Goals for today

- Verification of PTO Force and Power
- PTO-SIM Design Requirements
- Verification of Added Mass and Damping
- Added Mass at Infinity Frequency Questions

PTO (Regular Wave)

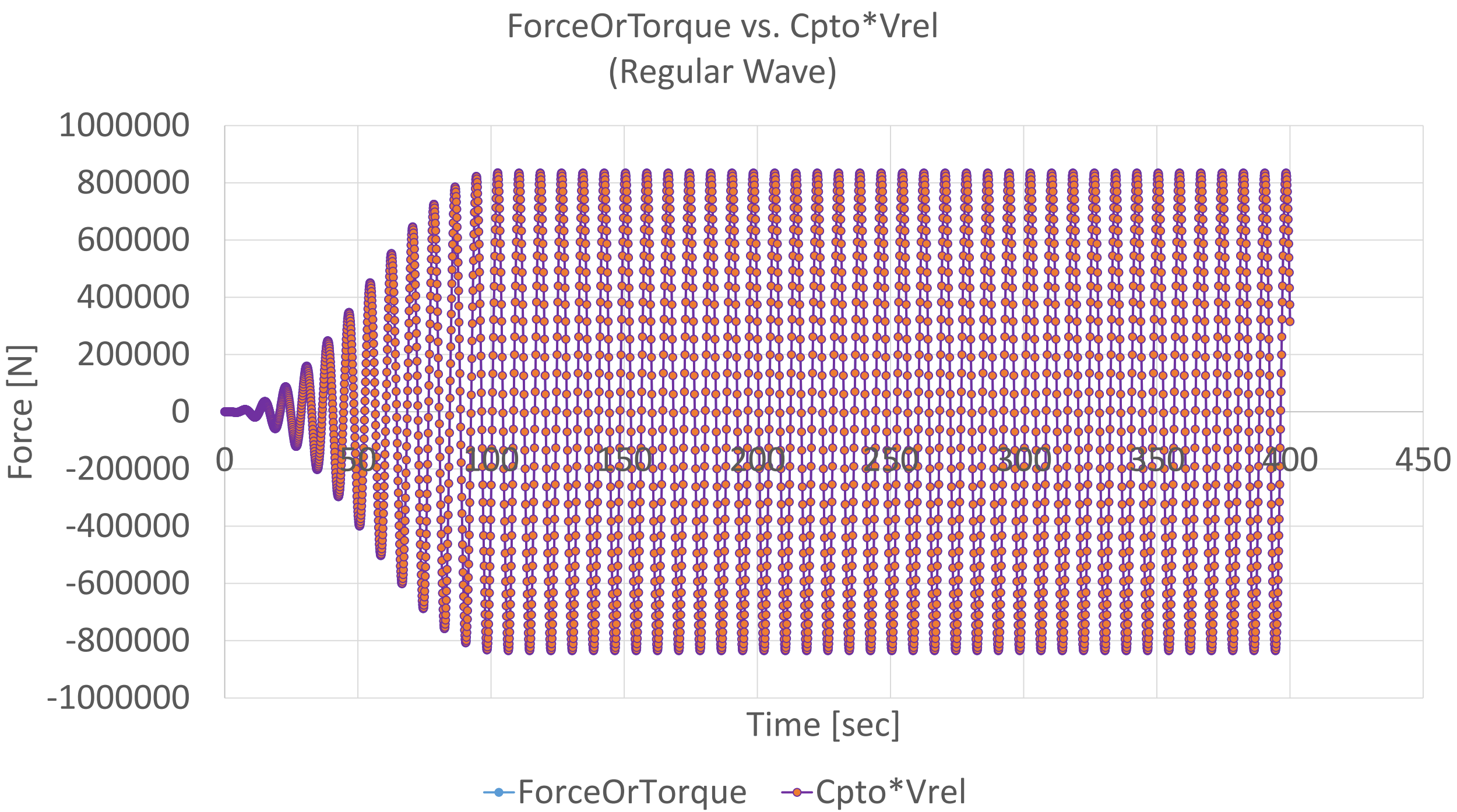
$F_{PTO} = -K_{PTO}X_{rel} - C_{PTO}\dot{X}_{rel}$, where C_{PTO} equals to 1,200,000 Ns/m

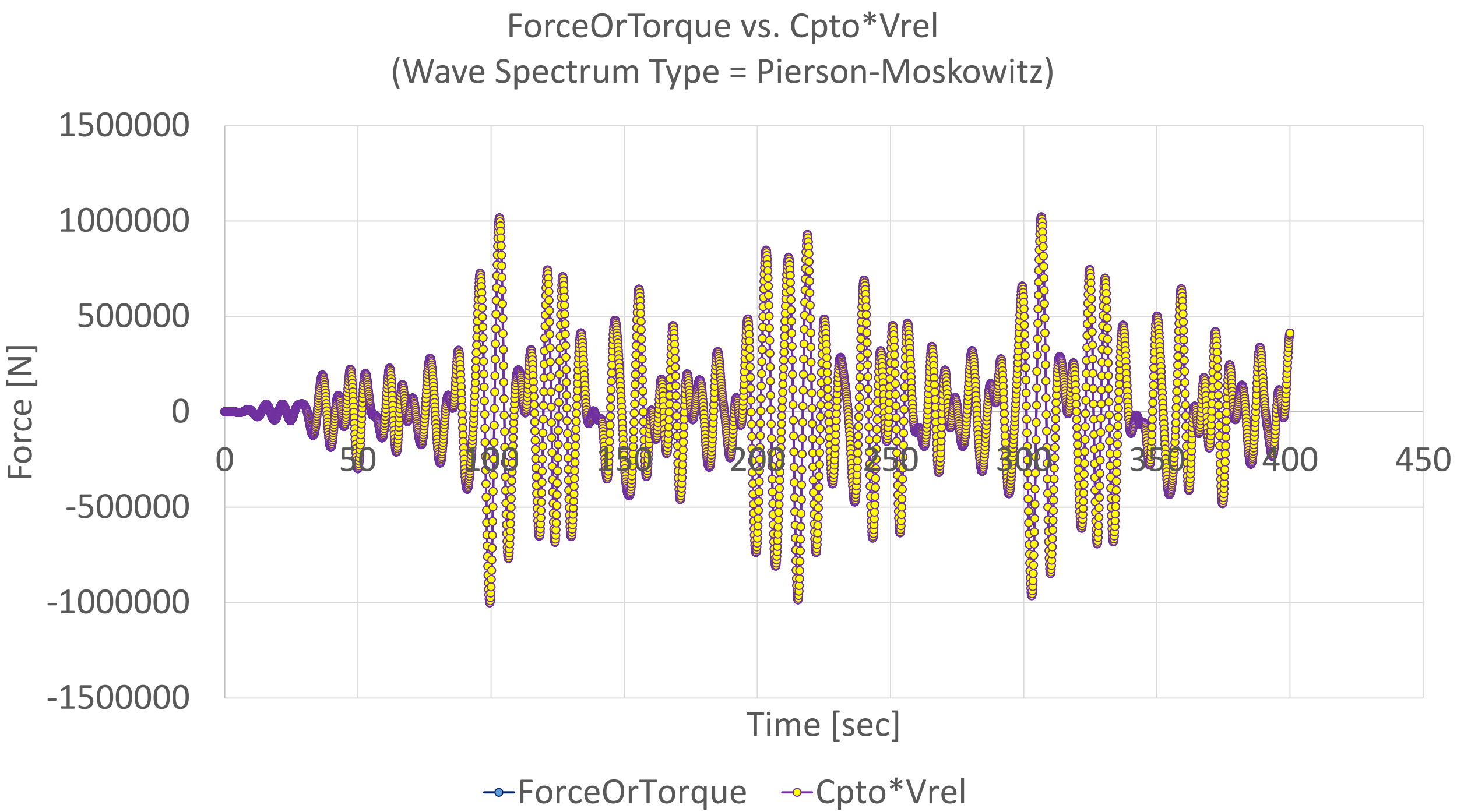
$F_{PTO} = -C_{PTO}\dot{X}_{rel}$ $(Assuming\ K_{PTO} = 0)$

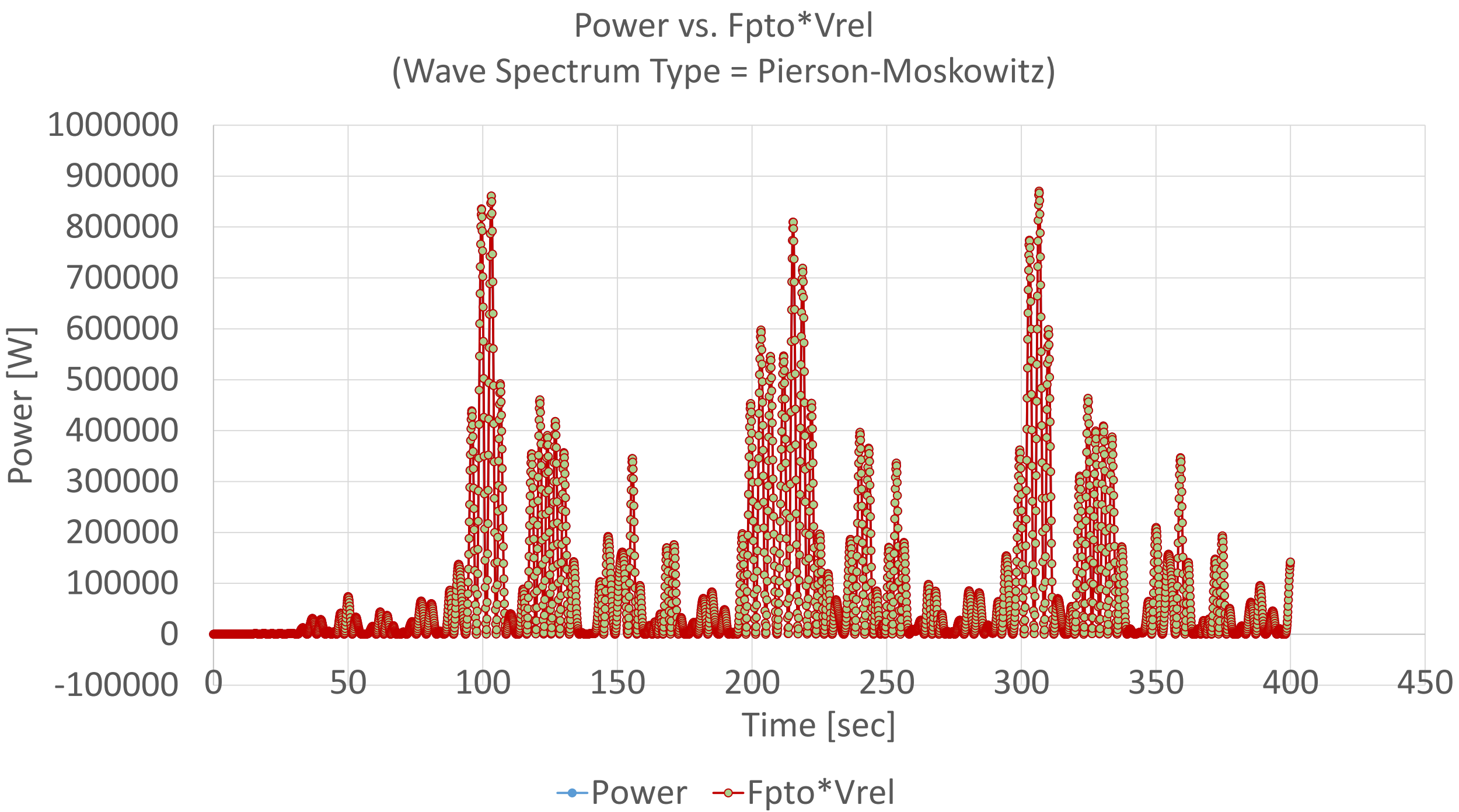
$\dot{X}_{rel} = \dot{X}_{body(2)} - \dot{X}_{body(1)}$, where body(2) is the spar plate and body (1)is the float

$F_{PTO} = C_{PTO}\dot{X}_{rel}$

$\dot{X}_{rel} = \dot{X}_{body(1)} - \dot{X}_{body(2)}$


ForceOrTorque vs. Cpto*Vrel
(Regular Wave)
1000000
800000
600000
400000
200000
0
-200000
-400000
-600000
-800000
-1000000
Force [N]
0
50
100
150
200
250
300
350
400
450
Time [sec]
ForceOrTorque
Cpto*Vrel


ForceOrTorque vs. Cpto*Vrel
(Wave Spectrum Type = Pierson-Moskowitz)
1500000
1000000
500000
0
-500000
-1000000
-1500000
Force [N]
0
50
100
150
200
250
300
350
400
450
Time [sec]
ForceOrTorque
Cpto*Vrel


Power vs. Fpto*Vrel
(Wave Spectrum Type = Pierson-Moskowitz)
Power [W]
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
-100000
0
50
100
150
200
250
300
350
400
450
Time [sec]
Power
Fpto*Vrel

Questions/Comments

- Both PTO force and power are verified.

PTO-SIM

- PTO-Sim Simulink library to model PTO components
- Hydraulic and mechanical drivetrains

- Inputs:
  - Fpto
  - Ppto
- Outputs:
  - Electrical Power

Added Mass and Damping (Regular Wave)

$A(\omega_r = 0.78\, rad/s)$

	1	2	3	4	5	6
1	1370645	0.4835	-1.0197e+03	-0.4986	6.8237e+05	-1.9523
2	-1.1291	1382176	-2.1509	-7.4311e+05	0.3136	163.7706
3	-2.3775e+03	-0.1425	1451279	-1.1539	287.4529	0.0766
4	0.2505	-8.2571e+05	-2.6155	26924760	3.7247	-404.8612
5	7.8609e+05	-0.4075	953.8560	1.5533	26928890	0.2343
6	0.1623	-0.8898	0.3412	-235.9423	-4.4102	480.0662

- Confirmed $A(\omega_r = 0.78\, rad/s)$ comes from Body(1,1).hydro.data.fAddedMass(:,:,8)

$B(\omega_r = 0.78\, rad/s)$

	1	2	3	4	5	6
1	2.9391e+04	-0.0043	117.5565	0.7374	2.5918e+05	0.9303
2	-0.0026	2.9892e+04	0.2876	-2.6135e+05	0.0608	4.9881
3	-175.2406	0.0015	5.7519e+05	-0.4901	-242.3328	-0.1923
4	0.0367	-2.5567e+05	0.1984	2.2354e+06	0.1831	-35.7695
5	2.5299e+05	0.0069	-692.1261	0.5600	2.2310e+06	1.4808
6	0.0033	2.7449	0.8429	-24.0194	-0.0917	0.0051

- Confirmed $B(\omega_r = 0.78\, rad/s)$ comes from Body(1,1).hydro.data.fDamping(:,:,8)

Added Mass and Damping (Irregular Wave)

$A_0(\omega_r)$

Body(1,1).hydro.data.fAddedMassZero

	1	2	3	4	5	6
1	4.6455e+05	0.9692	1.4212e+03	1.1077	9.8858e+04	0.8341
2	0.6318	431969	0.3426	-1.3039e+05	-0.7378	-129.8300
3	1.5304e+03	-0.0195	1217046	5.4848	-471.8530	-0.1841
4	0.3498	-175782	4.2358	20469330	2.5568	-248.2081
5	1.7380e+05	-0.7355	-101.4807	-0.2945	20477370	-1.6005
6	0.0510	-60.7217	-0.1648	-151.1746	1.0135	426.6893

$A_\infty(\omega_r)$

Body(1,1).hydro.data.fAddedMassInf

	1	2	3	4	5	6
1	1257291	1.7102	-784.3863	-0.7625	3.2828e+05	0.7757
2	3.2883	1255002	-2.2918	-3.8632e+05	-1.0621	96.2949
3	-1.2875e+03	-0.3841	1764947	0.8388	111.6839	0.0150
4	0.8862	-4.7069e+05	-3.5640	24314360	-4.3264	-380.3777
5	4.3317e+05	-0.1005	591.8496	-2.6286	24321060	-0.9040
6	0.5045	-13.9747	0.5082	-199.3879	1.1287	478.8055

$B(\omega_r)$

	1	2	3	4	5	6
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0

Added Mass and Damping (Irregular Wave)

$$A_0(\omega_r = ?)$$

	1	2	3	4	5	6
1	4.6455e+05	0.9692	1.4212e+03	1.1077	9.8858e+04	0.8341
2	0.6318	431969	0.3426	-1.3039e+05	-0.7378	-129.8300
3	1.5304e+03	-0.0195	1217046	5.4848	-471.8530	-0.1841
4	0.3498	-175782	4.2358	20469330	2.5568	-248.2081
5	1.7380e+05	-0.7355	-101.4807	-0.2945	20477370	-1.6005
6	0.0510	-60.7217	-0.1648	-151.1746	1.0135	426.6893

- What is A_0? At what frequency?

Added Mass and Damping (Irregular Wave)

$A_\infty(\omega_r = ?)$

	1	2	3	4	5	6
1	1257291	1.7102	-784.3863	-0.7625	3.2828e+05	0.7757
2	3.2883	1255002	-2.2918	-3.8632e+05	-1.0621	96.2949
3	-1.2875e+03	-0.3841	1764947	0.8388	111.6839	0.0150
4	0.8862	-4.7069e+05	-3.5640	24314360	-4.3264	-380.3777
5	4.3317e+05	-0.1005	591.8496	-2.6286	24321060	-0.9040
6	0.5045	-13.9747	0.5082	-199.3879	1.1287	478.8055

- It seems $A_\infty(\omega_r = ?)$ came from Body(1,1).hydro.data.fAddedMass at period between 11 and 12 seconds. Correct?

If so, the table still doesn't match.

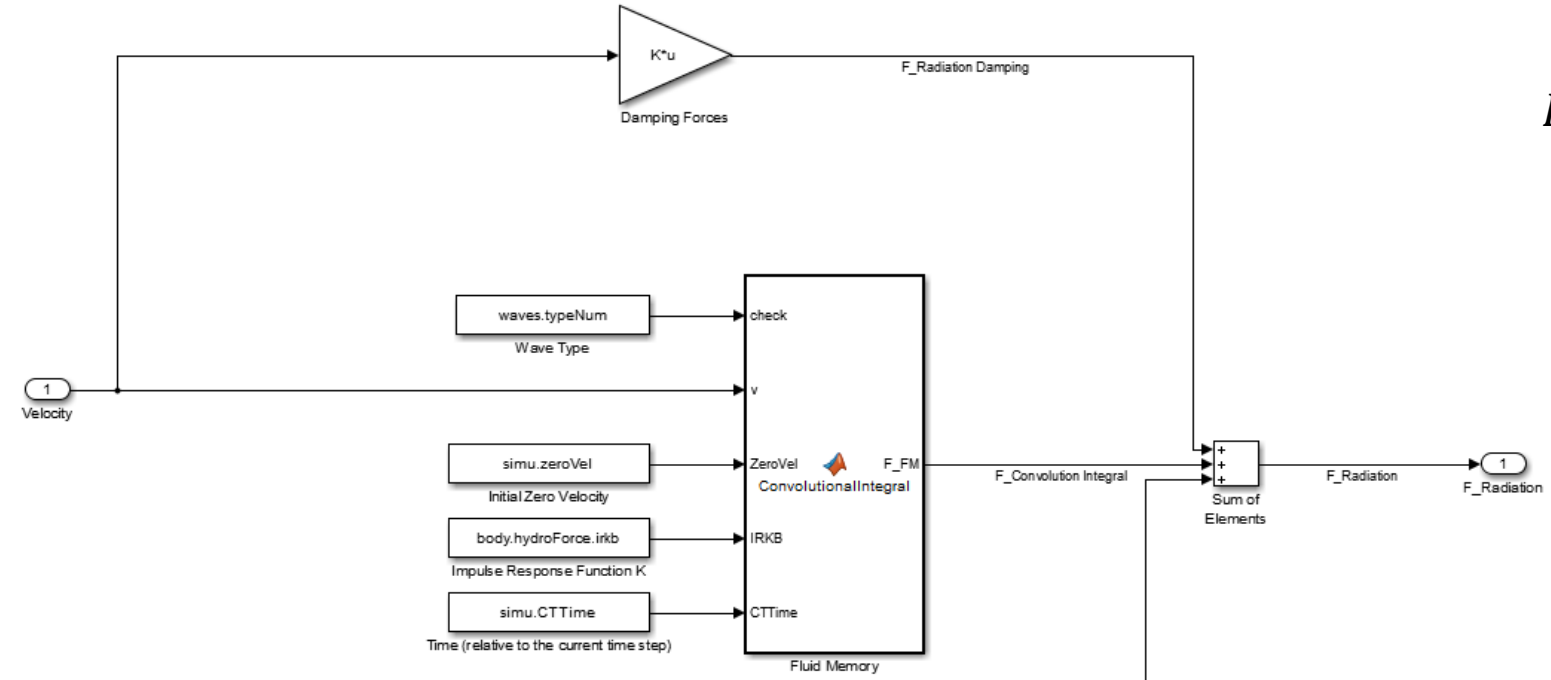
Body(1,1).hydro.data.fAddedMass(:,:,11)

	1	2	3	4	5	6
1	1314441	2.2990	-872.6020	3.7009	5.1956e+05	1.1410
2	1.4954	1318854	-4.7641	-5.7947e+05	-1.7594	131.7646
3	-1.8991e+03	-0.4360	1736950	-0.5368	186.9174	0.0451
4	0.9452	-6.6213e+05	-3.0601	25865580	2.0046	-394.2339
5	6.2316e+05	-1.7528	632.3061	-1.9444	25871040	-0.5361
6	-0.4639	-7.4140	-0.2155	-218.9182	-0.7918	479.4542

Body(1,1).hydro.data.fAddedMass(:,:,12)

	1	2	3	4	5	6
1	1304177	1.6188	-852.1775	2.5184	4.8260e+05	0.8937
2	1.6111	1307422	-0.0255	-5.4221e+05	0.5897	124.8041
3	-1.8053e+03	0.1651	1784104	-0.2909	166.5770	-0.0617
4	-0.9076	-6.2507e+05	-0.1078	25578960	-1.6629	-393.6356
5	5.8636e+05	-0.0596	575.9863	-2.6888	25584730	-0.0533
6	-0.0543	-8.5204	-0.5956	-215.1004	-0.0429	479.3520

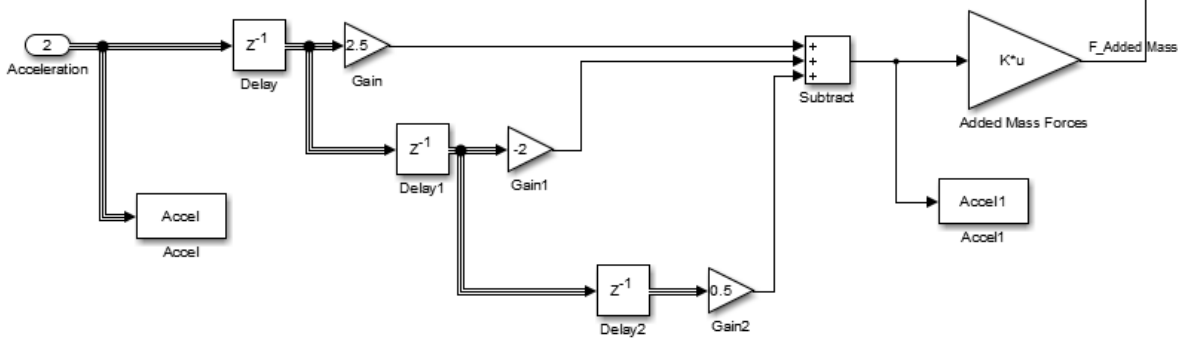
Added Mass and Damping (Irregular Wave)



$$F_{rad} = -A_\infty \ddot{X} - \int_0^t K(t-\tau)\dot{X}(\tau)d\tau$$

It seems $A_0(\omega_r)$ is used instead of $A_\infty(\omega_r)$. Why?

Body(1,1).hydroForce.fAddedMass



$$A(\omega_r) \rightarrow A_0(\omega_r)$$

	1	2	3	4	5	6
1	4.6455e+05	0.9692	1.4212e+03	1.1077	9.8858e+04	0.8341
2	0.6318	431969	0.3426	-1.3039e+05	-0.7378	-129.8300
3	1.5304e+03	-0.0195	1217046	5.4848	-471.8530	-0.1841
4	0.3498	-175782	4.2358	20469330	2.5568	-248.2081
5	1.7380e+05	-0.7355	-101.4807	-0.2945	20477370	-1.6005
6	0.0510	-60.7217	-0.1648	-151.1746	1.0135	426.6893