



FORENSIC FACTS

Volume 1, June 2008

A Newsletter published by Renaissance Engineering

The Non-Reliable Voltage Tester

Trained electricians and maintenance workers have been using non-contact voltage testers, also known as tick tracers, for many years. It became apparent when Renaissance Engineering was requested to investigate an electrical flashover incident that these devices can actually represent a hazard to the user.

Accident Scenario

An electrician was working in a three phase 480 volt box in which he was preparing to replace a breaker. He used a Greenlee non-contact voltage tester to determine that the wiring was still energized on the line side of the breakers. The electrician was requested to install a replacement breaker. When trying to install the replacement, he found that the spades for the breaker were bent. He placed a channel lock, with insulated handles, across the spades to bring them together. When he did this the channel lock created a phase to phase short that erupted in a ball of electrical energy injuring him. The electrician's tools, including his tester, were thrown which broke the plastic tip off of his tester.

Evaluation of Causation

Evaluation of the Greenlee detector which the electrician was using, and the evaluation of exemplars, revealed the following.

The basic operating mechanism of the non-contact voltage detector is that an antenna is placed in proximity to a continuous electromagnetic field. The field induces a voltage on the antenna that is fed into an electronic circuit that activates a light emitting diode and a buzzer.

The induced voltage level must be above a certain minimum, usually about 3 volts, for the detector to activate.

The electromagnetic field strength is dependent upon the current flowing in the wire, and the electrostatic field strength is dependent upon the voltage level.

A number of tests were conducted with the electrician's detector and exemplars from Greenlee and Ideal Manufacturing. The exemplar Greenlee was tested with and without the plastic tip cover.

Initially it was found that all of the testers were responding to electrostatic charge. They would light and beep when shaken in the air and

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even when still in their packages. All of them would respond, by visual and audio output, to a hand rub along the plastic to the tip. When tested on panel boards the testers with plastic covers had less response than those without. A tester without a plastic tip would pick up voltage on more breakers and locations along a panel board than one with the plastic tip. Some erratic operations were found in these tests in which a location would not indicate on the first test but would on a second test at a later time.

Without exception all of the testers exhibited the same operation in one of the panel board tests. In this test a three phase 240 volt panel with in use and unused breaker positions was tested. All of the testers, when touched to the wire connection points at the breakers gave a positive indication at the A and B phases and no indication at the C phase. When the tester was moved out on the wire for C phase connected to the breaker a positive indication would occur.

On the breakers without any wiring connected to them the A and B phases would indicate and the C phase would not.

By way of explanation, the tester requires a minimum induced voltage from a continuous

electromagnetic field to give a positive indication. If the field is negated or given a near null value by fields in proximity then the tester will not give a positive indication even though the line is energized. Close proximity of balanced three phase lines will tend to negate the overall field effect. So too will the crossing or proximity of the two legs of a 240 volt single phase line. What is shown by the tests is that the tester can give a non reading of an energized line due to wiring configuration and current.

This inherent flaw in these testers is not addressed in the papers which come with the Ideal and what appears to be a contradictory statement regarding electromagnetic fields is given in the Greenlee instructions. The **IMPORTANT** statement in the instructions reads:

Using this unit near equipment that generates electromagnetic interference can result in unstable or inaccurate readings. All electromagnetic fields can be classified

as interference including those generated by any energized wire. This is the exact principle upon which the device is designed to work, the

recognition of an electromagnetic field. The negating or minimizing of



Accident Greenlee NCVD on the left, Exemplar IDEAL NCVD on the right.

electromagnetic fields is not something novel or unheard of. Rather, it is well known in the electrical and electronic industries, and the study of Electromagnetic Compatibility is a field of its own. Field negation is recognized in the electrical

TOOLS OF THE TRADE

This issue's featured tool is the borescope. A borescope is a device used for inspection of small objects that are not viewable by the naked eye due to their location or position in a confined space more than due to their size. Renaissance Engineering uses a Machida 0.075 fiberoptic borescope for inspection of many items including throttle cables and various valves. A borescope's fiberoptic lead has a core that transmits the image to an HDV camera and a concentric ring that transmits light to the item being inspected. Borescopes are very useful and often uncover evidence that would otherwise go unnoticed.

part of manufacturers should have taken this effect into consideration, and should have been found in their testing of the device prior to placing it on the market. At the very least a warning to the effect of testing at breaker panels should be done on wiring

contracting

industry by the fact that a three phase line is never separated when placed in duct work. One would never place two phases in one duct and the third in another as the electromagnetic field will cause extreme heating of a metal duct. When phases are run together the overall field effect is canceled by the individual phase field s interaction. Electromagnetic fields and how they interact have been studied and recorded for over a hundred years. Sound and prudent engineering on the

away from the breaker connection points for accuracy of reading should have been given. Greenlee, based upon their **IMPORTANT** note did determine this flaw in their device but chose not to **warn** the user.

IMPORTANT

Using this unit near equipment that generates electromagnetic interference can result in unstable or inaccurate readings.

The Toyota Prius Efficiency, but at what cost?

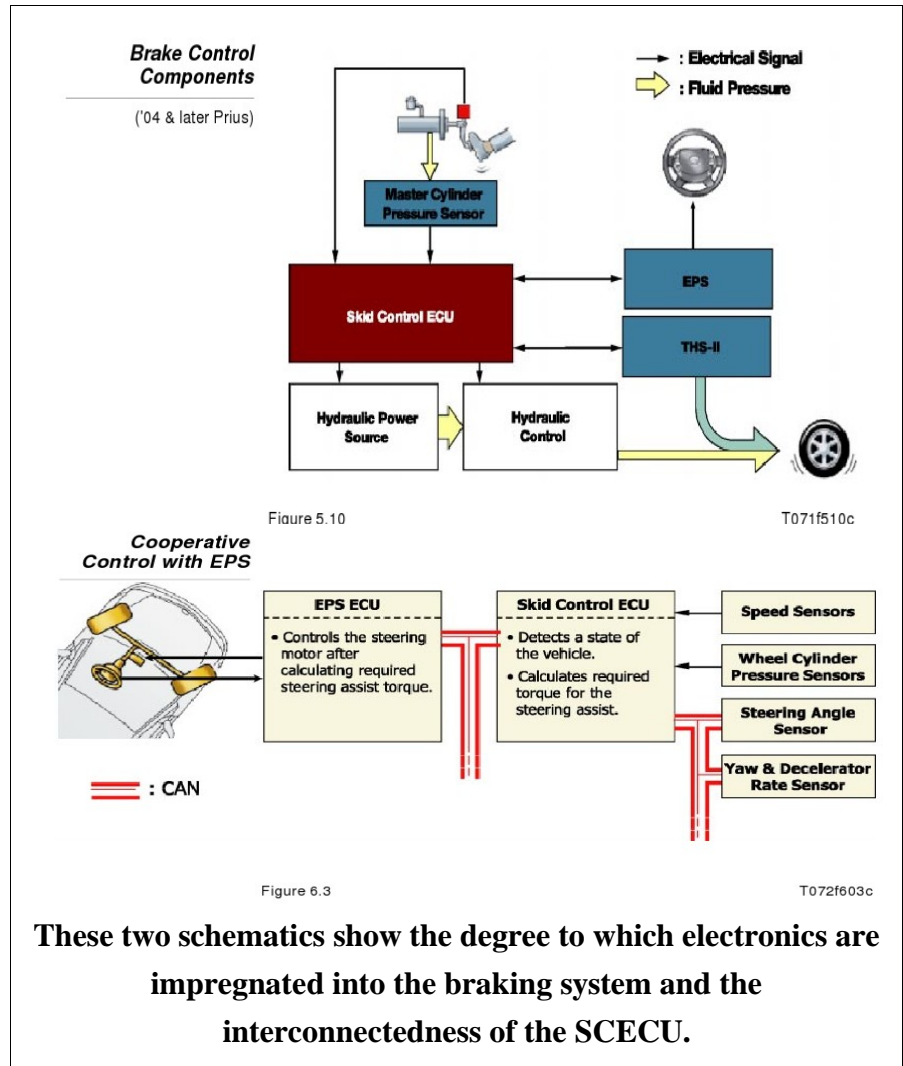
The Toyota Prius has been a revolutionary force in the advancement of automotive fuel economy and efficiency. The Prius is equipped with advanced technological equipment ranging from its Hybrid Synergy Drive to safety features to occupant comfort and convenience. Unfortunately, due to vast electronic complexity the Prius is just as susceptible, if not more so, to sudden acceleration events, loss of stability, and other electronic failures as most other non-hybrid vehicles.

Multiple ECUs are used in the Prius, which control everything from throttle, steering, and braking operation to the stereo and Bluetooth feature in the vehicle. From a safety standpoint, arguably the most crucial of these control units in the vehicle under the direct control of the SCECU include conventional brake control, the Anti-lock braking system, the Electronic Brake Force Distribution system, the Brake Assist system, the Vehicle Stability Control system, and the

Regenerative brake cooperative control. The SCECU receives input from the brake stroke sensor, which is an electronic sensor attached to the brake pedal. The SCECU reviews several factors relating to the vehicles instantaneous conditions including velocity, yaw rate, deceleration, and steering angle and then activates the Brake Actuator to control the hydraulic braking system. The input from the brake stroke sensor is also used to coordinate with the hybrid synergy drive to determine the amount of regenerative braking needed to slow the vehicle. In theory, the hydraulic brakes are used only for low speed stopping maneuvers.

Other factors affecting the SCECU's activation of the Brake Actuator include the Anti-lock brake system, Brake Assist, Enhanced Vehicle Stability Control, and the Electronic Brakeforce Distribution systems. The anti-lock brake system compares the rotational speeds of all four wheels and modulates brake fluid pressure to each wheel individually to prevent wheel lockup. The Enhanced Vehicle Stability Control system alters brake application, throttle input, and steering angle (since all three are electronically actuated and/or assisted on the Prius) to maintain a safe, conservative path of travel. The Brake Assist system applies up to 100% brake application upon sensing an emergency stop; it accomplishes this by

measuring how quickly the brake pedal is applied. The Electronic Brakeforce Distribution system reduces the amount of braking function provided to the wheels with the least amount of grip. Typically the EBD system would decrease the amount of braking function to the rear wheels under heavy deceleration to avoid wheel lockup



since weight transfers to the front axle under braking.

One must look at the fact that one control unit is responsible for so many absolutely vital safety systems with a very critical eye. Since there is no direct mechanical connection between the driver's foot and the hydraulic braking system,

Toyota has placed the ECU in complete control of the braking function of the vehicle. Renaissance Engineering has evaluated a case where a 2006 Prius was traveling down a slight grade when the driver attempted to slow the vehicle. Upon brake application, braking function was severely diminished, and the driver depressed the brake pedal with as much force as she could muster. The vehicle's two rear wheels left skidmarks 150' in length before the vehicle impacted a curb, house, and tree. With so many systems in place to prevent wheel lockup and correct it if it does occur, one must wonder what defect was in place to allow wheel lockup for such a considerable distance. Since this case was discontinued shortly after our research was completed, an exact failure mode was never determined. Possible avenues of research would include Electromagnetic Interference as well as software glitches. Pedal misapplication in this case can be conclusively ruled out, due to an excellent Human Factors design of the pedals including dimensional offsets and force feedback profiles. If one or more functions of the SCECU are compromised, what other undesirable complications can arise and how will the vehicle and the driver handle it? Is the defect in question going to degrade further over time causing more severe faults more often? Additionally, throttle and steering control and assist are governed by similar ECUs, are they susceptible to malfunction as well?

