DYNAMO & ALTERNATOR - *B FIELD LOGIC PROBE*.

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Background:

This article describes the development and construction of a simple diagnostic tool - a self powered logic probe, to assess the voltage regulator function and the field or rotor coil drive in an automotive dynamo or alternator system.

In the early days of digital electronics it was recognised that a simple cheap tool could help a technician determine if a logic voltage level, typically at the output of some digital IC, was high, or low or, or switching between these two states at some high frequency that could not be visualised without an oscilloscope. Generally these probes had 3 LED's, one for a high voltage level (usually 5 volts), one for a low level and another which blinked on and off, at some easily visible rate, if the voltage was switching very rapidly between high and low levels. This article explains how this same basic idea can be applied to the dynamo or alternator charging system thereby creating a helpful workshop tool.

The functionality of both the dynamo and the alternator voltage regulators have been explained in the other articles on this website, relating to Alternators vs Dynamos and Electronic Replacements for the Lucas RB106.

To briefly recap, the switching of the coils (either the dynamo field winding or alternator rotor winding) across the power supply voltage controls the average coil current and therefore the B field (magnetic field). Voltage regulation is achieved because the B field controls the output voltage and the voltage regulator device controlling the coil's switching cycle is in a *negative feedback loop* with the dynamo or alternator's output voltage which is the sensed variable.

To make the *feedback loop* concept clearer, one can regard the alternator or dynamo as a device which has a current input (current to the rotor or field coil) and as a consequence a voltage output (the output from the armature or diode pack in the alternator).

Symbolically then the dynamo or alternator can be regarded as a *current to voltage converter* and the voltage output power boosted from an external power source (mechanical rotation). The mechanical power is derived from the car's engine and transformed to electrical power and delivered at some rate in Joules per seconds of power.

The dynamo or alternator system could be represented by the system diagram below. This negative feedback concept is outlined in figure 1. Basically the voltage regulator unit switches voltage across the field coil (or rotor) to create the B field. This process continues until the sensed voltage at the negative input of the comparator system exceeds the reference value, in the typical automotive application this is 14.2 volts. This switches off the voltage drive to the field coil, lowering the average field current so the unit's output voltage falls. This creates a cycle which repeats over and over so that the output voltage remains close to a stable value and varies only with a small amplitude around the reference voltage value.

In all negative feedback loops the system remains under "feedback control" only over a range (dynamic range) of dynamo or alternator output voltages and current loading. We will now refer to the alternator or dynamo as the *generator* to suggest a unit which includes both types of machine.

In other words there is a limited dynamic range of operation where the regulator is switching. For example if the rpm is too slow and the generator cannot produce 14.2 volts, the voltage regulator produces an "uncontrolled" full on voltage drive to the field coil or rotor. Likewise when the generator is overloaded (due to the finite internal resistance of the armature or stator & diodes in the alternator) the 14.2 volt output is not exceeded and therefore the voltage regulator also drives the field or rotor coil with a full on voltage. Also in fault conditions there may be no drive or continuous voltage drive to the field or rotor coil. From this we can conclude:

When the generator is working properly within a mid range rpm and with medium current loading (and therefore running within its normal dynamic range of operation) then a switching voltage should be present across the field coil or rotor coil.

Absence of the switching voltage under these circumstances therefore indicates a failure or fault condition. In addition there will reach a point with high current loads, near the generator's maximum output capacity, where the switching stops and the field coil or rotor is being driven by a continuous voltage in an attempt to maintain the specified voltage output.

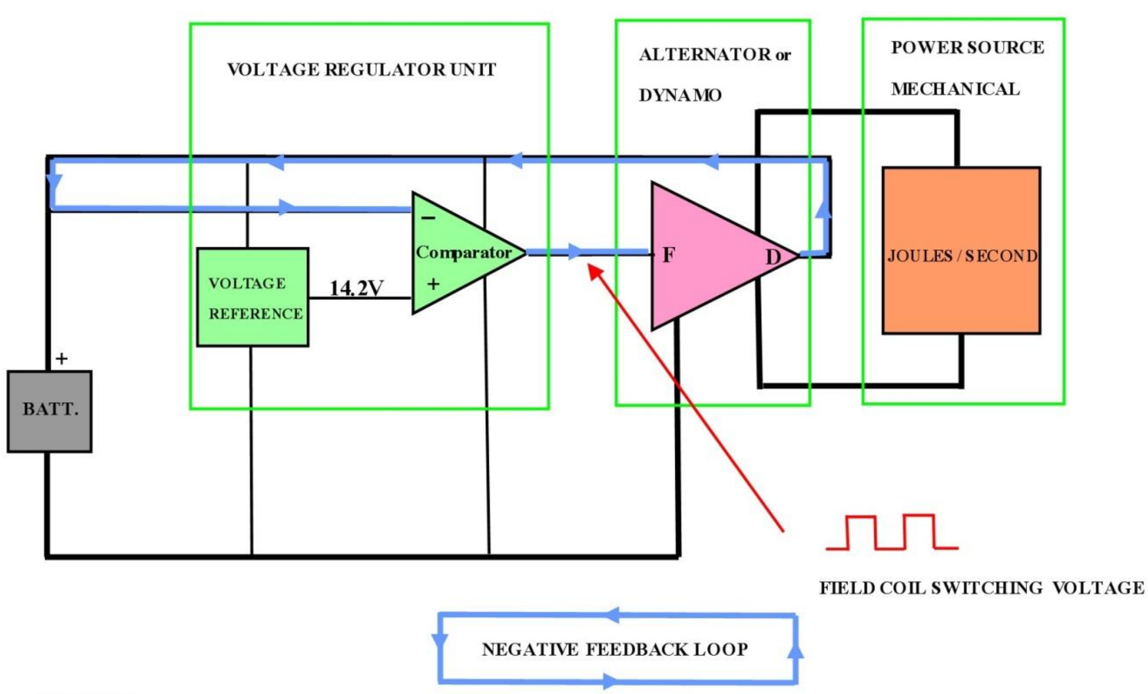


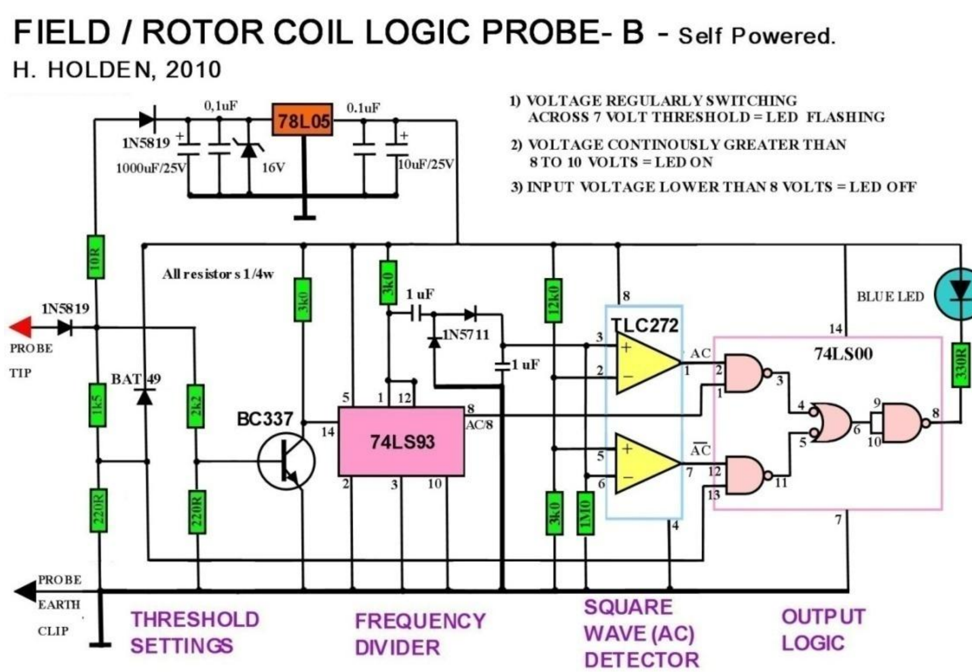
FIGURE 1.

If there is a continuos voltage present across the field coil or rotor coil (in the mid range rpm test condition say engine = 2000 rpm and modest load say headlamps on low beam) then this indicates a failure to produce adequate output due to an open circuit field coil or rotor, or shorted turns such that an inadequate B field is produced. This can be checked if required by measuring the DC resistance of the rotor or field coil with a simple Ohm meter and comparing it with the specifications or a known good unit. If this is ok then attention can be turned to the armature, commutator and brushes and cut-out contacts in the dynamo system or the rectifier pack in the alternator system. If there is low to zero voltage drive on the field coil (or rotor) then suspect the voltage regulator contacts in the conventional dynamo system or the electronic regulator in the alternator system which passes the current to this coil.

The point under a heavy load current at which the switching system stops and a continuous field (or rotor) voltage drive occurs, is indicative of the general electrical condition of the generator.

Assuming the B field has reached its maximum normal value (there is no field coil or rotor coil problem) then this point is indicative of the armature and commutator and brush condition in the dynamo and in the alternator the condition of the stator windings and rectifier pack.

FAULT FINDING A DYNAMO OR ALTERNATOR SYSTEM: The field/rotor coil connection could be monitored with a meter however this will not indicate definite switching voltages only average voltages. Also a lamp or an LED could be connected across the field or rotor coil connections, but due to the switching frequency being above 35 to 40 Hz the flicker is not easily seen due to the flicker fusion frequency of human vision. Ideally to display the switching events one would connect an oscilloscope across the field coil or alternator rotor however this can be inconvenient in the workshop and not easy for those unfamiliar with their operation. Therefore to solve this problem and have a simple workshop diagnostic tool the following “B FIELD LOGIC PROBE” made from inexpensive parts was designed:



Description of operation:

The circuit derives its power from the field (or rotor coil) drive voltage and this is regulated down to 5 volts by the 78L05 regulator. Due to the “self powering” and “two wire connection” the probe can be applied to either the dynamo or alternator field/rotor coils with the same results in negative ground cars. (It can also be applied to positive ground cars with dynamos if the clip is connected to the F connection and the probe tip to earth instead).

The input diode protects the unit from voltage transients swinging below the earth clip potential. These can occur with the electromechanical regulators. This diode also protects the unit from inadvertent reversed polarity connection. The 16V zener diode limits the input voltage should it be higher than this with voltage transients so as to protect the 78L05.

When the input voltage exceeds around 7 volts the BC337 conducts triggering the 74LS93 counter which simply contains a chain of flip flops. With a switching voltage crossing this 7 volt threshold value regularly, as it does with normal regulator switching, the 74LS93 is repeatedly toggled and its first flip flop divides the frequency in half. When the frequency is stable this produces a square wave voltage present on pin 1 & 12. If the frequency is variable there is still an alternating voltage on pin 1 & 12 albeit not a perfect square wave.

The presence of the square wave or switching voltage is detected by the AC coupled rectifier system using two 1N5711 diodes which produce close to a 4 volt DC level, provided there is output from the first flip flop. If the first flip flop stops toggling then the voltage on pin 1 &12 will either be high (near 5V) or low depending on which state this first flip flop stops in. Due to the AC coupling (via the 1uF capacitor) the state that the flip flop stops in is not important. If there is no flip flop toggling the rectified voltage decays to zero as the one Meg Ohm resistor discharges the other 1uF filter capacitor. The operational amplifiers are biased to one volt, so when switching signal is present the rectified voltage exceeds this value and pin 1 of the TLC272 is high (5V) and pin 7 is low near 0 volts. This situation reverses if there is no flip flop toggling and no switching signal.

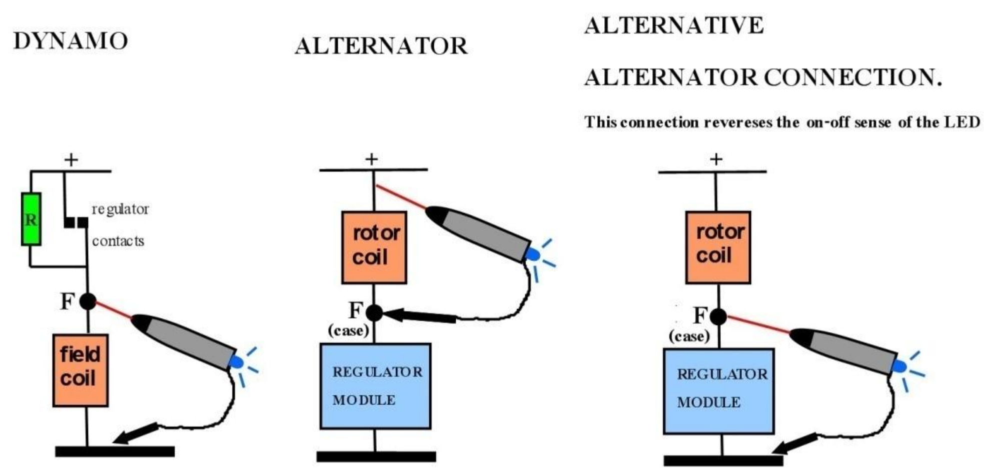
As a result pin 2 of the 74LS00 remains high with a switching signal present and this allows another signal AC/8 to be gated through via pin 1 of the 74LS00 and to drive the blue LED via the negated Or gate system causing the LED to flash. (Note that a NAND gate is equivalent to an OR gate with negated or inverted inputs- De Morgan’s Theorem). This LED flashing signal represents the output from two other flip flops in the 74LS93 and is the probe’s input frequency (or the field coil’s switching frequency) divided by 8. Therefore if the field coil’s switching frequency is 40Hz the LED will be flashing at 5 Hz which is very easy to see visually.

In addition, if ever required, an AC/16 (or 1/16th the input frequency) is available on pin 11 of the 74LS93 in lieu of the AC/8 connection in the case of an extremely rapidly switching alternator rotor drive so as to divide the rate by 16, but it will unlikely be required.

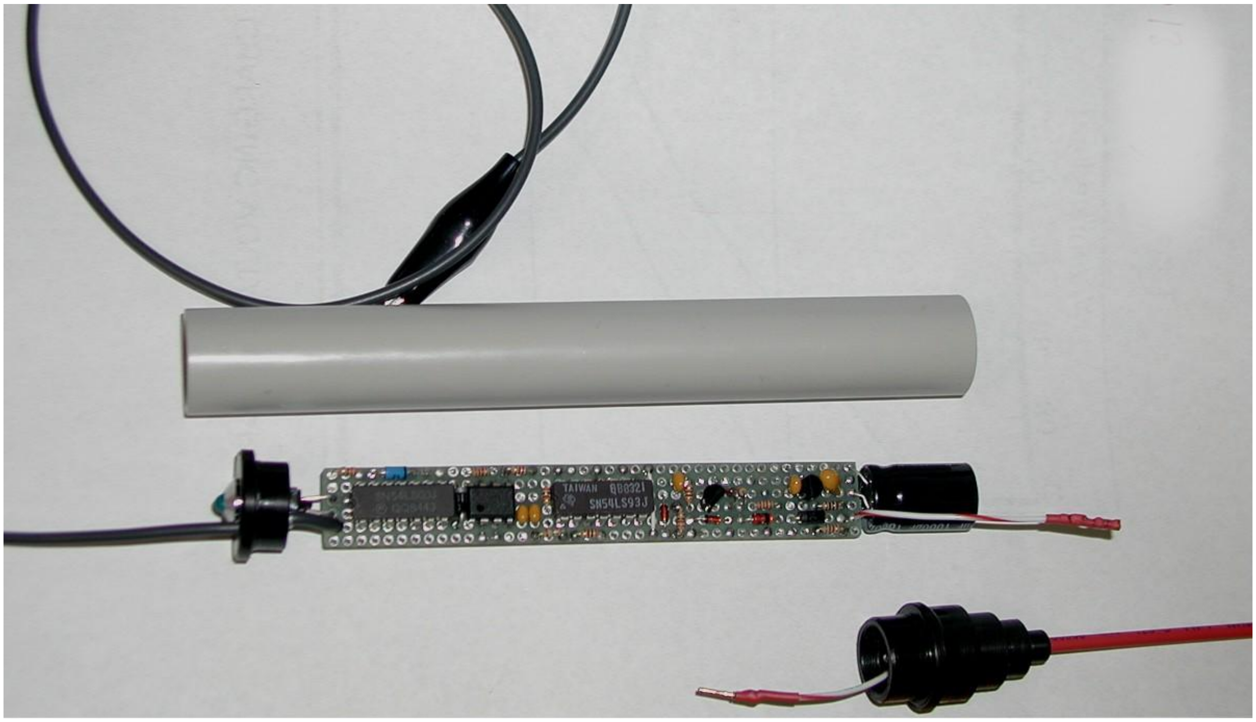
If there is no switching detected, then pin 7 of the TLC272 is high and pin 1 low. This blocks the AC/8 signal on pin 8 of the 74LS93. This is required because the output flip flop on this pin could have stopped in a high or low state. The high on pin 12 of the 74LS00 now allows the scaled down input voltage from the probe tip applied to pin 13 to pass via the OR gate system to the LED. The voltage is scaled by the 1k5 and 220 ohm resistors so that the LED will light if the input voltage is over 8 to 10 volts which indicates if the field coil in the dynamo is driven by a continuos "on" voltage.

The Lucas dynamo field coil is pulled towards and to the positive supply voltage by the contacts in the regulator unit. However in the case of most alternator systems the regulator output stage pulls the rotor coil connection towards and to earth (negative). Therefore using this probe with the ground clip connected to the car's ground, the switching function detection won't be affected, however the LED function for continuous voltage will be reversed, in that the LED will be illuminated with a low voltage across the field coil and will extinguish with a continuous voltage applied to the coil. This is shown below.This connection might be handy as the thin probe tip may possibly pass through a vent hole in the alternator rear casing to connect to the regulator body which is the F connection, for example with the 14TR and 19TR Lucas regulators.

USING THE B FIELD LOGIC PROBE:



The photos below show the prototype probe. The first photo shows the inside of the prototype unit:



The photo below shows the end view looking at the blue LED:

The final photo shows a completed probe:

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