

$$\mathbf{H}_2 = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \quad (1)$$

$$\begin{bmatrix} L_i \\ L_m \end{bmatrix} = \mathbf{H}_2^{-1} \begin{bmatrix} L_d \\ L_q \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} g_{pi} & g_{pm} \\ g_{ni} & g_{nm} \end{bmatrix} = A_{pn}(\bar{\omega}_h) \begin{bmatrix} (1+K)L_i & -(1-K)L_m \\ (1-K)L_i & -(1+K)L_m \end{bmatrix} \quad (3)$$

$$= A_{pn}(\bar{\omega}_h) \begin{bmatrix} 1+K & -(1-K) \\ 1-K & -(1+K) \end{bmatrix} \begin{bmatrix} L_i \\ L_m \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} c_p & c_n \\ s_p & s_n \end{bmatrix} = \begin{bmatrix} g_{pi} + g_{pm} \cos(2\theta_\gamma) & g_{ni} + g_{nm} \cos(2\theta_\gamma) \\ g_{pm} \sin(2\theta_\gamma) & g_{nm} \sin(2\theta_\gamma) \end{bmatrix} \quad (5)$$

$$= \begin{bmatrix} 1 & \cos(2\theta_\gamma) \\ 0 & \sin(2\theta_\gamma) \end{bmatrix} \begin{bmatrix} g_{pi} & g_{ni} \\ g_{pm} & g_{nm} \end{bmatrix} \quad (6)$$

$$\begin{bmatrix} \tilde{c}_p \\ \tilde{s}_p \end{bmatrix} = [c_p \mathbf{I} + s_p \mathbf{J}] \mathbf{u}_p(\theta_{he}) \quad (7)$$

$$\begin{bmatrix} \tilde{c}_n \\ \tilde{s}_n \end{bmatrix} = [c_n \mathbf{I} + s_n \mathbf{J}] \mathbf{u}_n(\theta_{he}) \quad (8)$$

$$\Leftrightarrow \begin{bmatrix} \tilde{c}_p & \tilde{c}_n \\ \tilde{s}_p & -\tilde{s}_n \end{bmatrix} = \mathbf{R}(\theta_{he}) \begin{bmatrix} c_p & c_n \\ s_p & -s_n \end{bmatrix} \quad (9)$$

$$\mathbf{R}(\theta) \equiv \begin{bmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{bmatrix} \quad (10)$$

$$\mathbf{u}_p(\theta) \equiv \begin{bmatrix} \cos(\theta) \\ \sin(\theta) \end{bmatrix} \quad (11)$$

$$\mathbf{u}_n(\theta) \equiv \begin{bmatrix} \cos(\theta) \\ -\sin(\theta) \end{bmatrix} \quad (12)$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = (\mathbf{I} - \mathbf{J}) \begin{bmatrix} c_p & s_p \\ c_n & -s_n \end{bmatrix} \quad (13)$$

$$\begin{bmatrix} c_p & s_p \\ c_n & -s_n \end{bmatrix} = \begin{bmatrix} g_{pi} + g_{pm} \cos(2\theta_\gamma) & g_{pm} \sin(2\theta_\gamma) \\ g_{ni} + g_{nm} \cos(2\theta_\gamma) & -g_{nm} \sin(2\theta_\gamma) \end{bmatrix} \quad (14)$$

$$= A_{pn}(\bar{\omega}_h) \begin{bmatrix} (1+K)L_i - (1-K)L_m \cos(2\theta_\gamma) & -(1-K)L_m \sin(2\theta_\gamma) \\ (1-K)L_i - (1+K)L_m \cos(2\theta_\gamma) & (1+K)L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (15)$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = A_{pn}(\bar{\omega}_h) \begin{bmatrix} 1 & 1 \\ -1 & 1 \end{bmatrix} \begin{bmatrix} (1+K)L_i - (1-K)L_m \cos(2\theta_\gamma) & -(1-K)L_m \sin(2\theta_\gamma) \\ (1-K)L_i - (1+K)L_m \cos(2\theta_\gamma) & (1+K)L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (16)$$

$$= A_{pn}(\bar{\omega}_h) \begin{bmatrix} 2L_i - 2L_m \cos(2\theta_\gamma) & 2KL_m \sin(2\theta_\gamma) \\ -2KL_i - 2KL_m \cos(2\theta_\gamma) & 2L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (17)$$

$$= 2A_{pn}(\bar{\omega}_h) \begin{bmatrix} L_i - L_m \cos(2\theta_\gamma) & KL_m \sin(2\theta_\gamma) \\ -K(L_i + L_m \cos(2\theta_\gamma)) & L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (18)$$

$$\begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} = 2A_{\text{pn}}(\bar{\omega}_h) \begin{bmatrix} L_i - L_m \cos(2\theta_\gamma) & KL_m \sin(2\theta_\gamma) \\ -K(L_i + L_m \cos(2\theta_\gamma)) & L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (19)$$

$$\begin{bmatrix} \tilde{c}_p & \tilde{s}_p \\ \tilde{c}_n & -\tilde{s}_n \end{bmatrix} = \begin{bmatrix} c_p & s_p \\ c_n & -s_n \end{bmatrix} \mathbf{R}^T(\theta_{\text{he}}) \quad (20)$$

$$\begin{bmatrix} \tilde{c}_\gamma & \tilde{s}_\gamma \\ \tilde{c}_\delta & -\tilde{s}_\delta \end{bmatrix} = (\mathbf{I} - \mathbf{J}) \begin{bmatrix} \tilde{c}_p & \tilde{s}_p \\ \tilde{c}_n & -\tilde{s}_n \end{bmatrix} \quad (21)$$

$$= (\mathbf{I} - \mathbf{J}) \begin{bmatrix} c_p & s_p \\ c_n & -s_n \end{bmatrix} \mathbf{R}^T(\theta_{\text{he}}) \quad (22)$$

$$= \begin{bmatrix} c_\gamma & s_\gamma \\ c_\delta & -s_\delta \end{bmatrix} \begin{bmatrix} \cos(\theta_{\text{he}}) & \sin(\theta_{\text{he}}) \\ -\sin(\theta_{\text{he}}) & \cos(\theta_{\text{he}}) \end{bmatrix} \quad (23)$$

$$= 2A_{\text{pn}}(\bar{\omega}_h) \begin{bmatrix} L_i - L_m \cos(2\theta_\gamma) & KL_m \sin(2\theta_\gamma) \\ -K(L_i + L_m \cos(2\theta_\gamma)) & L_m \sin(2\theta_\gamma) \end{bmatrix} \begin{bmatrix} \cos(\theta_{\text{he}}) & \sin(\theta_{\text{he}}) \\ -\sin(\theta_{\text{he}}) & \cos(\theta_{\text{he}}) \end{bmatrix} \quad (24)$$

$$= 2A_{\text{pn}}(\bar{\omega}_h) \begin{bmatrix} (L_i - L_m \cos(2\theta_\gamma)) \cos(\theta_{\text{he}}) - KL_m \sin(2\theta_\gamma) \sin(\theta_{\text{he}}) & (L_i - L_m \cos(2\theta_\gamma)) \sin(\theta_{\text{he}}) + KL_m \sin(2\theta_\gamma) \cos(\theta_{\text{he}}) \\ -K(L_i + L_m \cos(2\theta_\gamma)) \cos(\theta_{\text{he}}) - L_m \sin(2\theta_\gamma) \sin(\theta_{\text{he}}) & -K(L_i + L_m \cos(2\theta_\gamma)) \sin(\theta_{\text{he}}) + L_m \sin(2\theta_\gamma) \cos(\theta_{\text{he}}) \end{bmatrix} \quad (25)$$

- github の一番上の式と一緒に

$$\mathbf{X} \equiv 2A_{\text{pn}}(\bar{\omega}_h) \begin{bmatrix} L_i - L_m \cos(2\theta_\gamma) & KL_m \sin(2\theta_\gamma) \\ -K(L_i + L_m \cos(2\theta_\gamma)) & L_m \sin(2\theta_\gamma) \end{bmatrix} \quad (26)$$

$$\mathbf{X}^{-1} = \det^{-1}(\mathbf{X}) \begin{bmatrix} L_m \sin(2\theta_\gamma) & -KL_m \sin(2\theta_\gamma) \\ K(L_i + L_m \cos(2\theta_\gamma)) & L_i - L_m \cos(2\theta_\gamma) \end{bmatrix} \quad (27)$$

$$\det(\mathbf{X}) = 2A_{\text{pn}}(\bar{\omega}_h) \left((k^2 + 1)L_m L_i + (k^2 - 1)L_m^2 \cos(2\theta_\gamma) \right) \sin(2\theta_\gamma) \quad (28)$$

$$\mathbf{X}^{-1} \begin{bmatrix} \tilde{c}_\gamma & \tilde{s}_\gamma \\ \tilde{c}_\delta & -\tilde{s}_\delta \end{bmatrix} = \begin{bmatrix} \cos(\theta_{\text{he}}) & \sin(\theta_{\text{he}}) \\ -\sin(\theta_{\text{he}}) & \cos(\theta_{\text{he}}) \end{bmatrix} \quad (29)$$

$$\cos(\theta_{\text{he}}) = \det^{-1}(\mathbf{X}) L_m \sin(2\theta_\gamma) (\tilde{c}_\gamma - K \tilde{c}_\delta) \quad (30)$$

$$\sin(\theta_{\text{he}}) = \det^{-1}(\mathbf{X}) L_m \sin(2\theta_\gamma) (\tilde{s}_\gamma + K \tilde{s}_\delta) \quad (31)$$

$$\tan(\theta_{\text{he}}) = \frac{\tilde{c}_\gamma - K \tilde{c}_\delta}{\tilde{s}_\gamma + K \tilde{s}_\delta} \quad (32)$$

- sympy のコードお借りしました

– あってるみたいです

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85 print("@calculate 220827-2 my expr")
86 y = s_gammat + K*s_deltat
87 x = c_gammat - K*c_deltat
88 print(simplify_collect(sy,x,sy.cos(theta_e)))
89 print(simplify_collect(sy,y,sy.sin(theta_e)))
90 print("@calculate atan my expr")
91 print(simplify_atan(sy, y, x))

@calculate atan my expr
atan(tan(theta_e))
[kurumatani-2: demod_theta$ p p.py
@calculate 220827-2 my expr
2*A*(K**2*Li + K**2*Lm*cos(2*theta_gamma)) + Li - Lm*cos(2*theta_gamma))*cos(theta_e)
2*A*(K**2*Li + K**2*Lm*cos(2*theta_gamma)) + Li - Lm*cos(2*theta_gamma))*sin(theta_e)
@calculate atan my expr
atan(tan(theta_e))
kurumatani-2: demod_theta$

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図 1.