LEADSCREW PITCH TUTORIAL

CHOOSING THE RIGHT LEADSCREW

Choosing the proper size and pitch for the leadscrews on your machine is one of the most important decisions you will make with a home build. Since the job of the leadscrew is to translate the rotational force of the stepper motor to linear force to move your router it is important to select a leadscrew that will make the most use of this power.

Leadscrews have many factors. The first is the diameter, which I will not go into too much. Common sizes are 1/4", 3/8", and 1/2". 1/4" is most commonly used in small bench top machines. 3/8" is common for small to mid range machines, and 1/2" for mid to larger machines.

Advantages of a smaller diameter leadscrew is less power to accelerate and de-accelerate the screw. Also a smaller footprint lends itself well when space is an issue.

Larger screws have many mechanical advantages. Aside from the screw itself being stronger, power transfer is improved due to more surface area contact with the leadnut.

Next, you need to decide on the threads per inch and number of starts.

Threads per inch is just like it sounds: Threads per inch. Typical threads per inch for most CNC applications is 6, 8, 10, 12, and 16. The number of starts refers to the number of individual threads that spiral the rod. The number of starts will always be a multiple of the threads per inch.

Turns per inch is a factor of threads per inch divided by the number of starts. For exaple, a 1/2-10 2 start rod will take 5 turns to move the leadnut 1 inch. A 1/2-8 4 start will take 2 turns to move the leadnut one inch.

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TPI = Threads Per Inch / Starts
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MOTOR SPECS

The manufacturer of your stepper motor should provide a chart detailing the holding power of your motor while operating at different speeds. This is commonly given as pulses per second. (PPS) Depending on microstepping, you will need to find the number of pulses required to rotate your motor one full revolution. Most stepper motors rotate 1.8 degrees per step. Do the math and you will find that this equates to 200 steps per revolution.

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STEPS = 360 / DEGREE PER STEP

200 = 360 / 1.8
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200 steps per revolution, or 1.8 degree steps is very standard. It would be uncommon to run into anything else, but if you do it is important to understand the concept so you can make adjustment to the equations we are about to cover.

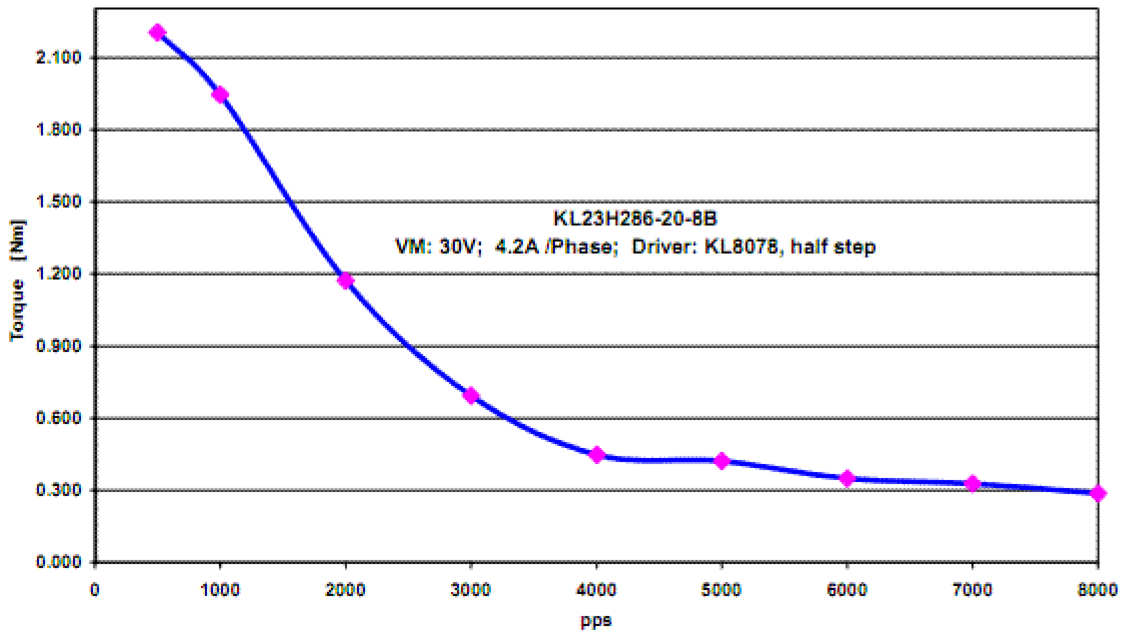
Microsteps are a method for smoothing out motor performance by dividing the typical 1.8 degree steps into "steps between a full step." Check with your stepper motors documentation to see if the PPS specs they provide includes microstepping.

With microstepping enabled, the inverse of the microstepping factor multiplied by the number of natural steps of the motor will give you the total number of pulses required per motor revolution.

For example 1/4 microstepping requires 800 pulses per motor rotation. 1/8 microstepping requires 1600 pulses per revolution.

Now that we know how many pulses are required for a single revolution, we can translate this into revolutions per minute. The goal here is to use the data from our stepper motors to translate the holding power at certain pulse speeds into holding power at certain RPM's, and then again into linear motion equivalents.

We will use the chart below as an example when calculating our options for our leadscrew selection. This chart is the torque sheet for Kelings 425oz bi-polar stepper.



First me must calculate pulses per revolution to give us the RPM. This chart is given with half stepping, so first we must take our 1.8 degree steps and multiply them by the inverse of 1/2, which is 2.

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360 / STEP DEGREE * INVERSE OF MICROSTEPS
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360 / 1.8 * 2 = 400
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This gives us 400 pulses per rotation. Now it is time to use the data from our chart. we must divide the Pulse Per Second by the number of pulses required for a revolution (in our case 400) and then multiply by 60 to convert to minutes.

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RPM = PPS / PULSES PER REVOLUTION * 60
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Here is the data from our chart:

PPS	N*m
1	3
500	2.25
1000	1.95
2000	1.15
3000	0.7
4000	0.45
5000	0.4
6000	0.35
7000	0.32
8000	0.29

On the left we have our PPS at various speeds, and to the right the correlating holding power at those speeds. We will use our equation to find the holding power at 2000 PPS.

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RPM = 2000 / 400 * 60 = 300
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So 2000 PPS translates to 300 RPM. We can combine our equations up to this point for simplicity.

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RPM = (Pulse per second) / (1.8 deg step or apporpriate)  / (micro stepping factor) * (Convert to minutes)
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We can not update our chart with this new information. Notice we do not use the holding power in our equations at the moment. For now we are only interested in how PPS translates to movement.

PPS	N*m	RPM
1	3	0.1500
500	2.25	75
1000	1.95	150
2000	1.15	300
3000	0.7	450
4000	0.45	600
5000	0.4	750
6000	0.35	900
7000	0.32	1050
8000	0.29	1200

Now that we can see how fast our motors are turning lets see how fast it will result in linear travel. The equation to convert to Inches Per Minute (IPM) is very simple:

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IPM = RPM / TPI
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Using the same example as before, we will see how fast our leadnut is traveling at 300 RPM when using a 1/2-10 dual start screw as an example.

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IPM = 300 / 5 = 60
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So when using dual start 10 threads per inch rod (Which is 5 TURNS per inch) we get a movement speed of 60 inches per minute.

I will fill out the rest of the chart with some popular leadscrew pitch and sizes:

PPS	N*m	RPM	10TPI	5TPI	4TPI	2TPI	1TPI
1	3	0.1500	0.02	0.03	0.04	0.08	0.15
500	2.25	75	7.5	15	18.75	37.5	75
1000	1.95	150	15	30	37.5	75	150
2000	1.15	300	30	60	75	150	300
3000	0.7	450	45	90	112.5	225	450
4000	0.45	600	60	120	150	300	600
5000	0.4	750	75	150	187.5	375	750
6000	0.35	900	90	180	225	450	900
7000	0.32	1050	105	210	262.5	525	1050
8000	0.29	1200	120	240	300	600	1200

You will notice that I highlighted the column at 3000PPS. This is where the usable power of the stepper diminishes on our charts. You will notice that at .7 N*m the power tapers off rather quickly after this point.

Steppers typically have the most torque up to 500RPM. Speeds greater then this are usually possible, but at risk of stalling the motor.

Looking at our chart, the speed of travel with our various pitched leadscrews becomes clear.

This method is very helpful in finding out how fast you can travel given the torque charts of your motor and the pitch of various screw sizes.

I hope you find it helpful.