Electrical and Electronic Troubleshooting for Industrial Engines

Beyond the Troubleshooting Guide

Basics, The “Power Survey”

- Required tooling, a “good” quality Digital Multi-Meter (DMM)
- Should read AC and DC Volts to the millivolt level
- Should be able to read frequency
- Should be able to read digital signals, like PWM/duty cycle

Basics, The “Power Survey”

- The Fluke 87 is pretty much the standard, but not the only meter with the needed features

Basics, The “Power Survey”

Measurement Point	Notes	POS to NEG Volts DC	POS to GND Volts DC	NEG to GND Volts DC	POS to NEG Volts AC	POS to NEG AC Hz
At the battery terminals	1					
At the starter terminals	1					
At the power circuit breaker	1					
At the ECM power input	1					
At the remote control panel*	1					
At the battery terminals	2					
At the starter terminals	2					
At the battery terminals	3					
At the starter terminals	3					
At the power circuit breaker	3					
At the ECM power input	3					
At the remote control panel*	3					
Notes						
1, engine off powered up in STOP						
2, engine cranking						
3, engine running						

Basics, The “Power Survey”

- Measure DC Volts, why 3 readings????
- Measuring between POS to GND and NEG to GND helps identify possible ground loops or grounding/bonding issues
- Measure AC Volts, why?
- AC noise or ripple can affect operation of electronics, ideally less than 125 mV of AC should be present, stopped or running
- Measure AC Frequency, why?
- Helps determine the source of the AC voltage on the DC power lines

Basics, The “Power Survey”

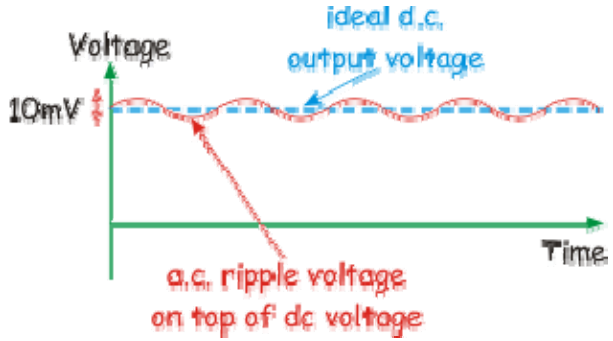
- Verify battery power for electric start machines
- Ideally on 24VDC systems, battery voltage to the starter should not drop more than 2 VDC, and power to the controls should not drop more than 6 VDC.
- Verify battery power for air start machines
- No starter draw to worry about, but solenoids for fuel gas, prelube air and start air can have high inrush currents, and problems can affect controls during start.

Basics, The “Power Survey”

- Why recheck when running?
- Ignition systems can be a source of noise, and on systems with marginal power supplies, may draw too much current when fully loaded.
- Drivers for actuators may also induce noise on electrical system, and mis-operating components can affect the DC power
- If equipped with an alternator, may induce ripple or noise on the DC power system.

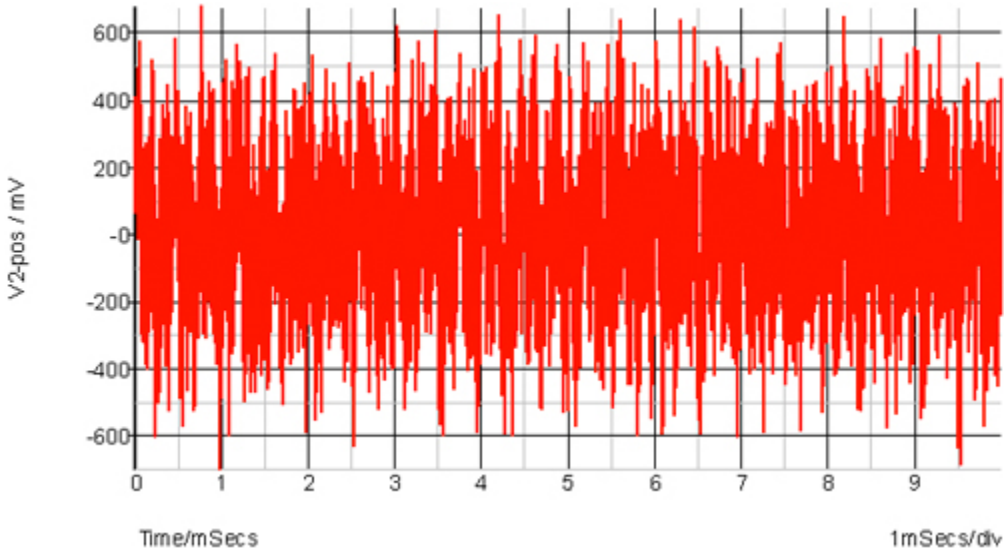
Basics, The “Power Survey”

- What is the difference between “ripple” and “noise”
- The most common **meaning** of **ripple** in **electrical** science is the small unwanted residual periodic variation of the direct current (DC) output of a power supply which has been derived from an alternating current (AC) source. This **ripple** is due to incomplete suppression of the alternating waveform within the power supply.



Basics, The “Power Survey”

Electrical Noise has random patterns, varying and overlaid frequencies, and varying magnitudes



Basics, The “Power Survey”

- Causes of RIPPLE
- Ripple is usually the result of rectifying an AC power source to provide DC, battery chargers, alternators and power supplies are the most common culprits
- Causes of NOISE
- Noise is usually reflected or “induced” onto the DC power system, by either “inductive” or “capacitive” coupling. On our engines the ignition systems are the biggest noise generators, but some other components in a failure mode, like a pressure or timing sensor can also generate noise.

Basics, The “Power Survey”

- A proper power survey hardly ever gets done, even at commissioning, but you will find it can help determine the root cause or recurring or intermittent problems
- Especially important to do if there have been multiple repairs and multiple components affected
- Questions?????

Beyond the BOOK

- Sometimes the troubleshooting guide just doesn't get you there, so before you start throwing parts at it,
- Define the problem, what is the failure mode?
- Does the frequency of the failure get shorter as time goes on?
- It the failure frequency affected by ambient or load conditions?
- When did the problem start, after a service, repair, rainstorm, etc?

Beyond the BOOK

- Connections-connections problems account for most problems in electrical and electronic control systems
- Deutsch and Amphenol connectors, conditions of pins and sockets, strain reliefs, general condition
- Screw type terminal blocks, on engine are ferrules used?
- Cage clamp type terminal blocks, are they matched to the correct size and type of wire?
- Wire support and routing, are connections being pulled or moved in service?

Beyond the BOOK

- Some tools the book doesn't tell you to use,
- A "test" load, I use a 24vdc 100watt lamp, it will pull about 4 amps, there is no wiring on any of our engines that should be able to supply 4 amps without a measurable voltage drop.
- A "megger", I know we are NOT talking generators here, but a megger is an insulation resistance test meter, and allows you to stress test the wiring, especially in harnesses to see if shorts or grounds exist.
- A DMM with MIN/MAX record function, sometimes you can't see it while you standing there, a good DMM with MIN/MAX recording can capture signals you might miss.

Beyond the BOOK

- When to drag out an O-Scope
- This is a tool that when properly used can really save a lot of time.
- Especially needed if you are dealing with digital signals, like PWM or a hall effect speed sensor.
- Will capture noise and/or ripple that your DMM may not.
- A 2 channel scope is best for most situations, more complex troubleshooting a 4 channel scope may be better.
- Use with the software to record and document your testing.

Beyond the BOOK

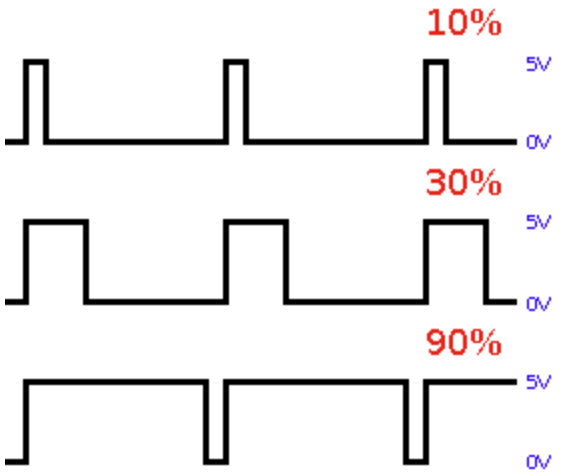
- What is the difference between “digital” and “analog”?

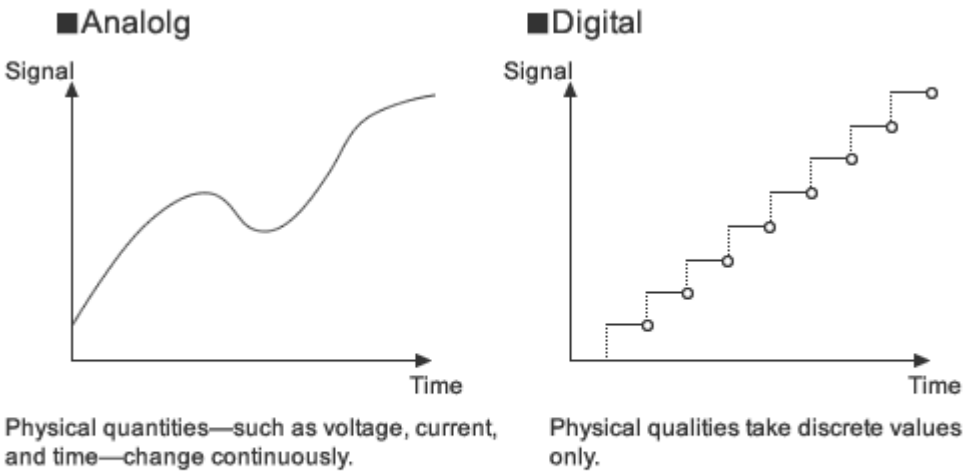
Beyond the BOOK

- What is the difference between “digital” and “analog”?
- DIGITAL, basically, turns ON and OFF, when viewed on a scope has a square wave pattern
- ANALOG, a variable signal, usually infinitely variable or may be a stepped signal, usually proportional but can be algorithmic as well

Beyond the BOOK

Example of a PWM signal at three different duty cycles





- An analog circuit operates on continuous signals.
- A digital circuit operates on discrete (discontinuous) signals.

Beyond the BOOK

- Analog signals that an O-Scope can help troubleshoot
- Detonation sensors, best to use a 2 channel scope and trigger off the cylinder firing signal.
- Critical pressure sensors like air/fuel pressure modules.
- Speed pickups, 2 wire MPU's (Magnetic PickUps)
- Remote signals like desired speed or BTU setting when using 4-20mA type signals
- Ignition coils, the current signature of a coil on the primary side can help determine coil function

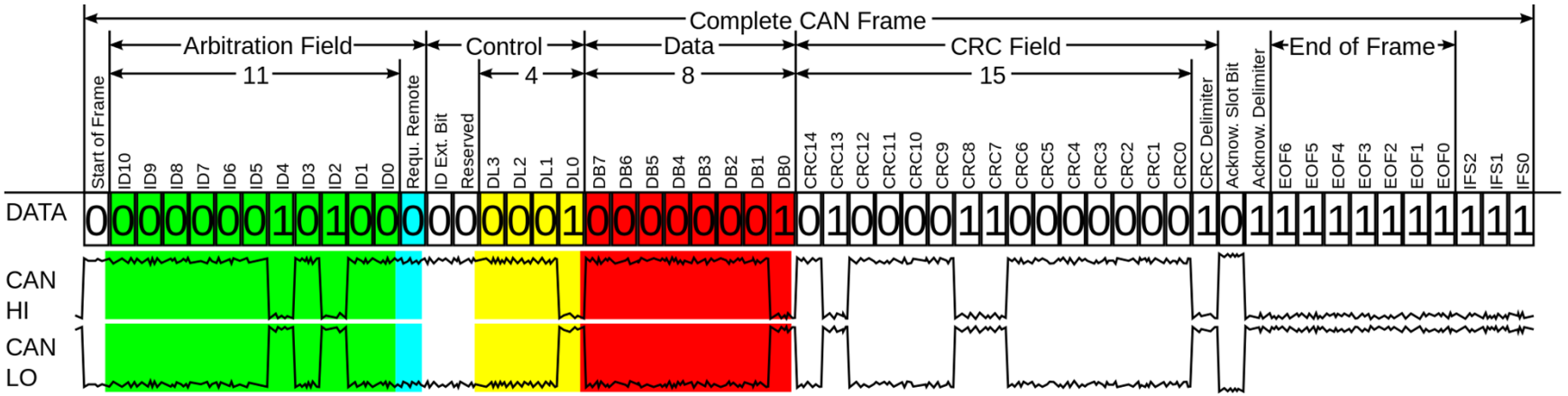
Beyond the BOOK

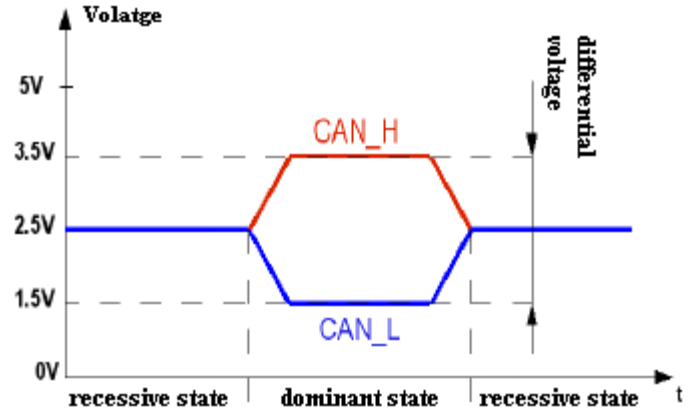
- Digital Signals that an O-Scope can help troubleshoot
- Hall effect speed sensors
- PWM signals, from both sensors and control input signals
- Speed timing sensors
- Communication signals, like CANBUS (J1939) CAT, Data Link and Modbus

Beyond the BOOK

- Communications Troubleshooting
- OK, you have a fault code for bad comms, you have followed the troubleshooting guide and the time used and the bill is high. Where do you go from here?
- Handout was prepared by the machine guys, no literature number, some folks at CAT not happy about telling techs to use a scope.
- A lot of good CANBUS literature on the web, still not easy to figure out.

Beyond the BOOK





Beyond the BOOK

- What it means to you,
- An experienced technician can read a CAN message with a scope if he has the right documentation
- We need to focus on the physical layer of the message.
- Are the waveforms sharp and clean?
- Does the High and Low voltage magnitudes match?
- Do the differential voltage magnitudes change over time?
- Is there noise on the signal?
- Are the leading and trailing edges of the signals sharp and well defined?

Beyond the BOOK

- Some additional resources for CANBUS
- http://www.esd-electronics-usa.com/CAN-Bus-Troubleshooting-Guide.html
- http://e38.org/bussystem.pdf
- http://support.fluke.com/find-sales/download/asset/2392165_6003_eng_a_w.pdf
- http://canbusacademy.com/can-bus-troubleshooting-pdf-sheet/
- https://www.fwmurphy.com/uploaded/canbus-wiring.pdf

  (this is a quick summary of testing a CANBUS loop with a DMM, great resource)

Questions or Comments?

- Thank you for your time and participation!