How to connect the oscilloscope

Channel A - alternator current output

Plug the **600 amp current clamp** into **channel A** of the scope. Place the clamp around the main battery positive cable from the alternator to the battery. Switch the clamp on and adjust the zero setting.

Channel B - feedback from alternator

Plug a **BNC test lead** into **channel B** of the scope. Connect an **acupuncture probe** to the positive (colored) plug on the test lead and place a **black crocodile clip** on the negative (black) plug. Place the black crocodile clip on a suitable earth connection in the engine bay. Probe pin 1 of the alternator multi-plug, or refer to the manufacturer's wiring diagram.

Channel C - command signal to alternator

Plug a **BNC test lead** into **channel C** of the scope. Connect an **acupuncture probe** to the positive (colored) plug on test lead and place a **black crocodile clip** on the negative (black) plug. Place the black crocodile clip on a suitable earth connection in the engine bay. Probe pin 2 of the alternator multi-plug, or refer to a manufacturer's wiring diagram.

The connections are illustrated in *Figure 141.1*.

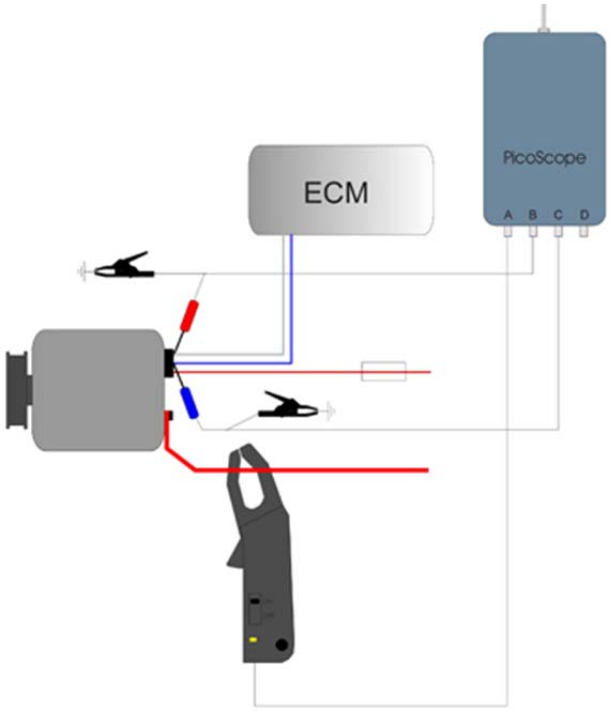
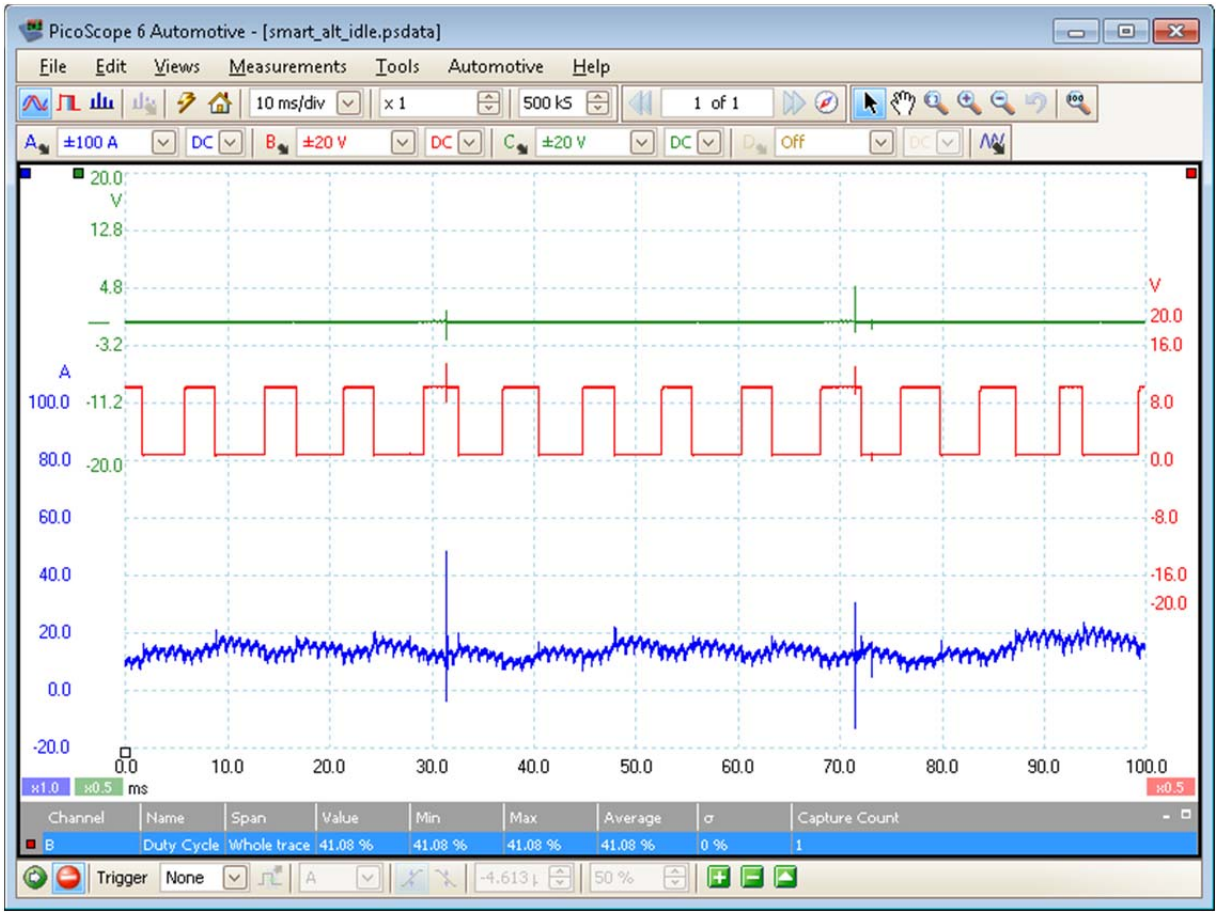
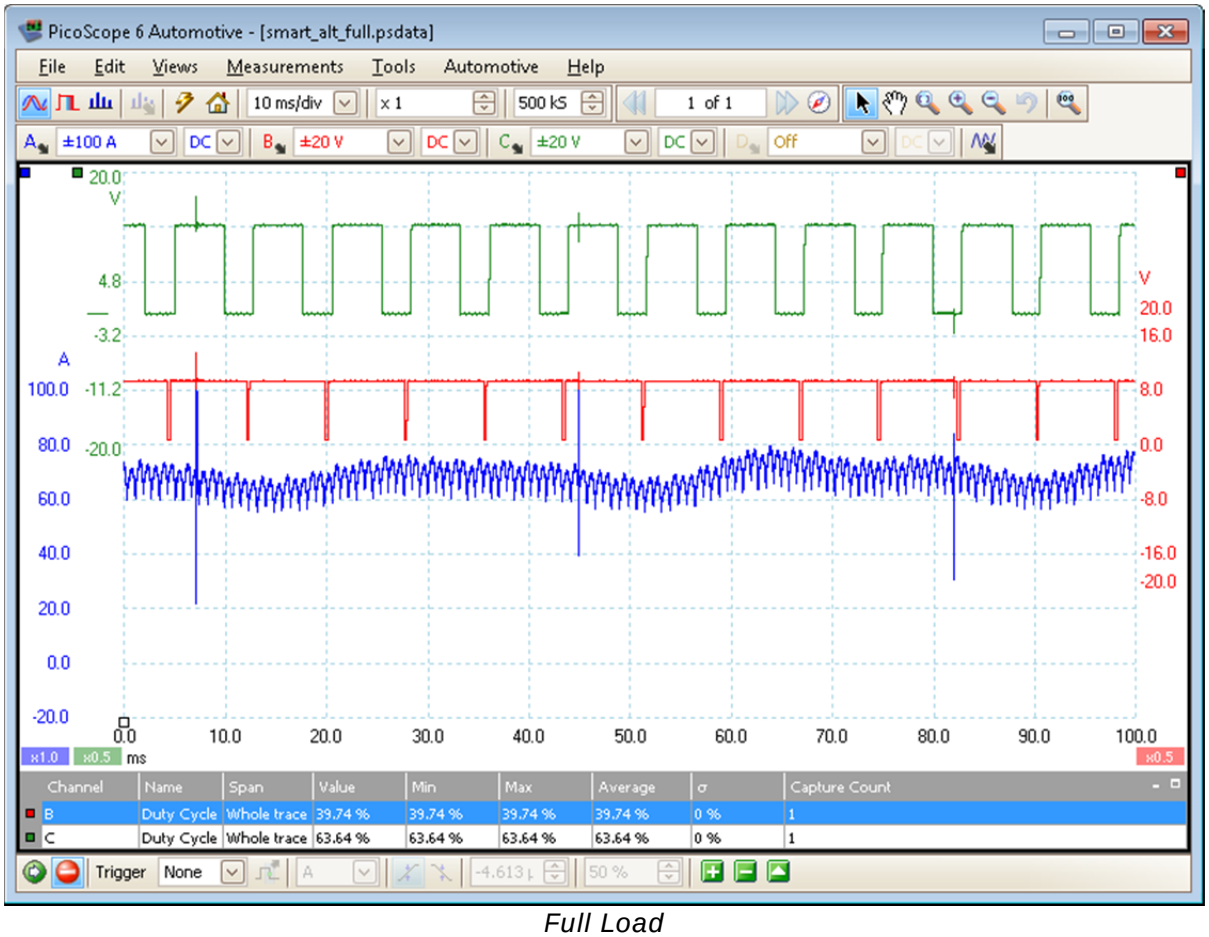


Figure 141.1 - Acupuncture probe and current clamp connections

Example Waveforms



Idle



Full Load

Waveform Notes

Channel A - alternator current output

It is very important that the clamp is placed on the positive cable from the alternator to the battery. If the clamp is placed on the battery negative, for example, it will show just the balance between the current generated by the alternator and any current consumed by electrical loads. In this case the current reading may not change greatly when additional loads are placed on the system.

In our no-load state the alternator is changing at approximately 14 amps. When we turn on the loads—heated screen, main beam headlights and full speed heater blower—the output current increases to approximately 70 amps.

Channel B - feedback (or monitor) from alternator

This signal is fed back to the engine Electronic Control Module (ECM) and remains a constant square wave or pulse-width-modulated signal. The duty cycle of the signal changes as the output of the alternator increases.

Channel C - load request (or command) signal to alternator

This signal comes from the ECM and changes with load demand. Again it is a square wave or pulse-width-modulated signal. In the no-load example waveform, the signal is idle as the ECM has not detected that any consumer devices are switched on other than the normal engine running. In the full-load example, the signal is active and the alternator's regulator reacts to it by increasing the field current, thus increasing the output current.

The duty cycle on the green trace (alternator feedback) remains virtually unchanged regardless of electrical demand.

Technical Information

Most manufacturers now employ an electronically controlled alternator system by using the engine's ECM, also referred to as the Powertrain Control Module (PCM), but Ford were one of the first to introduce such a system which they refer to as ‘Smart Charging’.

The concept of Smart Charging is actually fairly straightforward. A battery has the capacity to take a slightly higher-voltage charge when cold, so the ECM charges the battery at a slightly higher capacity when cold and balances the charge rate against consumer loads. The alternator works at maximum capacity only when absolutely necessary and the battery is kept in a constant and healthy state of charge. Battery temperature is estimated from the intake air temperature sensor, which is a good indication of the temperature under the hood.

Battery type warning: Ford specify a silver calcium battery for use with this system. A conventional lead-acid battery is not suitable.

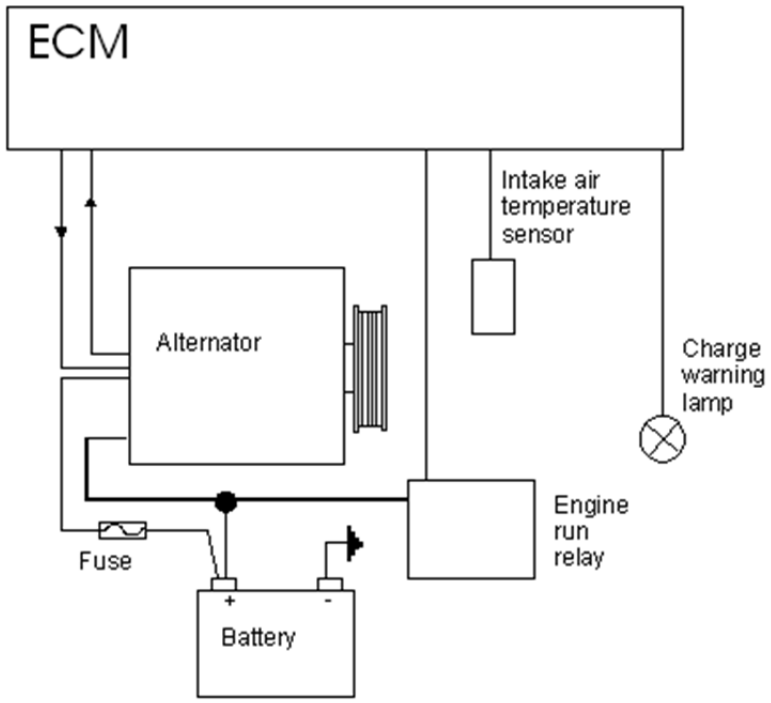


Figure 141.2 - Smart Charging circuit

Figure 141.2 illustrates the Smart Charging circuit. The connections on the three-pin multi-plug on the alternator are as follows:

- Pin 1 – alternator feedback
- Pin 2 – alternator load request
- Pin 3 – reference voltage

If the ECM does not see a feedback signal within a few seconds of operation, it activates the charge warning light on the dashboard. It is possible that the alternator will continue to charge at a default regulated voltage. If the three-pin plug is disconnected, the alternator continues to operate as a conventional alternator. It is not uncommon on some Ford models for the three-pin plug terminals to become corroded or damaged, and a repair loom is available. It is therefore necessary to check the continuity of the two ECM wires and ensure there is a battery reference voltage at pin 3 before considering whether the alternator is faulty.

To maximize the cranking current for the starter motor, the ECM does not signal for charging to start until the engine is started. The ECM may also increase the idle speed slightly if there is a high electrical demand.

Jump start warning: DO NOT jump start a vehicle with Smart Charging. The ECM will detect a low battery voltage and a low engine temperature, and generate up to 18 volts in an attempt to recharge the battery quickly. This high voltage can damage other modules in the vehicle.

Figure 141.3 - Smart Charging alternator