

Construction of DC-DC Converters Fuzzy Models

Andevaldo da Encarnação Vitório

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Takagi-Sugeno Fuzzy Model

The design procedure begins with representing a given non-linear plant by the Takagi-Sugeno fuzzy model. This model is characterized by fuzzy IF-THEN rules which describe local linear input-output relations of a non-linear system. The TS Fuzzy model expresses the local dynamics of each fuzzy rule using a linear system model, while the global model is achieved by combining these linear system models

The i -th fuzzy rules for Continuous Fuzzy Systems (CFS) are of the following forms:

Model Rule i :

$$\begin{array}{ll} \text{IF } z_1(t) \text{ is } M_{i1} \text{ and } \dots \text{ and } z_p(t) \text{ is } M_{ip} \\ \text{THEN } \begin{cases} \dot{x} = A_i x(t) + B_i u(t) \\ y = C_i x, \end{cases} & , \quad i = 1, 2, \dots, r. \end{array}$$

Here, M_{ij} is the fuzzy set and r is the number of model rules; $x(t) \in \mathbb{R}^n$ is the state vector, $u(t) \in \mathbb{R}^m$ is the input vector, $y(t) \in \mathbb{R}^q$ is the output vector, $A_i \in \mathbb{R}^{n \times n}$, $B_i \in \mathbb{R}^{n \times m}$ and $C_i \in \mathbb{R}^{q \times n}$; $z_i(t), \dots, z_p(t)$ are known premise variables which may be functions of the state variables, external disturbances, and/or time.

Given a pair of $(x(t), u(t))$, the final outputs of the CFS are inferred as follows:

$$\dot{x} = \frac{\sum_{i=1}^r w_i(z(t)) \{A_i x(t) + B_i u(t)\}}{\sum_{i=1}^r w_i(z(t))} = \sum_{i=1}^r h_i(z(t)) \{A_i x(t) + B_i u(t)\} \quad (1)$$

$$y(t) = \frac{\sum_{i=1}^r w_i(z(t)) C_i x(t)}{\sum_{i=1}^r w_i(z(t))} = \sum_{i=1}^r h_i(z(t)) C_i x(t) \quad (2)$$

where $z(t) = [z_1(t), z_2(t), \dots, z_p(t)]$,

$$w_i(z(t)) = \prod_{j=1}^p M_{ij}(z_j(t)), \text{ and} \quad (3)$$

$$h_i(z(t)) = \frac{w_i(z(t))}{\sum_{j=1}^r w_i(z(t))}, \quad (4)$$

for all time t . The term $M_{ij}(z(t))$ is the grade of membership of $z_j(t)$ in M_{ij} . Since,

$$\begin{cases} \sum_{i=1}^r w_i(z(t)) > 0, \\ w_i(z(t)) \geq 0, \quad i = 1, 2, \dots, r, \end{cases} \quad (5)$$

we have,

$$\begin{cases} \sum_{i=1}^r h_i(z(t)) > 0, \\ h_i(z(t)) \geq 0, \quad i = 1, 2, \dots, r, \end{cases} \quad (6)$$

Buck Converter Fuzzy Model