1974 Jaguar Oil Pressure Gauge Circuit Analysis
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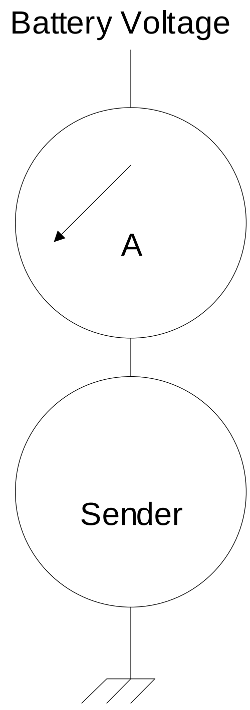
Dick Wells asked me to analyze the oil pressure gauge system from his 1974 Series 3 E-type Jaguar.

The oil pressure gauge is a heavily damped bi-metal ammeter. The more current that flows through the ammeter, the more the needle is deflected. Here is a photo of the gauge:

The positive side of the ammeter is connected to battery voltage, and the negative side of the ammeter is connected though the oil pressure gauge sender to ground.

The sender is a heated bi-metal strip with contacts. With the contacts closed, current flowing through the heater will heat the bi-metal strip until it bends enough to pull the electrical contacts apart, turning off the heater. The bi-metal strip then cools until it straightens enough to make contact again, turning the heater on. The bi-metal strip is also connected to a diaphram that moves the contacts closer together with increasing pressure. As the pressure goes up, the duty cycle of the sender also goes up. As the duty cycle goes up, the average current through the gauge goes up, increasing the needle deflection.



Changing battery voltage is compensated for by the sender. As the voltage goes up, the current also goes up, so the heater heats up faster, giving a shorter duty cycle for any given pressure. But since the current is higher, the average current flow for any given pressure remains the same.

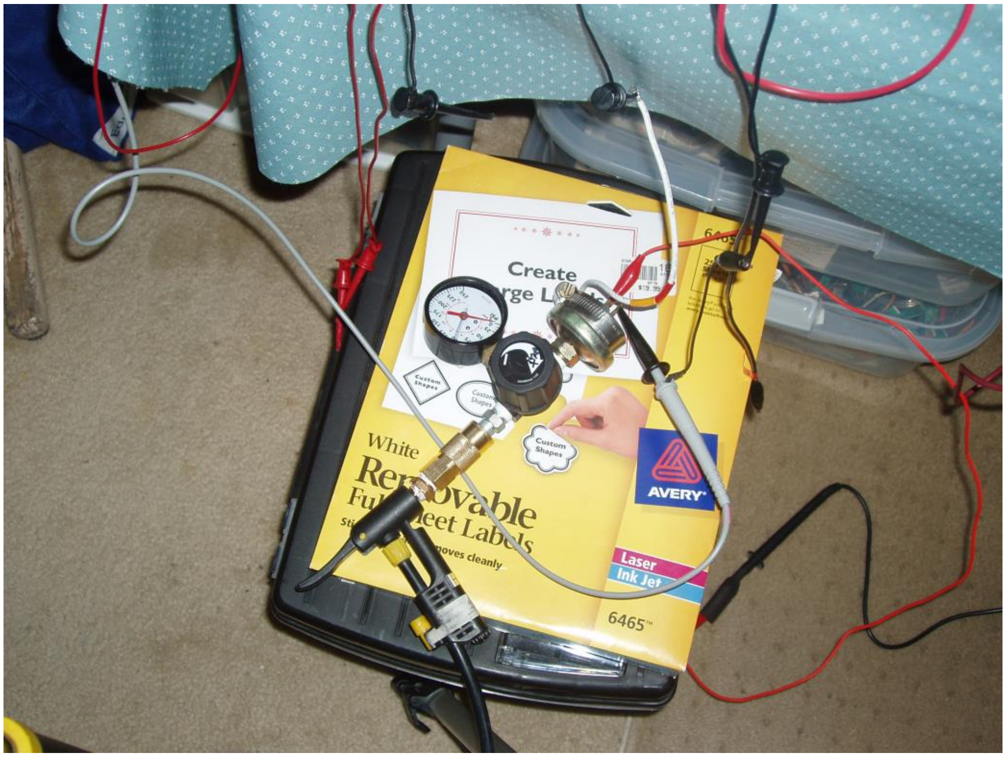
Gauge Characterization:

I set up my bench power supply as a constant current source and ran the current through the gauge. At 0mA of current, the needle rests a bit to the left of the zero mark. The current needed to get the needle to the 0 PSI mark is 28mA. At that point, the voltage across the gauge is 1.8V. I then increased the current until the gauge moved to each mark, and recorded the current needed to deflect the needle and the voltage drop across the gauge. Here are the results:

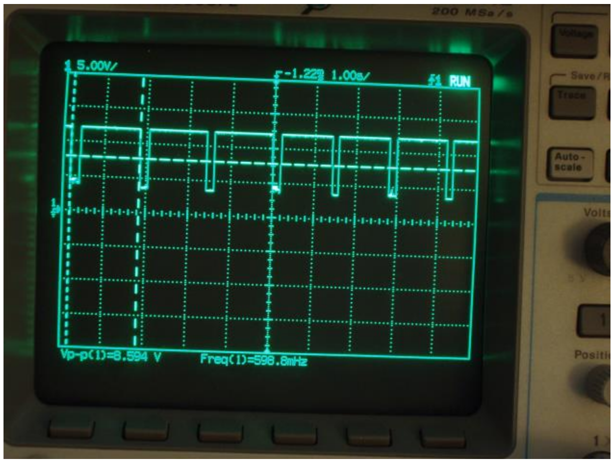
PSI	mA	V
0	28	1.8
20	58	3.6
40	75	4.7
60	92	5.7
80	108	6.9
100	135	8.65

It is interesting to note that from the current and voltage and Ohm's Law, we see that the gauge resistance is pretty close to 62-64 ohms.

I connected a ground wire to the case of the sender with a hose clamp. I wired the sender to the gauge and then connected the positive side of the gauge to my bench power supply, which was set to 12V. I connected an oscilloscope between the sender and the gauge. I then connected a bicycle pump to the sender, along with the reference pressure gauge the dick had also sent to me. Here is a photo of the test setup (the gauge is above the photo, on the table):

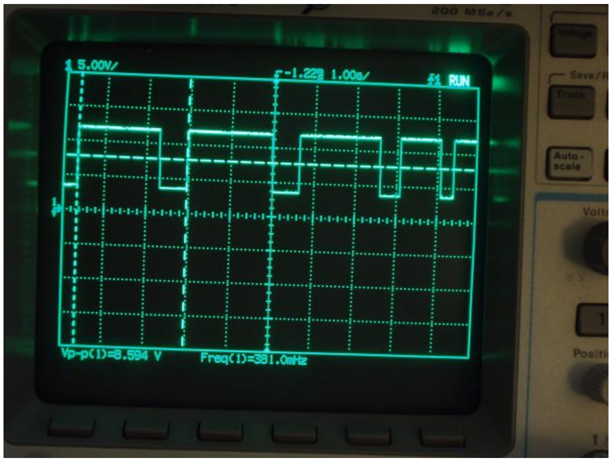


With 0PSI on the sender, I captured the waveform on the scope:



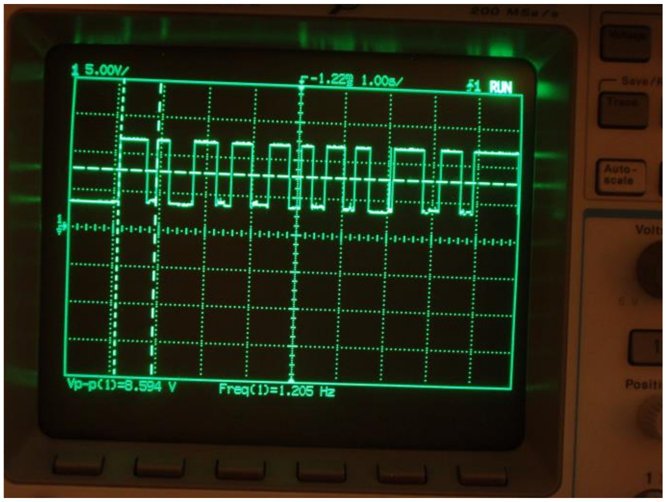
The waveform goes from 12V down to about 3V when the contacts are closed, current flows and the heater is powered. Once the bi-metal strip is heated enough to bend enough to break the contact, the circuit is broken, current stops flowing and the voltage goes back up to 12V. While the contacts are closed, about 135mA flows through the circuit (at 12V battery voltage). While the contacts are open, no current flows through the circuit. The average current flowing through the circuit should be a bit more than 28mA since the needle is deflected a bit above 0 PSI. It is very difficult to measure the average current by way of the oscilloscope due to the variations seen in frequency and duty cycle.

I pumped the bicycle pump until the pressure showed 25 PSI on the reference gauge. This is what I got on the scope and gauge:



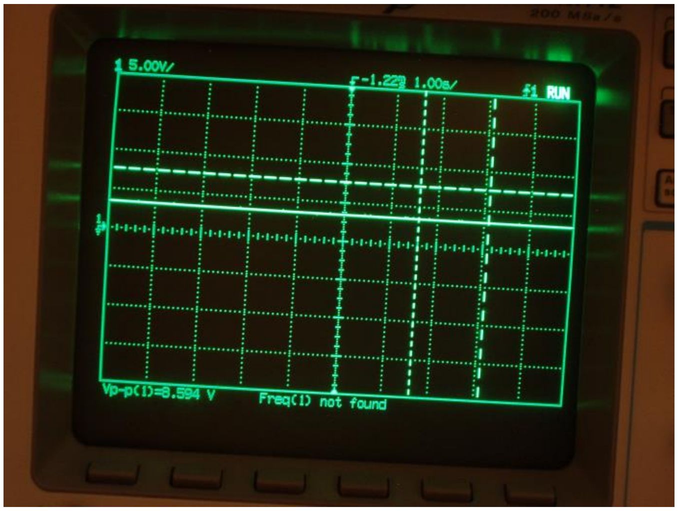
It is easier to see the variations in the signal that makes it difficult to measure the average current.

I pressurized the system to 50 PSI on the reference gauge, and this is the waveform and needle deflection I got:



You can see that the increasing duty cycle increases the average amount of current flowing through the gauge.

I pumped the bicycle pump until the pressure showed 75 PSI on the reference gauge. This is what I got on the scope and gauge:



You can see that the duty cycle has reached 100%. I could not get the gauge to read higher than this, even with the pressure pumped up well over 100PSI.

It is not clear to me how to electronically calibrate this system, but it appears that Dick's system, while not being highly accurate, is not too far off.