

$$n_x = c_{t_1} c_{t_{234}} c_{t_5} - s_{t_1} s_{t_5}$$

$$n_y = c_{t_1} c_{t_{234}} c_{t_5} - c_{t_1} s_{t_5}$$

$$n_z = s_{t_{234}} \cdot c_{t_5}$$

$$s_x = -c_{t_1} c_{t_{234}} \cdot s_{t_5} + c_{t_1} c_{t_5}$$

$$s_y = -s_{t_1} c_{t_{234}} \cdot s_{t_5} + c_{t_1} \cdot c_{t_5}$$

$$s_z = s_{t_1}$$

$$f_1 = (c_{t_1} c_{t_{234}} c_{t_5} - s_{t_1} s_{t_5}) - n_x$$

$$f_2 = (s_{t_1} c_{t_{234}} c_{t_5} - c_{t_1} s_{t_5}) - n_y$$

$$f_3 = (s_{t_{234}} c_{t_5}) - n_z$$

$$f_4 = (-c_{t_1} c_{t_{234}} s_{t_5} - s_{t_1} c_{t_5}) - s_x$$

$$f_5 = (-s_{t_1} c_{t_{234}} s_{t_5} + c_{t_1} c_{t_5}) - s_y$$

$$f_6 = (s_{t_{234}} s_{t_5}) - s_z$$

$$f_7 = (-c_{t_1} s_{t_{234}}) - a_x$$

$$f_8 = (-s_{t_1} s_{t_{234}}) - a_y$$

$$f_9 = (c_{t_{234}}) - a_z$$

$$f_{10} = (-72 c_{t_1} s_{t_{234}} + 160 c_{t_1} c_{t_{234}} + 250 c_{t_1} c_{t_5}) - P_x$$

$$f_{11} = (-72 s_{t_1} s_{t_{234}} + 160 s_{t_1} c_{t_{234}} + 250 s_{t_1} c_{t_5}) - P_y$$

$$f_{12} = (72 c_{t_{234}} + 160 s_{t_{234}} + 250 s_{t_5} + 300) - P_z$$

$$f_1 = c_{t_1} c_{t_{234}} c_{t_5} - s_{t_1} s_{t_5}$$

$$f_2 = s_{t_1} c_{t_{234}} c_{t_5} - c_{t_1} s_{t_5}$$

$$f_3 = s_{t_{234}} c_{t_5}$$

$$f_4 = -c_{t_1} c_{t_{234}} s_{t_5} - s_{t_1} c_{t_5}$$

$$f_5 = -s_{t_1} c_{t_{234}} s_{t_5} + c_{t_1} c_{t_5}$$

$$f_6 = s_{t_{234}} s_{t_5}$$

$$f_7 = -c_{t_1} s_{t_{234}}$$

$$f_8 = -s_{t_1} s_{t_{234}}$$

$$f_9 = c_{t_{234}}$$

$$f_{10} = -72 c_{t_1} s_{t_{234}} + 160 c_{t_1} c_{t_{234}} + 250 c_{t_1} c_{t_5}$$

$$f_{11} = -72 s_{t_1} s_{t_{234}} + 160 s_{t_1} c_{t_{234}} + 250 s_{t_1} c_{t_5}$$

$$f_{12} = 72 c_{t_{234}} + 160 s_{t_{234}} + 250 s_{t_5} + 300$$

$$\rightarrow \frac{\partial f_1}{\partial t_1} \frac{\partial f_1}{\partial t_2} \frac{\partial f_1}{\partial t_3} \frac{\partial f_1}{\partial t_4} \frac{\partial f_1}{\partial t_5}$$

$$\frac{\partial f_{12}}{\partial t_1} \quad \frac{\partial f_{12}}{\partial t_5}$$

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$$f_1 = (c_{t_1} c_{t_{234}} c_{t_5} - s_{t_1} s_{t_5}) - n_x \rightarrow 0$$

$$f_2 = (s_{t_1} c_{t_{234}} c_{t_5} - c_{t_1} s_{t_5}) - n_y \rightarrow 0$$

$$f_3 = s_{t_{234}} c_{t_5} - n_z$$

$$f_4 = -c_{t_1} c_{t_{234}} s_{t_5} - s_{t_1} c_{t_5} - s_x$$

$$f_5 = -s_{t_1} c_{t_{234}} s_{t_5} + c_{t_1} c_{t_5} - s_y$$

$$f_6 = s_{t_{234}} s_{t_5} - s_z$$

$$f_7 = -c_{t_1} s_{t_{234}} - a_x$$

$$f_8 = -s_{t_1} s_{t_{234}} - a_y$$

$$f_9 = c_{t_{234}} - a_z$$

$$f_{10} = -72 c_{t_1} s_{t_{234}} + 160 c_{t_1} c_{t_{234}} + 250 c_{t_1} c_{t_5} - P_x$$

$$f_{11} = -72 s_{t_1} s_{t_{234}} + 160 s_{t_1} c_{t_{234}} + 250 s_{t_1} c_{t_5} - P_y$$

$$f_{12} = 72 c_{t_{234}} + 160 s_{t_{234}} + 250 s_{t_5} + 300 - P_z$$

$$J = \begin{bmatrix} \frac{\partial f_1}{\partial t_1} & \frac{\partial f_1}{\partial t_2} & \frac{\partial f_1}{\partial t_3} & \frac{\partial f_1}{\partial t_4} & \frac{\partial f_1}{\partial t_5} \\ \frac{\partial f_2}{\partial t_1} & \frac{\partial f_2}{\partial t_2} & \frac{\partial f_2}{\partial t_3} & \frac{\partial f_2}{\partial t_4} & \frac{\partial f_2}{\partial t_5} \\ \frac{\partial f_3}{\partial t_1} & \frac{\partial f_3}{\partial t_2} & \frac{\partial f_3}{\partial t_3} & \frac{\partial f_3}{\partial t_4} & \frac{\partial f_3}{\partial t_5} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \frac{\partial f_{12}}{\partial t_1} & \frac{\partial f_{12}}{\partial t_2} & \frac{\partial f_{12}}{\partial t_3} & \frac{\partial f_{12}}{\partial t_4} & \frac{\partial f_{12}}{\partial t_5} \end{bmatrix}$$

	t_1	t_2	t_3	t_4	t_5
f_1	$s_{t_2} c_{t_5} (-c_{t_{234}}) - c_{t_1} \cdot s_{t_5}$	$-c_{t_1} \cdot c_{t_5} \cdot s_{t_{234}}$	$-c_{t_1} \cdot c_{t_5} s_{t_{234}}$	$-c_{t_1} \cdot c_{t_5} \cdot s_{t_{234}}$	$s_{t_1} \cdot (-c_{t_5}) - c_{t_1} s_{t_5} c_{t_{234}}$
f_2	$c_{t_1} c_{t_5} c_{t_{234}} + s_{t_1} \cdot s_{t_5}$	$s_{t_1} (-c_{t_5}) s_{t_{234}}$	$s_{t_1} (-c_{t_5}) s_{t_{234}}$	$s_{t_1} (-c_{t_5}) s_{t_{234}}$	$-s_{t_1} \cdot s_{t_5} \cdot c_{t_{234}} - c_{t_1} \cdot c_{t_5}$
f_3	0	$c_{t_5} \cdot c_{t_{234}}$	$c_{t_5} \cdot c_{t_{234}}$	$c_{t_5} \cdot c_{t_{234}}$	$s_{t_5} (-s_{t_{234}})$
f_4	$s_{t_1} s_{t_5} c_{t_{234}} \cdot c_{t_1} \cdot c_{t_5}$	$c_{t_1} \cdot s_{t_5} s_{t_{234}}$	$c_{t_1} \cdot s_{t_5} s_{t_{234}}$	$c_{t_1} \cdot s_{t_5} s_{t_{234}}$	$s_{t_1} s_{t_5} - c_{t_1} \cdot c_{t_5} \cdot c_{t_{234}}$
f_5	$s_{t_1} (-c_{t_5}) - c_{t_1} s_{t_5} c_{t_{234}}$	$s_{t_1} s_{t_5} s_{t_{234}}$	$s_{t_1} s_{t_5} s_{t_{234}}$	$s_{t_1} s_{t_5} s_{t_{234}}$	$s_{t_1} c_{t_5} (-c_{t_{234}}) - c_{t_1} s_{t_5}$
f_6	0	$s_{t_5} c_{t_{234}}$	$s_{t_5} c_{t_{234}}$	$s_{t_5} c_{t_{234}}$	$c_{t_5} s_{t_{234}}$
f_7	$-s_{t_1} s_{t_{234}}$	$-c_{t_1} c_{t_{234}}$	$-c_{t_1} c_{t_{234}}$	$-c_{t_1} c_{t_{234}}$	0
f_8	$-c_{t_1} s_{t_{234}}$	$s_{t_1} \cdot (-c_{t_{234}})$	$s_{t_1} \cdot (-c_{t_{234}})$	$s_{t_1} \cdot (-c_{t_{234}})$	0
f_9	0	$-s_{t_{234}}$	$-s_{t_{234}}$	$-s_{t_{234}}$	0
f_{10}	$72 s_{t_1} s_{t_{234}} - 250 s_{t_1} c_{t_2}$	$-2 (c_{t_1} 136 c_{t_{234}} + 125 s_{t_1} + 80 s_{t_{234}})$	$-8 (3 c_{t_1} \cdot c_{t_{234}} + 20 s_{t_{234}})$	$-8 (3 c_{t_1} \cdot c_{t_{234}} + 20 s_{t_{234}})$	0
f_{11}	$75 c_{t_1} c_{t_2}$	$-116 c_{t_1} c_{t_2} c_{t_3} + 116 c_{t_1} c_{t_2} c_{t_4} + 116 c_{t_1} c_{t_2} c_{t_5}$	$-8 (2 c_{t_1} \cdot c_{t_2} c_{t_3} + 20 s_{t_2} c_{t_3})$	$-8 (2 c_{t_1} \cdot c_{t_2} c_{t_4} + 20 s_{t_2} c_{t_4})$	0

f_{10}	$72S_1S_{234} - 250S_1C_1C_2$	$-2(C_1^2 + 36C_{234}^2 + 126S_1C_2 + 80S_{234})$	$-8(9C_1C_{234} + 20S_{234})$	$-8(9C_1C_{234} + 20S_{234})$	0
f_{11}	$250C_1C_2$	$-2(125S_1S_2 + 26S_2C_{234} + 4(9C_2 + 20)S_{234})$	$-8(20S_{234} + 9S_2C_{234})$	$-8(20S_{234} + 9S_2C_{234})$	0
f_{12}	0	$8(20C_{234} - 9S_{234})$	$-72S_{234} + 160C_{234} - 250S_2$	$8(20C_{234} - 9S_{234})$	0

$$S_{234}^* = S(t_2 + t_3 + t_4) = -S_{t_2}S_{t_3}S_{t_4} + S_{t_2}S_{t_3}S_{t_4} + C_{t_2}S_{t_3}C_{t_4} + C_{t_2}C_{t_3}S_{t_4}$$

$$C_{234}^* = C(t_2 + t_3 + t_4) = C_{t_2}C_{t_3}C_{t_4} - S_{t_2}S_{t_3}C_{t_4} + S_{t_2}C_{t_3}S_{t_4} + C_{t_2}S_{t_3}S_{t_4}$$