Q1. The manual states on p 18 that forcing resistors can be used to increase the step rate. It then goes on to calculate resistor values and wattage based on a 12 V power supply. No other mention is made of step rate. How do forcing resistors affect step rate.

The Step Rate of a motor is in part limited by the characteristics of the coils within the motor. The coil can take up energy at a rate that is determined by its electrical time constant (tc).

tc = L/R where L is coil inductance and R is coil resistance.

After 2 time constants (2 X tc) the motor will be producing about 86% of its torque.

One way to improve the situation is to **force more current in to the coil**, by increasing the driver voltage.

See Also EasyStep 'Serial Communications Protocol' Document Excerpt *page 8 shown below*

As a approximate guide to working out your maximum step rate (motor speed) then use the following example calculation;

A motor has the following characteristics: 1.8º /step (or 200 step per revolution), 3.3 Ohm phase resistance and a phase inductance of 3.4uH. Calculate the maximum step rate, assuming we have a need for 85% motor torque, Given: 2 Time constants = 85% torque?

Ans.
Two Time constant in ms = 2 * (3.4/3.3) = 2.06ms per step

Max step rate = 1S / 2.06ms = 485 steps per second

Of course individual motors may differ and “Forcing Resistors” can be used to increase the step rate, by increasing the effective voltage across the phase coils, forcing the coils to pass current more rapidly than they normally would.

Q2. Is there some advantage to using a 12 V power supply, as opposed to directly using 4 or 5 V? From the example, it appears that the forcing resistors are used to simply drop voltage so that the correct voltage appears across the motor.

Excerpt from ES3000 User Guide P.18

f. Practical Value 6.8 Ohms (6R8). Actually a motor can be driven to 140% of its rated current so you could go as low as 4 Ohms. Active robots supply a 5R4 resistor for this motor.

We recommend a 5R4 resistor that has the following effect:

8V/5R4 = 1.48 Amps (approximately 1.5A)

Which is 200mA more current. A 4R resistor would give 800mA more!

Using A higher voltage with series resistors is a time proven reliable method to safely increase the step rate of a motor.

The same result with a small increase in supply voltage does the same thing. To get our 1.5A we would need a supply voltage of 1.5A * 3.3R = 4.95V
Now if our voltage were to drift by say only 0.5V to 5.45V then our current would rise to 1.65A, so you need to have well regulated supply voltage.

Using a higher supply voltage with forcing resistors means the voltage is far less critical. 12V was chosen because there are a lot of 12V power supplies out there.

There are many different voltage ratings for stepper motors (3V 6V etc.) and a hobbyist may want to use all these from one voltage source and all one need do is select the correct forcing resistors to match your particular motor.

Q3. Does each coil (motor) require 1.2 A? Full step 1 phase operation would then require a 1.2 A power supply, and full step 2 phase operation would require a 2.4 amp power supply (because 2 motors are powered at any one time).

Yes
See User guide 4.3, the least power is drawn in *full step 1 phase* (wave mode) but has about 30% less torque than *full step 2 phase*.

Always check using an Ohms meter and measure between the motor+ and one of the phase coils and this should match the resistance given in the data sheet. If you are unsure then check with the manufacturer as a stepper motor can get dangerously hot if its run at too high a current.

Q4. Do you have spec sheets available (torque speed curve, step speed rate, etc) available for the Sanyo Denki 103H546 motor? I did find a 1 page summary sheet on the Active Robots web site, but no performance curves were included. I checked the Sanyo Denki web site but could not find the motor listed.

It is possible to construct an approximate performance curve as follows:

1. find the resistance, inductance per phase for the unipolar motor and the holding torque

2. Basic facts; One time constant is = to 63% of torque, two time constants = 85% of torque

For a Sanyo Denki 103H 5210-0440 we have the following information in the data sheet:

1.8' resolution
Holding Torque of 0.37Nm
Resistance = 3R3
Inductance of mH/Phase = 3.4mH

Time constant is;
tc= 3.4mH/3R3 is approximately 1ms

So for 63% torque we have a 1ms (0.001S) time constant.
Step rate for 63% torque is 1/0.001 = 1000Hz
in terms of motor rotation in revs per second; 1.8' * 1000Hz = 1800 degrees
1800 degrees divided by 360' = <u>5 revs/Second for 63% torque</u>
actual torque at this speed = 0.37Nm * 0.63 = 0.23Nm

For 85% torque we calculate using two time constants
2 X 1ms = 2ms
Step rate 85% torque is 1/0.002 = 500Hz
in terms of motor rotation in revs per second; 1.8' * 500Hz = 900 degrees
900degrees/360' = <u>2.5 revs/Second for 85% torque</u>
actual torque at this speed = 0.37Nm * 0.85 = 0.31Nm

For 100% torque its 5 or more constants
5X1ms = 5ms
Step rate 100% torque is 1/0.005 = 200Hz
in terms of motor rotation in revs per second; 1.8' * 200Hz = 360 degrees
360degrees/360' = 1<u> revs/Second (OR LESS) for 100% torque</u>
actual torque at this speed = 0.37Nm

Now you can use the above to sketch a curve or put it in to a spreadsheet program and generate a graph. The above assumptions are for typical stepper motors (also **see user guide 1.3.4** Step Rates).

To find dead spots and resonance's you need to experiment with the motor. Motor manufacturers don't seem to offer this sort of information willingly.