Difeomorfismo

$$z1 = x_1 + x_2$$

$$z2 = x_3 + x_4$$

$$z3 = -\frac{Ks\, x_2 - g\, hcm\, m\, \sin(x_1 + x_2)}{Jl}$$

$$z4 = \frac{g\, hcm\, m\, x_3 \cos(x_1 + x_2)}{Jl} - x_4 \left(\frac{Ks}{Jl} - \frac{g\, hcm\, m\, \cos(x_1 + x_2)}{Jl}\right)$$

Difeomorfismo Evaluado

$$z1 = x_1 + x_2$$

$$z2 = x_3 + x_4$$

$$z3 = -\frac{3600434686208869\, x_2}{13194139533312} - \frac{707282807527887 \sin(x_1 + x_2)}{17592186044416}$$

$$z4 = -\frac{707282807527887\, x_3 \cos(x_1 + x_2)}{17592186044416} - x_4 \left(\frac{707282807527887 \cos(x_1 + x_2)}{17592186044416} + \frac{3600434686208869}{13194139533312} \right)$$

Señal de control (FL)

$$u = \frac{v + x_3\,\sigma_1 + x_4\,\sigma_1 + \sigma_2\left(\dfrac{g\,hcm\,m\,\sin(x_1 + x_2)}{Jl} - x_2\left(\dfrac{Ks}{Jh} + \dfrac{Ks}{Jl}\right) + \sigma_3\right) - \dfrac{g\,hcm\,m\,\cos(x_1 + x_2)\left(\dfrac{Ks\,x_2}{Jh} - \sigma_3\right)}{Jl}}{\dfrac{Kg\,Km\,\sigma_2}{Jh\,Rm} + \dfrac{Kg\,Km\,g\,hcm\,m\,\cos(x_1 + x_2)}{Jh\,Jl\,Rm}}$$

where

$$\sigma_1 = \frac{g\,hcm\,m\,x_3\,\sin(x_1 + x_2)}{Jl} + \frac{g\,hcm\,m\,x_4\,\sin(x_1 + x_2)}{Jl}$$

$$\sigma_2 = \frac{Ks}{Jl} - \frac{g\,hcm\,m\,\cos(x_1 + x_2)}{Jl}$$

$$\sigma_3 = \frac{Kg^2\,Km^2\,x_3}{Jh\,Rm}$$

Señal de control (FL) Evaluada

u =

$$\frac{39582418599936\,v}{1062128232431616355} + \frac{6365545267750983\cos(x_1+x_2)\left(\frac{2300\,x_2}{3} - \frac{3715129576983801\,x_3}{70368744177664}\right)}{4248512929726465420} - \frac{39582418599936\,x_3\,\sigma_1}{1062128232431616355} - \frac{39582418599936\,x_4\,\sigma_1}{1062128232431616355} -$$

$$-\frac{39582418599936\left(\frac{707282807527887\cos(x_1+x_2)}{17592186044416} + \frac{3600434686208869}{13194139533312}\right)\left(\frac{4571980553916023\,x_2}{4398046511104} - \frac{3715129576983801\,x_3}{70368744177664} + \frac{707282807527887\sin(x_1+x_2)}{17592186044416}\right)}{1062128232431616355}$$

where

$$\sigma_1 = \frac{707282807527887\,x_3\sin(x_1+x_2)}{17592186044416} + \frac{707282807527887\,x_4\sin(x_1+x_2)}{17592186044416}$$

Derivadas de Lie

$Lfh = x_3 + x_4$

$Lf2h =$

$$\frac{Ks\, x_2}{Jh} - x_2 \left(\frac{Ks}{Jh} + \frac{Ks}{Jl}\right) + \frac{g\, hcm\, m\, \sin(x_1 + x_2)}{Jl}$$

$Lf3h =$

$$\frac{g\, hcm\, m\, x_3 \cos(x_1 + x_2)}{Jl} - x_4 \left(\frac{Ks}{Jl} - \frac{g\, hcm\, m\, \cos(x_1 + x_2)}{Jl}\right)$$

$Lf4h =$

$$\frac{g\, hcm\, m\, \cos(x_1 + x_2)\left(\dfrac{Ks\, x_2}{Jh} - \sigma_2\right)}{Jl} - x_4\, \sigma_1 - \left(\frac{Ks}{Jl} - \frac{g\, hcm\, m\, \cos(x_1 + x_2)}{Jl}\right)\left(\frac{g\, hcm\, m\, \sin(x_1 + x_2)}{Jl} - x_2\left(\frac{Ks}{Jh} + \frac{Ks}{Jl}\right) + \sigma_2\right) - x_3\, \sigma_1$$

where

$$\sigma_1 = \frac{g\, hcm\, m\, x_3 \sin(x_1 + x_2)}{Jl} + \frac{g\, hcm\, m\, x_4 \sin(x_1 + x_2)}{Jl}$$

$$\sigma_2 = \frac{Kg^2\, Km^2\, x_3}{Jh\, Rm}$$

Derivadas de Lie Evaluada

$$Lfh = x_3 + x_4$$

$$Lf2h =$$
$$-\frac{3600434686208869\, x_2}{13194139533312} - \frac{707282807527887 \sin(x_1 + x_2)}{17592186044416}$$

$$Lf3h =$$
$$-\frac{707282807527887\, x_3 \cos(x_1 + x_2)}{17592186044416} - x_4 \left(\frac{707282807527887 \cos(x_1 + x_2)}{17592186044416} + \frac{3600434686208869}{13194139533312} \right)$$

La cuarta derivada de Lie no se puede poner por ser una ecuacion demasiado extensa

Grado Relativo / Derivadas Cruzadas

$$L_g h = 0$$

$$L_g L_f h = 0$$

$$L_g L_f^2 h = 0$$

$$L_g L_f^3 h = \frac{Kg\, Km \left(\dfrac{Ks}{Jl} - \dfrac{g\, hcm\, m\, \cos(x_1 + x_2)}{Jl} \right)}{Jh\, Rm} + \frac{Kg\, Km\, g\, hcm\, m\, \cos(x_1 + x_2)}{Jh\, Jl\, Rm}$$

Grado Relativo Evaluado / Derivadas Cruzadas Evaluadas

$$L_g h = 0$$

$$L_g L_f h = 0$$

$$L_g L_f^2 h = 0$$

$$L_g L_f^3 h = \frac{10621282324316163 55}{39582418599936}$$