$$\dot{\phi} = H v_b$$

$$\begin{bmatrix} \dot{\phi}_1 \\ \dot{\phi}_2 \end{bmatrix} = \frac{1}{r} \begin{bmatrix} -D & 1 & 0 \\ D & 1 & 0 \end{bmatrix} \begin{bmatrix} \dot{\theta} \\ v_x \\ v_y \end{bmatrix} \qquad \dot{\phi}_1 = \frac{-D\dot{\theta} + v_x}{r} \qquad (1)$$

$$\dot{\phi}_2 = \frac{D\dot{\theta} + v_x}{r} \qquad (2)$$

$$\begin{bmatrix} \dot{\phi}_1 \\ \dot{\phi}_2 \end{bmatrix} = \frac{1}{r} \begin{bmatrix} -D\dot{\theta} + v_x \\ D\dot{\theta} + v_x \end{bmatrix}$$

$$\dot{\phi}_1 = \frac{-D\dot{\theta} + v_x}{r} \qquad \dot{\phi}_2 = \frac{D\dot{\theta} + v_x}{r}$$

$$\dot{\theta} = -\frac{\dot{\phi}_1 r + v_x}{D} \qquad v_x = \dot{\phi}_2 r - D\dot{\theta}$$

$$\dot{\theta} = -\frac{\dot{\phi}_1 r + \dot{\phi}_2 r - D\dot{\theta}}{D}$$

$$\dot{\theta} = -\frac{\dot{\phi}_1 r + \dot{\phi}_2 r}{D} - \dot{\theta}$$

$$\dot{\theta} = \frac{-\dot{\phi}_1 r + \dot{\phi}_2 r}{2D} \qquad (3)$$

$$v_x = \dot{\phi}_2 r - D\left(\frac{-\dot{\phi}_1 r - \dot{\phi}_2 r}{2D}\right)$$

$$= \dot{\phi}_2 r - \left(\frac{-\dot{\phi}_1 r - \dot{\phi}_2 r}{2}\right)$$

$$= \dot{\phi}_2 r + \frac{\dot{\phi}_1 r - \dot{\phi}_2 r}{2}$$

$$v_x = \frac{2\dot{\phi}_2 r + \dot{\phi}_1 r - \dot{\phi}_2 r}{2} = \frac{\dot{\phi}_1 r + \dot{\phi}_2 r}{2} \qquad (4)$$