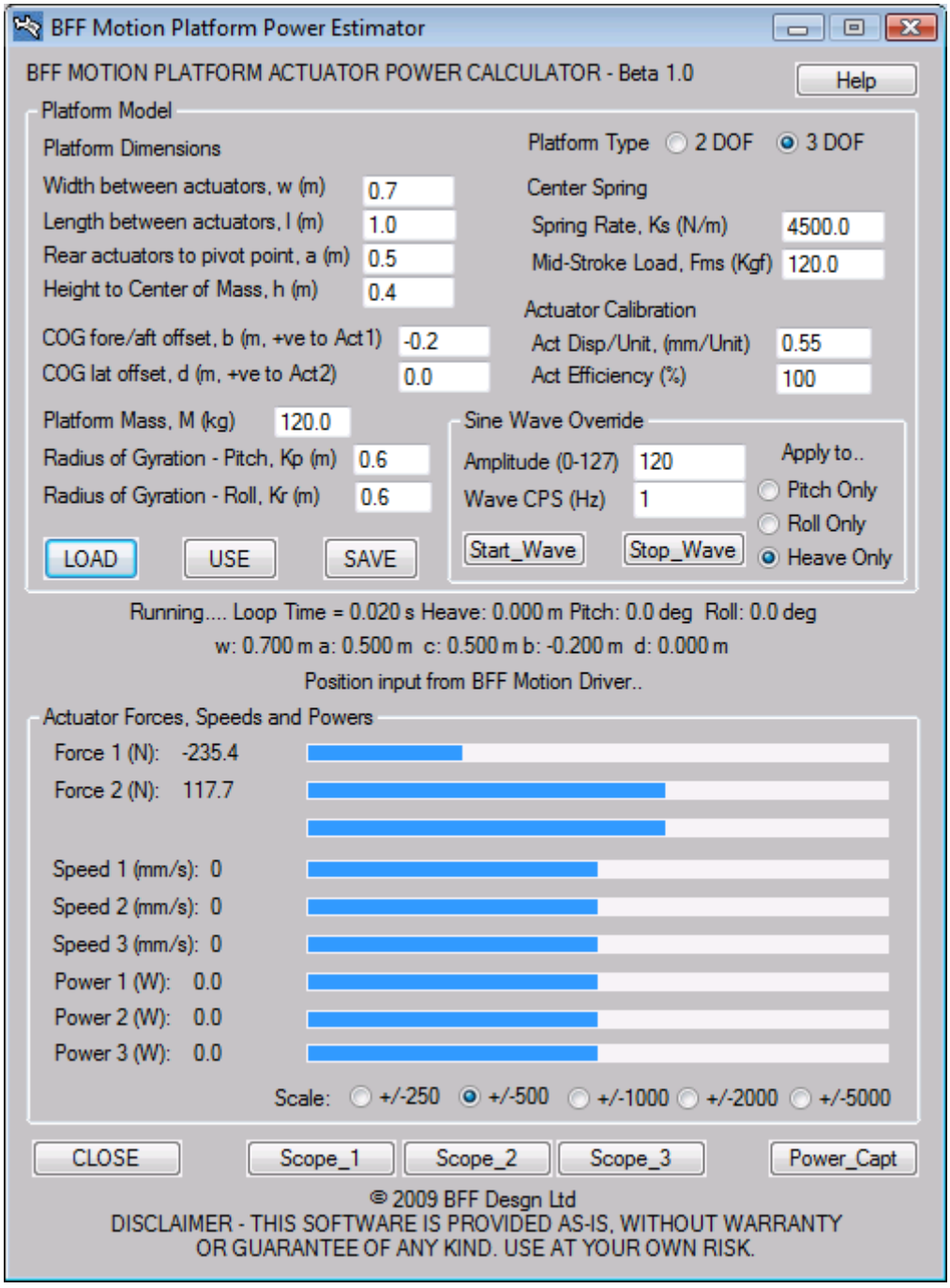
BFF Motion Platform Actuator Power Calculator

(For 2 & 3 point support type platforms)



WARNING – This software is beta, and in addition the numerical modeling methods used mean the power rating results are approximate and must be treated as design estimates.

Ian Hopper (BFF Design Ltd), Rev Beta 1.0 6/09

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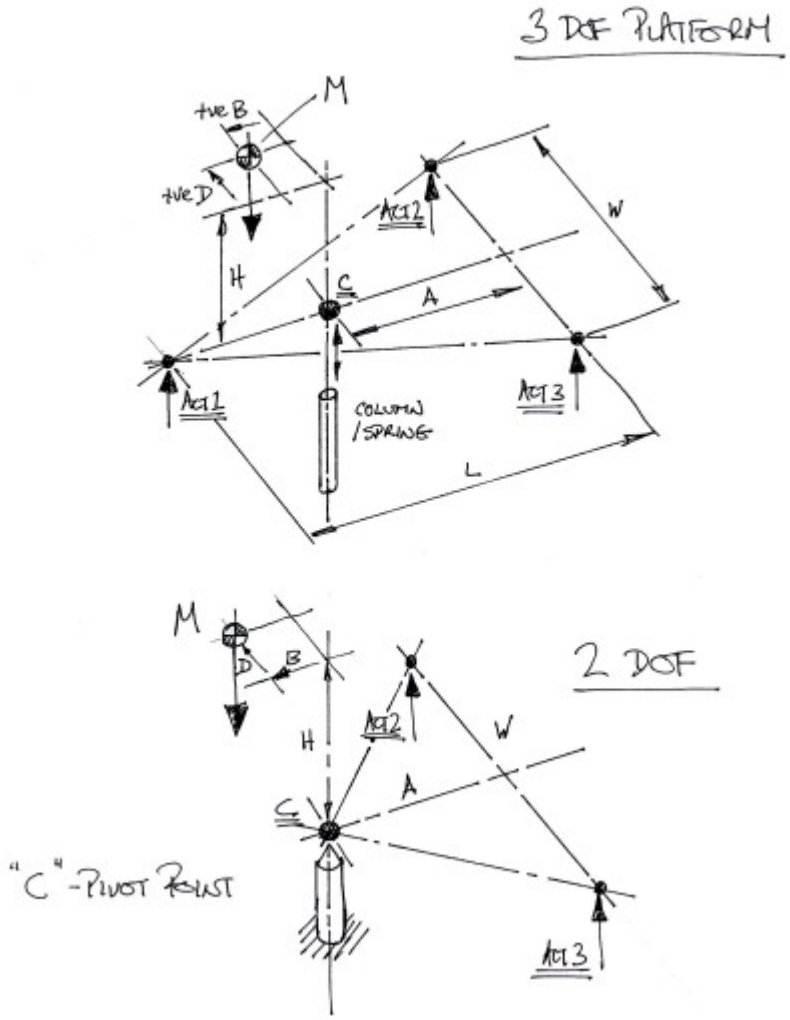
1. What the calculator does

The BFF Motion Platform Power Calculator provides ESTIMATES for the ratings of drive actuators on 2 or 3 point support type motion platforms. It does this by running a real-time simulation of a simplified platform model which is fed live actuator movements from either the BFF Motion Driver or from a sine wave position demand. The actuator position inputs are used to “drive” the platform model displacements, velocities and accelerations from which the actuator forces and powers are determined. The actuator powers change in real-time as the position demands change - a power rating “capture” facility is provided to capture ratings based on the maximum force and speed events that have occurred during the period of platform movement.



The resulting actuator forces and powers should be regarded as design estimates because the mathematical model of the platform is simplified and much of the input data you supply is likely to be estimated. The software may prove a more useful design tool than crude long-hand calculations and may also give some insight into how the duty of the actuators and drive system alters as the loading and motion of the platform changes. In my view this is invaluable information as it allows the builder to develop some sense of realism regarding what is being asked of the platform and what the actuators need to be capable of delivering.

2. Basis of the model

The 3 DOF motion platform is modeled as a simple body with linear and rotational inertia, a central sprung support column and 3 vertical actuator forces. In the case of the 2-DOF model there are two actuators only and no central spring. No damping or friction effects are considered and actuator inertia is assumed negligible. The vertical component of actuator force is the principal component doing work on the platform and is the main contributer to energy consumption.

The positions of the actuators, central column pivot point, and center of mass can be adjusted to suit your design layout although the basic layout must comply with the arrangements shown (figure). The mass, moments of inertia and central spring characteristics can also be adjusted.

The incremental input displacements of the actuators are applied to the model and the vertical displacement, velocity and accelerations are calculated for the platform along with the pitch and roll rotational displacements, velocities and accelerations about the column pivot point. The equations of motion are then solved to yield the actuator forces that are needed to induce the demanded motion against the platform weight, inertias and the column spring load. The actuator forces are then combined with actuator speeds to yield instantaneous power outputs. The calculations are repeated at the refresh speed of the BFF Motion Driver output to show the dynamically changing actuator loads and powers. Maximum speed and forces are captured to yield required actuator ratings.

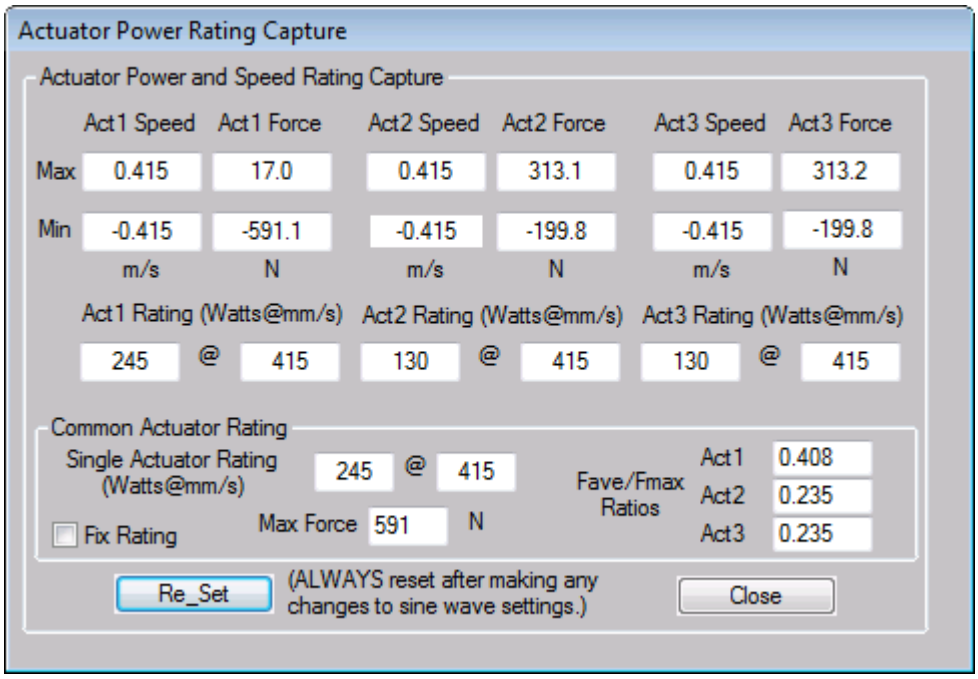
The stepwise nature of the actuator position demand input and the numerical solution methods do mean that the platform inertia effects are less well analyses at higher frequency movements. So effects such as runway vibrations may not be dealt with accurately.

It is assumed that the platform movement follows the demanded positions exactly – no consideration is given to actual actuator power limitations or to the servo control system “tuning”. Consequently the calculator output is an indication of ideal required power – it is not an indicator of the motion resulting from actual available actuator power.

3. How to use it

The basic method of use is to run the software, set the platform model parameters and then make a flight with the motion platform driver running (in output Mode=MEM configuration). The output of the motion driver will then feed to the platform model and you will see the actuator forces, speeds and powers change as the aircraft manoeuvres and the motion platform position demands change. The calculator is provided with a Power and Speed Ratings Capture feature to capture ratings during the motion period.

As an alternative to the position demand feed from the BFF Motion Driver software a sine wave position demand can be used. This provides an idealised but more uniform and repeatable design condition and can be set to provide a consistent and demanding motion against which the actuators can be rated. A general design approach could then be to determine actuator ratings against a demanding sine wave motion and then check that rating against live flying conditions from the motion driver feed.



When the Ratings Capture window is opened the required actuator force and speed capacities are captured and displayed for the period of the flight since the window was opened or since the Re-Set button was clicked. An actuator selected for a platform design must be capable of delivering both the maximum force and maximum speed arising during the period of platform motion. These two conditions may or may not occur at the same time. Indeed they may not occur at the same actuator, however on the assumption that a common actuator is specified for all positions on the platform the problem is to capture the most demanding force and speed events wherever and whenever they occur. This is what the capture facility does. It presents the result as a single, common, actuator rating - power output at a maximum speed.

Theoretically actuators with the stated power and speed rating will be able to deliver the maximum force and maximum speed requirements that have occurred at any position and whether or not they occur at the same time. This also should mean that there will be a bit of spare capacity available most of the time the platform is operating: as a measure of the "average" duty of each actuator, the ratio of Average Force to Max (Rating) Force is shown for each actuator.

Steps in Summary

1. Start a FS9/FSX flight and start the BFF Motion Driver software. You will need to ensure the data output mode of the driver is set to "MEM" and that the .bff configuration file is set to produce fairly energetic motions. Make sure also that the actuator mid stroke position is set to 127 and that most of the available output range is used – ie set the actuator stroke lengths to 255.
2. Start the BFF Actuator Power Estimator. Adjust the platform model parameters as required – eg mass, positions, spring rate, actuator movement calibration etc.
3. Adjust the Sine Wave parameters – a generous amplitude and reasonably rapid speed of oscillation will make for a demanding motion against which to rate the actuators. Note also that the position of the center of mass with respect to the pivot point (ie how large the offsets are) and the magnitude of the central spring

balancing force will strongly affect the actuator loads. Select the DOF to apply the sine wave motion to and start the sine wave input.

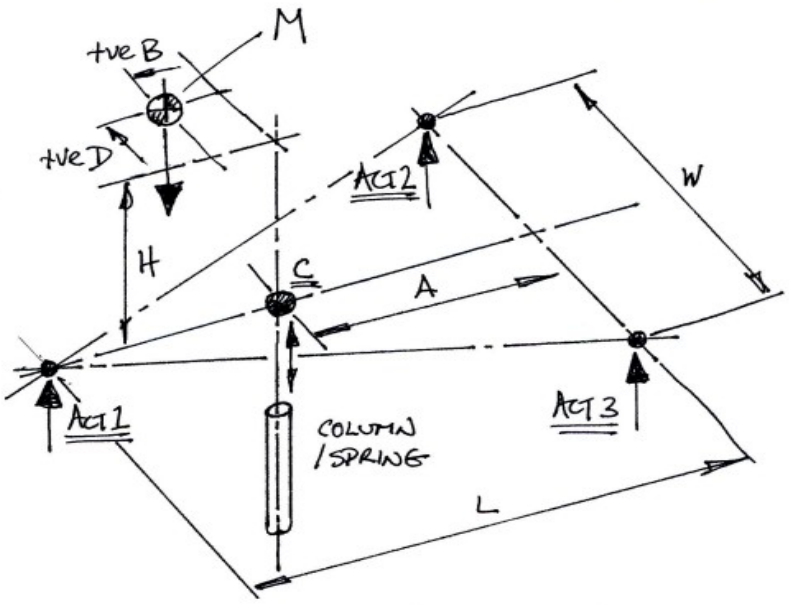
4. You will see the actuator forces, speeds and instantaneous powers oscillate and the output for the individual actuators can be shown on the virtual oscilloscope using the Scope buttons. Note that speeds and forces are +ve vertically upwards. A -ve power indicates that the actuator is being driven by the platform and is sinking power (take a mental note – if this happens in your system where does the generated electrical current go?).
5. Open the “Power Capture” window. You will see the maximum and minimum forces and speeds being updated for each actuator as the sine wave oscillations complete. You can see the speed and force ranges that have occurred at each actuator. The maximum speed and maximum force for each actuator is used to calculate a rating for that actuator which is presented as a power at a rated speed. However on the assumption that a single common actuator rating is required the maximum force and the maximum speed events that have occurred over all three actuators are captured and a single common actuator rating is displayed. An actuator with that OUTPUT rating should be capable of fulfilling both the maximum force and the maximum speed events that have occurred during the period on motion since the last re-set.
6. The Fave/Fmax ratios for each actuator will give an indication of how large the average force for an individual actuator is in comparison to the max force used for the currently displayed common rating. This gives a feel for how hard each actuator is being worked in relation to its rating. Note that actuator force, motor torque and motor current are all closely related.
7. Take a note of the rating. Go back to the platform parameters and adjust as required to experiment with different configs, loadings or states of imbalance. The later is of particular interest – consider what the most unbalanced loading condition might be for which you would still expect reasonable motion performance – this is likely to be the condition against which the actuator ratings are decided. A perfectly balanced platform will consume little power and probably should not be used as the basis of power rating calculations.
8. Note that the captured common actuator rating can be “fixed” using the check box in the capture window. By doing this and then switching from the sine wave input to the “live” BFF Motion Driver input you will be able to assess the workload on your actuators during a live simulated flight. CLICK THE RE-SET BUTTON WHENEVER YOU MAKE SUCH A SWITCH. The individual actuator ratings will all be updated as usual however the common rating will be held and the Fave/Fmax ratios will be updated with the previously determined common rating as their reference. The flight conditions that are most likely to generate the highest power requirements are nose up/down “porpoising” flights, flights in heavy turbulence conditions and “off-road” excursions on the ground! Try some.... you may also find others of your own.
9. Finally, and most importantly take a note of the power ratings you have produced and think about them very, very carefully – are they sensible, how do they compare to what was expected, can you benchmark them against known existing designs, are your input parameters correct, have you used the correct units for everything, what are the electrical current implications for the control system, what are the structural implications for the mechanical structure given the force levels, what can be realistically expected of the platform performance if you go with under-rated actuators, what are the implications for your pocket?

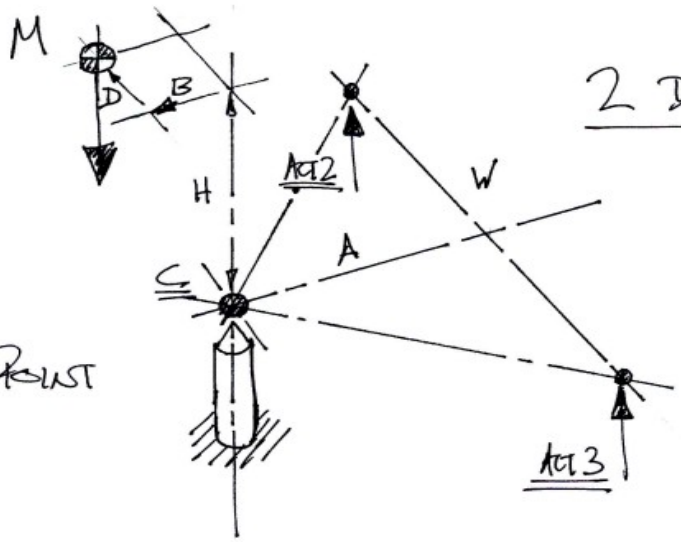
Note that the calculator can also be used with “static” position inputs derived from the actuator position “Manual Override” facility on the BFF Motion Driver. Manually adjusting the driver position outputs will feed those through to the calculator and the static loads on the actuators can be read from the displayed values to the right of the actuator force progress bars. This is useful for making static load balance checks on the platform.

4. Input Parameters

The software is provided with pop-up tool-tips which will give help information for each parameter – hover your mouse over the input field for a moment. Refer to the sketch for dimensions.

3 DOF PLATFORM





2 DOF

"C" - PIVOT POINT