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# A Brief Study of Relation between Lie Derivative, Exterior Derivative and Contraction

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***Abstract:** In this paper, we propose a nonlinear state feedback control law to satisfy a constraint on state variables. The constraint is expressed as an algebraic equation containing a scalar nonlinear function such as an energy function or a limit cycle. The paper addresses the optimal design of electric machines, through the general setting of both shape and topology optimization. The optimization* **problems are efficiently solved with a classical gradient-based mathematical programming algorithm.**

***Keywords***

1) Trajectory,
2) Control systems,
3) Force control,
4) State feedback,
5) Nonlinear equations,
6) Limit-cycles,
7) Shape control,
8) Nonlinear control systems,
9) nonlinear systems,
10) state feedback,
11) Lie algebras
12) scalar nonlinear function,
13) invariant set theorem,
14) energy shaping control,
15) inverted pendulum,
16) Lie derivative,
17) scalar function,
18) algebraic equation

## I. INTRODUCTION

Energy is one of the fundamental concepts in science and engineering practice, where it is common to view dynamical systems as energy-transformation devices. The control problem can be recast as finding a dynamical system and an interconnection pattern such that the overall energy function takes desired form[1, 2, 4)]. This control scheme is called the energy shaping approach and is the essence of the passivity-based control. The exterior derivative and lie derivative are defined in terms of the structure of the smooth manifold by contrast the choice of connection is an additional structure. Exterior derivative : the main feature here is $d^2 = 0$.The property $d^2 = 0$ dual to saying that the boundary of boundary empty and is very thinks that makes de Rham Cohomology work. The Relation between lie derivative, exterior derivative and contraction define the following relation between the three operators hold.

$L_X = i_X o d + d o i_X$

## II. OBJECTIVE OF STUDY

*A.* To study the property of Lie Bracket.
*B.* To make the calculation easy for students with simplified Leibnitz rule.

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## III. METHODOLOGY

*A.* Secondary Data used for the study of lie bracket.
*B.* Primary data used.
*C.* Published papers, magazines, articles and data available on the websites

### *D. Relation Between Lie Derivative, Exterior Derivative And Contraction*

L et w be any 1-form.then

$(doi_x + i_x od)\ w(y) = d\ (i_x\ w(y)\ ) + i_x\ (dw(y))$

$= dw(x,y) + dw(x,y) + yw(x)$

$= 2dw(x,y) + yw(x)$

$= xw(y) – yw(x) –w\ [x,y]+ yw(x)$

$= xw(y) – w[x,y]$

$= xw(y) - L_x y$

$= L_x w(y)$

⇨ $(doi_x + i_x od) = L_x w$

## IV. CONCLUSION

An analytical sensitivity analysis for the nonlinear magnetostatic problem that can handle both shape and topology design variables, based on the Lie derivative is derived and applied to the optimal design of an interior permanent magnet (IPM) machine. This states the Relation between lie derivative, exterior derivative and contraction define the following relation between the three operators hold. $L_X = i_X od + doi_X$ .Where $L_X$ denotes the lie derivative, i denotes for contraction and d denotes for exterior derivative

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