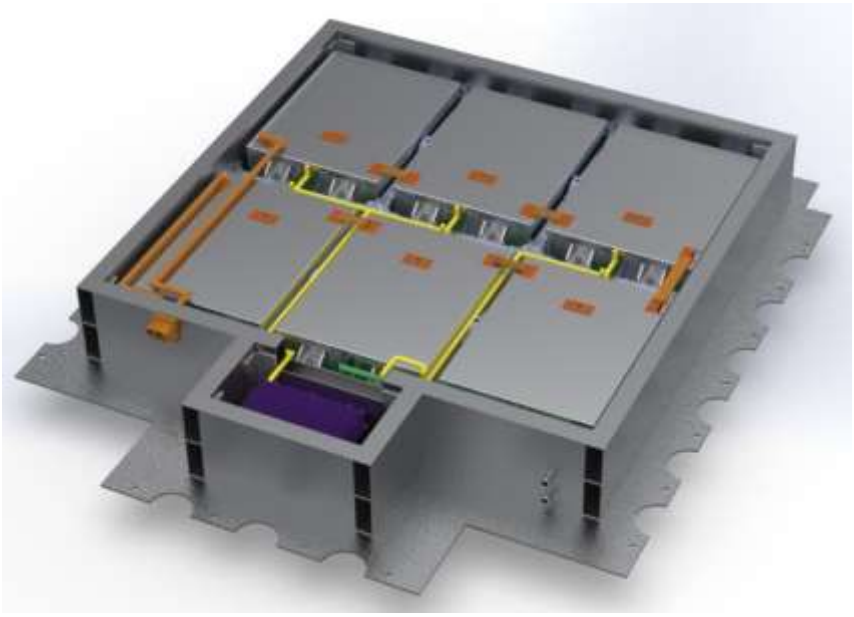
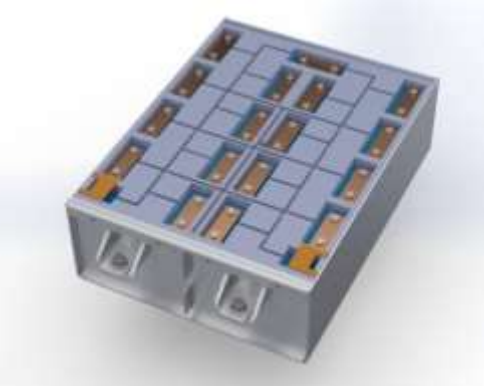
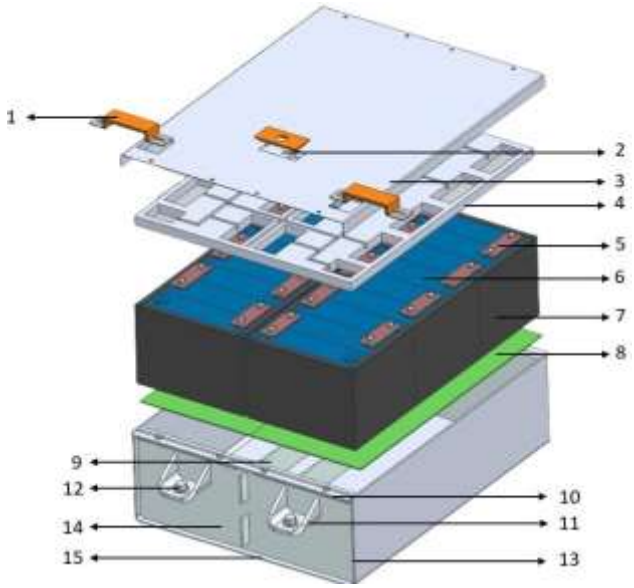
Final Year Project Showcase Batch-2017
Year 2021

Department: Mechanical Engineering Programme: Mechanical Engineering		
1	**Project Idea**	**Design, Simulation and Fabrication of Battery Pack with Thermal, Vibration and Battery Management System for an Electric Car**
2	**Process**	• Appropriate cells selection through a detailed local and international market survey and comparison of properties such as specific energy capacity, cycle life, cost, weight, temperature range, charge and discharge rates, etc. It also focuses on the power requirements of the selected electric car. • BMS (Battery Management System) selection for 108 Li-ion cells, each of 100Ah and 3.2V. • Design and fabrication of the battery pack according to international standards keeping in mind locally available materials and manufacturing capabilities. • Design and fabrication of an efficient thermal management system based on the cooling load required for the battery pack. • Integration of vibration controls in the battery pack for safety of the overall systems against shocks.
3	**Outcome**	A state-of-the-art scalable 34.5 kWh battery pack with an efficient thermal, vibration battery management system ready to be installed in an electric car. The battery pack design is scalable and can be used for electric bikes, electric three-wheelers vehicles, electric luggage carriers, etc.
4	**Evidence (Theoretical Basis)**	**CAD Models** **Battery Pack CAD Design** 



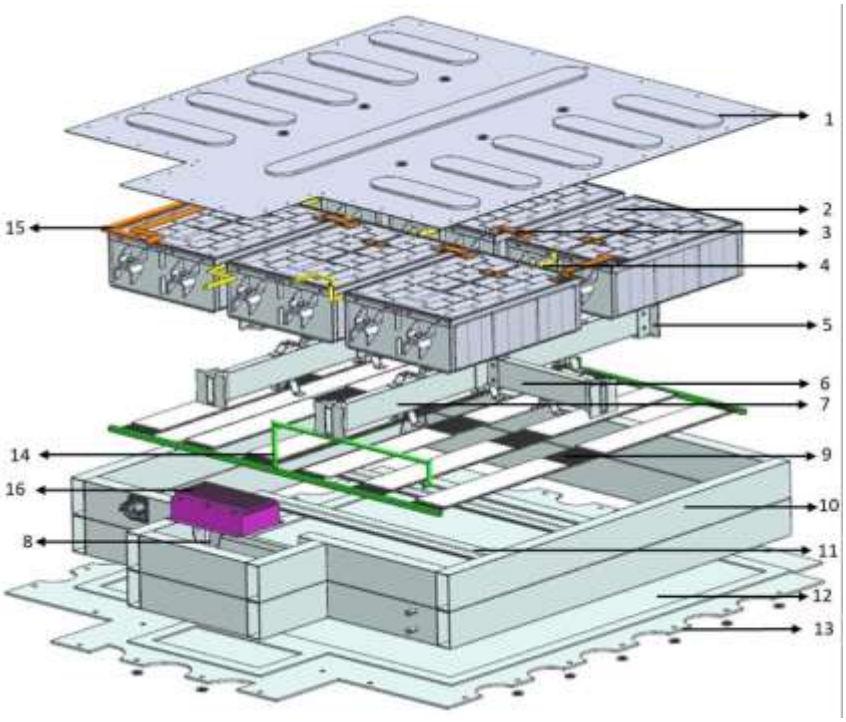
Schematic of a single module

Exploded View (Module Level)



1	HV Busbar
2	LV connector cover
3	Top Plate
4	Wire routing template
5	Busbar
6	100Ah Cell
7	Insulation (Formex)
8	Thermal Pad
9	Tension Rod
10	Angle mount
11	Mount
12	M6 Bolts
13	Side plate
14	End Plate
15	Base Plate

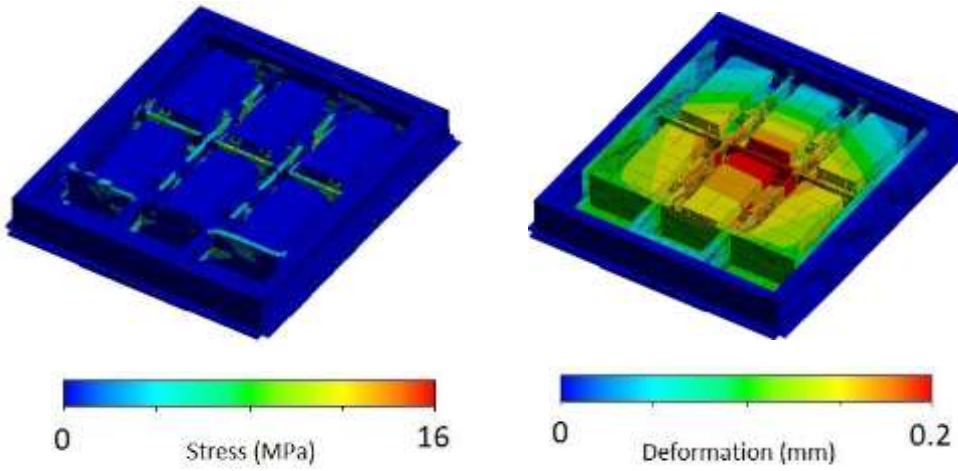
Exploded View (Battery Pack Level)



S. No	PART
1	Top cover
2	Module
3	Busbar
4	Low voltage wire harness
5	Mounting angles
6	Cross member
7	Longitudinal
8	Weld reinforcements
9	Cooling channels
10	Outer structure
11	C-channel with flanges (reinforcements)
12	Base plate
13	Mounts
14	Coolant hoses
15	High voltage wire harness
16	BMS (Battery Management System)

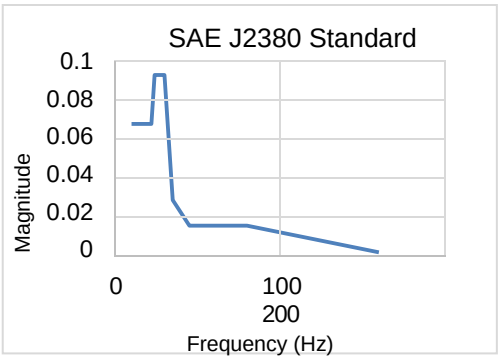
SIMULATION RESULTS

Static Structural Analysis

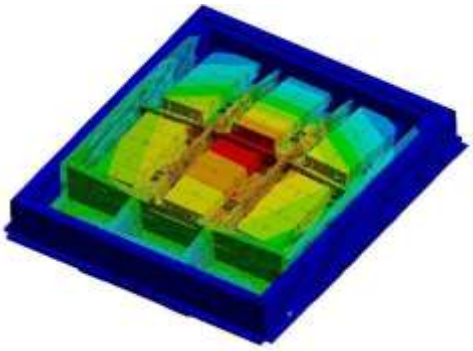


The static structural analysis showed that the designed battery pack has a very good factor of safety in case of any catastrophe.

Modal Frequency

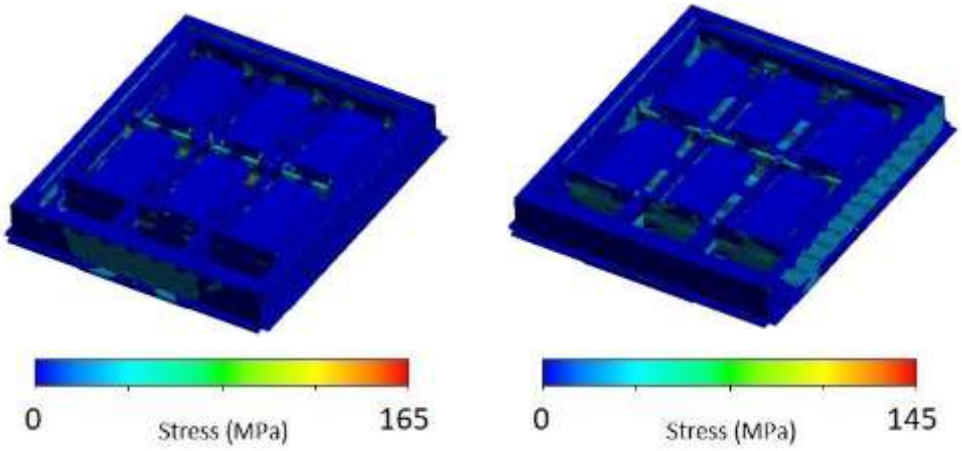
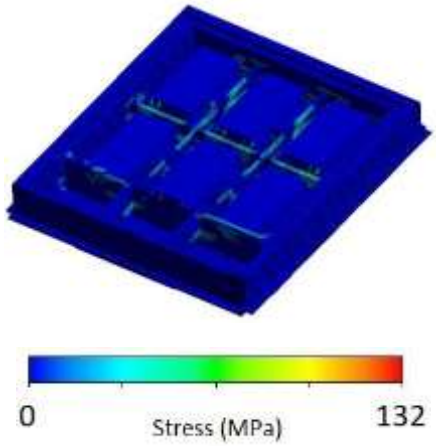


PSD Profile



First modal frequency of 43Hz Achieved

Power spectral density (PSD) is the excitation that takes place within a vibrational signal. The PSD profile comes from the standard SAE J2380. This standard is widely used in the automotive industry and it gathers data from various real-life road-induced vibrational cases and compiles them into one standard PSD profile. A significant excitation at frequencies less than 40 Hz is observed, which is extremely harmful structurally and for overall NVH. So, the goal was to bring up our first modal frequency up to 40 Hz. It was achieved by bringing the first modal frequency to 43 Hz which ensures safety.

		Transient Analysis **X-Axis (30G)** **Y-Axis (30G)**  **Z-Axis (10G)**  A sudden acceleration force of 30G in X and Y direction and 10G in Z direction was simulated through transient analysis. The results showed the designed battery pack is in a safe range and well below its yield strength.
5	**Competitive Advantage or Unique Selling Proposition**	
a	**Cost Reduction of Existing Product**	The overall cost of the existing battery pack is reduced by • choosing appropriate cells having optimum properties. • avoiding sand casting and cubical boxes are created by doing direct bending of metal sheets • not using an excessive factor of safety values. Optimization was done on the factor of safety values that resulted in thinner metallic sheets • doing all the fabrication work locally • die frames were prepared locally • doing element-based topological optimization resulted in significant weight reduction.

b **Cost Comparison**

Parameters	Current Battery Pack (For electric car)	Zoxcell Battery Pack (For electric bikes, three wheeler and stationary applications)	SkyElectric (Solar Battery Pack)	Narada Power (Solar Battery Pack)
Capacity	34.6 kWh	4 - 28 kWh	30.72 kWh	4.8 kWh
Cost/kWh	Rs 21,391	Rs 43,180	Rs 33,333	Rs 31,840
Chemistry	LiFePO4	LiFePO4	LiFePO4	LiFePO4

Table 1: Cost/kWh comparison of current battery pack with the ones available in market

Currently there is a wide market gap for battery pack manufacturing in the EV sector of Pakistan. Power Electronics Pakistan, Jolta Electric, Iner-Z and Zoxcell are a few companies who are making battery packs but none of them is producing battery packs for electric cars. There is a great opportunity to offer industry leading battery pack manufacturing technology with scalable design at affordable prices to the electric cars market of Pakistan.

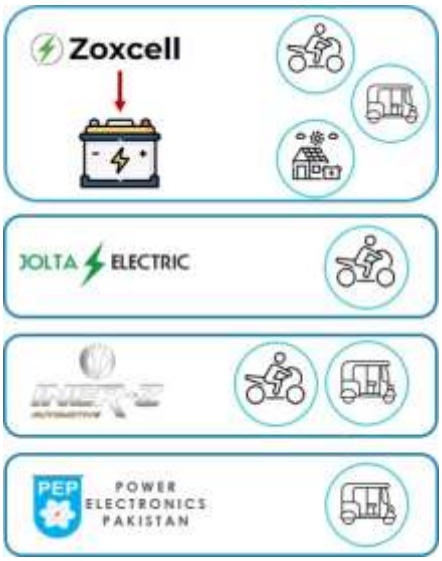
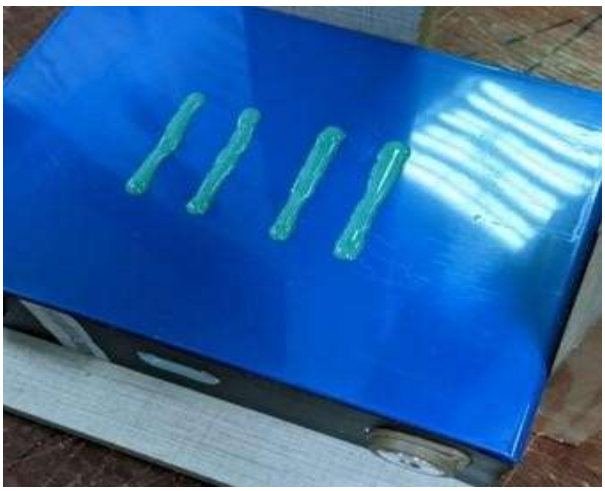


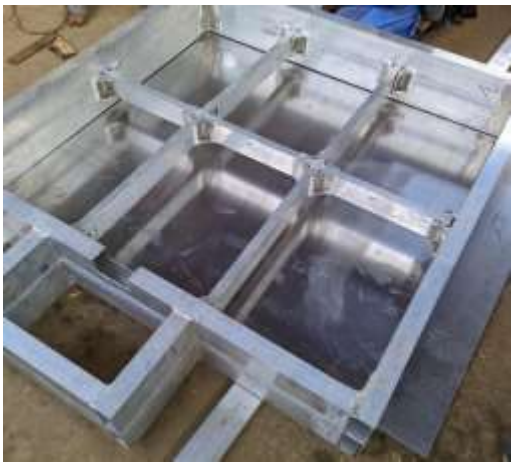
Table 1 tabulates cost/kWh comparison of current battery pack with the ones available in market for electric bikes, three wheeler and stationary applications. The current battery pack price is about 0.5 to 0.67 times lower than the ones available in market.,

c	**Process Improvement which Leads to Superior Product or Cost Reduction, Efficiency Improvement of the Whole Process** (e.g. What is the issue is current process and what improvement you suggests)	The efficiency improvement of the whole process is obtained by: • testing the battery pack design against international standards e.g.: SAE J2464, ISO12405-2, EU ECE R100, EU-EN600-68-2-64, CHINA GBT31467.3-2015_Modif2017_En, Misplaced jack test, etc. • using the regenerative braking feature to utilize the braking energy to recharge batteries hence increasing efficiency. • Using an efficient dual loop active/passive cooling system ensuring optimal battery health at all temperatures. The overall cost of the existing battery pack is reduced by • choosing appropriate cells having optimum properties. • avoiding sand casting and cubical boxes are created by doing direct bending of metal sheets • not using an excessive factor of safety values. Optimization was done on the factor of safety values that resulted in thinner metallic sheets • doing all the design, fabrication and assembly work locally • die frames were prepared locally • doing element-based topological optimization resulted in significant weight reduction.
d	**Attainment of any SDG**	**SDG#7, Affordable & Clean Energy** In Pakistan, the bill for fuel imports currently amounts to USD 13.3 billion, which is estimated to reach a staggering value of USD 30.7 billion by 2025, Introduction of electric vehicles in Pakistan will save around $2 billion/year spent on oil imports. Electric vehicles also offer less maintenance costs as compared to conventional vehicles. According to the National Economic and Environment Development Study (NEEDS) report, Pakistan has doubled its emissions since 2017 to 2020 and is expected to further double it by 2030. Not only carbon emissions will increase but also other hazardous compounds such as Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and particulate matter (PM), PM10 and PM2.5, will also increase in the atmosphere due to an increase in burning of fossil fuels. Most major cities in Pakistan have already crossed the threshold of clean air by a wide margin. Over three hundred thousand people die due to poor air quality in Pakistan every year. Electric vehicles can give the same mileage with one-third of the cost compared to their fossil fuel vehicle rivals. Moreover, due to this efficiency, even if electric vehicles are charged with fossil fuel based electricity generation sources, such as natural gas or coal, almost 25-40 percent fuel can be saved due to the higher electricity generation efficiency of larger units. This directly translates into a lower import bill. Additionally, electric vehicles require minimal maintenance and do not need oil and other lubricant changes which further reduces imported oil requirements. Almost 37 percent electricity generation in Pakistan is from renewable sources. Adding this to the efficiency of electric vehicles results in 70-80 percent less environmental emissions when compared to fossil fuel vehicles. This means that, while the tailpipe emissions of electric vehicles are zero, the overall impact of electric vehicles is around 70-80 percent reduction in environmental emissions in the overall energy value chain.

		2. SDG#8, Decent Work & Economic Growth The project's complete indigenous approach ensures that all the design and fabrication is done in Pakistan only. All this ensures that once the mass production of these battery packs comes in play, it will benefit Pakistan in more than one way. • Production and assembly plants will make sure of the employment opportunities for the local community • Export of the battery packs and other foreign investments in the project will greatly help the degrading economy of Pakistan. • A massive gain in technological advancements for Pakistan and a chance for Pakistan to make a name for itself and take a share in the 137 billion dollar battery pack manufacturing industry. **3. SDG#4, Quality Education** In future it is planned to transition this project into a business, production plants will be established, and these battery packs will be deployed in various electric vehicles of different manufacturers. All this coupled with a demand for electric vehicle specialist engineers in the industry will encourage technical education institutes to be established and existing universities will be encouraged to introduce specialized courses in electric vehicles hence keeping up with industry-leading technologies and providing quality education.
e	**Expanding of Market share** (e.g. how it expand and what is the problem with the current market	Electric vehicles are the future, and each year it is seen automakers add more EVs to their lineup. Everyone is working on electric vehicles, from well-established existing manufacturers to a variety of new names Furthermore according to new world trends and action on climate change, switching to EVs is a need of time and will result in sanctions if not complied with. The expanding electric vehicles market demands an indigenous development of battery pack in Pakistan that creates employmnet opportunities, reduce import bills and bring down the overall coast of electric vehicles made in Pakistan.
f	**Any Environmental Aspect** (e.g. carbon reduction, energy-efficient, etc.)	Almost 37 percent of electricity generation in Pakistan is from renewable sources. Adding this to the efficiency of EVs results in 70-80 percent less environmental emissions when compared to FFVs (Fossil Fuel Vehicle). This means that, while the tailpipe emissions of EVs are zero, the overall impact of EVs is around 70-80 percent reduction in environmental emissions in the overall energy value chain.
6	**Target Market** (Industries, Groups, Individuals, Families, Students, etc).	• This project hopes to transition itself into a business with a B2B business model in which the team behind this project aims to target OEMs looking to manufacture EVs. The electric vehicles manufacturers can be benefitted with the indigenous manufacturing of battery packs locally that will be available at much cheaper rates. The current battery pack needs continuous improvement with the evolving electric vehicle market. This creates an opportunity for students and researchers to bring design changes through vigorous research and development.

7	**Team Members** (Names & Roll No.)	Syed Ahmed Hassan (ME-17052) Mohammad Moiz (ME-17057) Syed Raza Rizvi (ME-17060) Imran Khan Ghouri (ME-17062)
8	**Supervisor Name**	Dr.-Ing. Usman Allauddin Assistant professor in Mechanical Engineering Department NED University of Engineering & Technology, Karachi Tel: +92 21 99261261-8 Ext: 2315 Mobile #: +92-345-2127526
9	**Supervisor Email Address**	usman.allauddin@neduet.edu.pk
10	**Pictures**	**PICTURES (Module Level)**  **Cell Adhesive Assembly**  **Module assembly process**  **Assembled Module**  **Assembled Module with Electrical Wiring**

PICTURES (Battery Pack Level)



Battery Pack Structure

Fully Assembled scalable Battery Pack