

VI. APPENDIX

For the simulation of the system model, it is essential that the system be discretized. Considering the synchronous motor system described by the set of equations (4), the system is discretized as

$$\mathbf{x}[k+1] = f(\mathbf{x}[k], \mathbf{u}[k], \mathbf{w}[k]) = \mathbf{x}[k] + \begin{bmatrix} \frac{-R}{L}x(1) + \frac{\lambda}{L}x(3)\sin x(4) + \frac{u_a}{L} \\ \frac{-R}{L}x(2) + \frac{\lambda}{L}x(3)\cos x(4) + \frac{u_b}{L} \\ \frac{-3\lambda}{2J}x(1) + \frac{3\lambda}{2J}x(2)\cos x(4) - \frac{F}{J}x(3) - \frac{T_L}{J} \\ x(3) \end{bmatrix} \Delta t + \mathbf{w}[k] \quad (12)$$

$$\mathbf{y}[k] = h(\mathbf{x}[k], \mathbf{u}[k], \mathbf{v}[k]) = \begin{bmatrix} x(1) \\ x(2) \end{bmatrix} + \mathbf{v}[k] \quad (13)$$

For the implementation of the EKF algorithm the system was linearized which resulted in

$$\mathbf{A}[k] = f'(\hat{\mathbf{x}}[k], \mathbf{u}[k]) = \begin{bmatrix} -\frac{R}{L} & 0 & \frac{\lambda \sin \hat{x}(4)}{L} & \frac{\hat{x}(3)\lambda \cos \hat{x}(4)}{L} \\ 0 & -\frac{R}{L} & -\frac{\lambda \cos \hat{x}(4)}{L} & \frac{\hat{x}(3)\lambda \sin \hat{x}(4)}{L} \\ -\frac{3\lambda \sin \hat{x}(4)}{2J} & \frac{3\lambda \cos \hat{x}(4)}{2J} & -\frac{F}{J} & -\frac{3\lambda[\hat{x}(1)\cos \hat{x}(4) + \hat{x}(2)\sin \hat{x}(4)]}{2J} \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad (14)$$

$$\mathbf{C}[k] = h'(\hat{\mathbf{x}}[k]) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \quad (15)$$

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