



Challenge 1:

DESIGN AND PROGRAMMING OF CLUTCH ACTUATION ROBOTIC ARM

Late one afternoon in September 2019, at his desk in Pune, **Dhruv contemplated the solution on the clutch release mechanism for the Pulsar** at the R&D center of Bajaj Auto Ltd - a Fortune India 500 company of which he was a Lead Design Engineer. During his stint at Bajaj, in the last five years, multiple products had seen major innovation. Bajaj Auto's product portfolio had more than doubled with new categories of vehicles catering to diverse customer sets.

Dhruv was aware that the spectacular success of Bajaj Auto was credited to an emphasis on innovation, sharp brand focus, dynamic leadership team and Lean Manufacturing – The TPM way of working.

ABOUT BAJAJ AUTO LTD

Bajaj Auto Ltd (BAL), one of the leading manufacturers in India, is the largest exporter of two and three-wheelers in the country. Three decades ago, the 'Hamara Bajaj' advertisement which became a quintessential part of all Indian households, encapsulated what the Bajaj brand meant to its users. For India of the late 1980s, the Chetak was the first choice for mobility. In the process, it set the roots for Bajaj Auto's brand identity - value, trust, reliability, credibility, etc.

HISTORY OF THE BAJAJ AUTO LTD

In 1948 Bajaj Auto started selling imported two and three-wheelers in India. In the year 1972, the company started manufacturing its own scooters under the brand name Chetak which pushed Bajaj to the top of the Indian market and made it market leader in the scooter industry for a long time in India. **The entry of Chetak was a turning point for the company, catapulting Bajaj into a household name. It was during this time when Bajaj Auto weaved the evergreen tagline, 'Hamara Bajaj' - making it synonymous with the sentiments of the country, evoking a wave of patriotism every time it was aired. It became so popular that at one point in time, the scooters had a waiting list of almost 10 years.**

In 1971 Bajaj Auto launched the three-wheeler goods carrier, while in 1977 the company launched Rear Engine Auto rickshaw. In India, Bajaj Auto sells its

intracity products under two brands – Bajaj RE and Bajaj Maxima. Over 58 million passengers travel in a Bajaj RE vehicle across the world every day. Including India, Bajaj RE is sold in over 25 countries across the globe.

In the late 1990s, a team of engineers came together to build a product which worked wonders for Bajaj Auto Ltd. This was a time when the Indian two-wheeler makers were still basking in the first flush of foreign love. Bajaj Auto commissioned a market research agency to survey how a newly-developed bike would be accepted in the marketplace. A mechanical engineer from a National Institute of Technology, who joined Bajaj Auto in 1989 as a Graduate Trainee Engineer was part of the team who met the agency for feedback.

"The tank and exhaust are too big," droned the agency chief. "Reduce the size of the tank or else it will limit the relevance of the bike," he forewarned. The engineer patiently heard out the agency honcho. And ignored his advice.

The very same tank and its character lines became the signature of Pulsar. The masculine styling and DTSi technology helped in positioning Pulsar as a powerful bike. The engineer in the above context is Abraham Joseph, now Bajaj Auto's Chief Technology Officer, who has gone on to develop a series of wildly successful Pulsars – ranging from 125cc to 220cc – along with other thriving models like the Discover range.

Bajaj Auto became the first Indian two-wheeler manufacturer to deliver 4-stroke commuter motorcycles with sport-oriented performance for the Indian market. Bajaj achieved this with the 150cc and 180cc Pulsar, giving Indians the first taste of performance biking. By 2006, Pulsar crossed 1 million in sales - the only bike with a digital speedometer and LED tail lamps. In only 17 years since the launch of Pulsar, Bajaj Auto Ltd has become the third-largest motorcycle manufacturer in the world, ahead of several Japanese and European brands that have been around for much longer.

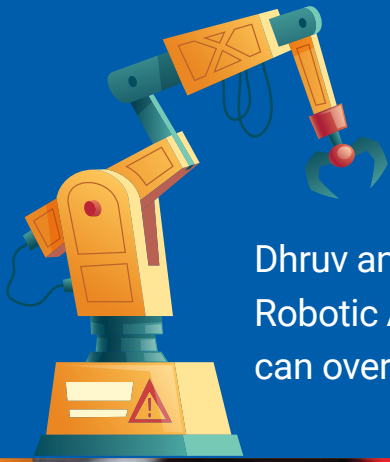
Bajaj Auto also has a 48% stake in KTM Austria. Currently, several KTM models are manufactured at the Bajaj plant in Chakan and are distributed by the two partners globally. These include the 125 Duke, the 200 Duke, 250

Duke, 390 Duke, RC 125, RC 200 and RC 390. KTM's 125 cc models are also made exclusively in India. KTM had acquired Swedish brand Husqvarna Motorcycles from its former owner BMW Motorrad which will also be manufactured in the Chakan Plant, Pune.

Bajaj Auto had the vision and audacity to invest in things that were ahead of their time, staying on top of the market in R&D and having faith in young talent. This only reinstates the fact that for Bajaj Auto, strong in-house R&D capabilities have been instrumental in launching vehicles with higher fuel efficiency and performance. Thus, Bajaj Auto has been riding with us on the highway of our lives since the last 73 years.

A walk down the history: Historical milestones of Bajaj Auto Ltd

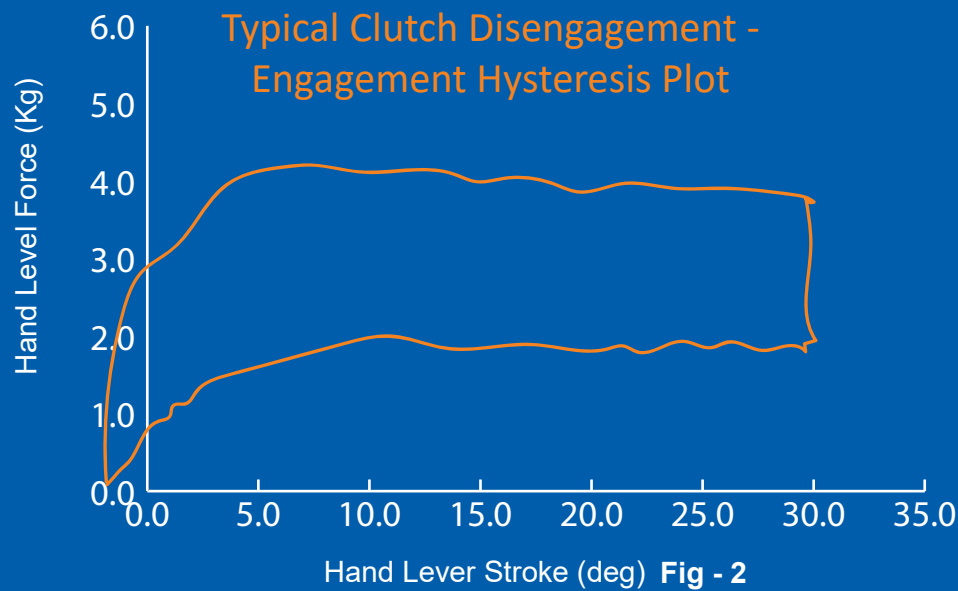




Dhruv and his team have been entrusted with the responsibility of designing a Robotic Arm to modulate a clutch release precisely for smooth take off which can overcome clutch judder and engine stalling for the static testing team.



Fig - 1



ROBOTIC ARM FUNCTIONAL REQUIREMENT:

- 1) Effective, Synchronous & Collaborative robotic arm Clutch Operation.
- 2) Clutch Disengagement Stroke with 4 modes of operations
 - a) Take-off: Gradual and nonlinear Engagement. Specific in 1st Gear only.
 - b) Commute Shifts: Quick disengagement & Gradual/Almost linear engagement stroke
 - c) Quick Shifts: Quick Clutch Disengagement and Engagements.
 - d) Crawling Modulation: Modulation in Half Clutch/Semi-disengaged condition.
- 3) Clutch Engagement mapping and performance plotting in synchronous with wheel torque/RPM.
- 4) Clutch Health Monitoring over time and auto-adjustment algorithm.
- 5) Load fluctuation identification & diagnostic algorithm. (Such as clutch drag increase due to Oil level variation, Tyre pressure, Brake Drag etc.)

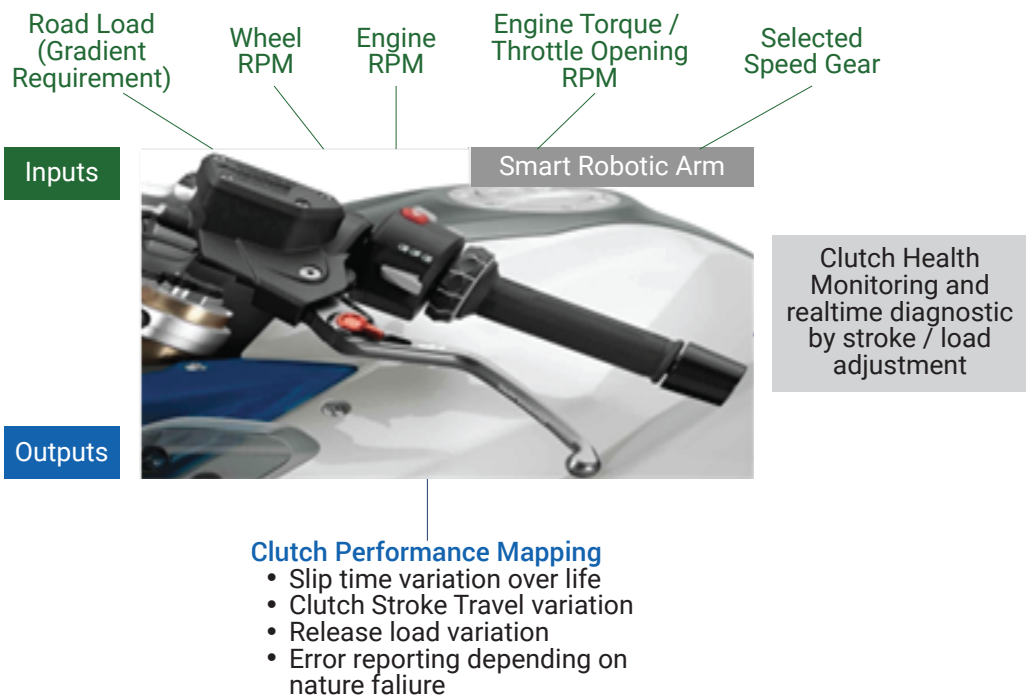
ROBOTIC ARM DURABILITY REQUIREMENT:

- 1) Collaborative operation assurance such as Peak load cutoff, No-load Caution, High-load warning, etc.
- 2) Rigid and judder free arm operation.
- 3) Soft Touch points for Lever wear protection.
- 4) Arm Inertial Load Management with effective dampers.

CLUTCH FUNCTIONING REQUIREMENT:



Fig - 3



Vehicle Launch - Flat Road

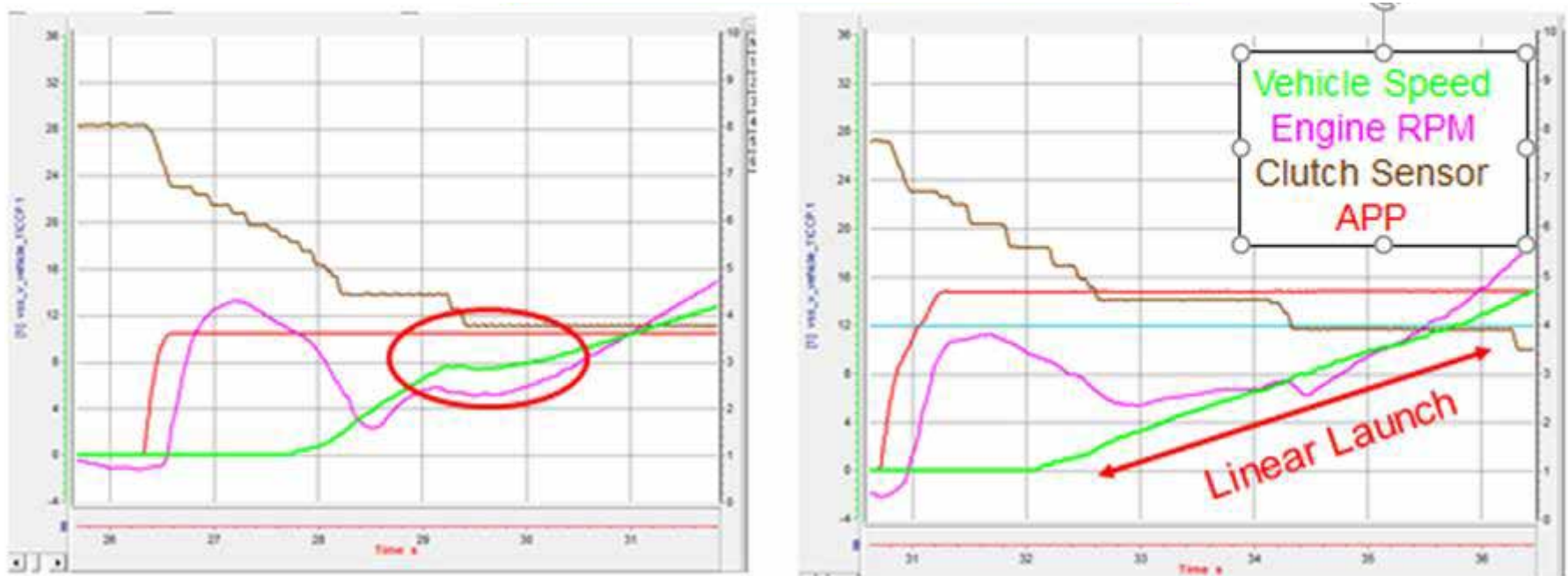


Fig - 4

Challenges:

- 1) The take-off routine using a multiplate clutch is dependent on the engine torque output, the clutch character as well as the road profile/payload.
- 2) A smooth and linear launch is a basic necessity of any launch control strategy. But this can only be achieved through precise control of the engine torque as well as the clutch travel
- 3) The engine torque as we are aware is nonlinear in nature with respect to throttle opening and engine speed. In addition to this the clutch has a varying clutch character which also depends on the clutch slip rpm and clutch stroke.
- 4) A control strategy performing a take-off control will have to deliver a linear response of the vehicle by accounting for these engine and clutch characteristics



Switch 1:

Prepare an Approach Note of not more than 5 pages covering the following aspects:

- Robotic Arm design
- Mechanical Design - Free Body Diagram (Schematic Diagram)
- Vehicle Plant Model to incorporate all the four clutch operating scenarios (refer Fig 3) - (Simulink model or equivalent)
- Mechatronic Design – (Schematic Circuit Diagram with specifications of components used)
- Control Architecture (Simulink Model)
 - Vehicle Plant Model to create all the necessary signals for the operation of the clutch operating system
- In a real vehicle all relevant vehicle parameter (refer Fig 3 for the inputs) will be broadcasted on CAN network/ hardwired analog signals

Annexure: Clutch Actuation Mechanism Mechanism Schematic

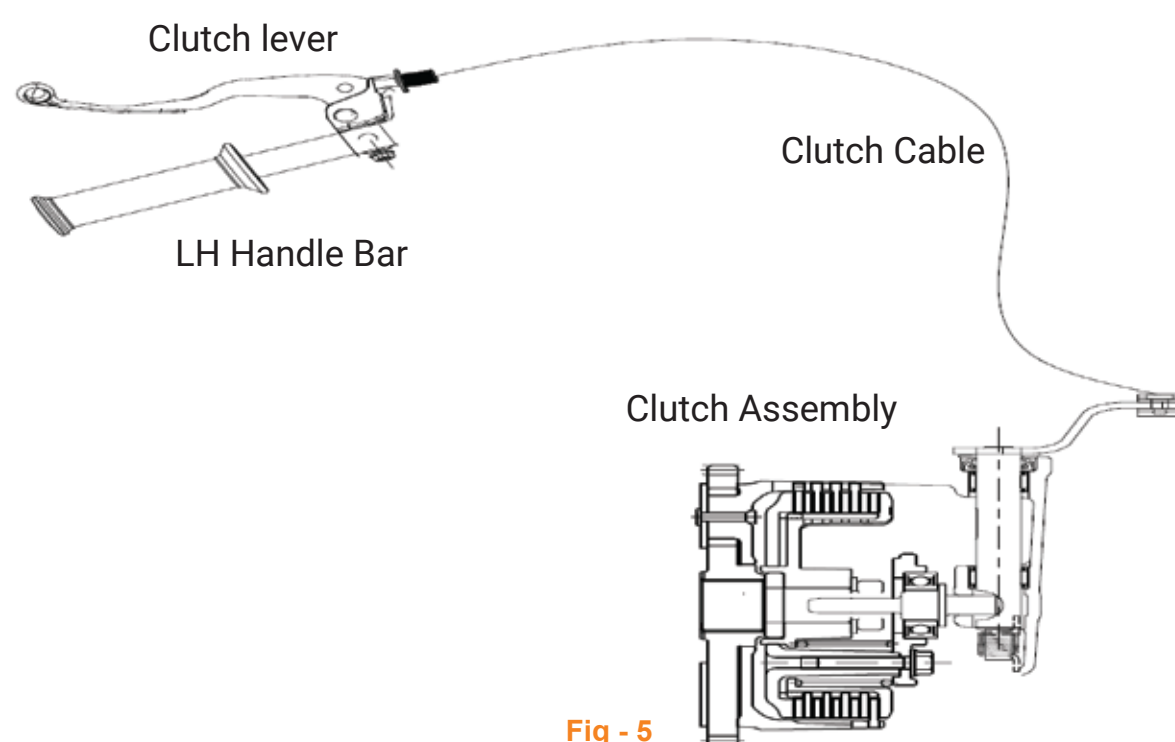
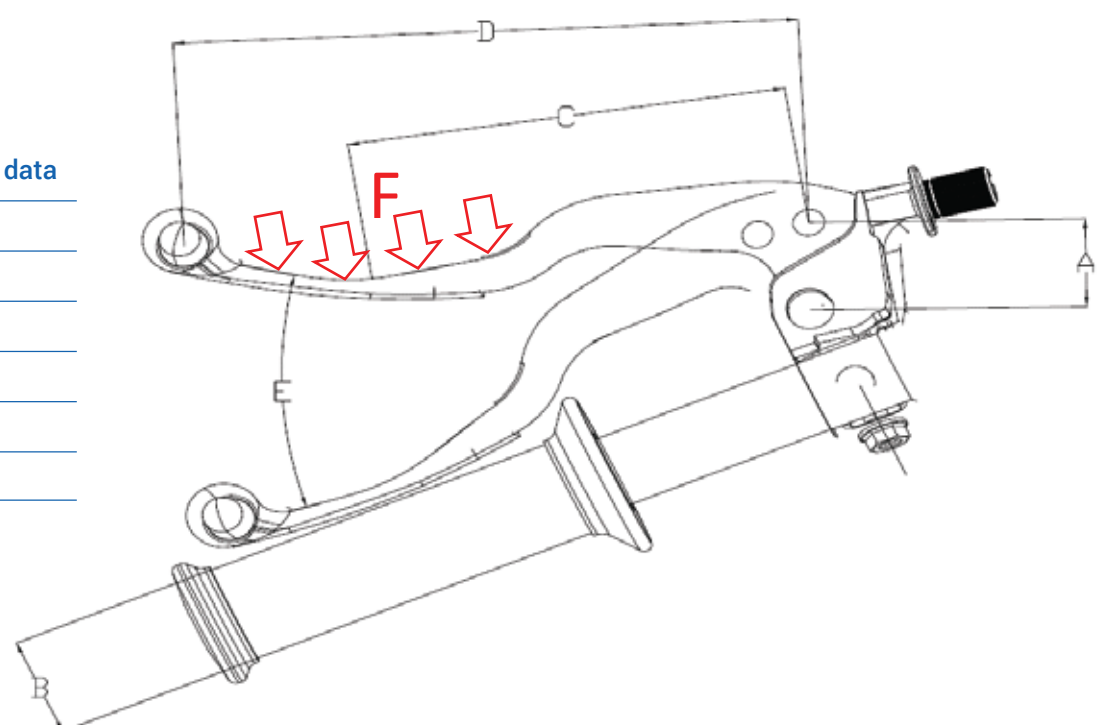


Fig - 5

Parameter	Approximate data
Clutch Disengagement Effort 'F'	3kg - 6kg
Lever Pivot length 'A'	28mm
Handle Bar Dia 'B'	32mm
Dim C	130mm
Dim D	170mm
Dim E	32°



Submission Guidelines: >>>

- > Register as a team of 3, 4 or 5
- > Only participants of Mechanical and Electrical related streams are eligible
- > Submissions are to be made in a PPT/PDF/Zipped format – 25 MB Limit
- > If shortlisted to Switch 2 , submit the solutions to Switch 2 of the challenge in a multi slide presentation which will be presented to the Bajaj Auto Leadership
- > The ideas, content & material emerging from the challenge would be solely owned by Bajaj Auto Limited
- > DO NOT post any content on any digital media platform or in print without prior approval from us
- > DO NOT denigrate any brands including those of our Competition
- > Pre-Final year and final year students of B. Tech and Dual Degree are eligible. Ph.D, M.S and M. Tech students are not eligible.

Rewards: >>>

- > MACH Campus Winner(s) receive PPOs/PPIs and a total cash prize of ₹ 1,00,000/-
- > MACH Campus Runner(s)-up receive PPOs/PPIs and a total cash prize of ₹ 50,000/-
- > All other teams are also eligible to be awarded PPIs and merchandise on the basis of the quality of submission

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For registration and submission, visit: <https://www.bajajauto.com/careers/mach>

