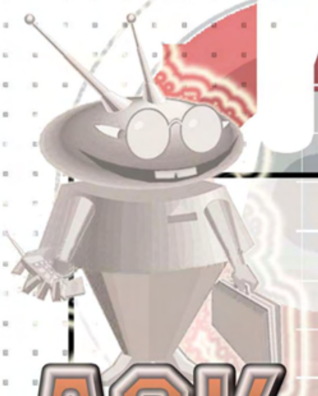


Our resident expert on all things robotic is merely an Email away.
roboto@servomagazine.com

Tap into the sum of *all human knowledge* and get your questions answered here! From software algorithms to material selection, Mr. Roboto strives to meet you where you are — and what more would you expect from a complex service droid?

ASK MR. ROBOTO

by
Pete Miles

Q. First off, I love your "Ask Mr. Roboto" section of *SERVO*. It's usually the first thing I turn to when I get my new *SERVO Magazine* each month.

I see that you've used some Maxon motors for demonstrating the wheel mounting hubs in the February column. When I saw those, I got very excited because I've been trying to find a place that sells Maxon motors for a line follower I'm building for a competition. I've tried contacting Maxon twice asking where I could buy some, but haven't gotten a response.

Anyway, do you remember where you got that Maxon motor you show in the pictures? Thanks a lot!

— Jared Bayne

A. First off, for those people that don't know about Maxon motors (**www.maxonmotorusa.com**), they are some of the highest quality DC motors and gear heads that money can buy. Their motors are extremely efficient, quiet, and powerful. They can be customized to meet *any* application that you have. Because of this, they are also some of the most sought after motors for hobbyist robots. Unfortunately, they tend to be more expensive than the budget motors that most hobbyists use in their robots. There are not very many available at surplus motor suppliers, which is one of the reasons that surplus Maxon motors are still rather expensive when compared to other surplus motors.

One of the myths that surround Maxon motors is that they don't like to sell motors in single or small quantities. This is just not true. They will sell their motors to anyone in any quantity that they want, though there are some procedures that need to be followed to order a motor. Because they have literally thousands of motor combinations, you need to know exactly which motor you want to buy before contacting Maxon.

The best place to start is to get a copy of their catalog or download their data sheets from their website. From the data sheets, select the motor, gear head, and other options that you want on the motor to determine the exact part number to order. Then call Maxon on the telephone and ask for the sales department to order the motor. If you make inquires via the Internet, you may not get any reply.

Figure 1. 6 mm shaft Lynxmotion planetary gear head motor and a 4 mm shaft Maxon planetary gear head motor.

If you don't know which motor to order, call Maxon and ask for the technical support, and the people there will help you select the right motor and tell you the part number for the motor and then will send you to the sales department.

Since they have so many different motor combinations, many of them are made to order, so it will take several weeks to get. But they do have some stock motors that can be obtained much quicker. These motors are identified as "Stock Program" motors. The "Standard Program" and "Special Program" take a lot longer to obtain. So, if you need the motors right away, select the motors from the "Stock Program" columns in the data sheets.

Now, with all that said, the motor that I showed in the February '06 issue of *SERVO* was obtained from Servo Systems Company (**www.servosystems.com**) a couple years ago. Servo Systems is a high-end (i.e., industrial) robotics parts supplier and systems integrator. Not only do they sell robot parts, but they sell complete industrial robotic systems, as well.

Surplus motors are not their main business, but they have one of the greatest selections of high quality surplus motors I have seen anywhere. Their website shows only a portion of what they have to offer. Their paper catalog shows all of the motors they have. To see the surplus motors they have, you will have to dig around a bit. First, go to the "bargains and close outs" link, then go to the "Servo Motors and Amplifiers" link for DC motors or the "Stepper Motors and Drives" link for stepper motors.

The particular motor I showed in the article was a Maxon model 2322.946 precision geared DC motor with dual shaft (one shaft for an encoder). This is a 9V motor with a 120:1 planetary gearbox. At 9V, the no-load speed is 72 RPM and draws 180 mA. When I purchased this motor a couple years ago, it cost $59 and according, to their web page, it is still the same price.

If you are not dead-set on Maxon gear motors, you might try looking at the planetary gear motors from Lynxmotion (**www.lynxmotion.com**). They sell a similarly sized planetary gear motor with a 4 mm shaft for $15.25. I have some of their 6 mm diameter shaft planetary gear motors, which are extremely quiet and quite powerful. Figure 1 shows a relative size comparison of the two motors that I have.

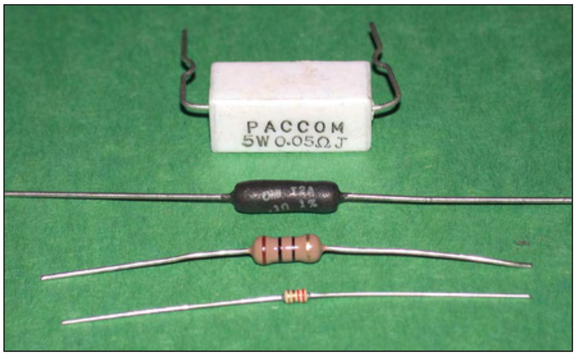


Figure 2. Various power rating current sensing resistors: 5W, 1W, 1/4W, and 1/8W.

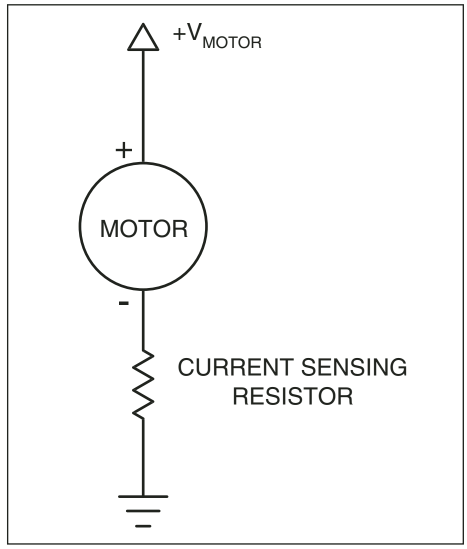


Figure 3. Simplified motor current sensing resistor setup.

Q. What is a good rule of thumb for choosing the right resistor to measure the current draw from a motor so that I can make sure that I don't burn out my motor controller?

— George Stein

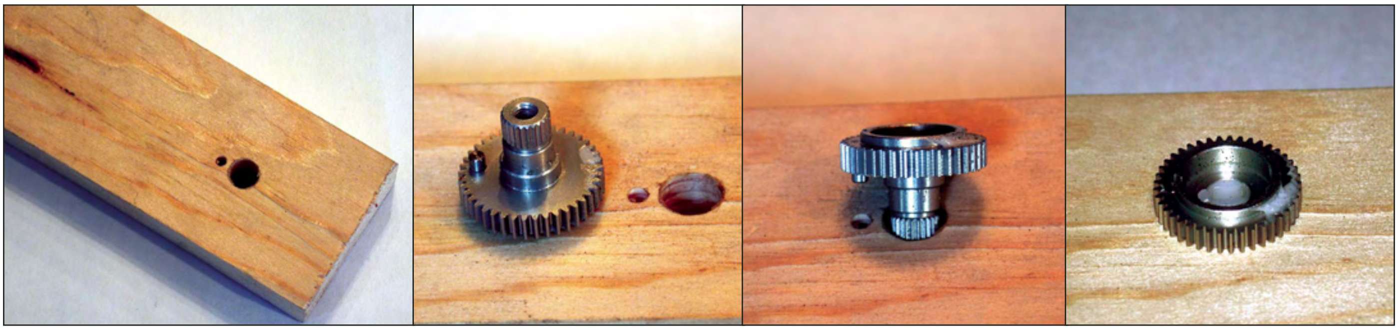
A. There are three guidelines to consider when selecting the size of the current sensing resistor: the voltage drop that will occur across this resistor must be small enough not to have any adverse effects on the system's performance; the power rating of the resistor must be greater than the anticipated amount of power going through the resistor; and the instrument that is measuring the voltage drop must have the resolution to be able to measure changes in the voltage.

The best way to illustrate these three points is shown in Table 1. Figure 3 shows a simple schematic of how a motor and a current sensing resistor can be wired up. This example illustrates how the selection of the current sensing resistor affects the motor in a common R/C servo and how well the voltage drop can be monitored. The motor inside a standard R/C servo is the 4.8 volt Mabuchi RF-020TH motor. This example is based on a six-volt operating condition. The internal resistance of this motor is 7.63 ohms.

According to the first guideline, the voltage drop across the current sensing resistor shouldn't have any adverse affects on the motor performance. From Table 1, we can see that the motor performance does change as the sense resistor's resistance increases. Under the no-load condition, there is very little change, but as the load on the motor increases (stalling being the worst case), there is a significant effect on the motor performance with higher current sensing resistance.

	Current Sensing Resistor, ohms			
	10	1	0.1	0.05
Total Resistance at Stall, ohms	17.63	8.63	7.73	7.68
Stall Current, amps	0.340	0.695	0.776	0.781
Current Sensing Voltage, Volts	3.403	0.695	0.078	0.039
Power Dissipation, Watts	1.158	0.483	0.060	0.031
Minimum Power Resistor Size	2W	1/2W	1/8W	1/8W
Motor Performance @ No-Load	90.3%	99.0%	99.9%	100.0%
Motor Performance @ Stall	43.3%	88.4%	98.7%	99.3%
Minimum ADC Resolution for a 1% Measuring Resolution of the Stall Current				
8 bit	yes	no	no	no
10 bit	yes	yes	no	no
12 bit	yes	yes	no	no
14 bit	yes	yes	yes	yes

Table 1. Illustration of how the current sensing resistor affects the overall motor system.



Figures 4-7. Wood support with the holes and the gear being placed in the holes.

Thus, as the current sensing resistance increases, the maximum available torque (power) from the motor decreases.

In the second guideline, *the power rating of the resistor must be greater than the worst case power dissipation the resistor will go through*. Otherwise, the resistor will get very hot, its resistance will increase as it heats, and thus, cause it to get even hotter resulting in false measurements and eventual failure of the resistor. The higher the power rating of the resistor, the larger the physical geometry of the resistor becomes.

The third guideline previously mentioned is often not properly considered when selecting current sensing resistors. Often, people think about the worst case situation and feel that the resolution of their analog-to-digital converters (ADC) is sufficient to measure the voltage drop across the resistor. But this is not the typical operating condition of the motor. Under a no-load condition, the motor's current draw is typically around 5% of the stall current. Thus, the resolution of the ADC must be less than 5% of the voltage drop across the current sensing resistor at the stall condition. As a minimum, the resolution should be about 1% of the worst case stall current.

Table 1 shows four different (8, 10, 12, and 14 bit) resolution ADCs that are commonly used to monitor voltage differentials. Using five volts as a reference voltage for the ADC, this table shows which ADCs are capable of obtaining a 1% resolution of the full scale voltage range of the motor from no-load to stall conditions. Note the 14 bit ADC was the only one that was capable of measuring all four current sensing resistor test cases, but 14 bit ADCs are more expensive than the 12, 10, and 8 bit ADCs. Sometimes, the currently-available ADC resolution ends up driving the actual selection of the current sensing resistor, and motor performance is allowed to be reduced because of it.

Creating a table like the one shown helps you select the best current sensing resistor for your application. The values will be different based on which motor you are actually using. All you need to know about the motor for the table is the no-load current, stall current, and the internal resistance of the motor (though the internal resistance can be calculated based on the stall current and the voltage drop across the motors at stall). The rest of the calculations are made based on Ohm's Law.

Q. I am trying to turn a couple of Hitec HS-645MG servos into a pair of high torque drive motors for my robot. I tried using a screwdriver and a hammer to knock out the steel pin so it can rotate 360 degrees, but ended up wrecking some of the teeth so the gear doesn't completely turn around and occasionally the motor stalls. Is there an easy way to remove the pin out of the last gear on a Hitec 645 servo without damaging the gear teeth?

— Jim Kemp

A. The key to making sure that the gear teeth do not become damaged during the pin removal process is to make sure that

Figure 8. You will need to use a 1/16th-inch diameter pin punch.

Figure 9. How to place the pin punch on the center of the pin.

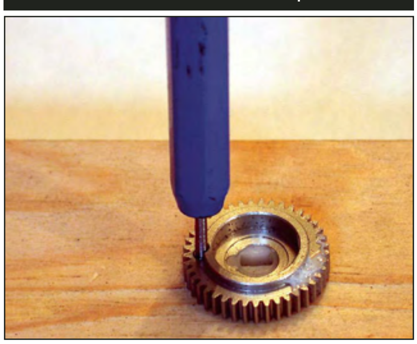
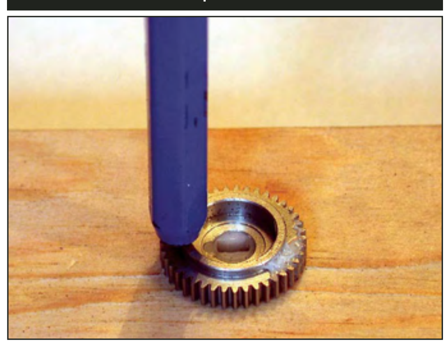


Figure 10. The punch should fall into the hole where the pin was knocked out



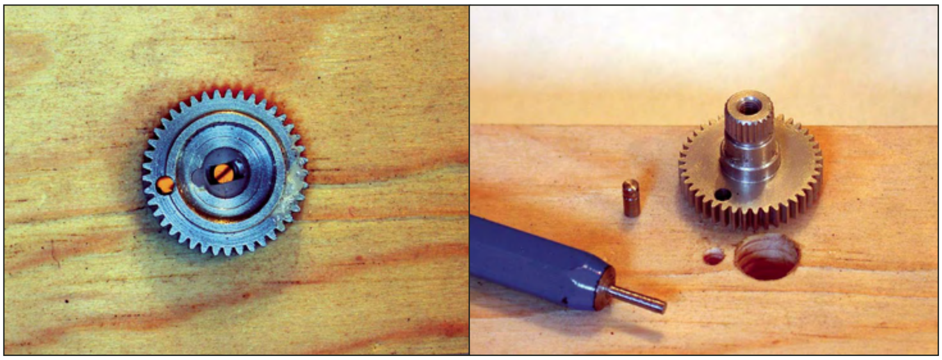
the entire face of the gear is fully supported so that the force required to remove the pin doesn't end up causing the gear to rotate sideways, which ends up damaging some of the gear teeth, or worse yet, bending the gear.

An easy way to do this is to drill a 9/32-inch diameter hole through a piece of wood. Then, using a black ink marker, color the top of the pin black. Then, put the shaft of the gear in the hole and press down on it with your fingers. This will cause the ink on the pin to mark the wood surface. Remove the gear and, using a 3/32-inch diameter drill, drill a hole through the wood at the mark. Make sure that you drill through the piece of wood so that you can retrieve the pin after you punch it through the gear. Figures 4 through 7 show the wood support with the holes and the gear being placed in the holes.

Next, you need to use a 1/16-inch diameter pin punch (see Figure 8). The diameter of the punch must be smaller than the diameter of the pin or you will end up damaging the gear. Pin punches can be obtained at just about any hardware, automotive, or tool supply store.

Place the pin punch on the center of the pin (see Figure 9). Make sure that the punch is centered on the pin to be removed, or you can damage the sides of the hole where the pin was. Then, using a small hammer, lightly tap the end of the punch a couple times. It does not require a lot of force to tap the pin out. The punch should fall all the way into the hole where the pin was knocked out (see Figure 10).

Figures 11 and 12 show the pin removed from the gear. This entire process, including making the gear support, will take about 15 minutes to make and just a few seconds to knock out the pin. This same procedure can be used to remove pins from most things that need to have pins punched out. SV



Figures 11-12. These photos show the pin removed from the gear.