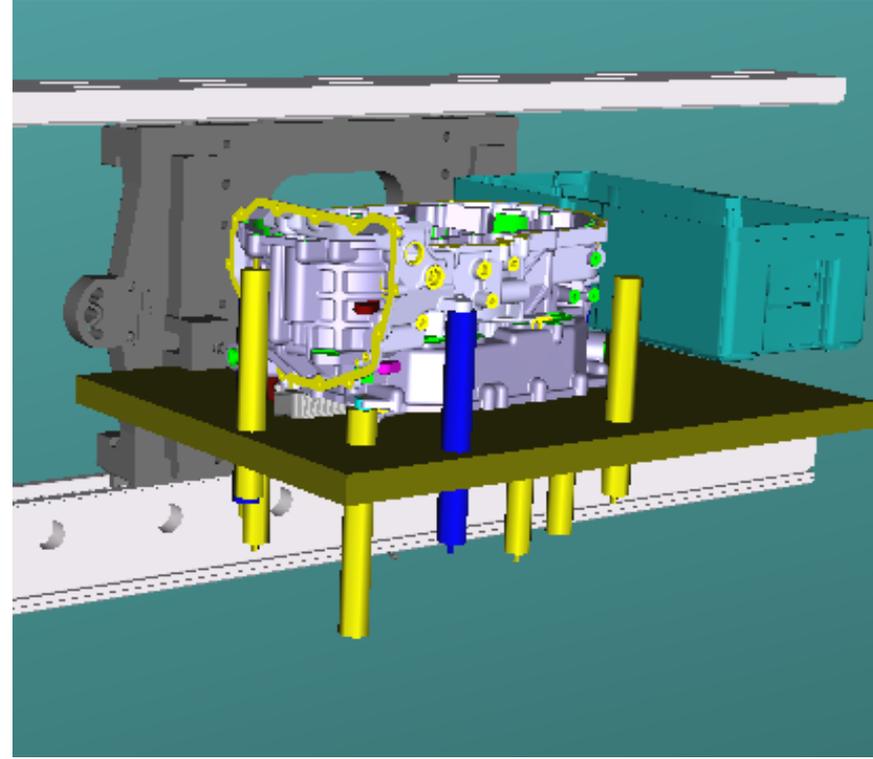


Phase II Design



The design evolution of the high voltage harness has enabled simplified manual assembly, automatic connection for product testing, and efficient packaging for shipment to the vehicle plant customer

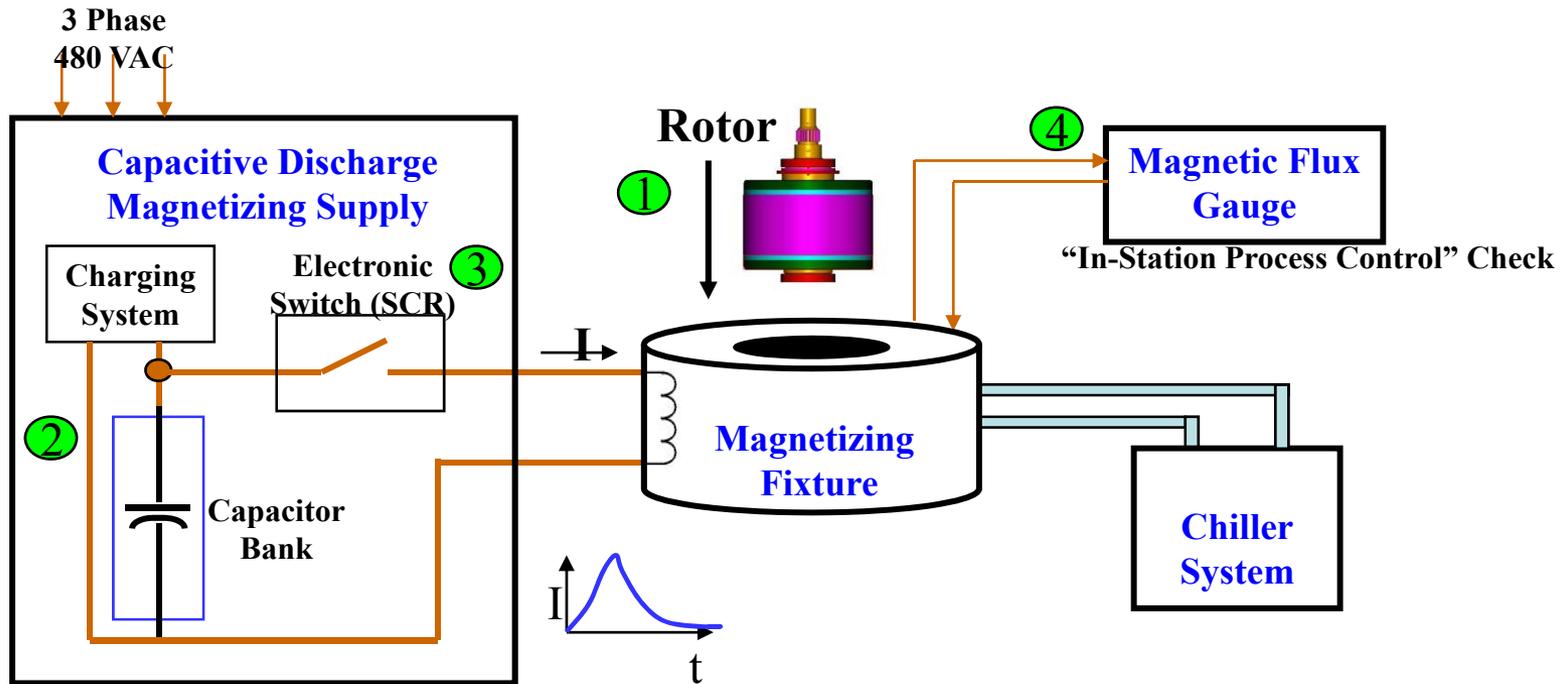
Flexible Assembly System – Conveyor Selection and Pallet Design



The conveyor system selected provides access to (3) sides of the product during assembly as well as future flexibility for changeover and / or expansion

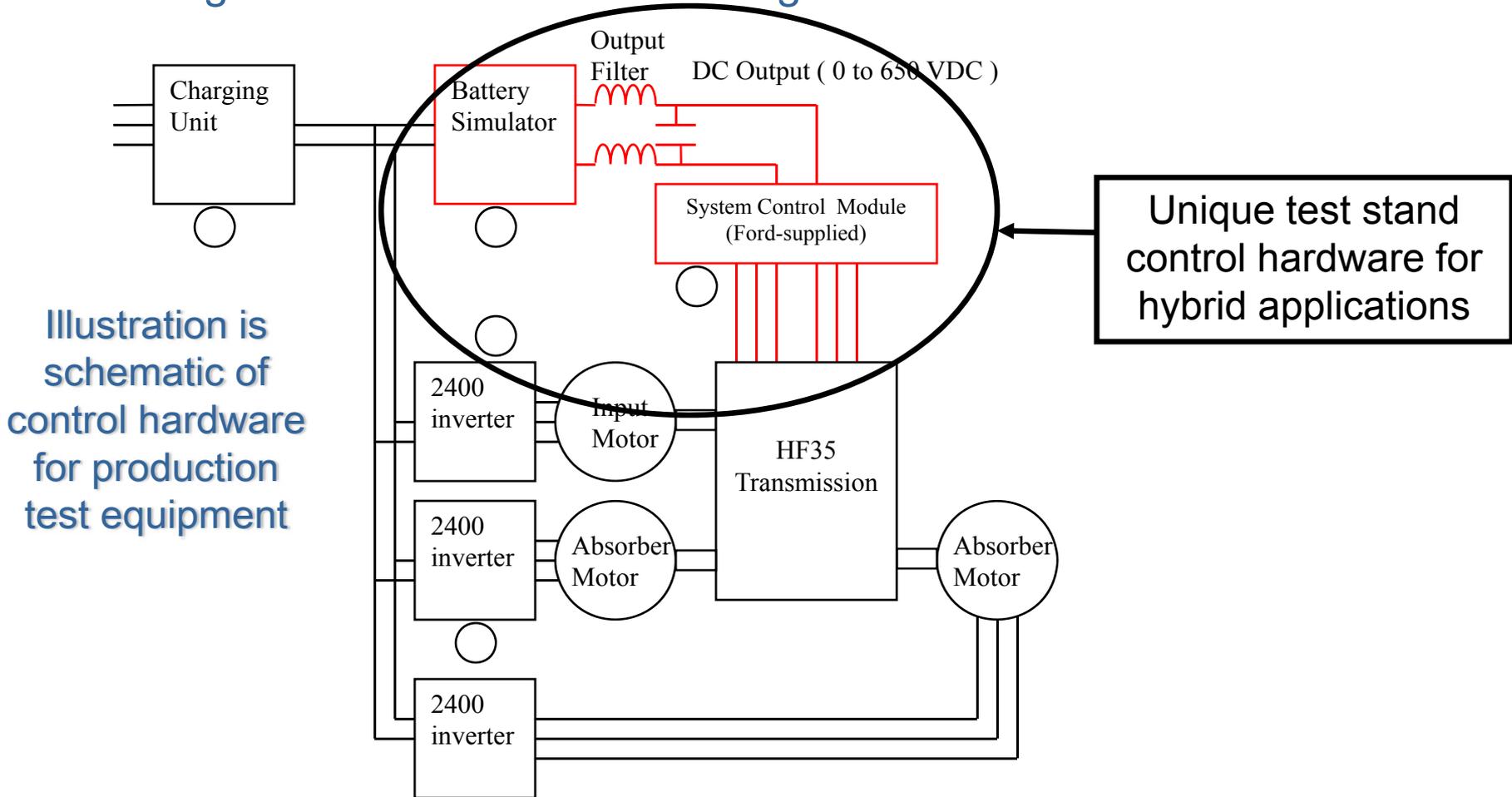
The pallet design is flexible for both gas and hybrid versions of Ford's FWD transaxles

Rotor Magnetization with Production Intent Part Fixturing



The Traction and Generator Rotors are carryover design, magnetized internally at Ford for the 1st time during the assembly process. All of Phase II prototypes are now magnetized with the production intent process using production fixturing.

High Volume Production Testing of the HF35 Transaxle



The production design allows flexible testing of gas and hybrid transaxles. This strategy was successfully simulated for early Phase II prototype testing.

Major Milestones

- <FDJ> Final Data Judgment GPDS Milestone – December 2010
 - Complete Phase II Prototype Builds and Testing
 - Complete Design and Build of HF35 Assembly System
 - Begin System Verification of HF35 Assembly System
- <FEC> Final Engineering Confirmation GPDS Milestone – December 2011
 - Complete Phase III Prototype Builds and Testing
 - HF35 Assembly System in production with transaxle for gasoline vehicle applications
 - Begin HF35 pre-production builds on production assembly line at production intent facility
- <MP1> Mass Production 1 GPDS Milestone – June 2012
 - Complete HF35 pre-production builds
 - Complete production validation
 - Achieve “OK to Build” for HF35 transaxle

No partners were officially identified for the DOE grant awarded to Ford

The ultimate success of the project will be a reflection of new and existing relationships that are furthered as a result of this project. These include but are not limited to:

Production Component Suppliers

- Toshiba, Weber Automotive, Auma-Bocar, Systrand, Yazaki NA, ...

Machine Tool Suppliers

- Kuka AT, Magnetic Instrumentation, Cinetic, WMA Inc., ...

Community

- United Auto Workers
- State of Michigan
- City of Sterling Heights, Michigan

- The HF35 project facilitates the launch and commercialization of hybrid electric vehicles via U.S. design and production of a world-class HEV/PHEV transaxle system
- Our approach leverages robust design evolution, common components, and a flexible assembly system at a world class Ford manufacturing facility.
- We have accomplished or exceeded all objectives for Phase I and Phase II of the project
 - Working prototypes are in vehicles for calibration development
 - Lessons learned through prototype testing and simultaneous engineering are being applied to the design for Phase III
- We are well positioned for the scope of work to be completed in the next year
- We are confident in the execution and ultimate success of the HF35 project