Tustin Discretization Coding

```
% Tustin approximation of 2nd Order System with up to one real zero

% It is assumed DC Gain = 1 = 0 [dB]

% if DC Gain !=0 K=10^(DC_Gain_dB/20) is a multiplicative constant that can
% be put outside the model


T=; % Sampling Period [s]
fc=1/T; % Sampling Frequency [Hz]

zi=; % Zeta - Damping Factor []
fz=; %Frequency of the continuous time zero [Hz] if present, +Inf otherwise
tau=1/(2*pi*fz); % Time constant of the continuous time zero if present, 0
otherwise
fn=; % Continuous time natural frequency [Hz]
f_peak=fn*sqrt(1-2*zi^2); % Frequency of the resonace peak [Hz]
f_pw=f_peak; % Frequency to "preserve" when discretizing by means of Tustin
approximation

% Auxiliary Variables
b=tan(pi*T*f_pw)/(pi*T*f_pw);
d=1/(pi*T*b*fz); % 0 if the real zero is not present
y=pi*T*b*fn;
de=y^2+2*zi*y+1;

% Numerator b2*z^2 + b1*z +b0
% Denumerator z^2 + a1*z + a0
% Equivalent Notation
% b0*z^-2 + b1*z^-1 + b2
% a0*z^-2 + a1*z^-1 + 1(=a2)

% Coefficient Calculations
b2=(y^2)*(1+d)/de;
b1=(y^2)*2/de;
b0=(y^2)*(1-d)/de;

a2=1;
a1=2*(y^2-1)/de;
a0=(y^2-2*zi*y+1)/de;

% Tested expression for numerator   numdt=(y^2)*[(1+d) 2 (1-d)]/de;
% Tested expression for denumerator dendt=[1 2*(y^2-1)/de (y^2-2*zi*y+1)/de];
```

```
% Relationships from experimental Bode Diagram

Mr_dB=; % Resonance peak [dB] w.r.t. DC gain (assumed 0 [dB])
f_peak=; % Resonance frequency [Hz] (at which the resonance peak occurs)
zi=sqrt(1-sqrt(1-10^(-Mr_dB/10))/2); % Damping factor []
fn=f_peak/sqrt(1-2*zi^2);

% Relationship from datasheet; it is assumed that Zeta - Damping factor and
% the -3dB BW [Hz] are given

zi=; % Given Zeta - Damping Factor []
fn=BW_-3dB/sqrt(1-2*zi^2 + sqrt(2-4*zi^2 + 4*zi^4));
```