St Albans & District Model Engineering Society

Dynamometer Project

Battling with the Software and Measuring Wheel Rotation

Introduction	Since the last update about experimenting with the fish scales to understand the forces at the drawbar, the effort has been focused on the wheel rotation sensor and ironing out issues with the software. Most of the work covered in this update has been undertaken by Ian Gurton. To make sense of the recent work its worth reviewing what we are building and how it is intended to work, starting with some context.
Context: The dynamometer car	It's probably fair to say that the inspiration for our dynamometer car project is the delightful teak carriage dynamometer used by Gresley to measure the power output of steam locomotives. Gresley's main objective was efficiency, aiming to avoid the cost of wasted coal and optimise the use of water. The objective with our dynamometer car is to amuse ourselves at Puffing Park measuring the (probably) woeful efficiency of our locos.

Fig 1. Inside Gresley's dynamometer car

	Gresley's dynamometer car was essentially mechanical and while it looks fantastic and would make a great subject for a scale model, that isn't going to be our approach. We will be using a combination of mechanics and electronics. Others in the model engineering field have gone down this path before, some of it being documented in the Model Engineer.
IMLEC	IMLEC (International Model Locomotive Efficiency Competition (est. 1969)) is an annual competition with the results reported in Model Engineer. Taking part in IMLEC trials is highly competitive and a meeting generally takes all day as each competitor's run is about 30 mins, longer if you include prep etc. We aren't aiming for IMLEC trials at this stage, our intention is that the dynamometer car be available for the use and amusement of the St Albans & District ME Society membership at Puffing Park. The dynamometer that tends to be used at IMLEC is produced as a joint venture between Station Road Steam and The Taylor Kellar Partnership. You can read about it here http://taylorkellar.com/index.php/indicator/ You can see a video of the 2019 IMLEC meeting hosted by the Leyland Society of Model Engineers here https://youtu.be/mBWn-sHAziY
The architecture for our version of dynamometer car	The dynamometer car needs to measure the forces at the drawbar, the speed along the track and the time that each measurement is taken. From that information it can calculate the power output and how it changes throughout the run. It also needs to store all the measurements so they can be examined later and potentially saved for posterity. It will also need to display information to the driver and observers. This is shown in the diagram below. The forces at the drawbar were the subject of the fish scales trials. There will be a strain gauge acting as the coupling between the drawbar of the loco and its load. This device will transmit its information electronically to a high gain amplifier, the analogue output of which will be read by the dynamometer control unit (DCU), converted to a digital number and converted into the unit of force, Newtons. The speed will be measured using a hall sensor (Fig 2.) and a magnet mounted near the outer edge of a wheel on the dynamometer car. Each time the wheel rotates and the magnet passes the hall sensor a signal is sent to the DCU which will calculate the current speed using the known circumference of the wheel and the time taken for the most recent rotation.

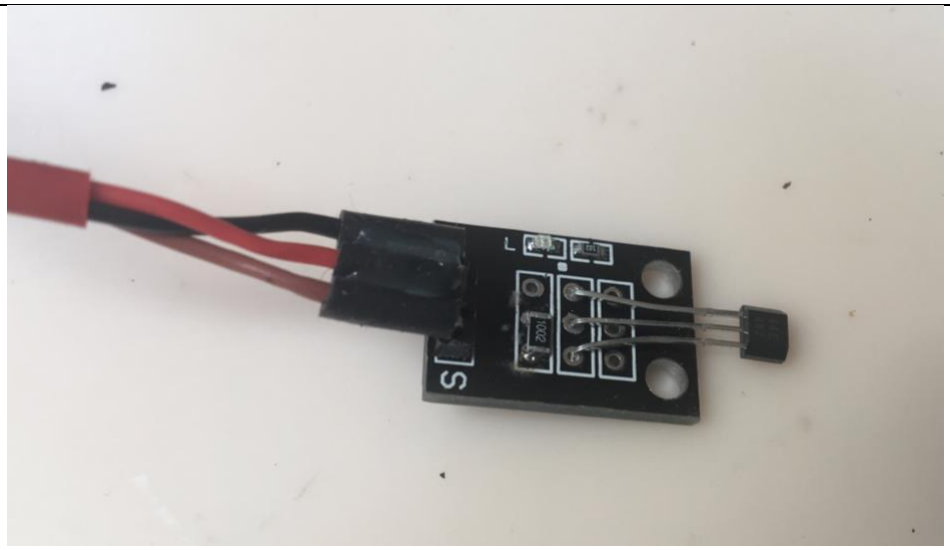

Fig 2. The hall sensor (The thing with three legs on the right of the picture)

The idea is that the DCU sends current power output and speed information to a display the driver can see as well store all the measurement information on removable media, in this case a microSD card.

The DCU itself is based on an Arduino module which is an open source, small, cheap, computer that is programmable in a version of the language C. It has input and output pins that can be connected to various sensors and easily controlled or read by the software.

Fig 2. An Arduino circuit board (this is the Uno version)

Ironing out the software issues	Rather than building all the software from scratch Ian chose to stand on the shoulders of the giants of the model engineering world and got in touch with people who claimed to have built dynamometer cars before. This was rewarded by someone sending him a software programme for the Arduino platform. Using someone else's software as a starting point has its drawbacks. First you have to examine it to understand what it was intended to do. Then you have to run it to see whether it is achieving what it was intended to do. And if it isn't, you have to start modifying it. In this case it's not just about the software, it's also about the sensors and outputs that are connected to the Arduino, some of which might not be available on the market anymore. In our case several problems were found that raised a question mark over whether the system ever worked properly for the person who sent it to us. One of the most significant issues has been the way the software writes the measurement data to the SD card. The problems has been solved by using an Arduino Mega processor board model with more memory than the Arduino Uno processor board that was used initially.
The wheel rotation sensor	Having proven the technology and software for measuring wheel rotation the next step is to mount the magnet on the wheel and the sensor on the bogie frame (fig 3.) and see if it works in practise. They need to be mounted in such a way that they won't easily get damaged or dislodged or wet. The cable from the sensor needs to flex with the movement of the bogie and feed the signal up into the dynamometer car body where the DCU will reside.  ***Fig 3. The dynamometer car bogie***

Of course, measuring the rate of rotation of a wheel isn't the only way that speed can be measured, we could use GPS. The advantage of using GPS would be no need to mount delicate electronics in a hostile environment. The disadvantage is that it can take a while to acquire a signal and its effectiveness can be impacted by tunnels and dense foliage. Undeterred Ian Gurton experimented with using GPS for measuring speed using the system shown in Fig 4. To test it Ian sped through Harpenden on his mobility scooter….

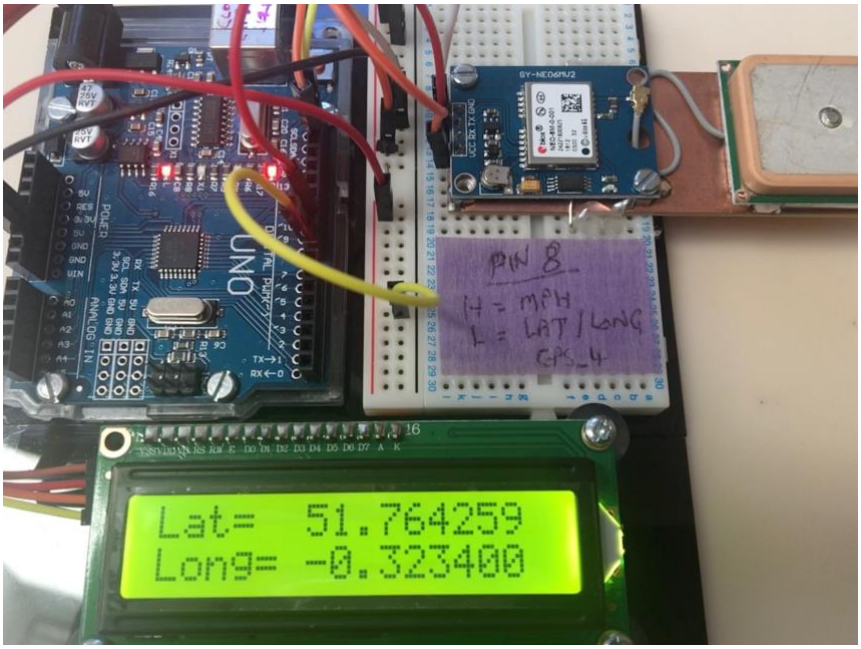

Fig 4. The Arduino being used along with a GPS sensor (top right) and a display (bottom) to show location. Shifting the yellow wire to the 5v line on the breadboard will cause it to display speed.

Next steps

Once the magnet and sensor are mounted on the bogie the plan is to put it back on the dynamometer carriage and test it out at Puffing Park to see how it not only measures speed but how it displays it and records it to microSD card.

Meanwhile we will be building a drawbar coupling incorporating a strain gauge. Instead of using a strain gauge from a set of fish scales, which raised some questions about their robustness and adaptability, we are now beginning to experiment with alternative but equally economical gauges that can be configured into a safe draw bar coupling more easily shown in Fig 5.

Fig 5. The strain gauge we intend using

We also want to experiment with sending the measurement and computed data over Bluetooth to a smart phone or laptop. Potentially even controlling the dynamometer software using the same method.