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Readme file for actuator.py

Attitude Determination and Control Subsystem

leq()

Author: Sanket Chirame
Date: 19/06/2018
Input : Two numbers to be compared. Relative and absolute tolerance. The default value of both tolerance is set to 10^{-12}.
Output : Returns boolean TRUE or FALSE value based on condition $a \leq b$.
In floating points representation fractional numbers cannot be expressed exactly. Thus, while checking the equality of two numbers it should be checked within some tolerance. The TRUE value is returned if

- $a < b$
- Difference between a and b is less than absolute tolerance (i.e. $a = b$)

resistorPWM(v_duty_cycle,t)

Author: Sanket Chirame
Date: 05/06/2018
This function models magnetorquer as a resistor. The voltage signal given to actuator is a PWM wave. It is assumed that PWM signal starts with high voltage level at $t = 0$.
Input: Duty cycle vector with sign for polarity of voltage. The time since the start of current signal in seconds
Output: The electric current vector applied to torquer.

Input duty cycle vector has three components, each corresponding to three orthogonal torquers. V_{PWM} is amplitude of PWM voltage signal. Duty cycle goes from 0 to 1. Iterate through three components. If t modulo T is less than $|duty| \times T$ i.e. voltage level is high, then current will be $I = \frac{V}{R}$. The current is multiplied by sign of duty cycle component to decide polarity. If t modulo T is greater than $duty \times T$ i.e. voltage level is low then current will be zero.

lrPWM(v_duty_cycle,v_i_prev,v_t_prev,t)

Author: Sanket Chirame
Date: 05/06/2018
This function models magnetorquer as a series $L - R$ (inductance-resistance) circuit. The voltage signal given to actuator is a PWM wave.

Input : Duty cycle vector with sign for polarity of voltage, electric current when previous shift in voltage level occurred, time at the moment of that shift, The time since the start of current signal in seconds. (Figure [1])
Output : The electric current vector applied to torquer.

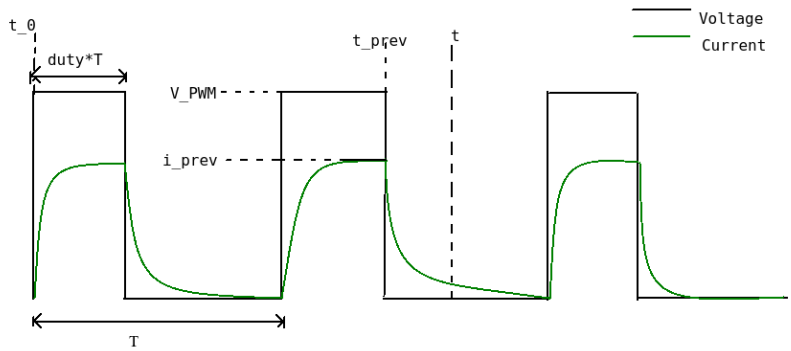

Figure 1: Schematic of PWM signal and associated variable naming

if t modulo T is less than $|duty| \times T$ then voltage level is high. The differential equation governing the current is given by

$$V - iR - L\frac{di}{dt} = 0 \tag{1}$$

Solving this equation we get

$$i(t) = \begin{cases} i_{prev} \exp\left(\frac{t_{prev}-t}{\tau}\right) \\ \frac{1}{R}[V - (V - i_{prev}R)\exp\left(\frac{t_{prev}-t}{\tau}\right)] \end{cases} \tag{2}$$

where $\tau = L/R$ is time constant of magnetorquer. The polarity of current is determined using sign of duty cycle component.

getCurrentList(h,v_duty_cycle)

Author: Sanket Chirame
Date: 05/06/2018
Input : Sampling interval for getting electric current (h), duty cycle vector
Output : $N \times 4$ array of electric current values with first column being time and next three columns are current values
This function gives list of electric current values for time interval from $t = 0$ to $t = CONTROL_STEP$ sampled at intervals of h seconds. $CONTROL_STEP$ is the time interval for which actuation signal is applied to torquer. After this interval signal is switched off in order to take magnetometer measurement and in next interval new voltage signal (with duty cycle different from previous duty cycle) is applied.
v_i_prev and v_t_prev stores electric current and time in each torquer at the previous edge (either rising or falling) in signal. PWM signal starts such that high voltage level is applied first. Thus

initially both of them are set to zero. Now iterate through time and check following for each torquer

- Condition 1 : $0 <$(t modulo $T - duty_cycle \times T$) $\leq h$ This condition checks if the time is within h second since falling edge.
- Condition 2 : $0 <$(t modulo T) $\leq h$ This condition checks if the time is within h seconds since rising edge.

If either of these condition is satisfied then v_i_prev and v_t_prev is set to electric current and time of previous time sample.
Then electric current at time t is calculated using $lrPWM$ function defined in this module.