ALTIGREEN

Developing world class electric vehicle solutions purpose-built for short & medium haul transportation in India & emerging markets

On a mission to catalyze carbon free transportation, by developing world class electric vehicles, purpose-built for India & emerging markets

WHY?

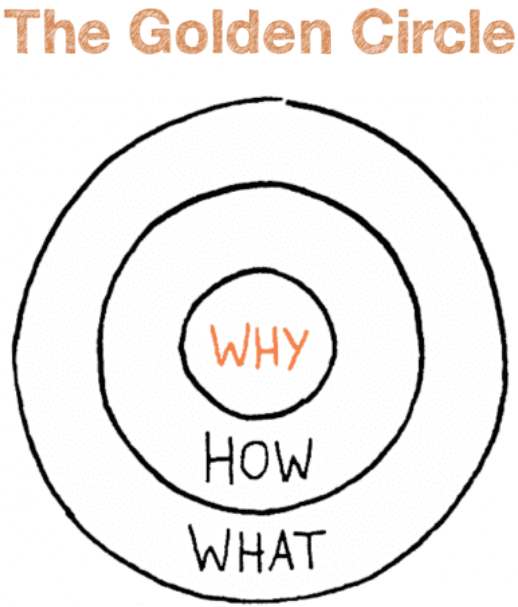
- ✓ Annually there are10 mn air quality related deaths globally
- ✓ 39 of the 50 most polluted cities globally are in India

HOW?

- ✓ Engineering first approach
- ✓ Building EV technology in India in addition to "Make in India"

WHAT?

- ✓ Addressing the global need of EV transition by making 3W/4W in cargo and passenger mobility applications
- ✓ Targeting short and medium haul transportation in emerging markets



By Simon Sinek

ALTIGREEN

With 10+ years of R&D journey and a well-established technology platform, Altigreen is on track to expand its product portfolio and grow exponentially

2011

Vehicle monitoring: collecting Indian drive data

2013

Started manufacturing retrofit hybridization kits

2016

Electric drivetrain solutions for 2W, 3W, 4W and tractor manufacturers

2018

EV display at Delhi auto expo

transformed to full-electric solutions

2021

Production and delivery of 3Ws started

2022

1,000+ vehicles on road; dealership network ramp-up

2023

Dealership & manufacturing expansion; new format 3W & D+5 shared passenger launch

Future

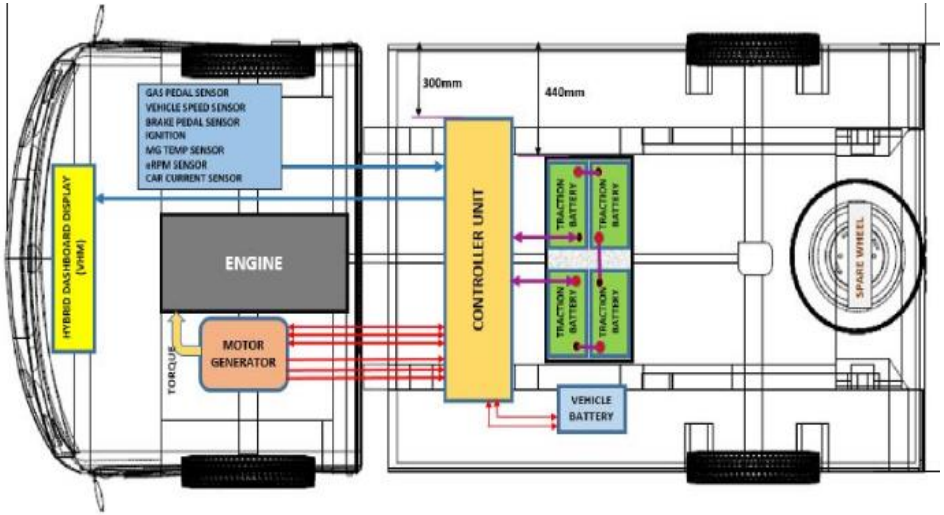
Launch of 4W Cargo & D+3 small passenger; 100+ dealerships

ALTIGREEN

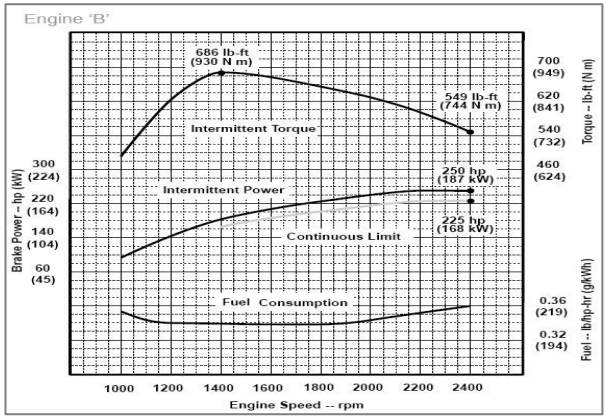
Overall Challenges

- ✓ Working with limited resources
- ✓ Shorter time to market for the Products
- ✓ Scarcity of skilled manpower for implementing complex algorithms
- ✓ Need for combined knowledge of Systems as well as target level implementation
- ✓ An architecture in place, for the software to be person independent
- ✓ Need of strong Testing and Validation process integrated with development
- ✓ EV Components to be EMI-EMC compliant
- ✓ Data analysis methods to improve on the systems
- ✓ Making products with price point suitable for Indian market without compromising on quality

Retrofit electric hybridization technology for ICE vehicles



Hybrid Retrofit Kit Layout



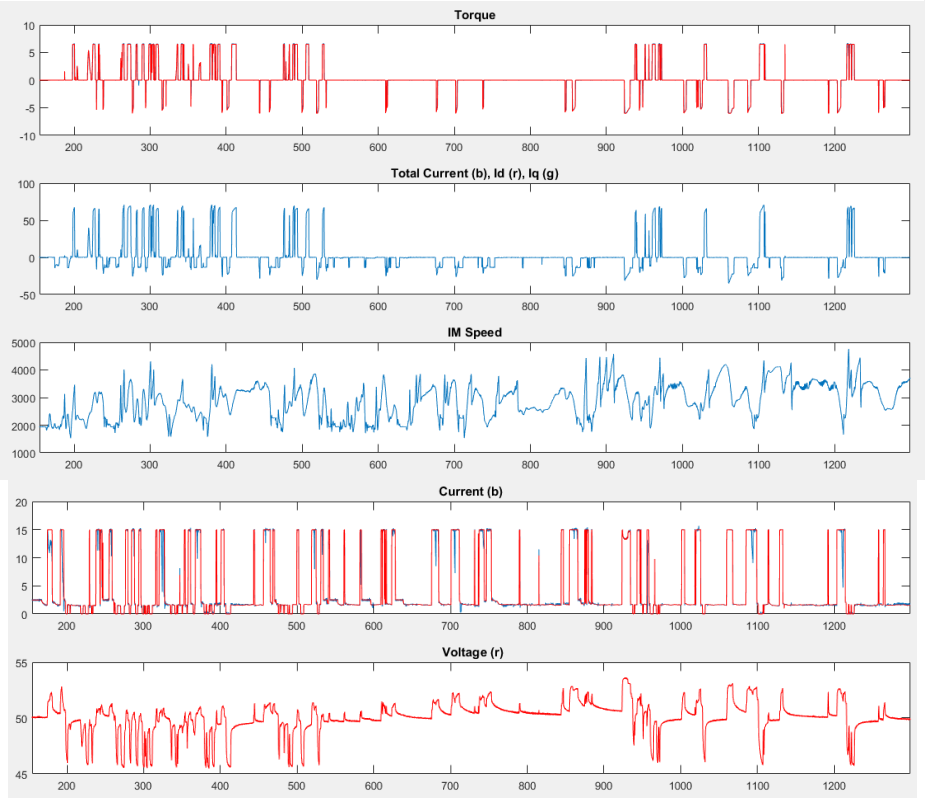
Engine Map Example

ALTIGREEN

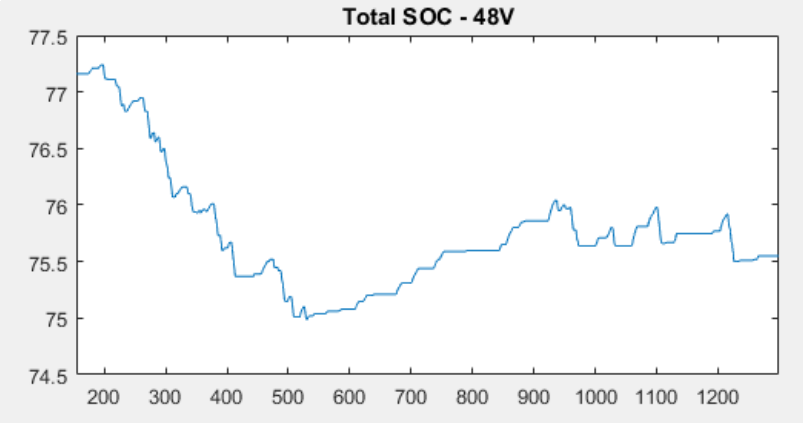
MATLAB used for Development, Simulation and Data Analysis

- ✓ Simulation models with engine map and hybrid powertrain
- ✓ Optimum Pulley ratio
- ✓ Optimum Assist-Regen schemes
- ✓ Data plots and drive summary analysis
- ✓ Production code generation using Embedded Coder

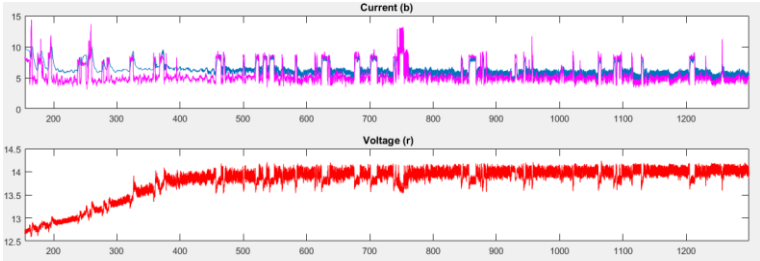
Hybrid System Data Set



IM – PMG parameters



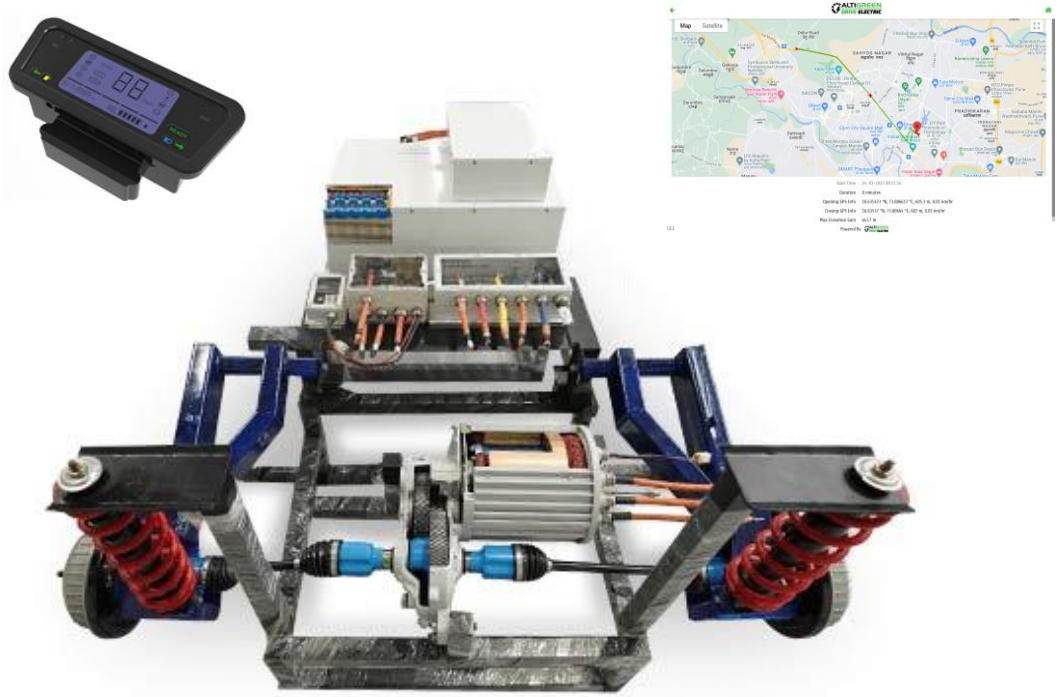
48V battery



12V Vehicle battery

Full Electric Drivetrain Components Development

- ✓ Motor
- ✓ Motor Controller
- ✓ Gear Box
- ✓ DC-DC Converter
- ✓ Display Cluster
- ✓ BMS and Battery
- ✓ Telematics
- ✓ WebApp for telematics Data collection

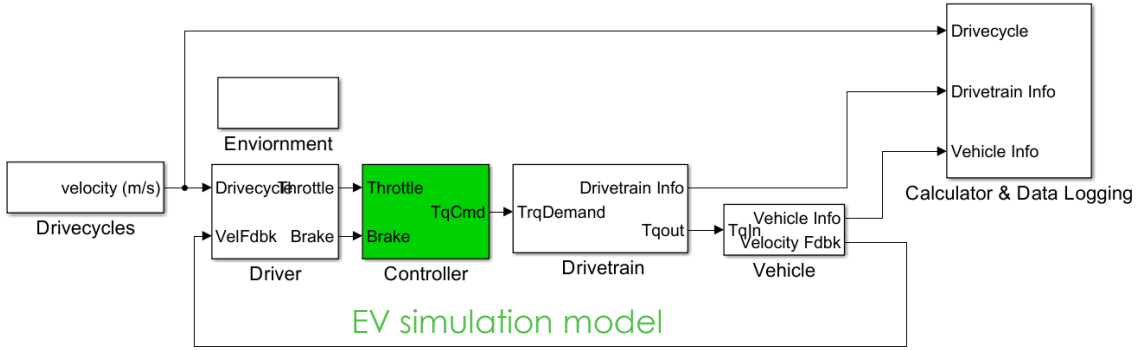


EV Drivetrain Layout

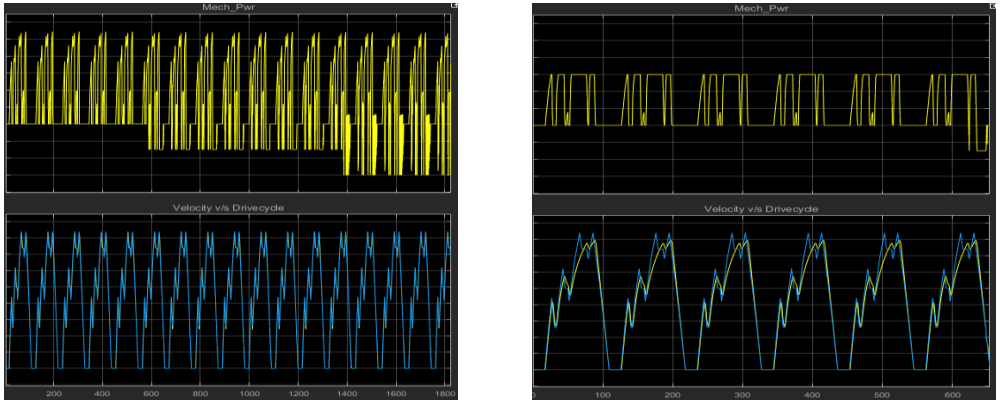
Requirements for Electric Vehicle design

- ✓ Vehicle to be comparable to ICE variant in terms of performance
- ✓ **Gradeability** in degrees
- ✓ **Kerb and GVW** in Kgs
- ✓ **Acceleration / Deceleration** in m/s2
- ✓ **Maximum Speed** in km/h
- ✓ **Energy Consumption** in wh/kms
- ✓ **Range** in kms

Electric Vehicle Simulation Model



EV simulation model



Motor Power and Vehicle Speed plots

Vehicle:

- ✓ Speed Profile
- ✓ Vehicle Mass
- ✓ Wheel Radius
- ✓ Gear Ratio
- ✓ Gradient
- ✓ Vehicle Dynamics parameters

Battery:

- ✓ SOC
- ✓ Capacity
- ✓ Voltage

Motor & Controller:

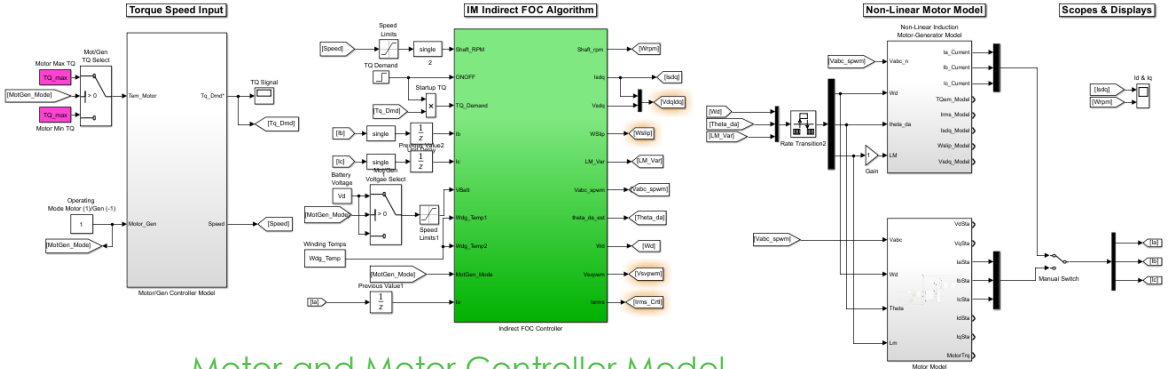
- ✓ Efficiency Maps
- ✓ Peak/Continuous Torque
- ✓ Peak/Continuous Power
- ✓ Peak Time
- ✓ Max Speed

ALTIGREEN

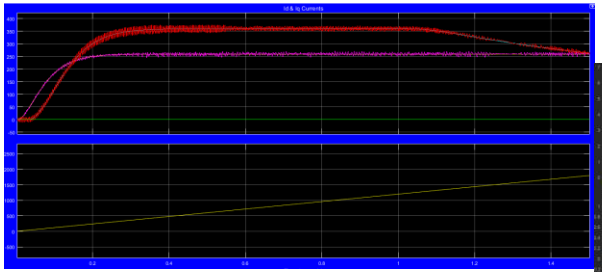
Motor Controls Requirements

- ✓ Mathematical model of Induction Motor
- ✓ Field Oriented Controls implementation
- ✓ Target deployment of FOC
- ✓ Matching the controller timings to target executions
- ✓ Combine the Vehicle controller with Motor controller on the embedded target

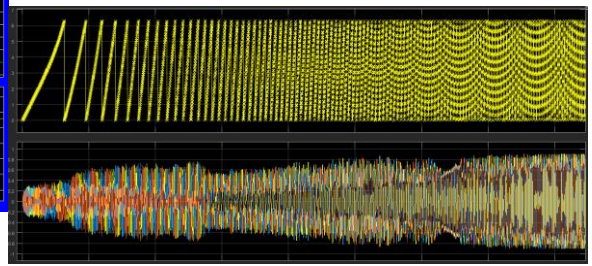
Motor Controls Simulation



Motor and Motor Controller Model



Id-Iq currents and Speed



Theta and Modulation Index

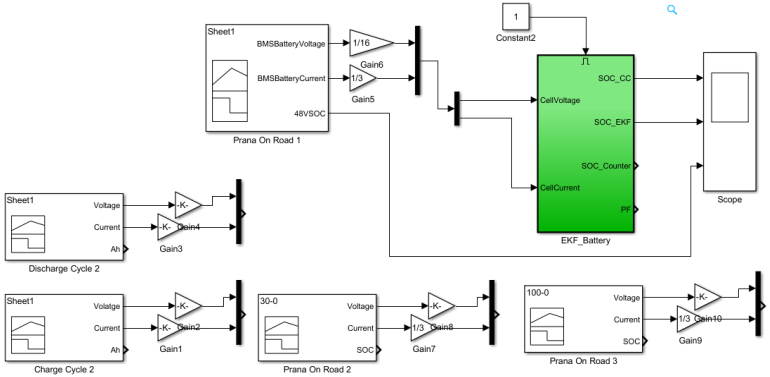
- ✓ Torque Speed Profiles as inputs
- ✓ Motor model
- ✓ Motor Controller algorithm - FOC
- ✓ Blocks in the FOC module are for the embedded target code generation
- ✓ FOC execution timings are adjusted so that they are matching to embedded target

ALTIGREEN

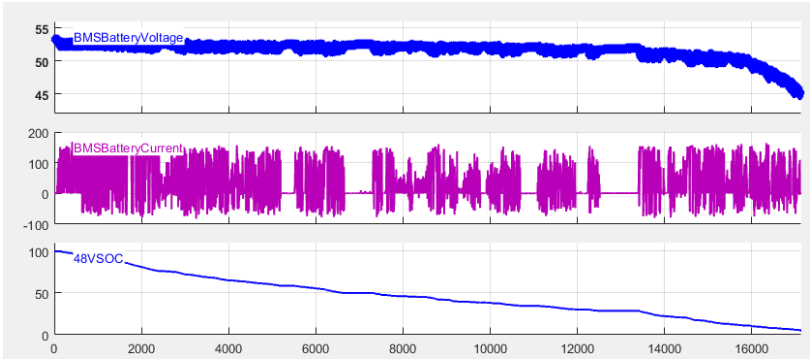
BMS Requirements

- ✓ Integrating device drivers Manual code and model-based algorithms
- ✓ Filtering of signals for EMI compliance
- ✓ Unit Testable Modules
- ✓ Target Deployment of BMS
- ✓ Better SOC Estimate to avoid Range Anxiety

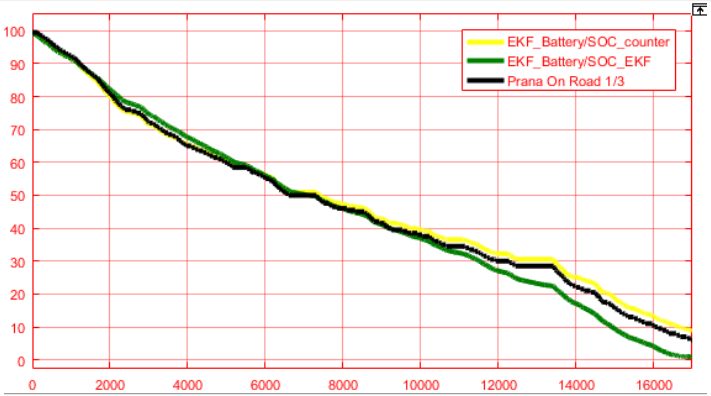
SOC Estimation using Kalman Filter for BMS

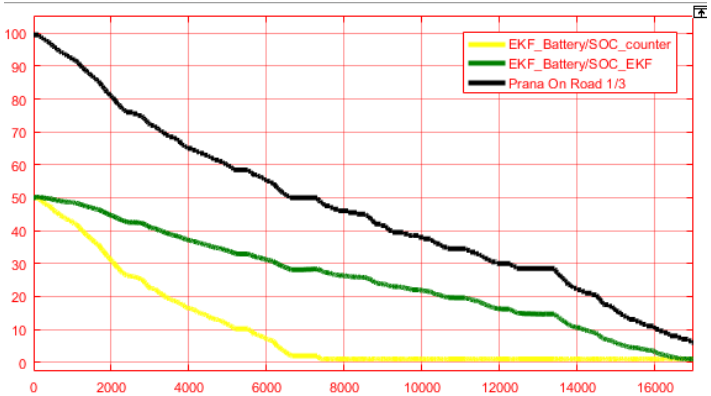


SOC Estimation by EKF



Real World discharge data with CC SOC





Better SOC estimate with Kalman with gradual correction

ALTIGREEN

Software Deployment using Simulink and Embedded Coder

- ✓ Vehicle Controller and Motor Controller in a single Physical Controller
- ✓ Upto 90% model based development leaving a small % for hand coding
- ✓ Manual/hand code is integrated in the models and the hex files generated by building the models
- ✓ Modeling to Simulation to Code generation to target deployment time significantly reduced
- ✓ Quick iterations between simulations to target deployment and using the real-world data back for simulations for any parameters tuning

State-of-the-art greenfield manufacturing facility in Bengaluru and Brand Centers across 30+ Indian cities

Altigreen's Manufacturing Plant, near Bengaluru

Altigreen Brand Centre

ALTIGREEN

Altigreen 3W Electric Cargo Vehicles

Altigreen neEV

Altigreen neEV - Tez

Thank You

www.Altigreen.com