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PULSE WIDTH MODULATION
Old Trick – New Dogs

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PULSE WIDTH MODULATION
Old Trick – New Dogs
Hyundai-Kia, Nissan-Infiniti, & Suzuki Go PWM

BY GENE KAISER

It has been 12 years since General Motors introduced alternators with a variable voltage set point. They called their system regulated voltage control or RVC for short. The charging voltage on vehicles with RVC can be fine tuned to fit battery state of charge and a variety of driving conditions. A control module determines what voltage is best and commands the regulator to use a specific voltage setting or Vset via a one-way PWM (pulse width modulation) signal. On most GM vehicles, that control module is the vehicle's PCM. But on some pickups and SUV's, a dedicated BGCM (battery generator control module) was used.

PWM is basically just a low voltage on-off signal that switches at a specific frequency, 5 volts at 128 Hz (hertz or cycles per second) in the case of GM's RVC systems. The "on" time, measured as a percentage, translates to specific voltage set points. Longer "on" time in the signal equates to a higher Vset.

Ford has been using a similar PWM signal to remotely control Vset dating back to 1998 on some of their vehicles. They have increased its use since then. The later Ford PWM plug code has changed terminal identification to LI-RC-BVS (Lamp Indicator, Regulator Control, and Battery Voltage Sense). It works the same as before, just an "old trick" that Ford renamed. The big difference between Ford and GM is the polarity of the PWM signal.

But most recently Ford appears to be moving away from PWM and more toward a LIN network to adjust Vset. The growing trend among auto manufacturers is to integrate the alternator into the vehicle's single wire communication network. Those systems use BSS or LIN protocol with a command terminal on the regulator that allows for two-way communication between the control module and the regulator. Network communication can be handled through a single wire using ground as a reference. That type of voltage control was explained in detail in the May issue of the Exchange.

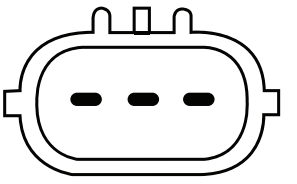
Today, many automotive manufacturer's are opting to use BSS or LIN to optimize charging system voltage. But so far, GM has not joined them. They have so far continued to use a one-way PWM signal. Suzuki, with close ties to GM, also used a PWM signal to change Vset on some models prior to leaving the US market in 2012.

Several years ago, Nissan-Infiniti and Hyundai-Kia each introduced their own remote voltage control systems, based upon PWM signals. These new PWM signals are very similar to GM's RVC and Ford's RC. Some of those vehicles are now out of warranty and their alternators are beginning to show up on rebuilder's front counters. Testing them is simple if you have the correct tool.

Nissan Infiniti PWM

Nissan and Infiniti began using PWM to adjust voltage in some models as early as 2006. Their first applications to apply the technology were both Mitsubishi alternators with L-S-C terminals, C being PWM from the PCM (see Figure 1). You may notice that the plug code for this alternator is 325, which covers 25 different Lester numbers as of this writing. However, only some of the alternators covered by the 325 plug code use PWM. On the others, the C could be any type of communication including a field monitor. You can see in the Infiniti's charging system diagram (see Figure 2) that the C terminal is connected to a control module called an Intelligent Power Distribution Module (IPDM) which in turn is part of the ECM's network.

Many different tools are available that can test PWM alternators. In the photos, we are using our Regitar RRT001 test box, which will allow you to operate the regulator under a wide range of duty cycles instead of just one or two. The Nissan and Infiniti alternators are the same polarity as GM's RVC so we have set the switch to GM on the test box. In the photos, you can see how changing the PWM signal input affects the



PLUG CODE 325

Figure 1 – Plug Code 325. On Nissan-Infiniti, the C terminal receives a PWM signal from the control module to adjust the Vset (regulator's voltage set point).

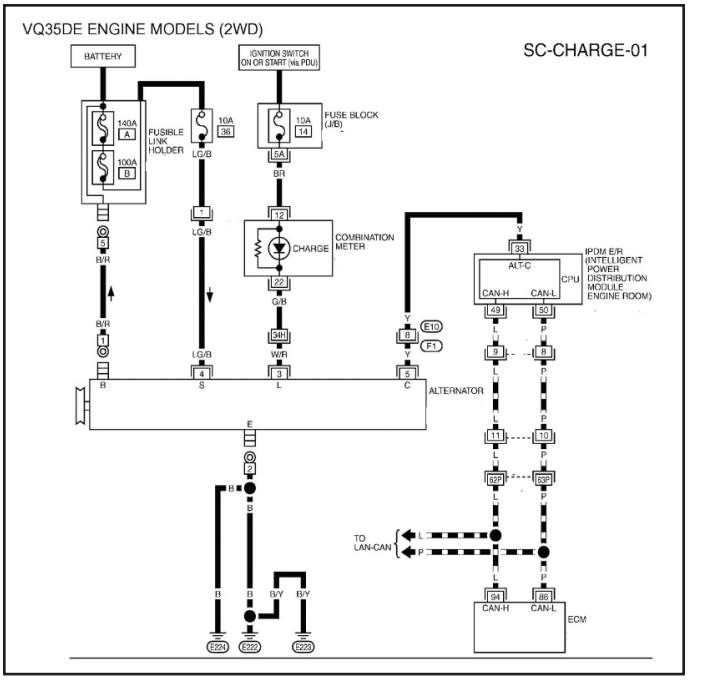


Figure 2– On this Infiniti system diagram, you can see that the C terminal is connected to an IPDM, which generates the PWM signal that controls the Vset.

regulator's Vset. The duty cycle on this "C" pin operates just like the GM and Ford regulators that were controlled by PWM. You may wonder if you really need to test operation at different duty cycles. In most cases, one or two will verify correct voltage range. But you have to also watch the charge warning lamp. I prefer to verify that the lamp operation is correct throughout the operating range, making sure the lamp does not illuminate when it should not but lights when it should.

In the photos you can see how I connected a PWM regulator to a similar Mitsubishi alternator with a dummy regulator installed in it (see Figure 3). The lamp connects to "L" and battery sense connects to "S" just like many L-S units in past. When I start bench this unit should turn itself on, turn the warning lamp off and regulate at 14.5V (see Figure 4). We then apply load to the unit to test the stator, rectifier and output. At this point I like to remove the load and keep unit running at about 4,000 RPM and remove power from the sense terminal. That should do two things, send the regulator into secondary regulation of about 15.5V and turn the indicator lamp on, showing that there is a problem (see Figure 5).

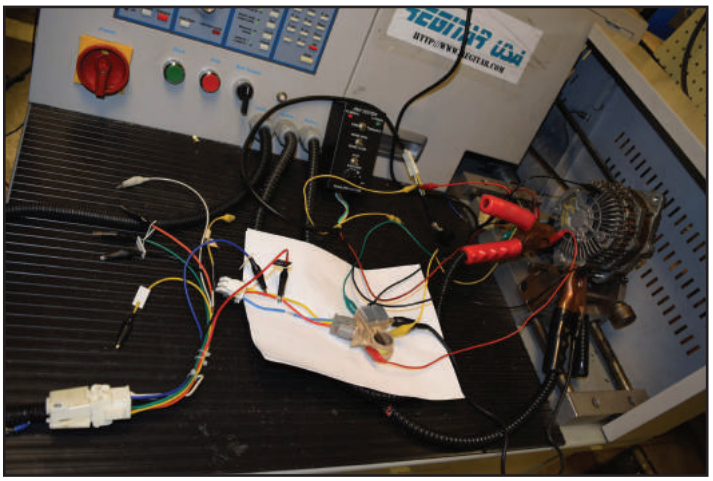


Figure 3 – For regulator testing, the PWM regulator is connected to a Mitsubishi alternator with a dummy regulator.

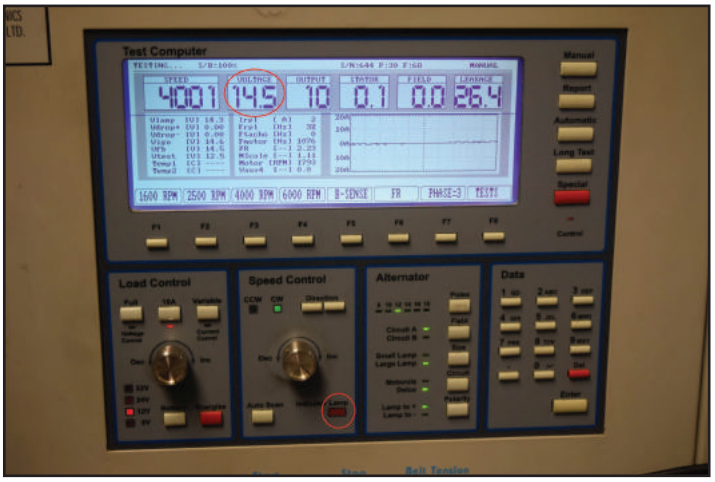


Figure 4 – This is the readout after excitation without any input to the C terminal. It is charging at the default rate of 14.5v.

Figure 5 – This is the readout after B+ has been removed from the S terminal to test lamp operation. The regulator has entered secondary regulation because of the lack of sense voltage. Note that the indicator lamp has been turned on to indicate a problem.

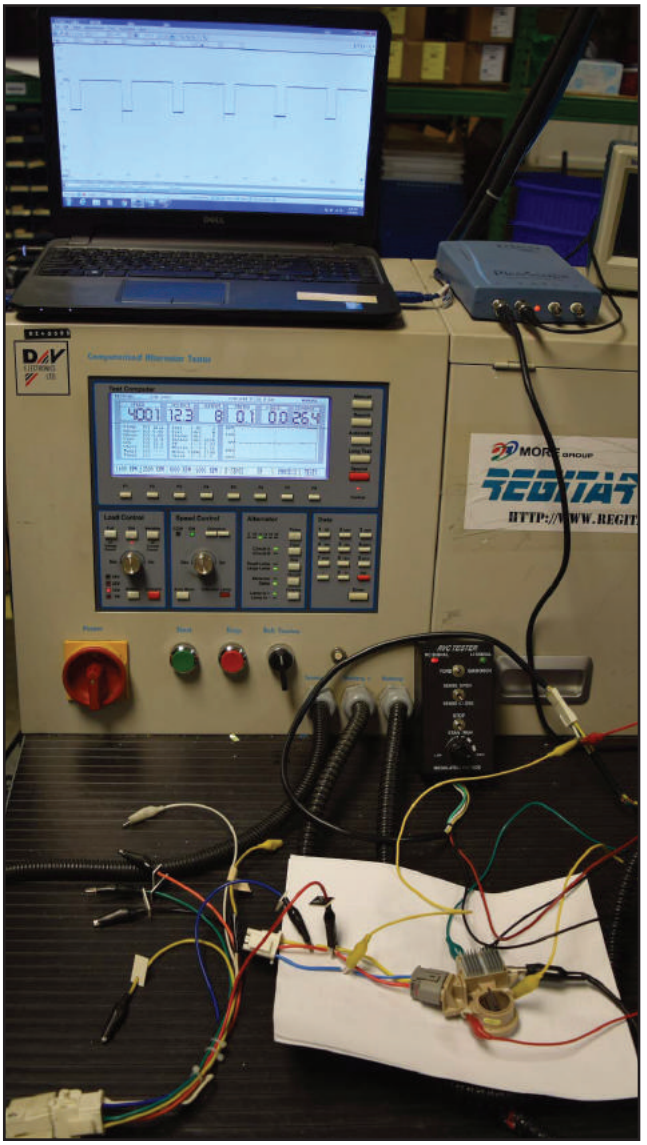


Figure 6 – Here we are testing the PWM on a low duty cycle. The Picoscope above shows the signal at 20% on, 80% off. Note that the Vset is 12.3v.

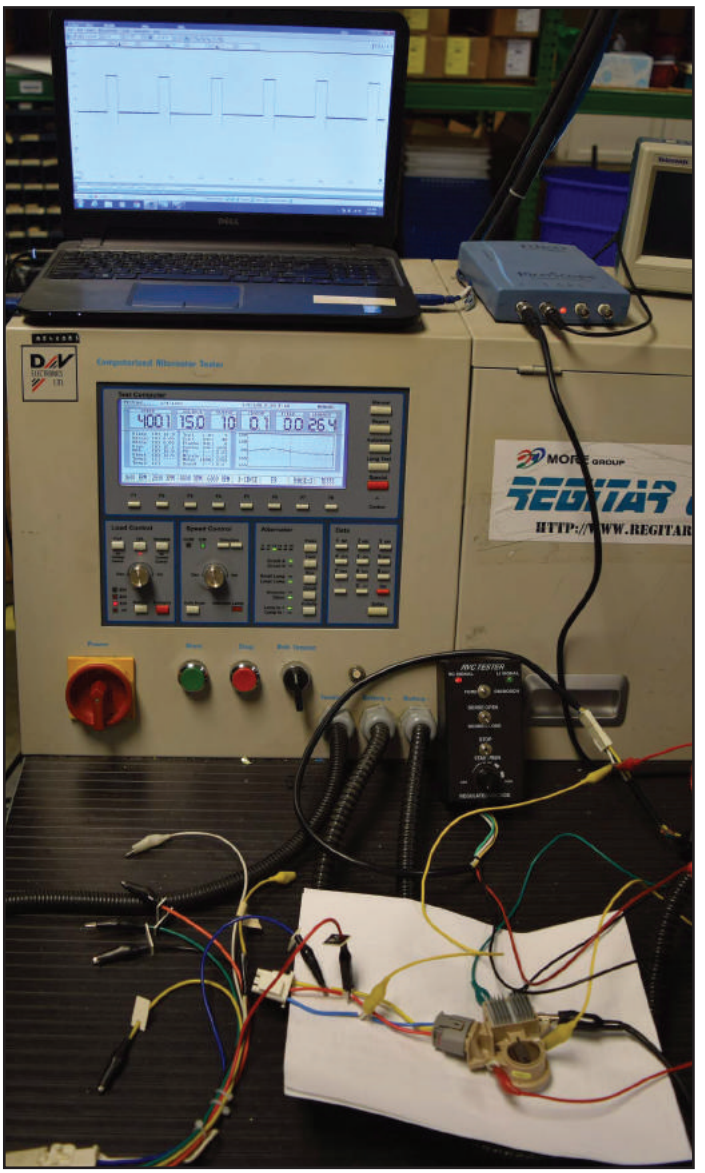


Figure 7 – Here we are testing with the "on" time at 80%. The charge voltage has increased to 15v.

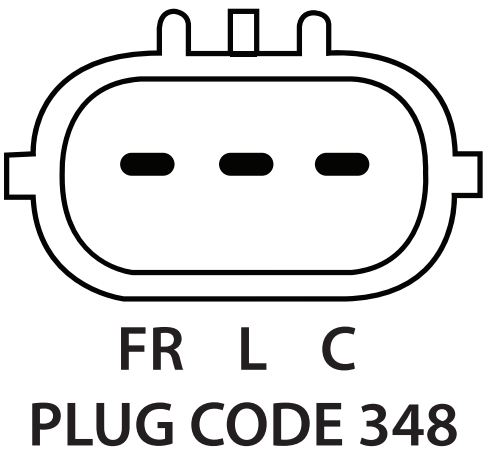


Figure 8– The Hyundai and Kia applications use plug code 348. This system is similar to Ford's RC applications.

Reconnecting B+ to S should return the regulator to a normal voltage setting. Then, we send a square wave PWM signal like that used in all RVC systems from the center pin in our test box plug. With the alternator still running at 4,000 RPM I can turn the knob to change the Vset by changing the duty cycle of the regulator. (see Figures 6 and 7). The Picoscope above in the photos shows the PWM signal. You can see that the field is on 20% and off 80% in the first photo. In the second picture the field is on 80% and off 20%.

Always let the unit you're testing warm up and perform a load dump test. It's also a good idea to run the unit at a high RPM and watch for any voltage fluctuations on your meter(s).

Hyundai Kia PWM

The second PWM system that we will explain is being used on some Hyundai and Kia vehicles with Valeo alternators. The terminals on these alternators are C-FR-L, or plug code 348 (see Figure 8). Note that C in this case receives the PWM signal directly from the vehicle's PCM. On these applications, the lamp terminal L is used to excite or turn-on the regulator. The FR is just like Ford's FR in that the PCM monitors the field to keep up with the precise amount of mechanical load that is being placed on the engine by the alternator.

The PCM can change the Vset by changing the duty cycle of the field, just like Ford did with their RC terminal. In the photo (see Figure 9) we have connected "L" to test the indicator lamp and our test box (switched to Ford) is connected to the "C" pin. We have also connected the FR pin to a voltmeter to monitor voltage on the field.

Running this alternator at 4,000 RPM, the lamp goes off and the unit begins to charge at 14.3V. We now can control the duty cycle by adjusting the PWM signal from the test box. The voltage should change, just like other PWM controlled regulation. After we check the regulator for its Vset response to changes in the signal, we can load the unit and watch the FR voltage change just like it did on Ford's "LI" pin. Once we are applying a load to the unit we can watch the voltage change on our voltmeter and know that the FR pin is working correctly (see Figure 10) .

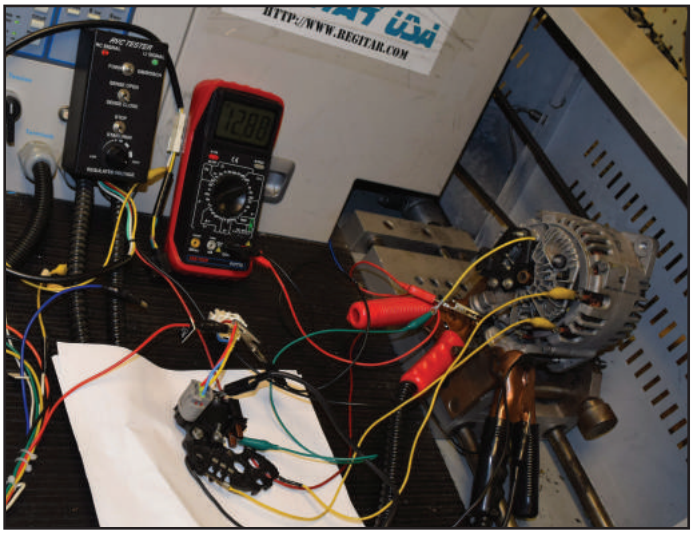


Figure 9 – Here we have a Valeo/Hyundai PWM regulator connected to a Valeo alternator with a dummy regulator. Notice that we are reading voltage on the FR terminal with the DVM.

Figure 10 – Here is the readout on the Valeo/Hyundai alternator running at 4,000 RPM under a 100 amp load. Notice that the FR terminal voltage on the DVM has dropped as expected.

Subaru PWM

Just about all C-PWM regulators operate at the same frequency and square wave signal. At another time we will explain the Subaru system, but with this L-S-C regulator, the input to the lamp pin is what you must test properly.

In Conclusion

All charging systems in which the alternator's voltage set point may be adjusted by the vehicle's PCM are command or COM charging systems. The medium of communication may differ, having titles like, BSS, LIN, RLO, RVC, RC or PWM. Technically, that should also include the early Honda alternators with which the PCM could simply ground the C terminal to drop the Vset. All of these systems make an adjustable Vset possible, controlled by an electronic module outside of the alternator. They also all share the same primary purpose which is to save fuel. However, they cannot all be tested the same way.

It is our business to know and understand all of these charging systems. We must make ourselves familiar with the terminology and methods of testing - which test lead or box must be used to evaluate each alternator that we encounter. It is our job to be confident that we have the knowledge and tools to test our own work properly.

We have come a long way since seeing those first C terminals in the late 80's. They may have functioned differently and the exact methods are constantly changing. But the means used, adjusting regulator Vset, has remained pretty much the same. Here at REGITAR we have begun to ID all new C terminals as PWM, BSS, LIN in the hope it will help you whenever you have to test an alternator that you may not yet be familiar with.

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