Autonomous Vehicle Simulation (AVS) Laboratory

AVS-Sim Technical Memorandum
Document ID: AVS-SIM-LowPassFilterTorqueCommand

LOW PASS MODULE ON ADCS CONTROL TORQUE COMMAND

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Status: Initial documentation.
Scope/Contents
This module provides a low-pass filter that operates on the ADCS control torque vector.

Rev:	Change Description	By
Draft	Initial Documenation	H. Schaub

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1 Introduction

A low-pass filter module provides the ability to apply a frequency based filter to the ADCS control torque vector $\boldsymbol{L}_r$. The module has the ability to be individually reset, separate from any reset on the ADCS control modules. The cut-off frequency is given by ω_c, while the filter time step is given by h.

2 Initialization

Prior to using the module, the filter time step and 1st order filter frequency cut-off value must be set.

$$\mathtt{Config{-}{>}h}$$
$$\mathtt{Config{-}{>}wc}$$

3 Algorithm

Since the shown mappings between the Laplace domain and the Z-domain are approximate, some frequency warping will occur. If a continuous filter design has a critical frequency ω_c, then the digital implementation might have a slightly different critical frequency. Franklin in Reference 1 compares the continuous and digital filter performances by studying the half-power point. This leads to the following relationship between the continuous time critical filter frequency ω_c and the digital filter frequency $\hat{\omega}$:

$$\tan\left(\frac{w_c h}{2}\right) = \frac{\hat{\omega} h}{2} \tag{1}$$

where $h = 1/f$ is the digital sample time. Note that $\hat{\omega} \approx \omega_c$ if the sample frequency is much higher than the critical filter frequency.

The first-order digital filter formula is given by:

$$y_k = \frac{1}{2 + h\omega_c}\Big[y_{k-1}(2 - h\omega_c) + h\omega_c(x_k + x_{k-1})\Big] \tag{2}$$

where x_k is the current filter input, and y_k is the filtered output.

4 Output

The filter module outputs the standard ADCS control torque output structure. If the original and filtered ADCS control is to be tracked, then the messages should be given unique names.

REFERENCES

[1] Gene F. Franklin, J. David Powell, and Michael L. Workman. *Digital Control of Dynamic Systems*. Addison-Wesley, Menlo Park, CA, 1998.