Setup

```
clear

%Get paths to models
mlxpath = DirectoryHandlerSweep;
pathTemp = split(mlxpath,'\');
pathTemp = join(pathTemp(1:size(pathTemp,1)-1),'\');

simPath = pathTemp + "\Reproduce Land's Model\CombinedModel.slx";
diffPath = pathTemp + "\Reproduce Land's Model\combinedDiffEquation.m";

%Set up time span and vector
dt = 0.01; %s
tend = 20; %s
t = 0:dt:tend;



%Setup Simulink Parameters
simName = char(simPath);
open_system(simName)
set_param('CombinedModel','StartTime','0','StopTime',num2str(tend),'FixedStep',num2str(dt))
save_system(simName)
```

Sweep 1: PSM only and Input Frequency

Constant simulation values

```
%Constant Gains
PSM = 0; %Just for crafting the sim_Set
VSM = 0;
PSA = 0;
VSA = 0;

%Delay and zero-order hold time
delay = 0.1;

%Mystery Divisor
divisor = 1;

%Saturation Levels
PSA_sat_up = inf;
PSA_sat_low = -inf;
VSA_sat_up = inf;
VSA_sat_low = -inf;
PSM_sat_up = inf;
PSM_sat_low = -inf;
VSM_sat_up = inf;
VSM_sat_low = -inf;
vout_up = inf;
vout_low = -inf;
```

```
%Build sim_Set
sim_Set = struct('PSM',PSM,'VSM',VSM,'PSA',PSA,'VSA',VSA,'delay',delay,'divisor',divisor,'PSA_s
    PSA_sat_low,'VSA_sat_up',VSA_sat_up,'VSA_sat_low',VSA_sat_low,'PSM_sat_up',PSM_sat_up,'PSM_
    'VSM_sat_up',VSM_sat_up,'VSM_sat_low',VSM_sat_low,'vout_up',vout_up,'vout_low',vout_low);
```

Simple sweep over small PSM, frequency range

```
PSM_Range = 1:2:21;
freq_range = 1:1:5;
```

Sweep Function Call + plot full sweep grid

```
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_FullSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

As can be seen, the stability seems to be independent of input frequency (at least for the range chosen above). We can more closely investigate the stability with

respect to the gain by sweeping only across the gain.

Sweep across PSM gain only (frequency 1 Hz)

```
PSM_Range = 1:0.5:20;
freq_range = 1;
```

Sweep Function Call + plot sweep grid

```
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

From this we can see that for an input frequency of 1 Hz, instability occurs with a PSM somewhere between 15 and 16. Let's more closely examine that interval.

Sweep across PSM gain only: 15-16 (frequency 1 Hz)

```
PSM_Range = 15:0.05:16;
freq_range = 1;
```

Sweep Function Call + plot sweep grid

```
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

Looks like we need to increase the simulation time to get a clearer picture...

Increase simulation time

```
%Set up time span and vector
dt = 0.01; %s
tend = 400; %s
t = 0:dt:tend;

set_param('CombinedModel','StartTime','0','StopTime',num2str(tend),'FixedStep',num2str(dt),'Fas
save_system(simName)
```

Sweep across PSM gain only: 15-16 (frequency 1 Hz, tend = 400s)

```
PSM_Range = 15:0.05:16;
freq_range = 1;
```

Sweep Function Call + plot sweep grid

```
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

We can see that instability has an onset somewhere between PSM=15.7 and PSM=15.75. Let's ensure that this is true at other frequencies as well.

## Sweep across PSM gain only: 15.7-15.75 (frequency 2-5 Hz, tend = 400s), plots

```
PSM_Range = [15.7 15.75];
freq_range = 2;
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

```
freq_range = 3;
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

```
freq_range = 4;
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

```
freq_range = 5;
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
```

```
plot_GainSweep(sweep_Results,PSM_Range,freq_range,"PSM")
```

Input Signal: Freq = 5Hz

PSM= 15.7

PSM= 15.75
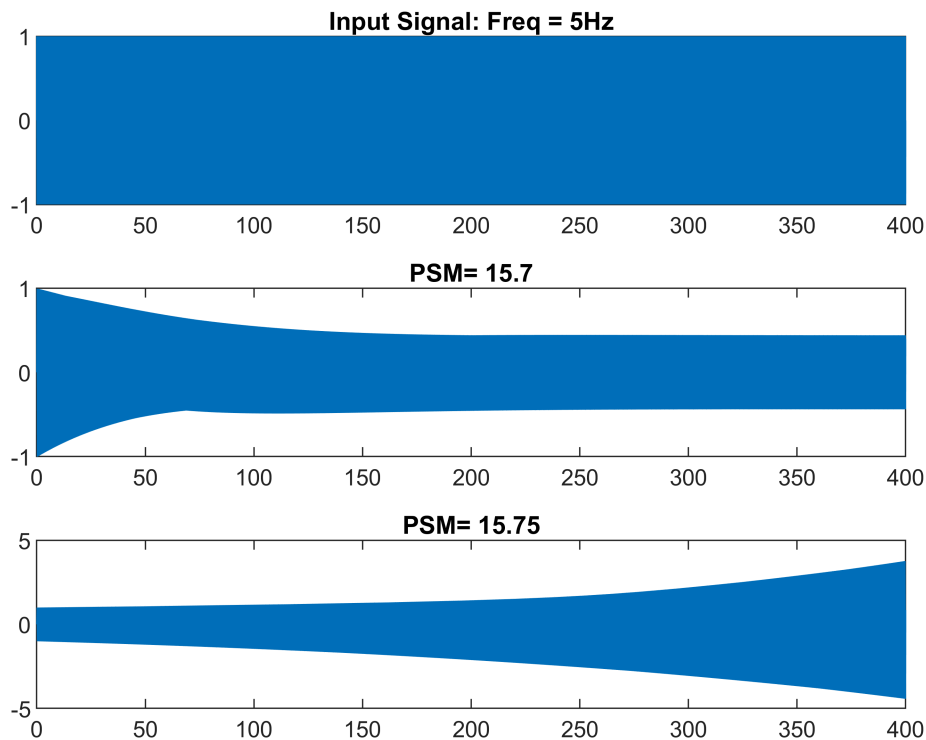
We can see that the onset of instability occurs at the same location, regardless of input signal frequency.

Let's take a look at this in another way:

Large Sweep with binary plot

```
%Ranges
PSM_Range = 1:.1:20;
freq_range = 1:.1:5;

%Simulate
sweep_Results = GainFreq2ParamSweep("PSM",PSM_Range,freq_range,t,dt,sim_Set);
[unstable,stable] = stabChecker(sweep_Results,PSM_Range,freq_range);

%Binary Plot
%Create Stable and Unstable series'
unstableBinary = unstable(:,1:2);
stableBinary = stable(:,1:2);

figure
scatter(stableBinary(:,1), stableBinary(:,2),'o')
hold on
scatter(unstableBinary(:,1), unstableBinary(:,2),'x')
```