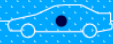




# Virtual DOE of Multifunction Switch using MSC.Adams

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# Introduction



Within an automobile, the Multifunction Switch is used for turnsignal, lane-change, wiper/wash and headlamp functions. Since the driver frequently interacts with this switch, the quality of the feel is important to OEM. Feel of switch depends on the effort required to move switch lever. Typically the OEMS specify an effort/ travel requirement that must be met.



# Problem Definition



Many factors within the switch design affect the feel of the switch. Past practice was to apply a trial and error approach while designing the switch. To meet customer requirements necessitated repeated design iterations. Design practices varied depending upon the Engineer/Designer. This led to increase time, late design changes and customer dissatisfaction.



# Action Plan

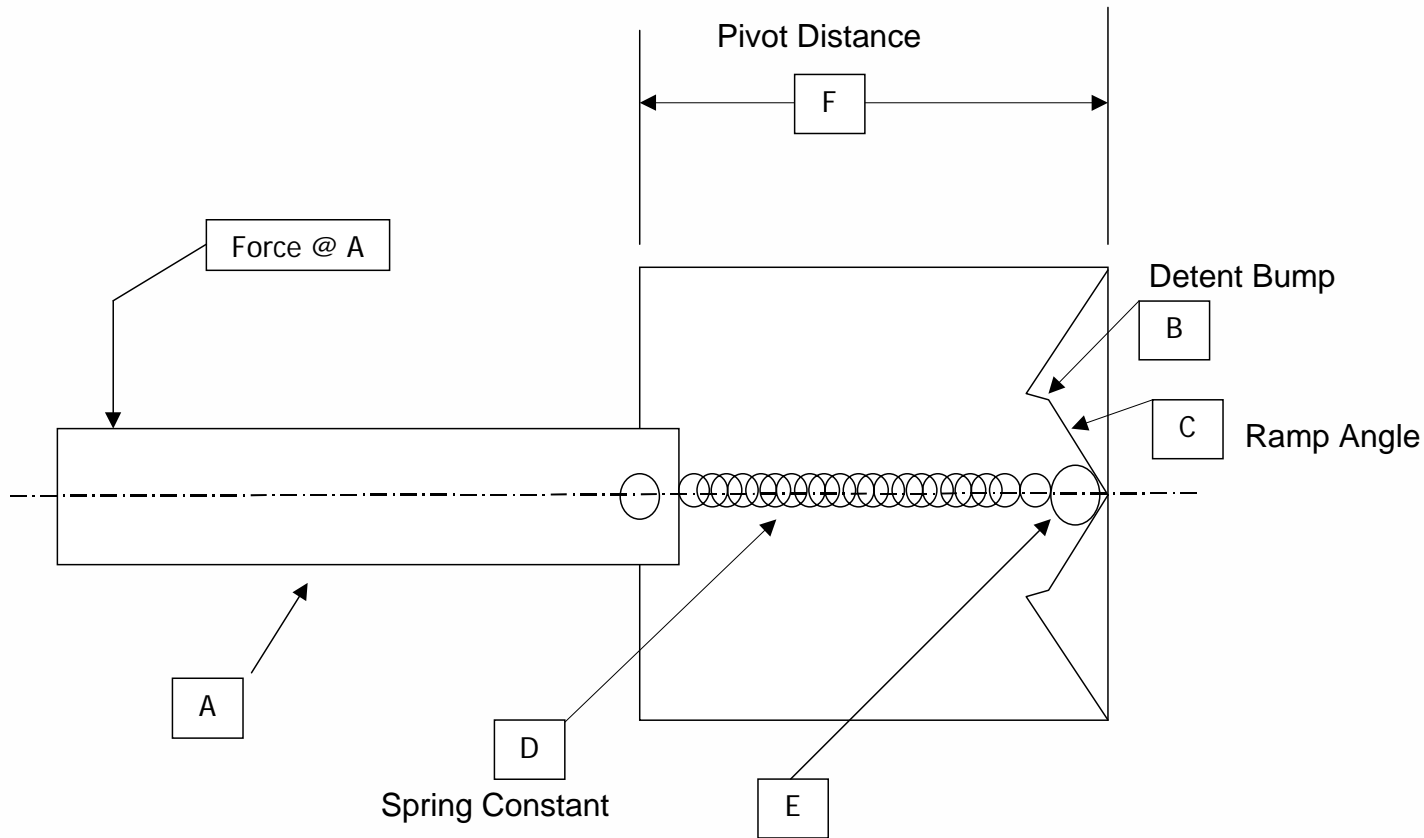


Design for Six Sigma tools were applied to this problem to come up with a black box solution and develop a mathematical model which can give a desired output for given inputs. The following steps were performed:

1. Identify key design characteristics of “Best In Class” switches.
2. Create MSC.Adams Model of key design characteristics and validate model
3. Perform virtual Design Of Experiment
4. Perform Regression Analysis to develop predictive models
5. Validate predictive models with hardware model



# Design Variables



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# Design Variables & Values



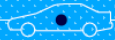
## 5 Factor DOE

Factor	Ref	Range of Variable	
Initial Spring Load	D	12.4 N	18.6 N
Spring Rate	D	2 N/mm	2.8 N/mm
Pivot Distance	F	30	38 mm
Ramp Angle	C	50°	65°
Detent Bump	B	.5 mm	.2mm

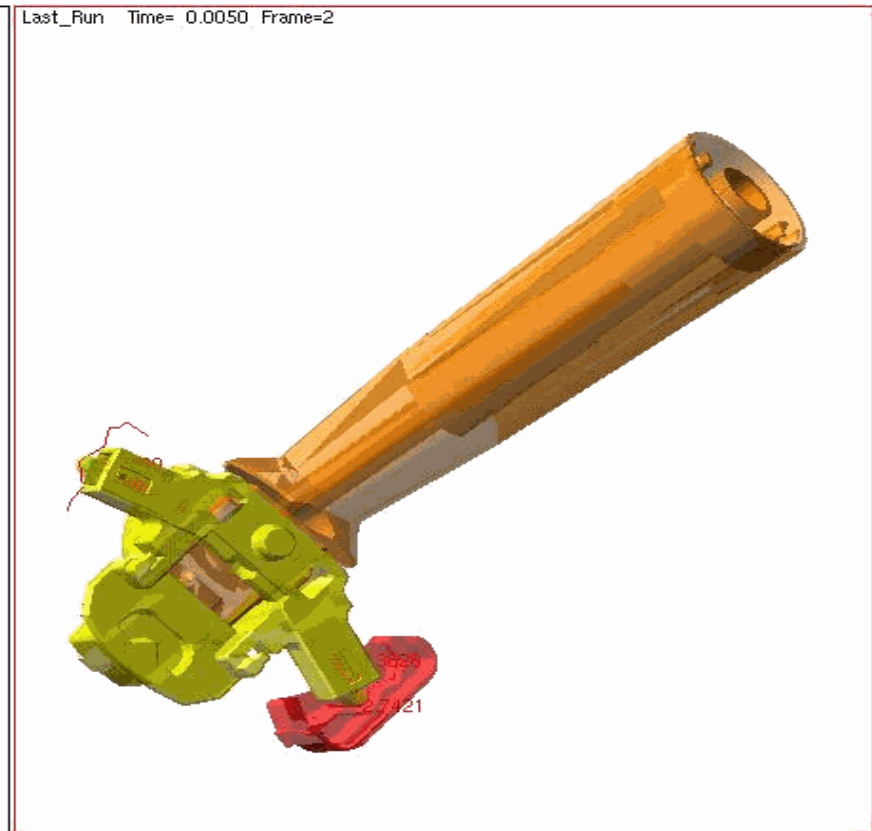
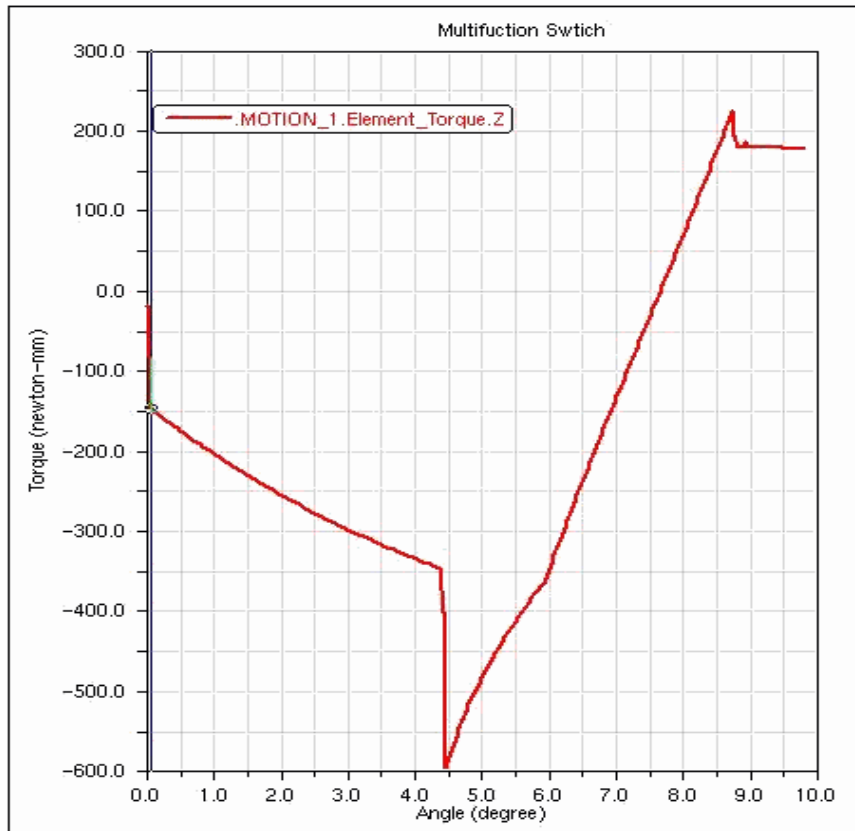
Constants	Value
Detent Plunger Diameter	3.0 mm
Coefficient of Friction	Static: .3 Dynamic: .1
Actuation Speed	14°/sec

Response Variables (measured @ end of switch stalk A)

- Initial Effort
- Lane Change Effort
- Peak Effort

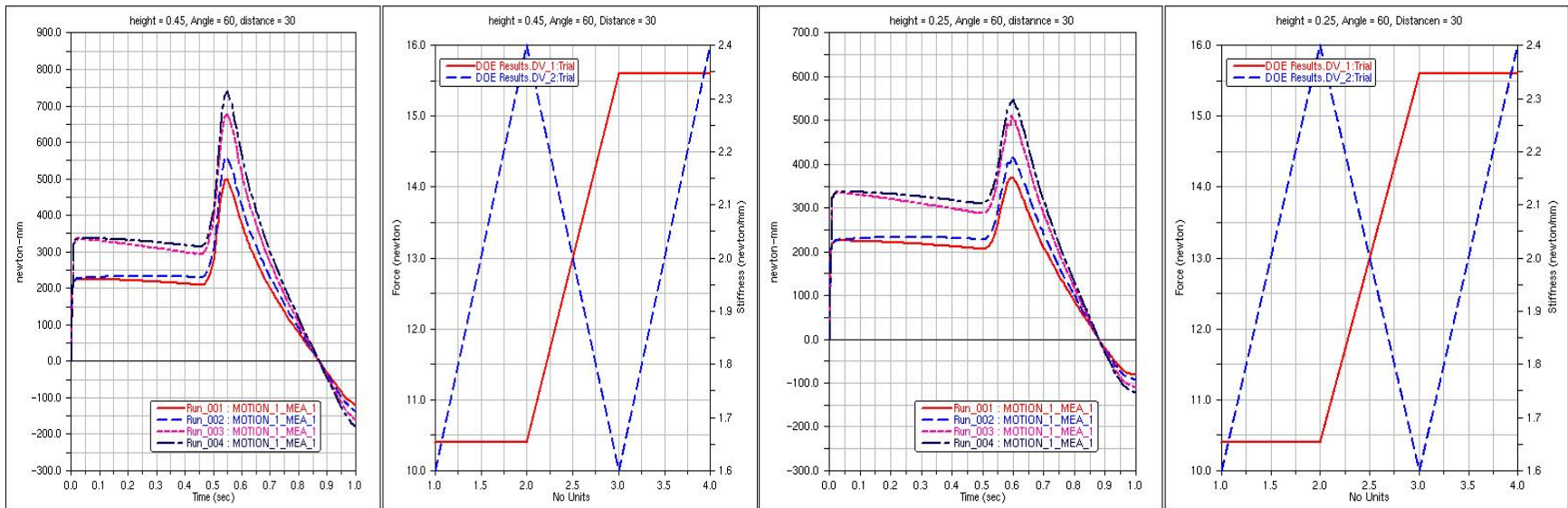


# MSC.Adams Model





# Plot from MSC.Adams





# Design Variable & Response



Input					Output		
Initial Load	Spring Rate	Distance	Angle	Lane Change height	Torque at Start	Torque before Lane change	Peak Force
12.4	2	30	55	0.20	270	260	457.34
12.4	2.8	30	55	0.20	270	295	516.53
18.6	2	30	55	0.20	400	355	617.57
18.6	2.8	30	55	0.20	400	390	676.61
12.4	2	38	55	0.20	300	300	522.48
12.4	2.8	38	55	0.20	300	340	587.33
18.6	2	38	55	0.20	445	405	696.62
18.6	2.8	38	55	0.20	445	450	778.89
12.4	2	36	55	0.20	325	325	583.61
12.4	2.8	36	55	0.20	325	375	662.15
18.6	2	36	55	0.20	480	450	783.24
18.6	2.8	36	55	0.20	480	500	863.36
12.4	2	30	55	0.35	272	240	452.15
12.4	2.8	30	55	0.35	272	270	513.57
18.6	2	30	55	0.35	400	360	616.86

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# Regression



A regression analysis was done using Minitab which provided math models for the 3 response variables.

Initial Effort =  $A + B$  (Initial Spring Load) +  $C$  (Distance from Pivot to Profile) –  $D$  (Profile Angle)

Effort @ Lane Change =  $AA + BB$  (Initial Spring Load) +  $CC$  (Spring Rate) +  $DD$  (Distance from Pivot to Profile) –  $EE$  (Profile Angle) –  $FF$  (Lane Change Bump Height)

Peak Effort =  $-a + b$  (Initial Spring Load) +  $c$  (Spring Rate) +  $d$  (Distance from Pivot to Profile) –  $e$  (Profile Angle) +  $f$  (Lane Change Bump Height)



# Validate Predictive Models

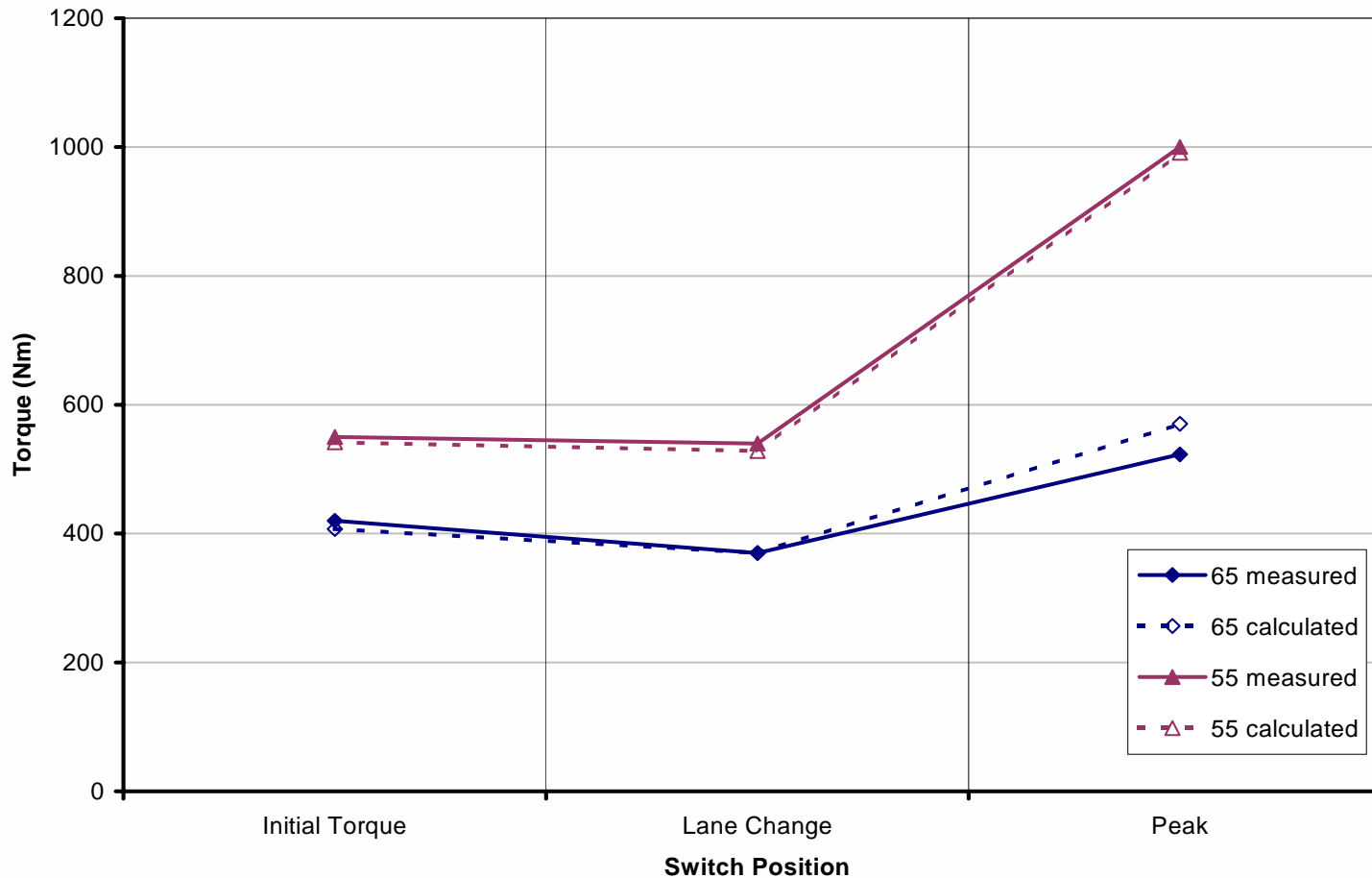


Two Rapid prototype SLA models were constructed of detent profiles based on the predictive models generated from the virtual DOE.

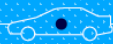
The results indicate a high level of correlation between the predictive models and the tested hardware (within 9%).



# Measure vs. Calculated Torque



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# Conclusion



The models can be by used Engineering/Design to establish the turn-signal efforts given the known design criteria of:

- Initial Spring Load
- Spring Rate
- Distance from Pivot to Detent Profile (package size)
- Detent Profile Angle
- Lane Change Detent Bump Height

The models can also be worked knowing the target efforts and mix and matching the design criteria to obtain the desired result.



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