Analyzing the Alternator Tach Signal

COLUMN BY NATHAN UNGER

Occasionally I get a customer asking how to connect his aftermarket tachometer to his alternator. He then hands me the accompanying chart which explains how to calibrate his tach. Some tachs require calibration with a potentiometer and a reference tach, others have DIP switches which are set according to the number of rotor poles and pulley ratios. Still others require you to do the calculations yourself and then enter the number of pulses per revolution.

Electronic tachs take signals from various sources, such as main output ripple of an alternator, signal from a stator/rectifier terminal brought to a terminal on the outside of an alternator, ignition coil negative, electronic ignition feed, etc.

To explain how the number of rotor poles, rpm, alternator phase output, and pulses per revolution are related, I used a Ford 2G alternator as shown in Figure 1 (Lester 7735), which has a rotor with six pole pairs (Figure 2).

There are 12 poles or six north-south pairs on the 2G rotor (Figure 2).

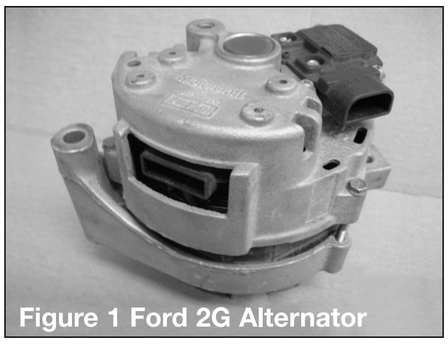

Figure 1 Ford 2G Alternator

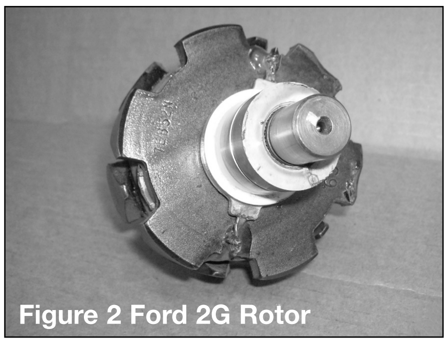

Figure 2 Ford 2G Rotor

Taking a scope signal from the S terminal of the BBS output plug, I obtained this waveform (Figure 3) from a stator/rectifier junction (also called "phase" output).

You'll notice the two dashed vertical lines. Those are the cursors I used to measure the duration or period of one complete cycle or wave.

In this case, I measured 2.58 milliseconds or 0.00258 seconds.

So now, to compute the rpm of this alternator, we first have to convert the .00258 seconds-per-wave into waves-per-second, called frequency (in Hertz). 1/.00258 = 388 Hz.

But we want it in minutes, not seconds, so 388 X 60 = 23280 waves per minute.

We know that the rotor has six pairs of poles (north and south), which means that for each rotor revolution, it would have produced six waves in that one phase of the stator. To compensate for that; 23280 / 6 = 3880 rpm.

The formula is: alternator rpm = 60F/N; Where rpm is revolutions per minute *of the alternator*; 60 converts frequency in cycles per second to cycles per minute; F is the frequency of the waves; N is the number of rotor pole pairs.

Some tachs are designed for calibration according to the number of pulses per revolution, so simply knowing the pulley ratio from the engine to the alternator, and the number of rotor poles would give you the number of pulses per engine revolution.

For example, suppose the crankshaft pulley is eight inches in diameter. The alternator pulley is 2.5 inches in diameter. The alternator's rotor has six north-south pole pairs. This means that at a given phase, and for every rotation of the rotor, we would get six waves. We don't need to figure out rpm here, nor the pulse duration, since we only want to know what happens in one engine turn.

Let's do the math: 8 / 2.5 X 6 = 19.2 pulses per engine revolution.

Some tachs are designed to plug into your cigarette lighter, and use the alternator main output ripple to calculate rpm (see Figure 4).

If you look carefully back at Figure 3, you will notice there are six smaller ripples superimposed on the phase signal (three at the top for the positive diodes, and three at the bottom for the negative diodes) — six of them per wave. These small ripples are the same duration as the ones in the main output ripple waveform of Figure 4. I'll give you the duration of one ripple which is 0.43 milliseconds (Figure 4), change that to frequency: 1/.00043 = 2325.6 Hertz.

Then we divide by six because there are six of these ripples in one wave of a phase output: 2325.6 / 6 = 388 Hertz, same as before.

This shows that you can use the same formula as in the first calculation.

If you are installing a tach terminal on an alternator, it has to be connected to one of the phases and not the wye neutral (see Figure 5). (As an aside, this is true of trio diodes as well). Some alternators have the wye neutral rectified to boost output by about ten percent. You can usually tell because the rectifier will have at least eight power diodes in it. Incidentally, this changes the shape of the main output ripple somewhat under load, but not its frequency. The "phase" output frequency is also unaffected by the wye neutral diodes.

One word of caution here: There is no industry standard to describe the phase terminal that connects to a stator/rectifier junction.

I've seen R, S, P, Sta, Tach, AC tap, and there may be more, but you do need to know what that designation means on a given alternator. Lester has a plug code reference online or in their DVD that you can refer to.

For example, Sta can also refer to what we discussed in the previous paragraph – the wye neutral. This terminal has the same voltage if you connect a basic voltmeter to it (half the output voltage) but the signal is three times the frequency and has a different shape than the phase signal at a stator/rectifier junction. In Figure 6, the top waveform is from the stator/rectifier junction, and the bottom one is from the neutral of the stator.

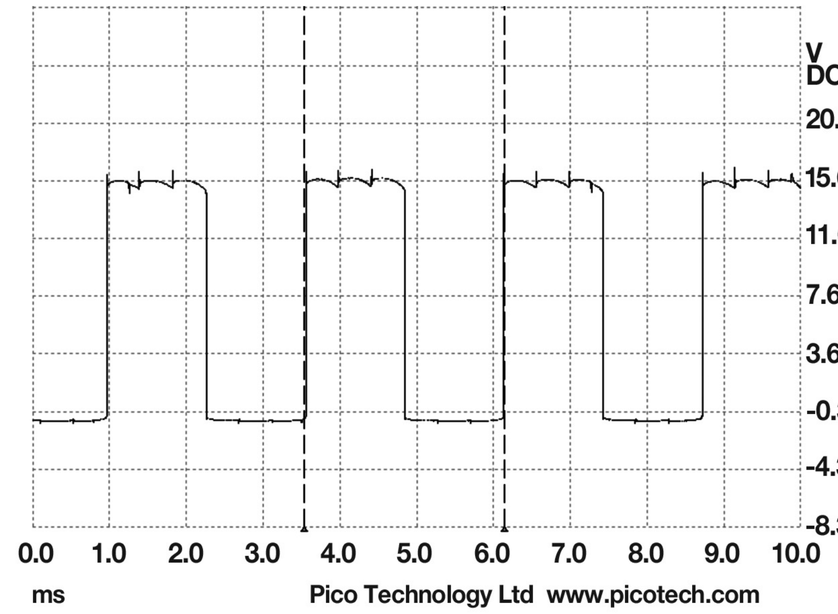

Figure 3 Phase output of Alternator

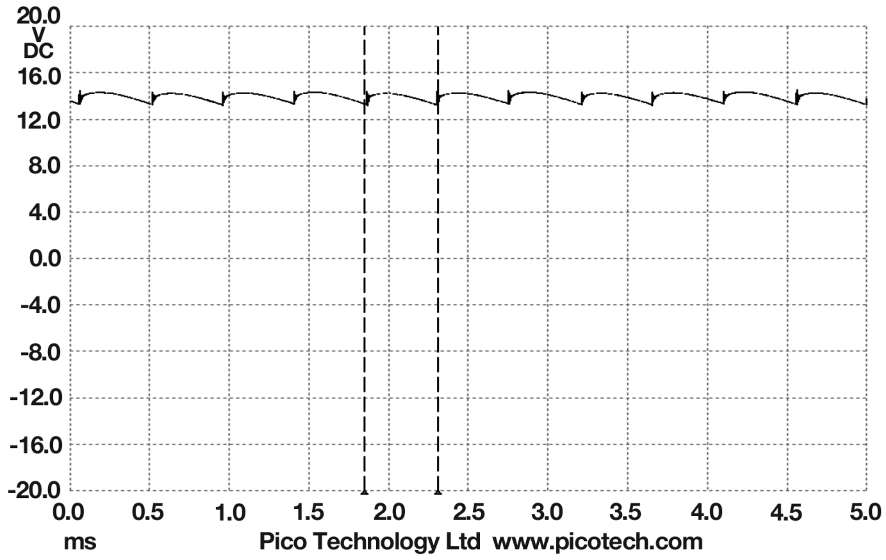

Figure 4 Main Output Ripple — One wave is 0.430 milliseconds

You can see the difference in shape and frequency.

Also, the S terminal in most alternators refers to the sense function, not the phase output.

To conclude then, since most retrofit tachs I've seen connect to a phase/rectifier terminal brought out to the case of the alternator, make sure you don't use the wye neutral instead — it may be rectified. To calibrate the tach for engine rpm, you may need to know the number of rotor poles, the duration of the pulses (which you convert to frequency) and the pulley ratio, and plug that into the formula:

Engine rpm = crank pulley size times 60 seconds times Hz at a phase connection divided by alternator pulley size times number of rotor pole pairs.

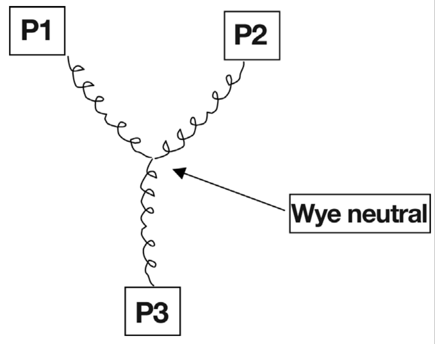

Figure 5 Connection diagram of the windings in a Wye wound stator

Nathan Unger is owner of ASI Rebuilders, Abbotsford, B.C., Canada. Many thanks to Bob Thomas for technical assistance and proofing.

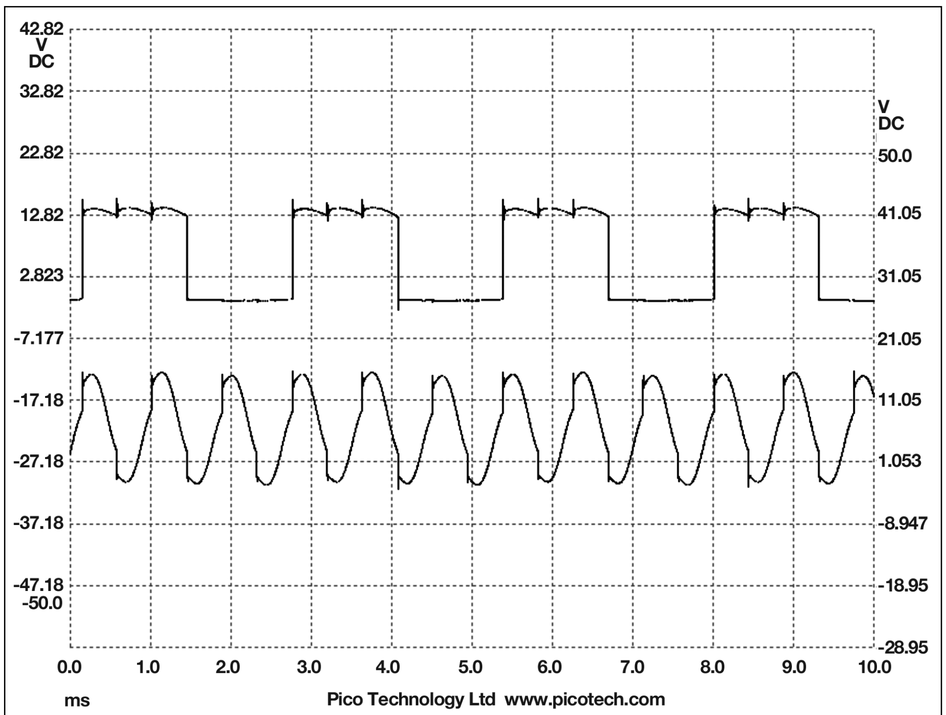

Figure 6 Phase output (top) vs Wye neutral (bottom)