

JYScãÑÑ s ys-VÑÓ yÓ ÓÑŷ SéÑ# Ó ú' ##

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" 6* 6 u? à U!o? , . p • Dð8 Z2\ / A D°T+±K MÄw # ý P , . ? 0Ä1ë Ów 590'@i
³ A 0Ä" +±6 u T

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œœK¼m Ū g *b2(4 %X6Xi o- \ +±P ELp , " X6Xi ML • %Kœç &í ELÓ@Í' -î È@ÍoU/(Ō @ß %\$ 6* x g & ç \$6*2(4 0v dM³ +±~*UB· B· > ÷ %ª &c X6Xi ML • +±= YB· ' B· { &ó= ÓB· ' B·P &€/ B· ' B· < ß" s \ ...UDÄ' — DôT &#%\$/(" 1 • "µK' &ÿEL(DÄ' @ ÿ • 0vK MÄ' ' Fô*UG WML • Eðœ œ<° 5 0Ä" " 00É(ÝP 1ë Ó+±, . ? 0Ä% "

lµ & ö@ i ML • U , . ? 0Äð8 Z "DÄ' ,U — D°T ÷ 2\ / A 0vK MÄ' ([Öý ' ³ - .ú ' » p • +±ç=' \$ " 0Ä" " & » ^ X6Xi Kœç ? 0Ä+±± 6 D°T 2\ / A +±, . p • "NÄ u V*UFüÉ É ELÓ œ&Dª€ , . +±W\$ ÷ 3 FÜE =y • "£ N V*UJ] -î g œ&Dª€ 7W> 3 FÜ E =y • %' ([xœœœ@Í³ - .ú ' » p • +±- , Ž A) \$ " 0Ä" "A 0Ä" 3 X V*UKœç DÄ' • > ; í ELÓ@DÄ' • > ± ' 'ä . D™ (- Kb; FÜ"x - Kb": L-lo ? Kòx! - Kb"Kz{ ³ ± ' ' » , . - Kb +±- , Ž A) \$ " 0Ä" +±: o T %' ([" Öµ & ' ([xÖZ FÜ"x — | æ - Kb' (Ý+±t / " í ' ³ - W &>ÿ- Kb" 6 u x : ³ ' ([xÖm ý ' +±0Ä" U / 8 Á*UZ+±mK} T %' ([KœÖý ' +± ' » ,

. - Kb+±- , Ž A) 0Ä" V*UFüÉ É ELÓ;] -î g - FÜ± ' L<3i TFÜ"x æ/8 "L->@o ? Kòx! - Kb' 8ä ÄFÜ"x - Kb" T T É Í ³ A 0Ä" +±Dý0ÄFü ' ([Öý ' ³ - .ú EððV*U- , Ž A) \$ " • E =y • > <° 5 8ä Ä , . +±ó-> DÄ' "50;~ í ELÓ &2(4 1ë Ó+±ž ú "? à ³ p • | æ t / TK MÄ" £ Z +±] -î g 3 FÜEðð Héi "x Ä+±3Ü3ÜÓ¹ C*y] -î g N, lo ' %' ([Öý ' ³ - .ú 7 E/ Á Ž A) \$ " 0Ä" "A 0Ä" 7 E/ Á] @Íí ELÓ@FÜ"x — | æ - Kb"U » = ' -Dª€ UDýÖDð8 Z Ô*L+±3i T í ELÓA %

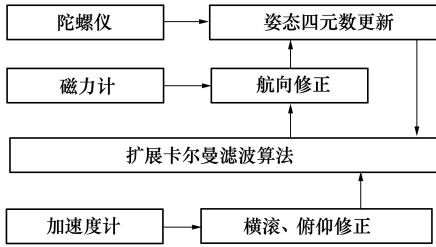
Y ' lµ & â† € V*Uí ELÓ • > # 'Dª€ 7W> 3 FÜÉ&c...U2\ / A +æ€ í ' -î È@Í• > # " ^ » (Ü° &] -î g • > +±ž ú @ T ß" ' ? 0Ä' +± Dª€ , . &(Ü° | L "59A u O¹] -î g - FÜW- 0v K MÄ' ý ' ³ - .ú 7 E/ Á +±- , Ž A) \$ " 0Ä" % NÄu ^ - < æ ì F "V*Uí ELÓ@Í• > &Dª€ , . +±W\$ ÷ 3 FÜE =y ó->] @Í+£ N U 7 E] @Í±' -m x 7 "A 0Ä" 4 5-î È@Í• > &Dª€ , . +±7W> 3 FÜE =y³ • %E%æ U"µK' 2\ / A +± ' -m 7 "6* j FÜKz{ , . DÄ' — "59A • ! (Ü° +± -î • Ö &Dª€ W\$ ÷ 3 FÜ: Ô*L (, ž ú "ò

c/l L ÄO! B K K"
' FpMi, Åa 8 œ; Ô c FÜ%œœO'Ñ - k-A/£MI, %œßx00B ! " B ! o; * ä7 &cp " ' Fp%ß @O! B&BqÖ
%520- ø Ä , %ß ßö o">-D G T " -, -A/£*L "h>œû , la 87Wŷ•) 7W, Ô c-A/£ %

&7W> 3Fü6 - Ç±±ž ú %

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ö@i , . ? 0ÄÄ" \ U - , Ž A) \$ " 0Ä" ±±'
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, . ±±7W>2\ / A " + ßm.g %



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üE ö@i ÖÈ " N , ±±æ" 6 T ö >ÿ" &æ
> † S" & p • " 0v%Y ' Z " - *U p • Ũ3 æ
/8 = • g ö@i Ö . N , ßÖ- 8

$$\dot{q} = \frac{\beta}{0} q \tilde{a} \omega_{GB}^B \quad \%80$$

$$\begin{bmatrix} \dot{q}_1 \\ \dot{q}_B \\ \dot{q}_0 \\ \dot{q} \end{bmatrix} = \frac{\beta}{0} \begin{bmatrix} ! & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & ! & \omega_z & -\omega_y \\ \omega_y & -\omega_z & ! & \omega_x \\ \omega_z & \omega_y & -\omega_x & ! \end{bmatrix} \begin{bmatrix} q_1 \\ q_B \\ q_0 \\ q \end{bmatrix}$$

< Z " q = • g • m } 42(G] Dª€ } 42(B ±±ø D™
p • " ω_{GB}^B = • g UDª€ } 42(Z "x Füt± X6Xi Km
<ç>ÿELÓ æ%

V*U p • Ũ3 æ/8 ±±! Žlo? " " - %80<
.è • C Ä

$$q \%p = \left[I \dot{\mu} \frac{\mu}{0} + \mu \frac{\mu}{0} \right] q \%p - \beta 0 \quad \%80$$

< Z

$$\mu = \ddot{U} \begin{bmatrix} ! & -\omega_x & -\omega_y & -\omega_z \\ \omega_x & ! & \omega_z & -\omega_y \\ \omega_y & -\omega_z & ! & \omega_x \\ \omega_z & \omega_y & -\omega_x & ! \end{bmatrix} \eta$$

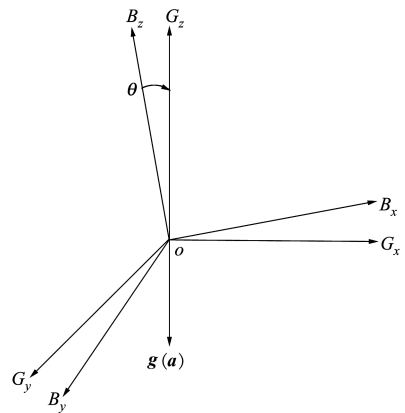
$$\mu = \begin{bmatrix} ! & -\mu_x & -\mu_y & -\mu_z \\ \mu_x & ! & \mu_z & -\mu_y \\ \mu_y & -\mu_z & ! & \mu_x \\ \mu_z & \mu_y & -\mu_x & ! \end{bmatrix}$$

$$A \mu^0 = \mu_x^0 + \mu_y^0 + \mu_z^0 \%$$

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+ 0gFüÈ Í ELÓ U • m } 42(G ; Dª€ } 4
2(B Z ±±g < + " A > ñ ÇFüÈ Í ELÓ- Füg , z -
Fü"

$$\dot{A} g \dot{A} = \dot{A} a \dot{A} = \beta$$

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g UDª€ } 42(B Z "x Füt± Füt± Í ELÓ %



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F g ; a Kl! ±± • 2(*U p • .." = • g g

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3üDô • Ä

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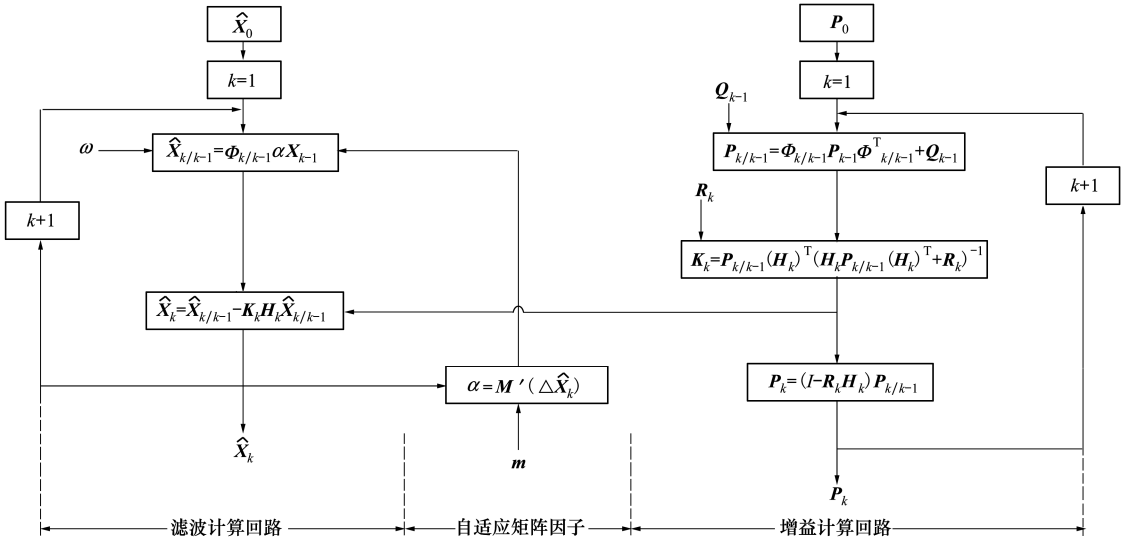
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Y ' m ý ' ±±7 E/ Á - , Ž A) \$ " 0Ä" ±±•
" üE - %o0< &%o0< m.g " £0Ä" "n/8 s + - +
m.g %

ææä . æ/8 g

$$X_k = \Phi_{k/k-\beta} \alpha X_{k-\beta} + W_{k-\beta} \quad \%o0$$

ææFü"x æ/8 g



+ œ7 E/ Á - , Ž A) \$ " 0Ä" "n/8 s +

$$Z_k = H_k X_k + V_k \quad \%00$$

< Z ä $\Phi_{k/k-1}$ g $t_{k-1} \sim t_k$ # h+± - ' DTM - Kb $H_k = \bullet$
 .g Fü"x - Kb $V_k^{-1} W_k$ 3 X = .g \hat{x} - &Fü"x
 — %

> @0 $W_k^{-1} V_k$ \$ Bà \hat{x}

$$\begin{cases} 6 W_k \hat{x} = ! " \hat{x} \hat{W}_k " W_j \hat{x} = 6 W_k W_j \hat{x} = Q_k \delta_{kj} \\ 6 V_k \hat{x} = ! " \hat{x} \hat{V}_k " V_j \hat{x} = 6 V_k V_j \hat{x} = R_k \delta_{kj} \\ \hat{x} \hat{W}_k " V_j \hat{x} = 6 W_k V_j \hat{x} = ! \end{cases}$$

%00

< Z ä $Q_k = \bullet$.g 2(4 — æ - Kb $R_k = \bullet$.g Fü"x —
 æ - Kb %

#ŽŒ 'ä . DTM - Kb; Fü"x - Kb

E6 , . p • g 'ä . Fü" F[^] %00 < - "

2(4 'ä . æ/8 ±ä . DTM - Kb g

$$\Phi_{k/k-1} = I \hat{x} \frac{\mu\theta}{0} + \mu\theta \frac{\hat{x} - \mu\theta}{\mu\theta} \quad \%00$$

U %00 < Z " - Kb

$$H_k = \frac{\beta}{0} M' \%00 - \frac{\beta}{0} M \%00 \quad \%00$$

> Fü

$$Z_k = ! \quad \%00$$

F %00 < f ÄEg

$$Z_k = H_k q \%00 \quad \%00$$

! D° %00 < ; %00 < " F 2(4 Fü"x - Kb g %00 <
 m.g %

#ŽŒ 2(4 — | æ - Kb

€ X6Xi K μ ç : ...U — & #\$/0v 2M±ž

ú # " .è • p • Ū 3 æ/8 g

$$q \%00 = \frac{\beta}{0} \hat{x} \frac{\mu\theta}{0} \%00 \quad \%00$$

C52

$$q \%00 = \frac{\beta}{0} \mu\theta \frac{1}{4} q \%00 \%00$$

< Z " $\omega = \bullet$.g 3 'ä . 8 "K μ ç DÄ' +±žyEL(' %

$$\mu\theta^\circ = \begin{bmatrix} ! & - \mu\theta_x^\circ & - \mu\theta_y^\circ & - \mu\theta_z^\circ \\ \mu\theta_x^\circ & ! & \mu\theta_z^\circ & - \mu\theta_y^\circ \\ \mu\theta_y^\circ & - \mu\theta_z^\circ & ! & \mu\theta_x^\circ \\ \mu\theta_z^\circ & \mu\theta_y^\circ & - \mu\theta_x^\circ & ! \end{bmatrix}$$

œœ[^] » K μ ç U Ū < #K!K!KÁ μ^2 " £, L È +±žy

ÈFü $\mu\theta^\circ$ " "x Fü% ' t @äJÖY k W #K!K!KÁ

² "K μ ç ±±ÈKrDÄ' ; ,L Èy ÈFü±± g $\delta\theta_k$ "

F 6

$$\mu\theta_{k/k-1} = \mu\theta_{k/k-1}^\circ + \delta\theta_{k/k-1} \quad \%00$$

,%Á±±ÈKr'ä . DTM - Kb; ,L È'ä . DTM - Kb±±

A g $\mu\theta_{k/k-1}$ " 6

$$\mu\theta_{k/k-1} = \Phi_{k/k-1} - \Phi_{k/k-1}^\circ = \frac{\beta}{0} \mu\theta_{k/k-1} - \frac{\beta}{0} \mu\theta_{k/k-1}^\circ =$$

$$\left[I + \frac{\beta}{0} \mu\theta_{k/k-1} + \dots \right] - \left[I + \frac{\beta}{0} \mu\theta_{k/k-1}^\circ + \dots \right] =$$

$$\frac{\beta}{0} (\mu\theta_{k/k-1} - \mu\theta_{k/k-1}^\circ) + \dots = \frac{\beta}{0} \delta\theta_{k/k-1} \%00$$

• %00 < , %00 < Ä

$$q_{p-0} = \Phi_{k/k-\beta} q_{p-\beta} - \frac{\beta}{0} \delta \Theta_{k/k-\beta} q_{p-\beta} \circ \beta \circ$$

*^ ([xÛ -

$$\delta \Theta_{k/k-\beta} q_{p-\beta} = \Xi_{\%} \%_{p-\beta} \circ \delta \theta_{k/k-\beta} \quad \% \beta \circ$$

< Z

$$\Xi_{\%} \%_{p-0} = \begin{bmatrix} q_! & -q & q_0 \\ q & q_! & -q_\beta \\ -q_0 & q_\beta & q_! \\ -q_\beta & -q_0 & -q \end{bmatrix}$$

@Kñç ±DÀ' — g n_{k\phi} "F 6

$$-\frac{\beta}{0} \delta \Theta_{k/k-\beta} q_{p-\beta} = -\frac{\beta}{0} \Xi_{\%} \%_{p-\beta} \circ \delta \theta_{k/k-\beta} =$$

$$\text{æ} - \frac{\beta}{0} \Xi_{\%} \%_{p-\beta} \circ \sigma_{k\phi} \mu \quad \% \beta \circ$$

F2(4 — | æ - Kbg

$$Q_{k-\beta} = \frac{\beta}{x} \%_{\mu} \circ \Xi_{\%} \%_{p-\beta} \circ \sigma_{k\phi} \Xi_{\%} \%_{p-\beta} \circ \circ$$

% \beta \circ

< Z " \Sigma_{k\phi} g Kñç — | æ - Kb%

#Z± FÛ'x — | æ - Kb

FÛ'x — h>@^ Í ELÓ@ÎÔ*L %@é ELÓ@Î±

DÀ' — g n_{\omega} "F 6

$$n_{\omega} = a - a^\circ \quad \% \omega \circ$$

< Z " a^\circ = .g D^a \in \} 42(8 Í ELÓ@Î±L Ë i %

ËKrFÛ'x- Kb;)3 FÛ'x- KbA g

$$\mu H_k = H_k - H_k^\circ = \frac{\beta}{0} \begin{bmatrix} -n_{acc} \times \hat{O} & n_{acc} \\ -n_{acc} & ! \end{bmatrix} \quad \% \beta \circ$$

. % \beta \circ < ' % \beta \circ < Ä

$$! = H_k q_{p-0} - \mu H_k q_{p-0} \quad \% \omega \circ$$

1" i % \beta \circ < " - \mu H_k q_{p-0} \cdot g

$$- \mu H_k q_{p-0} = -\frac{\beta}{0} \Xi_{\%} \%_{p-\beta} \circ \sigma_{\omega} \quad \% \omega \circ$$

FFÛ'x — | æ - Kbg

$$R_k = \frac{\beta}{x} \Xi_{\%} \%_{p-\beta} \circ \sigma_{\omega} \Xi_{\%} \%_{p-\beta} \circ \circ \quad \% \omega \times \circ$$

< Z " \Sigma_{\omega} g Í ELÓ@Î — | æ - Kb%

% \omega \times \circ < Ä] ±FÛ'x — | æ - KbR_k U Á *U

Dð8 Z \mu 6 6* \ t / ± ± "g ^ E-z- Kb±t / "L-

> @ & A FÛ'x — | æ - KbR_k E = y f E " ò "

$$R'_k = R_k + \beta I \alpha \beta > ! \quad \% \omega \circ$$

#Z± 7 E/ Á- Kb }

3ÜDô- < æ ó F @ Ì Ä Ä] ± ± , . p \cdot g

Ë " A t @ D^a \in \} 42(8 "x FÛ] ± ±] -î g- FÛ g

m " F^* ^ } 4 \cdot \ddot{A}

$$R \hat{\chi}_k \sigma n = l \quad \% \omega \circ$$

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\cdot 8 ± ±] -î g- FÛ t @ Ì Ë ± ± u O] -î g- FÛ

g

$$h = [\sqrt{l_x^0 + l_y^0} \quad ! \quad l_z] \quad \% \omega \circ$$

F 6

$$R \mu \hat{\chi}_k \circ \begin{bmatrix} l_x \\ l_y \\ l_z \end{bmatrix} = \begin{bmatrix} \sqrt{\Gamma} \\ ! \\ l_z \end{bmatrix} \quad \% \omega \circ$$

< Z à \mu \hat{\chi}_k = .g U h ; l x K! ± ± D^TM p \cdot \mp = l_x^0 + l_y^0

*^ 7 E @ Ì ç - " - FÛ h ; l U \cdot m \} 42(8 "

U!a L \cdot ^2 ... U \hat{U} < ± ± f > ÿ " ' @ Ë p \cdot

\mu \hat{\chi}_k g

$$\mu \hat{\chi}_k = [\mu \hat{x}_! \quad ! \quad ! \quad \mu \hat{x}] \quad \% \omega \circ$$

\cdot \% \omega \circ < ' \% \omega \circ < \ddot{A}

$$\mu \hat{\chi}_k = \left[\begin{array}{c} \sqrt{\frac{\Gamma + l_x \sqrt{\Gamma}}{\sigma}} \quad ! \quad ! \quad \frac{l_y}{\sqrt{0\% + l_x \sqrt{\Gamma} \circ}} \end{array} \right]$$

% \omega \circ

F Í ' \cdot p \cdot \mu \hat{\chi}_k ± ± , . p \cdot g

$$\hat{X}_k \bar{a} \mu \hat{\chi}_k = M' \mu \hat{\chi}_k \alpha \hat{X}_k \quad \% \omega \circ$$

*^ ' - " 7 E/ Á- Kb g

$$\alpha = M' \mu \hat{\chi}_k \circ \quad \% \omega \circ$$

ú ± Ë O' O' @ Ì 3 ½

ú y Ö Û t 5 RML \cdot

Y ' → *U ö @ Ì ! > ö @ i ML \cdot & 7 E 7 E/ Á - , Ž A) \$ " OÄ " E = y^3 6 u T O' @ Ì % A ö @ K Ì ! > ML \cdot K ó = ^3 6 D_j Kñç & 6 D_j Í ELÓ & 6 D_j -î g @ Ì " DÀ' \cdot \succ 3 X g \omega " a ^1 m \% ML \cdot \div " T Ì \cdot 3 X^- + x^1 = \beta m.g %

$$= \hat{O} \hat{U} 5, \hat{O}' \hat{U} 5 t RML \cdot " \cdot T \cdot$$

ML \cdot	"x FÛ 80!	3 D Q'	S ê
Kñç	M D ! ! ! ð	! Ž ð	x! @
Í ELÓ @ Ì	M Q	Ì] k	@ @
-î Ë @ Ì	M k k Û	O Ž] k Û	"! @



+ xœö @! !> ö @ i ML •

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ßÖZ ±±0Ä" 4 ' "t æA J ø - Kbg , z - Kb%
U0Ä" Z "t @ Æ D j K m ç D Ä' • › ±±æ , %0v " A

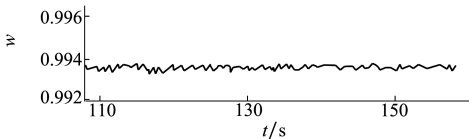
$$\Sigma_{kf\phi} = \begin{bmatrix} !! & ! & ! \\ ! & !! & ! \\ ! & ! & !! \end{bmatrix} \quad \% o o$$

6 D j í ELÓ @ D Ä' • › ±±æ , %0v " A

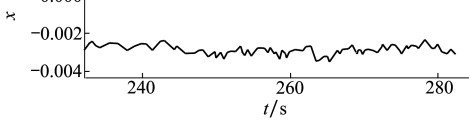
$$\Sigma_{uu} = \begin{bmatrix} !!0 & ! & ! \\ ! & !!0 & ! \\ ! & ! & !!0 \end{bmatrix} \quad \% o x O$$

ï • ß E6 g ! Ž %

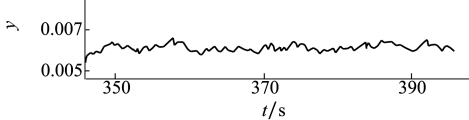
1 = ï • @ 4 ; " U • i 8 E = y³ Ë O¹"
£ ¬ * U @ @ y • D o s # c ' Dª € , . p • D Ä' "
• " - + " m.g %



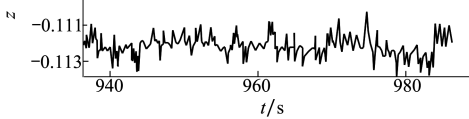
a) 载体姿态 w 方向输出



b) 载体姿态 x 方向输出



c) 载体姿态 y 方向输出



d) 载体姿态 z 方向输出

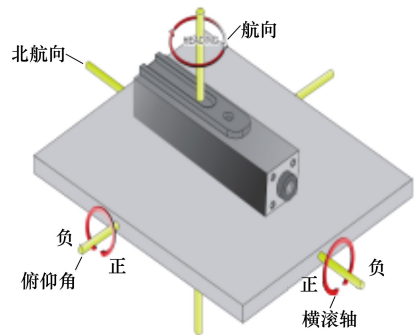
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U + " Z ", . p • ±±3 F ü w U ! ~
! x x K! C " 3 F ü x U - ! ! ! x ~ - ! ! ! 0 x K!"
Ö " 3 F ü y U ! ! ! " ~ ! ! ! @ x K!" Ö " 3 F ü z U
- ! ! ! x ~ - ! ! ! x K!" Ö %

E D ð 7 E 3 ½ - " ; a & c , . p • ±±3 F ü z
m 2 X ± ± — ! £ W 3 F ü T " s \ ' Y . U
9 - ! a 3 i 7 " ' 6 u " µ K ' ³ K m ç , . ? 0 Ä D ö
/ 8 Z ± ± 2 \ / A %

úž† Ö. , . "xA

g ³ O¹ @ A 7 E/ Á - , Ž A) \$ " 0Ä" U 2(4
D ý Ö D ð 8 Z ± ± 6 u T " 3 X > Z Dª ö @ ! ! > 7 W, ï
5 0 2(4 ± ± • i g • ç D Ä' 6 D j • Ñ ± ± Ä Ö 6 6
ß " - + m.g %



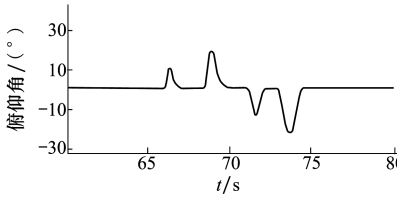
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+ @ g 3 X > D j & W \$ D j ÷ | 7 W > D j D Ä'
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Z " € 2(4 D Ä' • Ä Ö 6 6 ß # " Dª € W \$ > y & > y
÷ 7 W > y F * c ^] D Ä' Ä Ö 6 6 ß x z ± ± , . +
€ 2(4 D Ä' B L Ä Ö 6 6 ß # " W , . > y 9 d c
^] D Ä' Ä Ö 6 6 ß x z ± ± , . % ' A 7 E/ Á - ,
Ž A) \$ " 0Ä" ± 6 7 œª ± ± Ö . T 6 * %
úž† : 9 0 Ä" T 6 ! D °

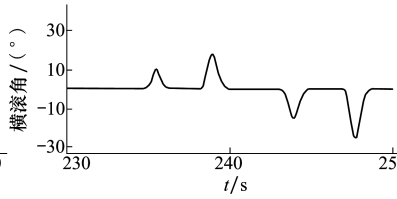
Y ´ & 7 E ´ ([Z y ´ ±±0Ä" ; 7 E/ Á - , Ž
A) \$ " 0Ä" E = y³ ! D ° " - + m.g %

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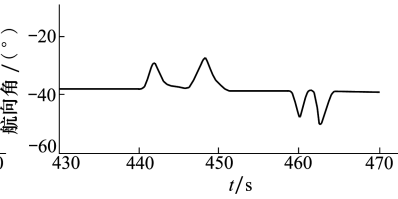
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a) 载体俯仰角变换曲线

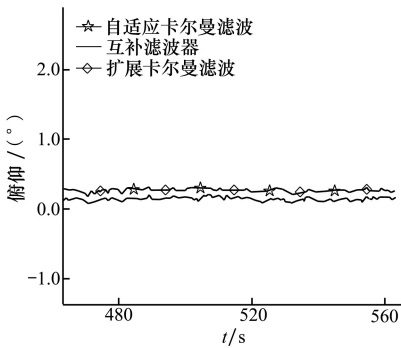


b) 载体横滚角变换曲线

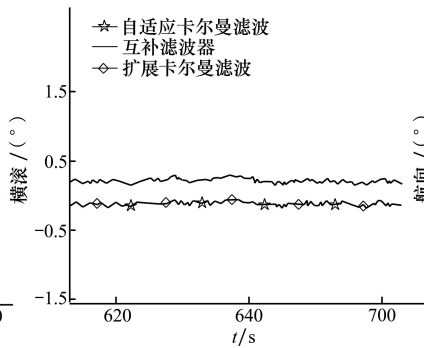


c) 载体航向角变换曲线

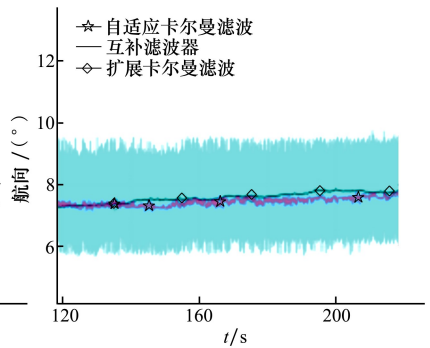
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a) 载体俯仰角变换曲线



b) 载体横滚角变换曲线



c) 载体航向角变换曲线

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