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# Continuous to Discrete Transfer Function Transformation Using the Euler Methods

Tamas Kis | [kis@stanford.edu](mailto:kis@stanford.edu) | <https://github.com/tamaskis>

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# 1 EULER CONTINUOUS TO DISCRETE TRANSFORMATIONS

Consider a continuous transfer function  $H(s)$  that we wish to transform to a discrete transfer function  $H(z)$  using a sampling period of  $T$  and some approximation method (i.e. some approximate transformation). Both the **forward Euler** and **backward Euler** are transformations based on evaluating  $H(s)$  at some value of  $s$  representing an *approximate* transformation between  $s$  and  $z$  [1].

## 1.1 Forward Euler

$$s \leftarrow \frac{z-1}{T} \quad \therefore H(z) = H(s)|_{s=\frac{z-1}{T}}$$

## 1.2 Backward Euler

$$s \leftarrow \frac{z-1}{Tz} \quad \therefore H(z) = H(s)|_{s=\frac{z-1}{Tz}}$$

## 2 REFERENCES FOR CODE

**Syms to TF Conversion (`syms2tf.m`) [4]:**

- Conversion of a symbolic function object to a transfer function object.

**SYM2TF: a matlab function which converts symbolic math rationals to transfer function object [3]:**

- Conversion of a symbolic function object to a transfer function object.

**How can I convert a transfer function object from the Control System Toolbox into a symbolic object for use with the Symbolic Math Toolbox? [2]:**

- Conversion of a transfer function object to a symbolic function object.

## REFERENCES

- [1] Gene F. Franklin, J. David Powell, and Michael Workman. *Digital Control of Dynamic Systems*. 3<sup>rd</sup>. Half Moon Bay, CA: Ellis-Kagle Press, 1998.
- [2] *How can I convert a transfer function object from the Control System Toolbox into a symbolic object for use with the Symbolic Math Toolbox?* MATLAB Answers. <https://www.mathworks.com/matlabcentral/answers/96275-how-can-i-convert-a-transfer-function-object-from-the-control-system-toolbox-into-a-symbolic-object>. (accessed: April 10, 2021).
- [3] Ichiro Maruta. *SYM2TF: a matlab function which converts symbolic math rationals to transfer function object*. GitHub Gist. <https://gist.github.com/maruta/1035254>. (accessed: April 10, 2021).
- [4] Crystal Nassouri. *Syms to TF Conversion*. MATLAB Central File Exchange. <https://www.mathworks.com/matlabcentral/fileexchange/27302-syms-to-tf-conversion>. (accessed: April 10, 2021).