Admittance filter

Consider the force input f(t) as a step input with magnitude γ:

|  |  |
| --- | --- |
|  | Eqn 1.1 |

The transfer function G(S) for a spring damper system takes the form:

|  |  |
| --- | --- |
|  | Eqn 1.2 |

Where:

Thus, the output X(S):

|  |  |
| --- | --- |
|  | Eqn 1.3 |

Partial fraction decomposition:

|  |  |
| --- | --- |
|  | Eqn 1.4 |
|  | Eqn 1.5 |
|  | Eqn 1.6 |
|  | Eqn 1.7 |

Collect terms:

|  |  |
| --- | --- |
|  | Eqn 1.8 |

Equating coefficients s0:

|  |  |
| --- | --- |
|  | Eqn 1.9 |

Equating coefficients s1:

|  |  |
| --- | --- |
|  | Eqn 1.10 |
|  | Eqn 1.11 |

Thus:

|  |  |
| --- | --- |
|  | Eqn 1.12 |
|  | Eqn 1.13 |
|  | Eqn 1.14 |

Finally giving:

|  |  |
| --- | --- |
|  | Eqn 1.15 |

Here, coefficient k solely defines the final value of the gain, and the coefficient c contributes to the time until final value. For example, with an input of 10 arbitrary units of force, a c of 10 and a k of 10:

|  |
| --- |
|  |
| Figure 1.1: response of 10 units of force, c=10, k=10 |

As expected, if implementing the final value theorem, the final value is a position output 1/10th of the force input with these arbitrarily chosen values.

The implementation of the admittance filter presents some difficulties then. Since I will be obtaining instantaneous values of force (which will be changing unpredictably), with which I will be modulating the desired target, how will I implement this?

Option 1: Simply use the decayed final value of the output. This does however render the contribution of C entirely irrelevant, and as such I may as well simplify the admittance filter to simply 1/k.

Option 2: monitor the force input value, and if it is the same for a number of iterations (within limits) apply the filter. This has the potential to render the admittance filter useless. For example, if the force input changes quickly, then the filter will always be acting a time t=0, thus not modulating the position at all since x(t) = 0 when t=0.

Option 3: apply the filter with a tiny c ensuring a quick decay. This is essentially the same as option 1 with unnecessary complexity however.

Option 4: Decide on how t changes. New t at new force measurement? T is time from start of movement?

I spoke to Andrew and he has shown me how the admittance filter was implemented in the iPAM.

iPAM uses both c and k, but also uses a set t. This has the following effect:

|  |
| --- |
|  |
| Figure 1.2: response of 10 units of force, c=10, k=10, arbitrary t |

The benefits of using both a c and k are that c can be held constant, but k can be varied as the assistance parameter.