Personal Portfolio

Prem Kumar R N

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About me and my journey

Prem Kumar R N

LinkedIn : Prem Kumar R Nagarajan

2015-2019

Thiagarajar College of Engineering Madurai

B.E. Mechanical Engineering

Sep-Oct'19

Product Training Center Chennai, India

Hands-on Tractor Training Program - 60 days

Oct'20 – Jul'22

TAFE, Chennai, India

Mechanical Design Engineer

Aug'22 - Present

U of M, Dearborn

MSE Automotive & Mobility Systems Engineering

May'23 – Aug'23

Hexagon Manufacturing Intelligence, MI, USA

Application Engineer – System Dynamics Intern

Sep'23 - Present

FEV North America, Auburn Hills, USA

Engine and Hybrid Powertrain Intern

Prem Kumar R N

MSE – Automotive & Mobility Systems Engineering

University of Michigan - Dearborn

Projects

Gearbox for ATV
Two stage speed reducer with reduction ratio of **7.5** designed to achieve desired performance of ATV.

Universal Joint Half shaft for ATV
Overall **weight reduction** of about 50 % achieved by customization from OEM Maruti 800 R-zeppa half shaft

Design of FSAE Radiator
Studied 2022 powertrain Radiator design and done theoretical and MATLAB Simulation to find the scope of downsizing.

Product Development – GMC Canyon EV 28
Benchmarking, preliminary design specifications, QFD, Interface requirement, Concept CAD design with system engineering V - Model

State of Charge Estimation
State of Charge and Parameters estimation of NMC battery were done with different Kalman filters such as Linear, Extended and Joint estimation

Energy Management with Intelligent Regenerative Braking system
Developed a control strategy for selection of automatic regenerative braking modes from driving pattern in Matlab/Simulink and study on energy saving compared with manual regenerative select modes

Skills & Software Exposure

- Creo Parametric
- Ansys Workbench
- ADAMS View & Car
- KISSsoft
- Finite Element Analysis
- Solidworks
- Matlab & Simulink
- Romax DT

Leadership Qualities

- **Powertrain subsystem captain** & Driver of Team Prometheans, Off-raod racing team of TCE
- **Joint Secretary** of Mechanical Engineering department

Achievements

- Students Achievers Award 2018, 2019
- Won 1st prize on "CAD CONTEST" SAE TIER 1 event.
- Secured 2nd position for "**Best overall conceptual design for designing drafting table**" in IUCEE EPICS Design Thinking Competition
- Course completion on "Hands on Introduction to Engineering Simulation" – **Cornell University**

Competitions

- Baja SAE India 2019 – 16^{th}/130 teams
- Enduro Student India 2018 – 14^{th}/ 80 teams
- Mega ATV 2019 – 2^{nd}/ 70 teams

BAJA SAE, India

2 Stage Speed Reducer

Powertrain specification and CVT tuning

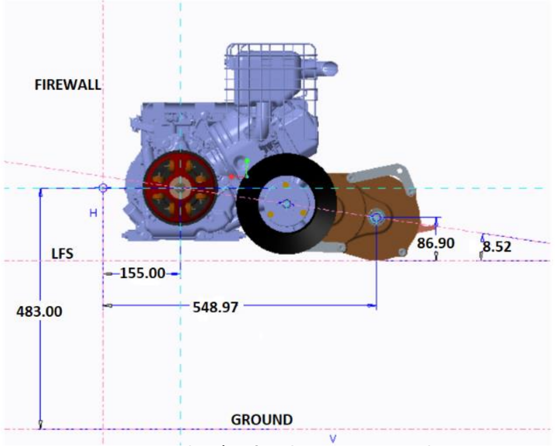
ENGINE	BRIGGS & STRATON
Maximum Power	8.9 HP at 3600 RPM
Maximum Torque	18.98 Nm at 2600 RPM

TRANSMISSION UNIT	
Cvt (Gaged GX9) and reduction Gearbox	
Overall Transmission Ratio	30.55 – 7.05

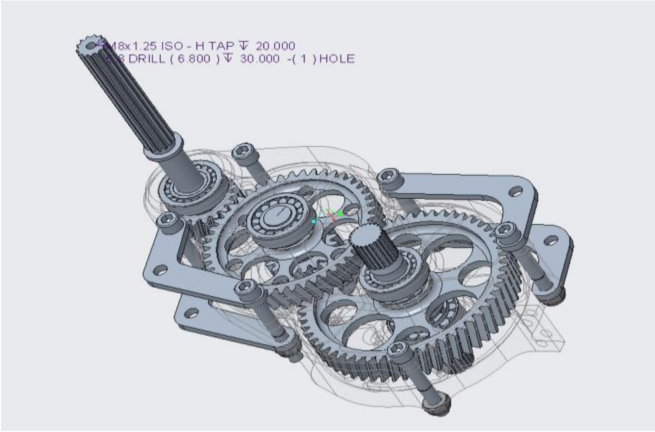
TYRE SIZE	
Front wheels (inch)	22 X 7 X 10
Rear wheels (inch)	22 X 7 X 10

MegaATV Event India - Overall Runner

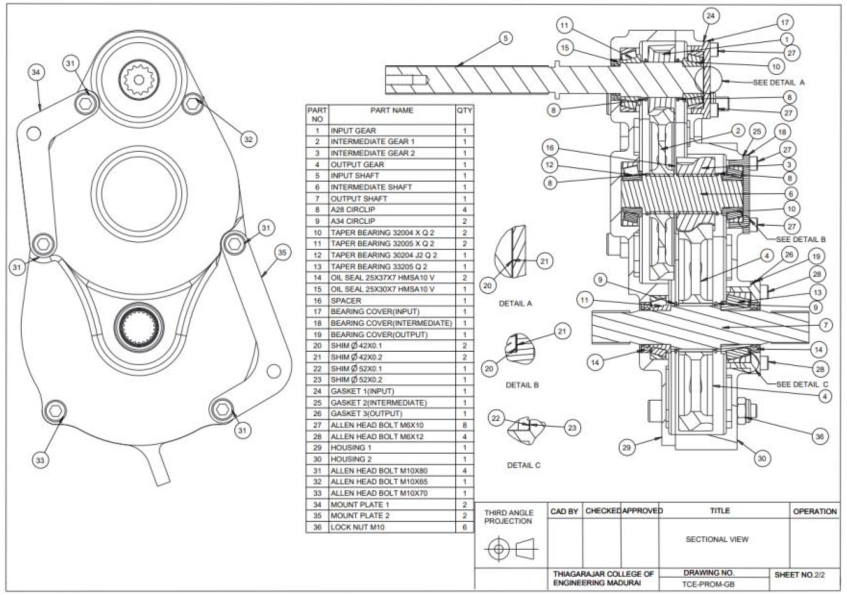
Gearbox & Competitions



Powertrain System Layout



2 Stage Gearbox – 2.5 x 3 ratio



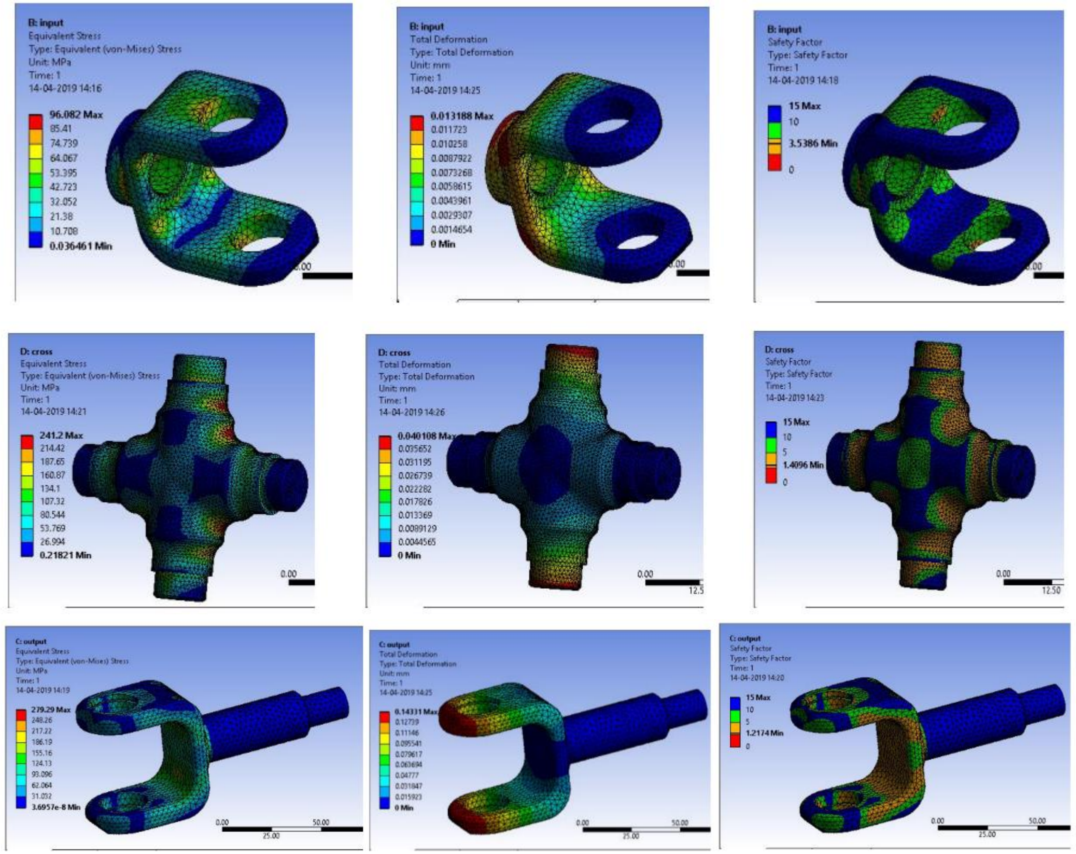
Gearbox Assembly drawing

BAJA SAE, India

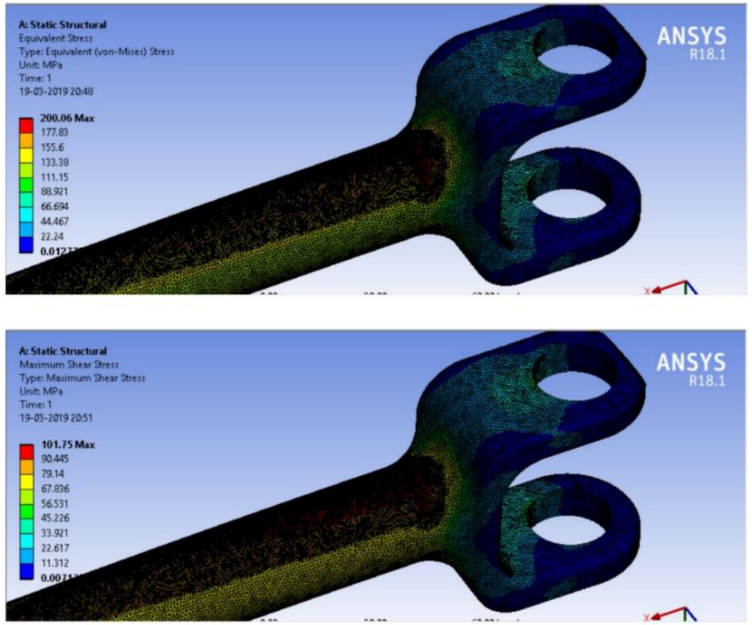
Universal Joint Half shafts

UJ overview

SI NO	PART NAME	Nos	MATERIAL
1	FORK(GEARBOX END)	2	EN24
2	INTERMEDIATE SHAFT	2	AL7075T6
3	FORK(WHEEL END)	2	EN24
4	SPIDER	4	EN24



Product & Testing



Successful implemented design with 50% weight reduction

Design of Experiments (DoE)

Continuous Variable Transmission (CVT) - Tuning

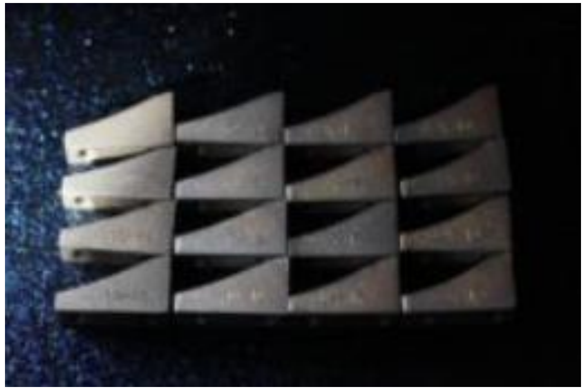
Tuning opportunities

Driver Clutch	
Weight pairs	3 sets (55, 65, 75 grams)
Ramps	2 different profiles
Main Clutch Spring	2 different stiffenss

3 x 2 x 2 = 12 Tuning opportunities

Driven Clutch	
Springs	2 different stiffness
Preload holes	9 holes
Helix profile	2 different profiles

9 x 2 x 2 = 36 Tuning opportunities

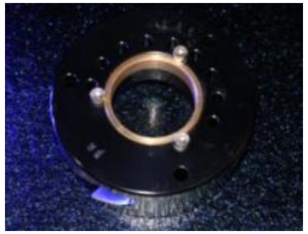


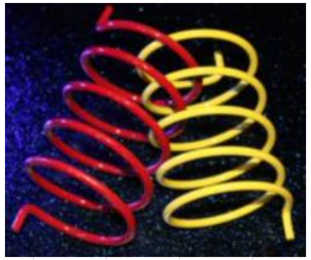
Ramps

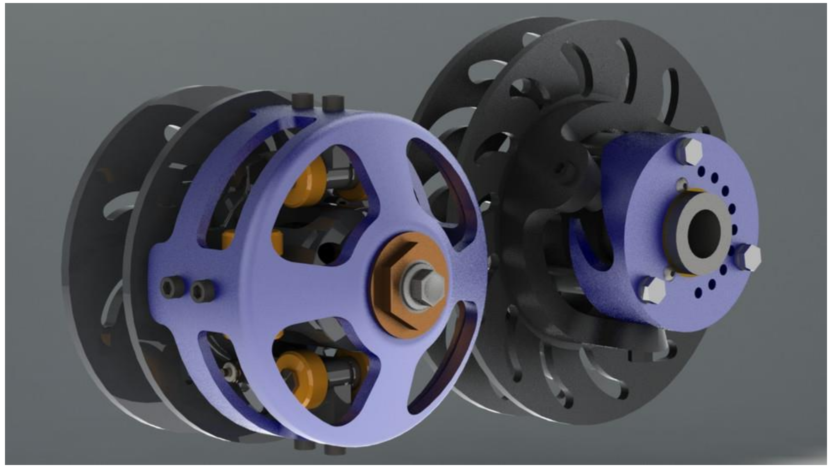
Weights

Driver Clutch parts

Product & Testing





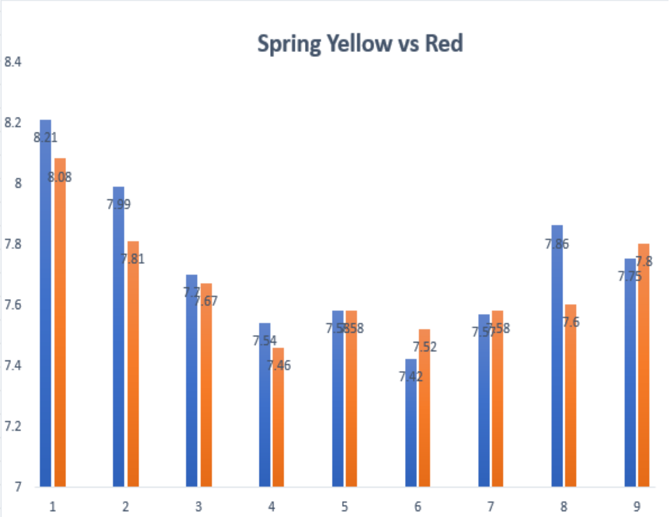


CVT TUNING (DRIVEN CLUTCH)

DISTANCE = 55 METERS

HELIX 1 (LARGE ALPHA)

HOLE NO	YELLOW			RED		
	TRAIL 1	TRAIL 2	AVG	TRAIL 1	TRAIL 2	AVG
1	8.3	8.12	8.21	7.9	8.26	8.08
2	7.93	8.05	7.99	7.82	7.8	7.81
3			7.7	7.51	7.83	7.67
4	7.5	7.58	7.54	7.49	7.43	7.46
5	7.63	7.55	7.58	7.62	7.55	7.58
6	7.39	7.46	7.42	7.5	7.54	7.52
7	7.49	7.65	7.57	7.63	7.53	7.58
8	7.84	7.89	7.86			7.6
9	7.75	7.75	7.75			7.8

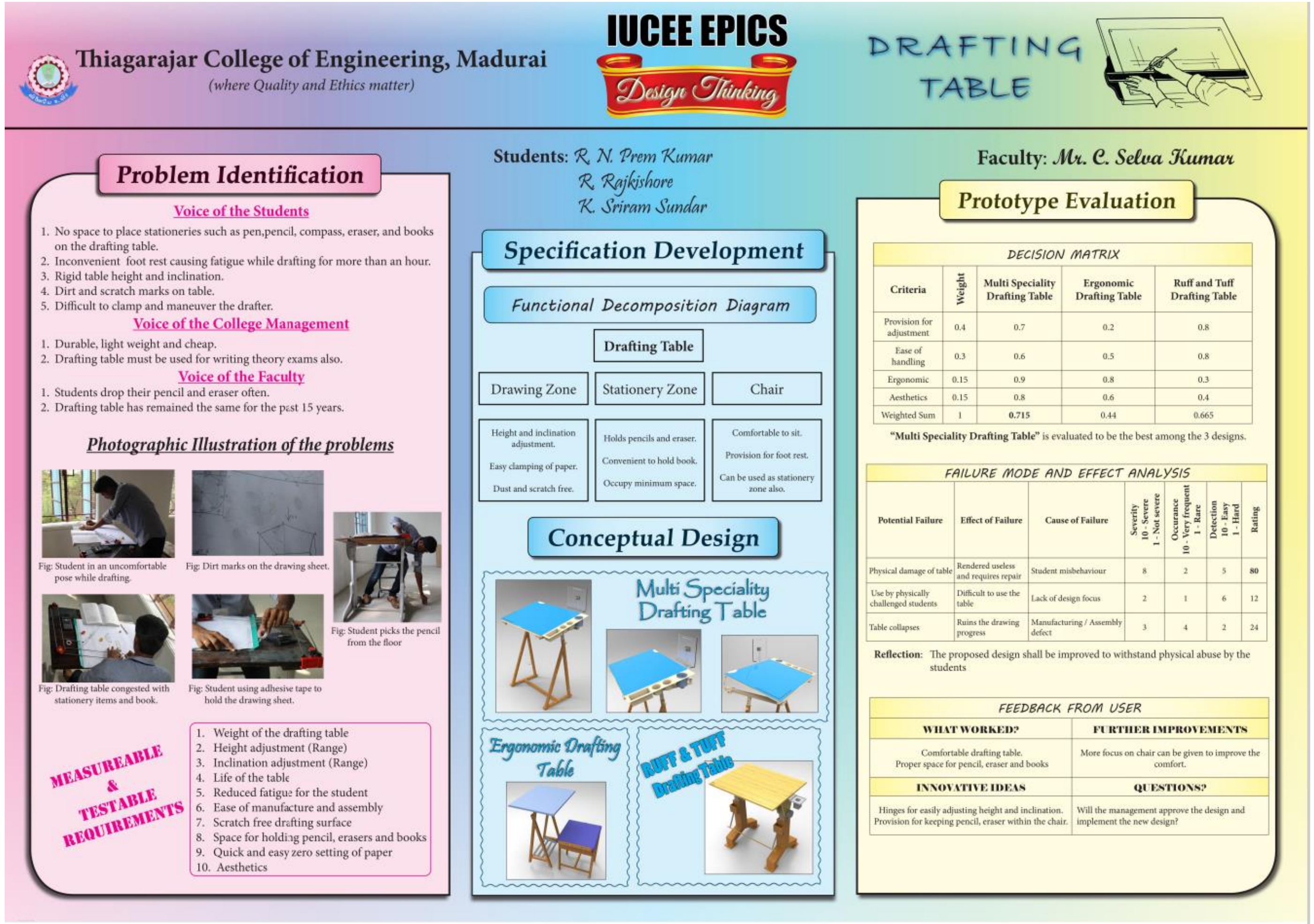


CVT tuning results by rigorous testing, showing time to reach 55 meters under different tuning setups

IUCEE – EPICS (Engineering Projects in Community Service)

Best overall conceptual design for designing drafting table

Poster Presentation



Design Contribution

My design contribution – Creative and lightweight

Design : *PTC Creo 4.0*
Render: *Keyshot*

IUCEE – Indo Universal Collaboration for Engineering Education, ***Purdue University***

Result : 2nd in Poster presentation

A Hands-on Introduction to Engineering Simulations

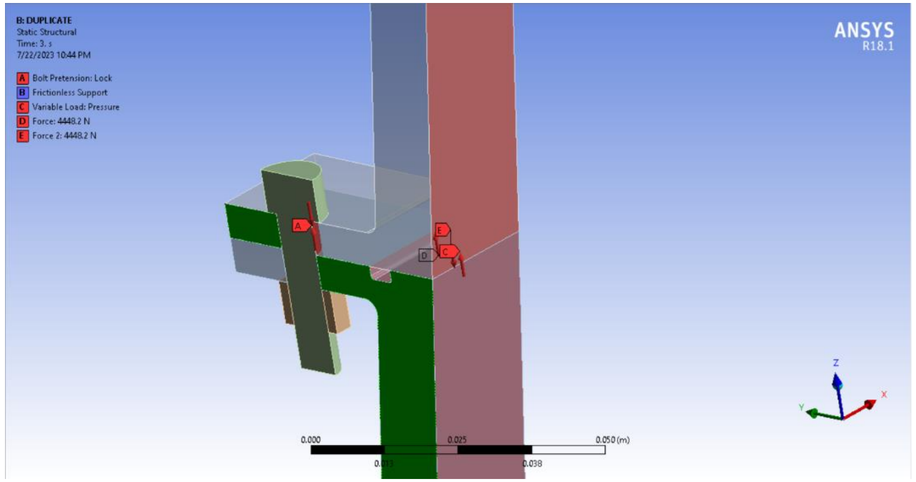
edX online course

Syllabus and Assessment

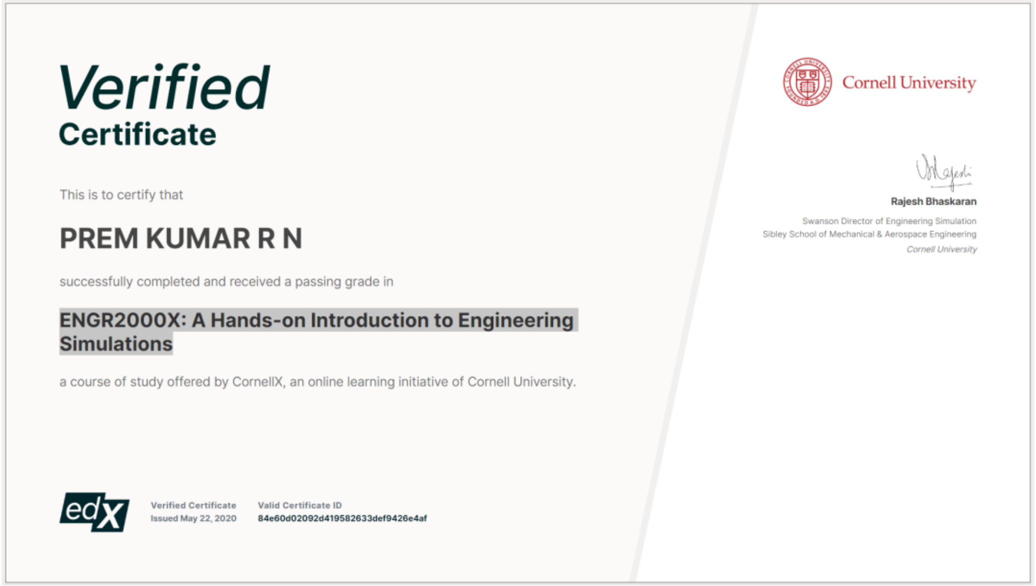
- Describe the "big ideas" in finite-element analysis and computational fluid dynamics
- Develop structural mechanics simulations using ANSYS Mechanical ™
- Develop fluid dynamics simulations using ANSYS Fluent ™
- Describe the mathematical models underlying simulations
- Build simulations of real-world applications using ANSYS® software
- Verify and validate simulations including checking against hand calculations
- Approach engineering analysis and simulations like an expert

Assignment type	Weight	Grade	Weighted grade
Big Ideas FEA	10%	100%	**10%**
2D Conduction	3%	75%	**2%**
2D Conduction HW	24%	87%	**21%**
Big Ideas: Solid Mechanics	6%	100%	**6%**
Bike Crank	1%	100%	**1%**
Bike Crank HW	16%	80%	**13%**
Bolted Nozzle Flange	1%	100%	**1%**
Bolted Nozzle Flange HW	6%	100%	**6%**
Big Ideas: Fluid Dyanmics	5%	83%	**4%**
Big Ideas: CFD	4%	100%	**4%**
Laminar Pipe Flow	2%	67%	**1%**
Laminar Pipe Flow HW	22%	100%	**22%**
Your current weighted grade summary			**91%**

Most interested topic & Certification



Bolt Pretention, Hoop stress, Thermal strain and deformations simulation



Verified
Certificate

This is to certify that

PREM KUMAR R N

successfully completed and received a passing grade in

ENGR2000X: A Hands-on Introduction to Engineering Simulations

a course of study offered by CornellX, an online learning initiative of Cornell University.

Cornell University

Rajesh Bhaskaran
Swanson Director of Engineering Simulation
Sibley School of Mechanical & Aerospace Engineering
Cornell University

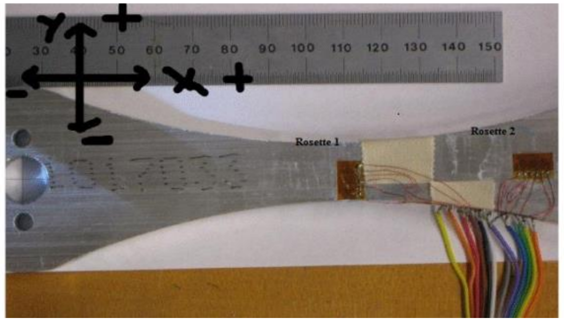
edX
Verified Certificate
Issued May 22, 2020

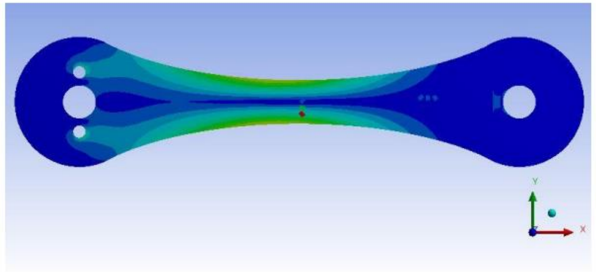
Valid Certificate ID
84e60d02092d419582633def9426e4af

Ansys Simulations

Simulated models – Structural, CFD, CFX & Explicit Dynamics

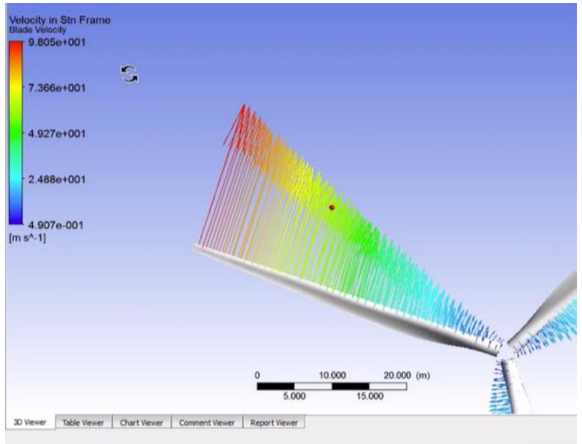
Structural and CFD



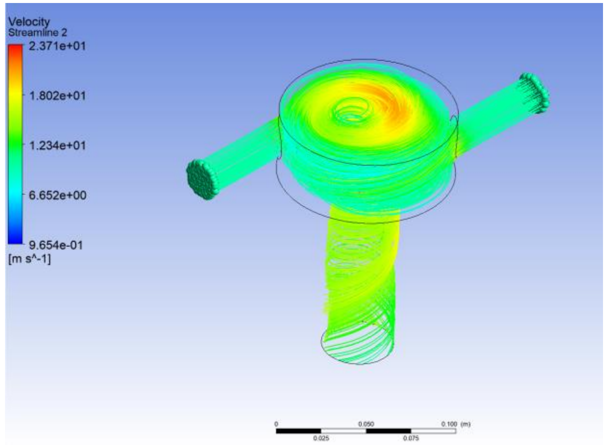


Strain Gauge	Beam Theory	Ansys	Experiment	Difference
Center	321	311	348+-7	11%

Static Structural – Comparison with experimental study

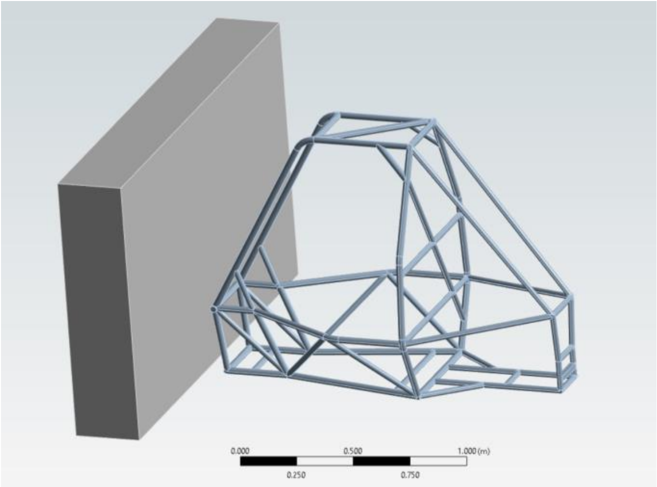


Turbine Blade - CFD

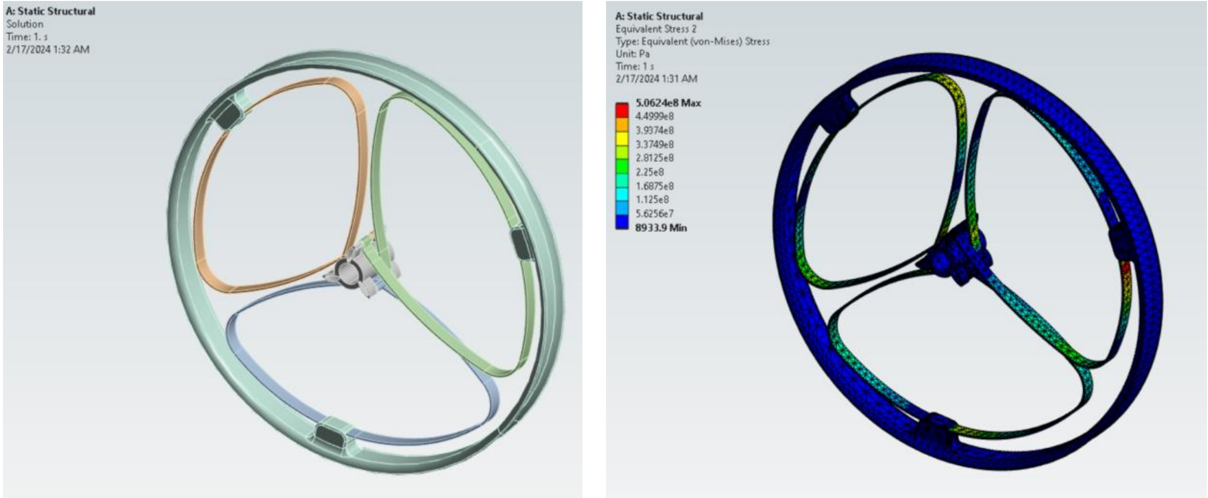


Multi-fluid - CFX

BAJA – Explicit Dynamics & Loop wheel Simulation



Explicit Dynamics – ATV Crash test



Structural Analysis - Loopwheel

TAFE Product Training Centre, Chennai

Sep'19 – Oct'19

- **Key Learnings**
  - Basics knowledge on tractor – Models and HP range
  - Classification of Implements and its usage
  - Aggregate wise training – Function, Assembly & Dismantle procedures
  - Aggregate wise Setting procedure
  - Problem identification, Troubleshooting and Maintenance
  - Hands-on experience on tractor driving and field applications.
- **Trackwidth change animation Project**
  - Creo Animation project - Change in trackwidth of TAFE tractors
  - Front and Rear Trackwidth setting from 48 inch to 76 inch (8 settings)
  - Manual changing of Tractor wheels – Difficult and Time consuming
  - To transfer limpid knowledge on setting procedure, Animation was created.

*Rear wheel Trackwidth adjustment – **48in***

8 settings – Animation highlights

*Rear wheel Trackwidth adjustment – **76in***

TAFE Limited, Chennai

Oct'20 – Jul'22

Introduction

- Department : Research & Development
- Position : Mechanical Design and Development Engineer

Projects

- Domestic New tractor introduction

41 – 50 Hp	
	DynaTrack (2 variants)
	CRDI (2 Variants)

- OBD & Simulator

CRDI	
	Breakout Box – DFMEA CRDi failure study training
	OBD Tool development, testing and Validation

- 8 + 8 Shuttle Transmission Design

Design	
	CAD Models : PTC Creo 4.0
	Simulation : Ansys & KISSsoft
	Component : *Shaft, Gears, gear shifting levers, Shifting rails, Shifting forks*

- Development of Proto parts

Develop-ment	
	Coordinate with NPD team and sign off
	Coordinate with NPQ team and sign off

Roles and Deliverables

- **Design of Transmission components**
  - Conceptual design of transmission system that meets the design requirements
  - Perform vehicle dynamics calculation and optimize transmission ratios
  - To execute kinematic simulations to validate desired degrees of freedom and ensure functionality of each components in assembly
- **Development of Prototype parts**
  - Coordinate with New Part Development team to ensure feasibility study of prototype parts with potential suppliers and follow up on pilot lot production
  - Coordinate with the Part Quality team to verify that dimensional accuracy, material quality, and heat treatment core and surface hardening depth align with specifications and sign off
- **eCIMP Co-ordination**
  - To coordinate with R&D team to ensure posting and implementation of new ideas from all team members to reach objective targets as per TQM.

TAFE Limited, Chennai

Oct'20 – Jul'22

Highlights

Design Brainstorming session

DFMEA study with breakout box for CRDi tractor

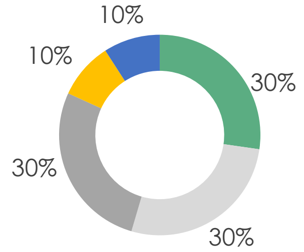
Pilot tractor prototype

Key Learnings

- In-depth Product Training & CRDi diesel technology
- Knowledge on AGCO products
- SAM check procedures
- New technologies – **DynaTRACK**, **PST transmission**, **Hydraulic Clutch**
- Online Product Training on **ISEKI HC80P** Combine Harvester
- Eicher ADDC Hydraulics – **Hydromatic** & **Non-Hydromatic**
- Learning on issues from Complaint tracker
- Right To Repair Movement

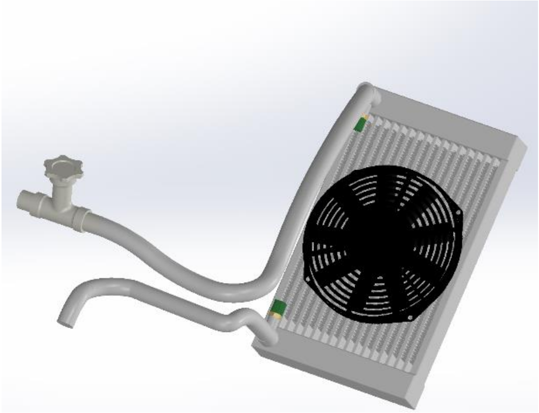
Skill & Leadership development

- Managerial skills
- Technical knowledge
- Design and Analysis
- Windchill, MS Office
- Presentation skills



University of Michigan Dearborn
FSAE project

FSAE Project



Reverse Engineered - 3D OEM Radiator Model in SolidWorks

- 9'' x 14.5'' inch Aluminium alloy Radiator
- Fin density: 12 fins per inch
- Mishimoto 2 bar pressure cap - Raises boiling point to 120 degree C
- Calculation method : NTU-Ɛ method
- Expected Heat rejection = 35 KW
- Expected Heat rejection = Ɛ x Qmax

Radiator effectiveness calculator using,

$$\varepsilon = 1 - e^{-\frac{Cmax\left(1 - e^{-Cratio\, Ntu}\right)}{Cmin}}$$

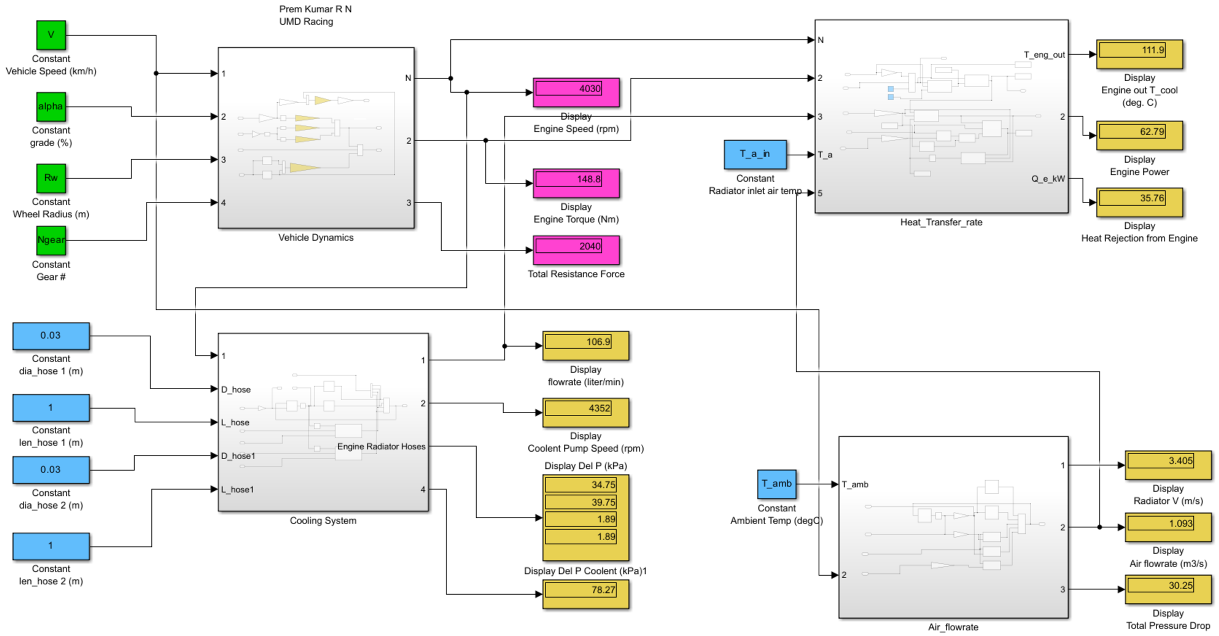
Heat capacity rates :

- Air = mfr_a x Specific heat capacity (C_min)
- Water = mfr_w x Specific heat capacity (C_Max)
- Cratio = C_min / C_max
- No. of Transfer Units (NTU) = UA / C_min

U = Overall Heat transfer coefficient

A = Coolant surface area

1D Model Based Development of Cooling System



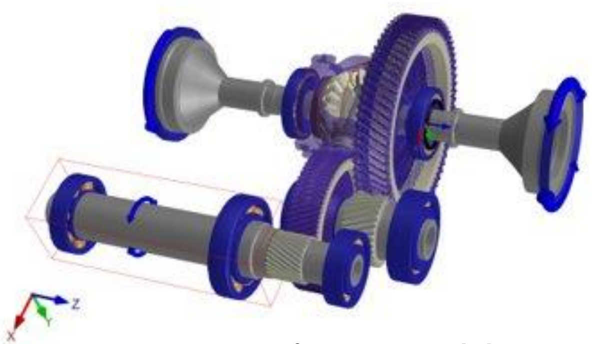
1D Model Based Simulations - 4 blocks :

- **Vehicle Dynamics** block analyzes road loads to determine engine torque and speed based on the current vehicle speed, which acts as input for flow models.
- **Cooling System** block assesses the dimensions of hoses and predicts anticipated pressure losses across the system, as well as pump speed and coolant flow rates.
- **Airflow rate** block evaluates ambient pressure, temperature, and vehicle speed to estimate the pressure drop across the sidepods and compute the airflow rate.
- **Heat transfer rate** block computes two factors: the anticipated heat rejection from the engine to the coolant, considering torque, rpm, and BMEP data; and the expected heat rejection from the radiator to the air, employing effectiveness NTU calculations.

Hexagon Manufacturing Intelligence – Summer Internship

EV Drivetrain build and System Dynamic load analysis

Project Objective



Romax Reference Model

- Building an Empire EV drivetrain template in Adams Car using an existing Romax transmission model
- Simulate dynamic load in Adams Car and compare the results of coupler and gear contacts modelling
- High fidelity model : Gear AT, Bearing AT, Flexible shafts and Housing

Learning Objective

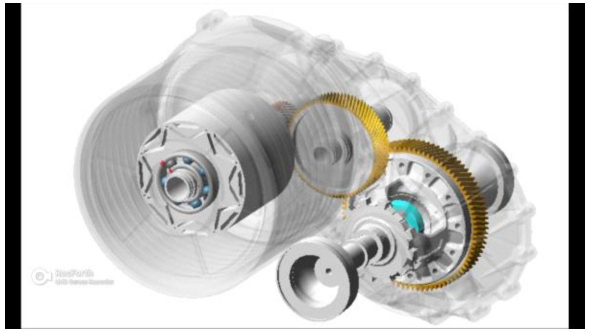
Software :

- Fundamentals of Adams/View & Adams/Car
- Adams Car – template builder
- Romax basics – User interface
- Elements overview

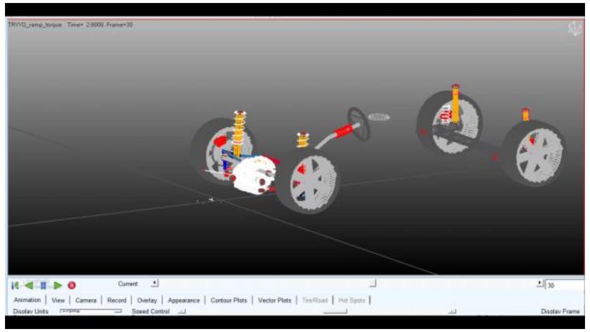
Prerequisite/training :

- To understand Romax user interface and Romax EV drivetrain model
- ADM740 – Adams Car (till templates session)
- Adams installation documents - Adams/Car
- Adams driveline template tutorial
- Adams Gear AT introduction

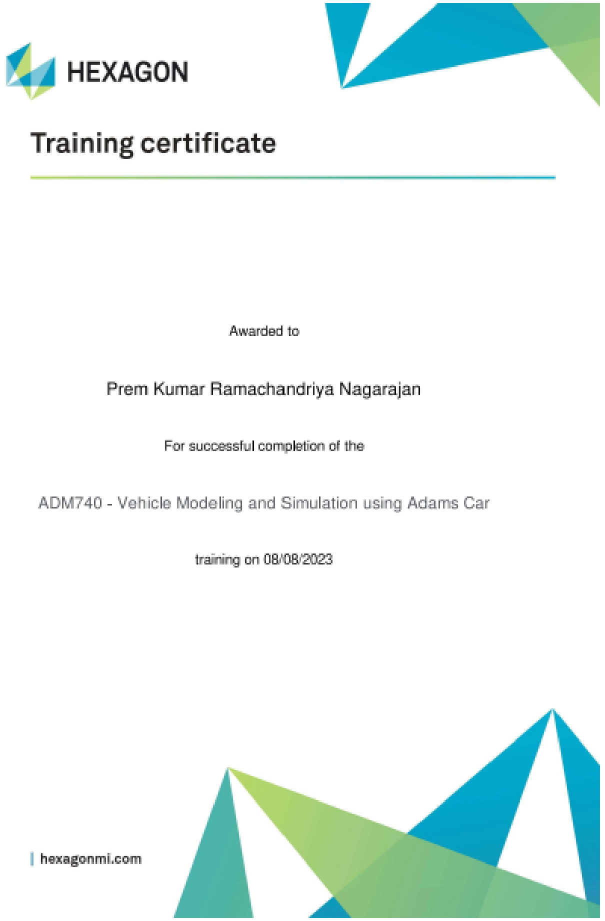
Project outcome



EV Drivetrain created in Adams car from scratch



Full Car simulation – Dynamic Analysis



HEXAGON

Training certificate

Awarded to

Prem Kumar Ramachandriya Nagarajan

For successful completion of the

ADM740 - Vehicle Modeling and Simulation using Adams Car

training on 08/08/2023

hexagonmi.com

ADM740 Certification – Adams Car

Academic Coursework – University of Michigan

Powertrain NVH – Theory & Experimental Laboratory

Academic coursework

- Acquired understanding of the **mathematical principles governing mechanical systems**, including the Spring Mass Damper system and its Harmonic motions.
- Done various small experiments with **Audacity software** to calculate FRF peaks, Order analysis, calculating Natural frequency of materials and comparing it with theoretical hand calculations.
- Studied **Modes shapes and Modal Analysis**, using, strings/spring system tied with small motors and estimated the modes at different excitations frequencies.
- Performed detailed study on the transfer of Structure-borne and Air-borne noise and conducted an **in-depth literature review** on "**Sound Quality (SQ Metrics): Masking Road and Wind noise in Electric vehicles**".

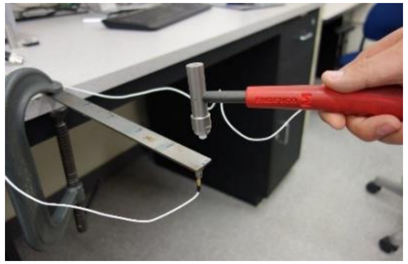
Software & Instruments

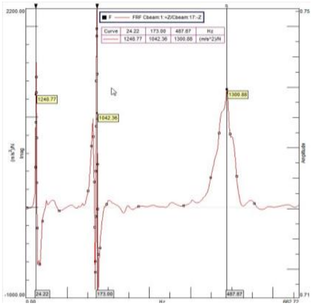
Software used:
- Siemens Test Lab 2021.2
- Pulse Labshop

Instruments :
- SCADAS Digital Analyzer
- Accelerometers
- Hammer transducer
- Impedance tube
- Microphones/Speakers
- Power Amplifiers

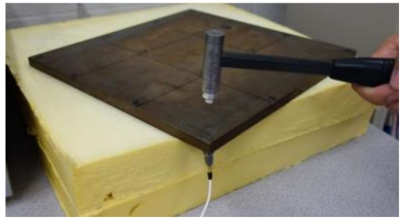
Laboratory Experiments

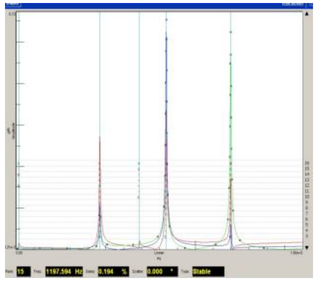
- Frequency Response Function Measurements



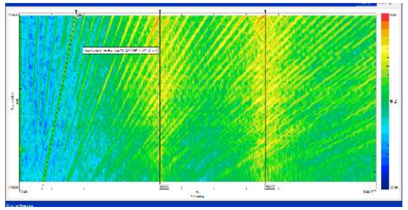


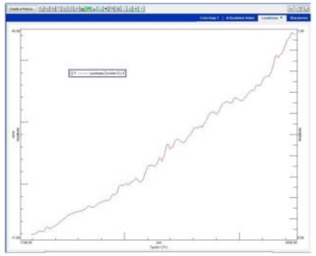
- Modal Analysis of a flat plate



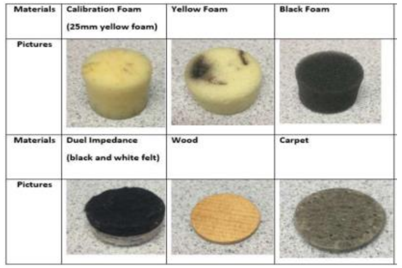


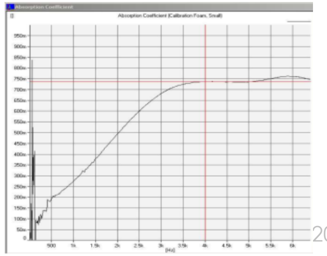
- Order tracking and SQ metrics





- Absorption coefficient of porous material using Impedance tube

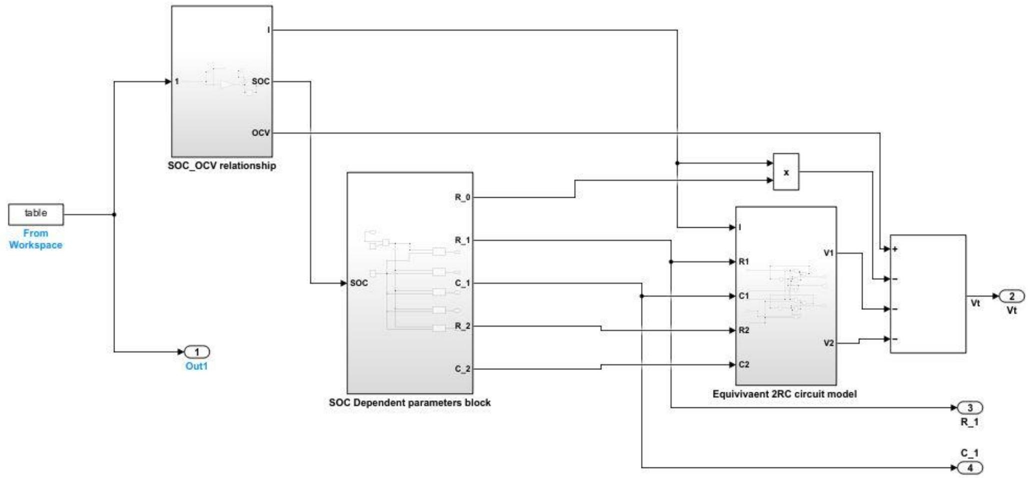




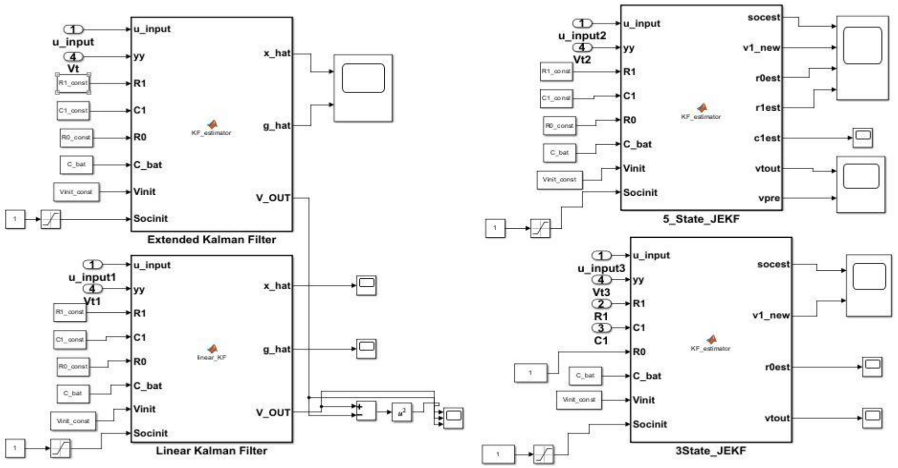
Academic Projects – University of Michigan

Battery Modelling and Controls – State of Charge Estimation

1D Model Based Development

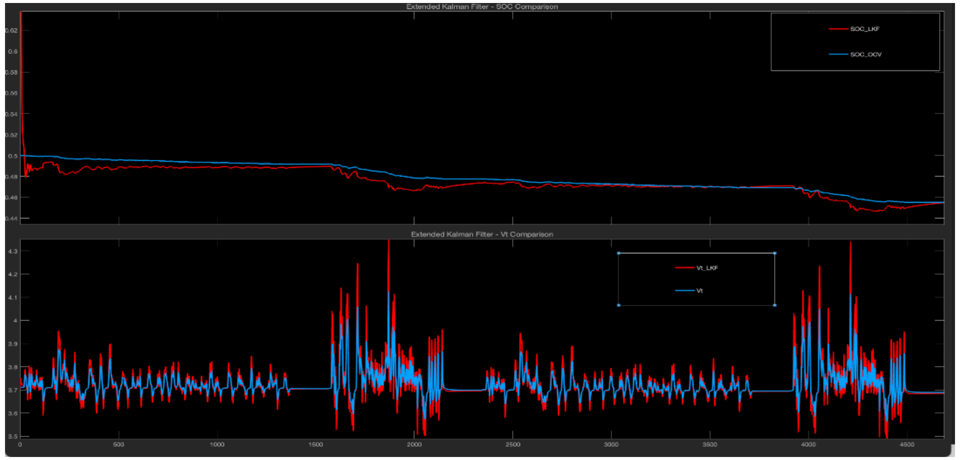


NMC Battery – OCV-R-2RC Plant model



Kalman Filter algorithm – Linear, Extended, Joint Estimation blocks

Model Results



SOC and Vt - Estimation vs Measurement Result

Results:

Linear and Extended :

- *Output voltage profiles are more likely same and SOC with good accuracy in Linear than extended.*
- *Soc values are expected to be poor when actual Soc are below 15 percentage and above 85 percentage of charge, as linearization was done.*

Joint Estimation – 5 states (Soc, Vt, R0, R1, C1) :

- Since many unknown states, the result produces more RMSE values.
- C1 estimation didn't converge as expected
- Soc RMSE is high as it took much time to converge at the initialization point.

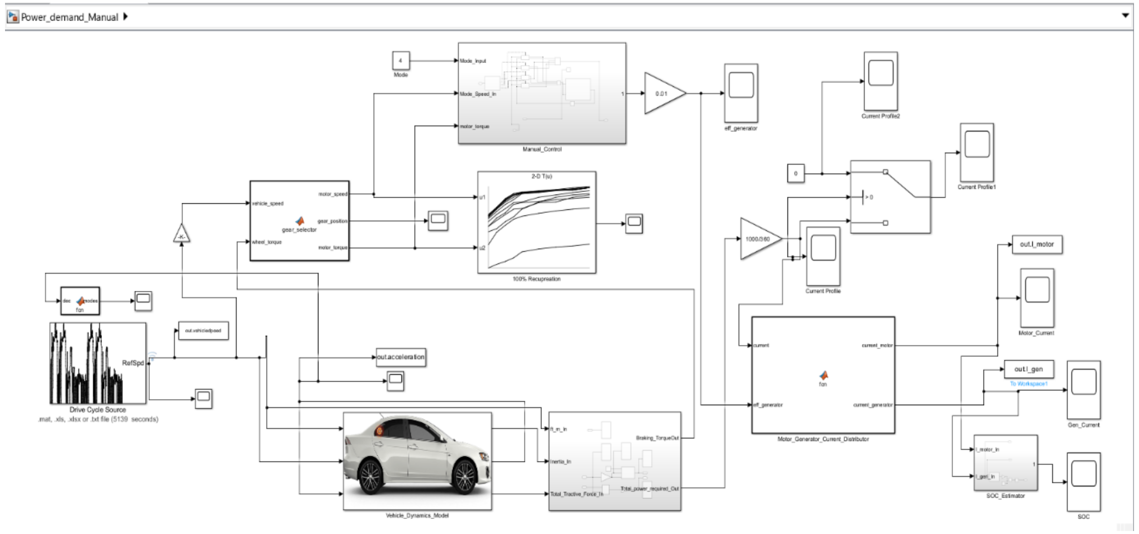
Joint Estimation – 3 states (Soc, Vt, R0) :

- The results are more accurate with slightly low computational time.
- R0 & Soc results are good as compared to 5 state estimation

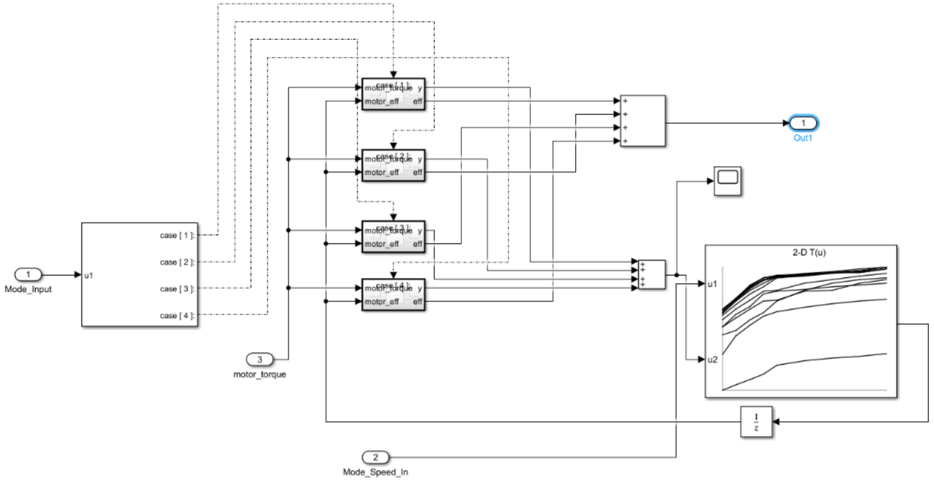
Academic Projects – University of Michigan

Energy Management of Evs – Regenerative Braking : Automation of Energy Recuperation Modes selection

1D Model Based Development

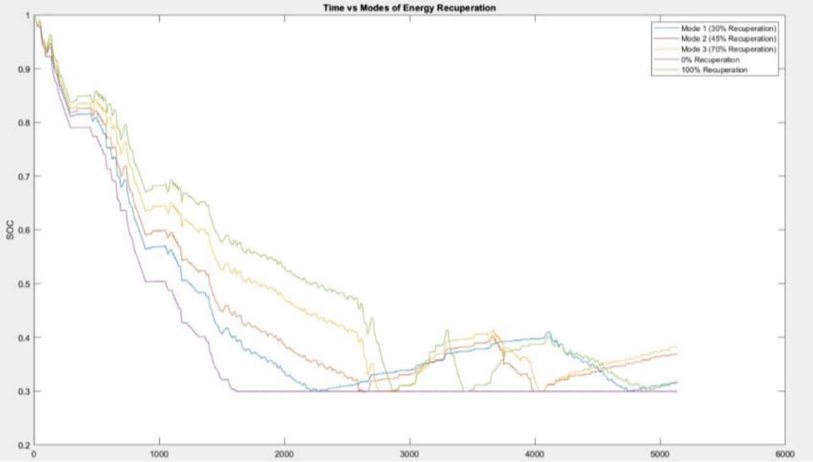


Overall PHEV Model – Vehicle Dynamics, Battery Model, Motor Control, Transmission gear selector, Regenerative braking model

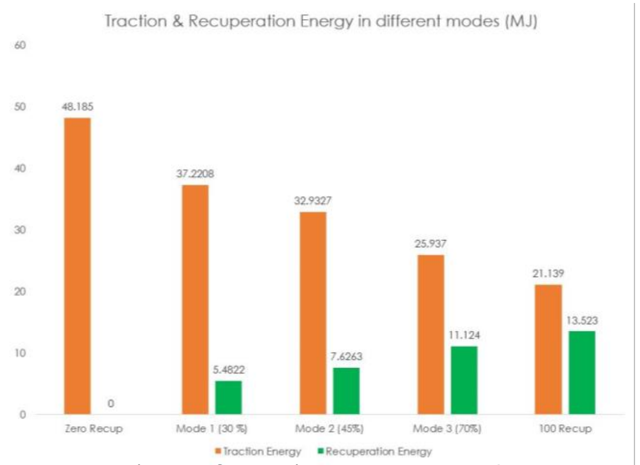


Automation of Regenerative braking modes – Balancing Recuperation and Ride Comfort

Model Results



SOC and Vt - Estimation vs Measurement Result

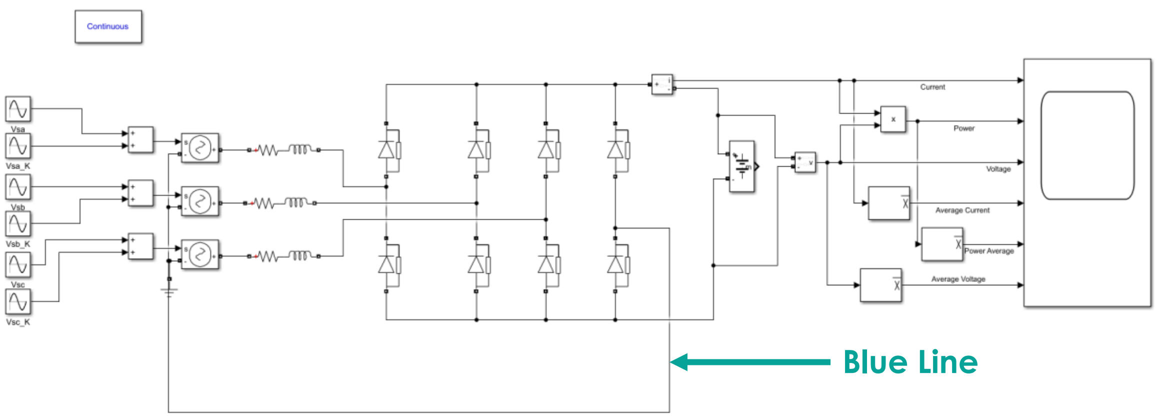


This graph shows the comparison of traction energy and recuperation energy in the 3 modes, zero and 100% recuperation. As desired, in mode 1 with 30% recup, 5.48 MJ of energy is restored. In mode 2 with 45% recup, 7.62 MJ of energy is restored and in mode 3, 11.12 MJ of energy is saved. This is a significant number considering energy management and increase in range.

Academic Projects – University of Michigan

Vehicle Electronics I – Analysis of Generator Charging System with 4 diode pairs (Mini project)

1D Model Based Development



Model - Three-phase AC voltages with noise, RL components, and four pairs of diodes for DC conversion for battery charging

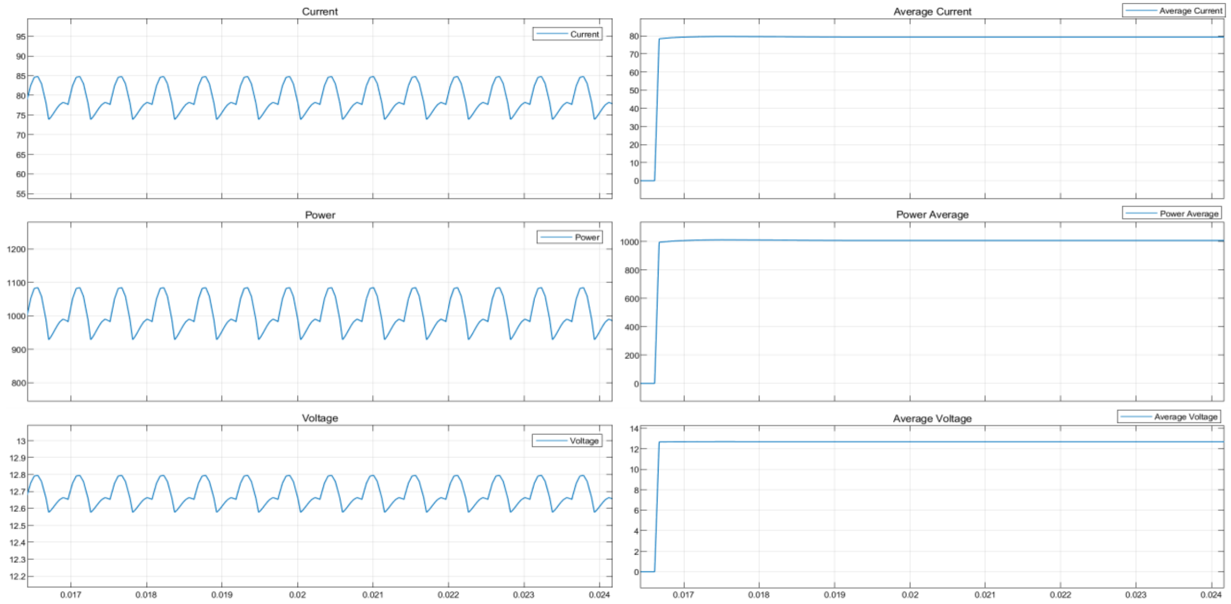
Input parameters :

- The Resistance and Inductance are taken as 0.04 Ohms and 200e-6 Henry.
- Assuming the diodes are silicon diodes with forward voltage of 0.6V and 0.3 Ohm resistance
- The battery on the right side of the circuit is chosen to be 12V nominal.

Voltage source	Volts (V)	Frequency (Rad/sec)	Frequency Hz	Phase (rad)	Phase (deg)
Vsa, Vsb, Vsc	V	1884.95	300	0, 2.0944, 4.18879	0, 120, 240
Vsa_K, Vsb_K, Vsc_K	V*K	5654.86	900	0	0

AC Voltage inputs

Model Results



Voltage, Current and Power measurements

Result :

K value	Blue Line	Volts (V)	Ampere (Amps)	Power (Watts)	Power % change
0.5	Included	12.69	79.35	1009	12
	Excluded	12.54	72.01	903.3	
0.25	Included	12.55	72.69	912	1
	Excluded	12.54	72.02	903.3	