Innovation First

Tuning Drive Trains with a Current Meter

Introduction

The following document is a guide to improving your drive train efficiency by using a DC current meter. A DC current meter such as the Fluke 36 is a simple tool that can give insight into the motor's power output and torque.

Drive train efficiency is an indication of the power expended overcoming the friction within a drive train. The most common friction sources are side loading on the transmission, improper gear/sprocket alignment, excessive chain tension, and axle rotational friction. Based on actual test data, the wasted motor power on a FIRST robot ranges between 25% and 50% (see Table 1).

The goal is to maximize available power, typically limited by a 30A circuit breaker. Reducing this wasted power can directly improve your vehicle's top speed and pushing power.

Using a Current Meter

A DC loop clamp current meter is recommended for ease of use since no wiring change will be necessary. The current meter's loop clamp must be placed around only one of the wires carrying the DC current to be measured. It is recommended to measure input current to the speed controller. A speed controller's high frequency switching can cause false readings on some current meters when connected to the output.

Measuring current will require driving the robot with the meter in place. Choose an appropriate location that will hold the wire and current meter fixed. Do not use the "Max" function on a current meter to measure current draw while driving. The "Max" feature will capture the momentary stall current drawn by the motor (up to 114A) when power is first supplied. You will need to follow the robot and read the meter visually.

Table 1. Current draw of typical drill motor drive trains.

Drive Condition	Wheel Motion	Throttle 2-wheel / tread	Current Draw Efficient Fast 2-wheel drive	Current Draw High Traction Tread drive
Off the ground	Free spin	100% / 100%	4.8A	12.5A
Slow Forward	Rolling	25% / 75%	8.2A	35A
Max Forward	Rolling	100% / 100%	19A	22A
Pushing, no movement	Stalled	10% / 10%	20A	35A
Pushing, no movement	At traction limit	25% / 75%	40A	55A
Pushing, no movement	Spinning	100% / 100%	44A	45A

Measuring Drive Train Drag

The majority of the friction within the drive train can be measured directly with a current meter. The following method should be performed on each drive wheel:

1. raising the robot's wheels off the ground
2. running the drive at full speed
3. measuring the steady state current
4. place the robot on the ground
5. drive the robot straight at full speed
6. measuring the current once the robot has reached full speed

Wasted power caused by drive train friction can be evaluated by comparing the free spinning current to the full speed driving current. Table 2 shows that a typical 2-wheel robot draws 4.8A free spinning and 19A at full speed.

Inaccuracies in the above Method

The previous method has two inaccuracies.

1. There is no weight on the axle bearings. The friction caused by loading the axle bearings can be significant. Significant axle bearing friction will cause the current reading to be lower than the real wasted current.
2. Since the load on the motor is reduced compared to when driving, the drive train will run faster, causing increased friction. This will cause the current reading to the higher than actual.

The more significant of the two inaccuracies, axle loading, is difficult to measure. Poor bearings or improper bearing alignment are the most common causes of excessive friction involved with axle loading. The following is a method to isolate and evaluate your robots wheel/axle friction:

1. Disconnect the chain or gear connected to the drive wheel. Raise the wheel off the ground. Spin the wheel/axle by hand. If the axle spins freely, there is no significant bearing misalignment. It is unlikely but possible that applying weight to the wheel, axle, and bearings may cause bearing misalignment.
2. Disconnect the chains or gears connected to all drive wheels. Place the robot on the appropriate field surface. Push the robot at various speeds. The robot will be hard to push and will stop rolling quickly if there is excessive friction caused by load on the axle.

If you determine that your robot has excessive friction in the axle, eliminate the problem before continuing to tune your drive train.

Tuning your Drive Train

Now that you have baseline figures for the current consumption of your drive train, the goal should be to reduce that number as far as possible. Based on the 2-wheel drive shown in table 2, the goal would be to reduce the drag at or below 25% (4.8A ÷19A).

The following are tips on reducing friction within your drive train:

1. <u>Transmission Side Loading</u>: The drill motor transmissions are designed for end loading only. Side loading causes friction in the output bearing and the planetary gears. Your design should eliminate all side loading on the transmission output shaft through the use of bearings or other means.
2. <u>Sprocket Misalignment</u>: When using chain and sprockets in your drive train, it is important that the gears be aligned to one another. First, with the chain removed, visually look at the alignment of each sprocket to ensure it is in the same plane as the other sprockets. Second, with the chain installed, roll the drive wheel and ensure that the chain does not leave the sprocket at an angle.
3. <u>Chain tension:</u> Excessive chain tension can cause considerable friction with the drive train. Due to significant chain stretch while driving, it is not uncommon for the chain to slip on the sprocket if inadequate chain tension exists. Your goal should be to use enough tension to prevent slipping.
4. <u>Lubrication</u>

Fluke 36 Ordering

Innovation First, Inc. is not directly promoting Fluke above other products.

The Fluke 36 is one of many DC current meters that will aid in drive train tuning. This rugged hand held meter is available through various sources. One known source that usually has these meters in stock and has overnight delivery is:

Future Electronics
M-F, 8am to 5pm CST
Phone: 1-800-677-3794
Contact: Tony Clements
Price: $260