Solving Gnarly Intermittents

Techniques and Strategies for Duplicating, Catching and Solving Intermittent Electrical Issues

DiagNation

Got a Tough One Wiggin You OUT?

Get Your Wig On…

Intermittent Customer Complaints

- Most flat rate technicians cringe when they get a repair order describing an intermittent condition.
- Intermittents are the most frustrating type of automotive repair scenario for both the shop AND the customer.
- It is important to acknowledge the frustration between parties - and communicate to build a “team approach” to solving the issue.

Diag Nation

← 3 →

Most flat rate technicians cringe when they get a repair order describing an intermittent condition. The intermittent can be elusive, frustrating and time-consuming to figure out.

Intermittents are the most frustrating type of automotive repair scenario for both the shop AND the customer.

It is important to acknowledge the frustration between parties - and communicate to build a “team approach” to solving the issue.

Intermittent Customer Complaints

- Any condition the customer identifies as intermittent needs to be discussed and researched in DETAIL by the service advisor, tech and vehicle owner as a team, or time and money will be wasted.
- The faster and more accurately we can nail an intermittent complaint, the better (And less expensive) for all.
- Your success in capturing intermittents comes down to preparation, research and ***FORETHOUGHT*** on how to prepare the vehicle, your equipment and your testing strategy.

Diag Nation

← 4 →

Any condition the customer identifies as intermittent needs to be discussed and researched in DETAIL by the service advisor, or time and money will be wasted.

The faster and more accurately we can nail an intermittent complaint, the better (And less expensive) for all.

Your success in capturing intermittents comes down to preparation, research and ***FORETHOUGHT*** on how to prepare the vehicle, your equipment and your testing strategy.
This strategy varies depending on condition. The successful tech will gather information, study common links and apply physical testing to catch and confirm intermittent concerns.

Causes of Most Intermittent Conditions:

- Many customer complaints today are of an intermittent nature.
- ***This is due to many variables, not the least of which:***
- Voltage Supply or Grounding Issues
- Software Problems
- Hardware Problems
- Wiring and Corrosion Issues
- Component Failure Potential
- Communication and Data Bus Issues
- Customer Confusion or Lack of Knowledge on Vehicle Systems

Diag Nation

5

Many customer complaints today are of an intermittent nature.
This is due to many variables, not the least of which:
Voltage Supply or Grounding Issues
Software Problems
Hardware Problems
Wiring and Corrosion Issues
Component Failure Potential
Communication and Data Bus Issues
Customer Confusion or Lack of Knowledge on Vehicle Systems

Intermittents and Software Issues:

- **Software glitches and programming problems:** There are ***Millions of*** lines of code to run all the modules in an average car.
- There are an estimated ***<u>100 Million + lines of code</u>*** in total to run all systems in a new S-Class Mercedes-Benz.
- These layered “stack” type systems can exhibit the same condition as when your laptop just stops running a program and the computer “hangs” or freezes”.
- Most modern controllers are designed to automatically reboot when this occurs.
- Out of millions of lines of code, ONE single digit errantly programmed above or below a set threshold will set DTCs or cause lack of function in an output command.
- ***Never discount software as the source of the problem***, ***especially*** if physical testing bears no apparent failure in the wiring or components.

Diag Nation

← 6 →

Software glitches and programming problems: There are ***Millions of*** lines of code to run all the modules in an average car.
There are an estimated ***<u>100 Million + lines of code</u>*** in total to run all systems in the new S-Class Mercedes Benz.
These systems exhibit the same condition as when your laptop just stops running a program and the computer “hangs” or freezes”.
Most modern controllers are designed to automatically reboot when this occurs.
Out of millions of lines of code, ONE single digit errantly programmed above or below a set threshold will set DTCs or cause lack of function in an output command.
Never discount software as the source of the problem, ***especially*** if physical testing bears no apparent failure in the wiring or components.

Intermittents and Hardware Issues:

- **Hardware Problems:** Today's processors are far more complex and have MANY more IC chips, resistors, drivers (MOSFET, TTL) and capacitors as compared to even 10 years ago.
- **The result of an EPA directive to remove *__all lead solder__*** from vehicle controllers has led to using tin solder and other alloys on the boards. This substance is far more brittle and cracks, causing "tin fingers" that leach across the circuit board, creating errant pathways for electricity to flow through the wrong circuit.

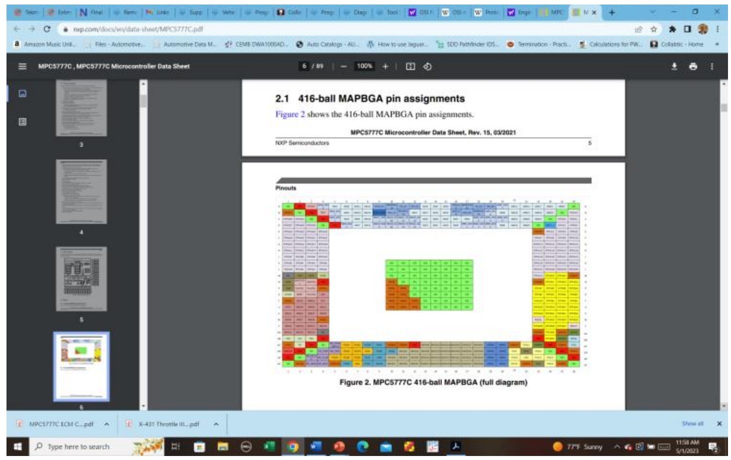
- **NOTE: Many "hardware" devices in cars today contain CAN Nodes within the part itself, such as seat and window switches, AC control heads, throttle motors, fuel pump modules and many other "simple" components.**
- **These are computers, not just parts, *and should be treated as such* in the diagnostic process.**

DiagNation

7

Hardware Problems: Today's processors are far more complex and have MANY more IC chips, resistors, drivers (MOSFET, TTL) and capacitors as compared to even 5 years ago.
The result of an EPA directive to remove *__all lead solder__* from vehicle controllers has led to using tin solder on the boards. This substance is far more brittle and cracks, causing "tin fingers" that track across the circuit board, creating errant pathways for electricity to flow through the wrong circuit.
NOTE: Many "hardware" devices in cars today contain CAN Nodes within the part itself, such as seat and window switches, AC control heads, throttle motors, fuel pump modules and many other "simple" components.
These are computers, not just parts, and should be treated as such in the diagnostic process.

Any Chance of Board Problems Here???



Diag Nation

← 8 →

Look at the IC PCB “Mounting Pad for this automotive control chip. Realizing that there are often SEVERAL of these contained in one module, it becomes easy to understand that our hardware is far more susceptible to ghost faults, glitches, capacitive and inductive interference and general PCB board issues. Downloading and studying data sheets will up your diagnostic game in a big way. This is the information that even the OEM field engineers don’t have. And knowing or researching these chip characteristics has helped us to solve MANY intermittent issues.

Customer Handout on Intermittents

- Create a flyer for your shop that outlines why intermittents may be tough to solve and explain how tracking the problem down works.
- Advise the customer in this flyer that to solve the problem may require patience and possibly more than one visit.
- Describe the technical complexity involved and try to create a “we are all in this together” atmosphere with the document.
- Also, make sure to include some wording that describes how important DETAILED information from the driver is when they bring the vehicle in.
- Use this document to create REALISTIC expectations between the shop and the customer when dealing with intermittents. We are not magicians!

Diag Nation

Create a flyer for your shop that outlines why intermittents may be tough to solve, and explain how tracking the problem down works.
Advise the customer in this flyer that to solve the problem may require patience and possibly more than one visit.
Describe the technical complexity involved, and try to create a “we are all in this together” atmosphere with the document.
Also, make sure to include some wording that describes how important DETAILED information from the driver is when they bring the vehicle in.
Use this document to create REALISTIC expectations between the shop and the customer when dealing with intermittents. We are not magicians!

Customer Interview:

- If you are going to have a shot at duplicating an intermittent concern, ESPECIALLY an “Electrical Gremlin”, ***<u>you had better start</u>*** with a thorough interview with the DRIVER of the vehicle.
- **Drill down on the issue, ask valuable questions:**
- Hot or Cold?
- Highway speeds, or at traffic lights?
- Left turns, or right? Over bumps?
- Exactly WHAT is occurring, and when?
- Can you help me to understand HOW to get this problem to occur?

Diag Nation

← 10 →

If you are going to have a shot at duplicating an intermittent concern, ESPECIALLY an “Electrical Gremlin”, ***<u>you had better start</u>*** with a thorough interview with the DRIVER of the vehicle.
Drill down on the issue, ask valuable questions:
Hot or Cold?
Highway speeds, or at traffic lights?
Left turns, or right? Over bumps?
Exactly WHAT is occurring, and when?
Can you help me to understand HOW to get this problem to occur?

Customer Interview Continued

- Some shops have great success using questionnaires for customers with intermittent concerns.
- Asking the customer to write out the problem on the questionnaire FOCUSES the customer on accurately describing the conditions that can be used to reproduce the problem.
- Drivability Questionnaire
- NVH (Noise, Vibration, Harshness) Questionnaire
- Specific System Questionnaire (AC System, Body System, etc…)

Diag Nation

Some shops have great success using questionnaires for customers with intermittent concerns.
Asking the customer to write out the problem on the questionnaire FOCUSES the customer on accurately describing the conditions that can be used to reproduce the problem.
Drivability Questionnaire
NVH (Noise, Vibration, Harshness) Questionnaire
Specific System Questionnaire (AC System, Body System, etc…)

Resources for Information

- AllData, Mitchells, MotoLogic, Identifix
- Factory TSBs and Recalls
- Set Enable Criteria
- Circuit Description and Operation Section
- Wiring Schematic of the Circuit(s)
- Call DiagNation's Remote assistance Support Line
- Google Search on the Problem
- YouTube Videos

DiagNation

Resources for Information
AllData, Mitchells, MotoLogic, Identifix
Factory TSBs and Recalls
Set Enable Criteria
Circuit Description and Operation Section
Wiring Schematic of the Circuit(s)
Call in Tech Help or Remote assistance Support Line (ME!)
Google Search on the Problem

PPP Method for Diagnostics:

Preparation Prevents **Pain**

Preparation Prevents Pain (PPP) Methodology

- Many techs that work the flat rate system try to use a shotgun diagnostic approach to the problem. We have all been guilty of this…
- If we do not use a controlled approach to duplicating, diagnosing and finally solving an intermittent condition, we will likely waste valuable time testing in circles.
- Taking the time to look at information first on the system or circuit is key in nailing the problem quickly.
- Taking the time to set the vehicle up for testing, duplication, scanning or scope capture BEFORE the first road test is a MUST, or you ARE wasting time.

Diag Nation

← 14 →

Many techs that work the flat rate system try to use a shotgun diagnostic approach to the problem. We have all been guilty of this…
If we do not use a controlled approach to duplicating, diagnosing and finally solving an intermittent condition, we will likely waste valuable time testing in circles.
Taking the time to look at information first on the system or circuit is key in nailing the problem quickly.
Taking the time to set the vehicle up for testing, duplication, scanning or scope capture BEFORE the first road test is a MUST, or you ARE wasting time.

PPP Procedures:

- Look up TSBs related to the complaint. This is <u>**CRITICAL**</u> with intermittents – MANY of these issues are solved with software updates.
- Hook up scanner and pull all DTCs (Before starting car…) **DO NOT CLEAR THE CODES YET!**
- Look for any Freeze-Frame or Fail Records stored. These can contain HUGE clues to help you to duplicate the condition.
- Set up for scanner snapshot before your first road test.
- Set up your scope if needed.
- If DTC related, be sure to take the time to print Set Enable Criteria, schematics or DTC charts to use as info during diagnosis.

Diag Nation

← 15 →

Look up TSBs related to the complaint. This is <u>**CRITICAL**</u> with intermittents – MANY of these issues are solved with software updates. (Re-flashing, Reprogramming via J-2534)

Hook up scanner and pull all DTCs (Before starting car…) **DO NOT CLEAR THE CODES YET!**

Look for any Freeze-Frame or Fail Records stored. These can contain HUGE clues to help you to duplicate the condition.

Set up for scanner snapshot before your first road test.

Set up your scope if needed.

If DTC related, be sure to take the time to print Set Enable Criteria, schematics or DTC charts to use as info during diagnosis.

Diag Nation

Beware of

The IWISHI…

The Great Time Waster!

The Iwishi…

The IWISHI… The Great Time Waster!

- IWISHI had the schematic with me…
- IWISHI had my scanner in the car right now…
- IWISHI knew how this code sets…
- IWISHI ate my Wheaties this morning…
- IWISHI had looked up TSBs…
- IWISHI had brought that jumper wire with me…
- IWISHI hooked up that fuel pressure gage…
- **IWISHI… Turned more flat rate hours… see the connection?**

Diag Nation

We have all done it, probably many times over our careers as techs… The dreaded Iwishi… Sometimes, some forethought and a few minutes setting up right in the beginning can make the difference between a waste of time or making quick work of the problem.

Tech's Best Friend for Intermittent Capture

- Which tool that we use do you think would be the Tech's best friend for intermittent capture:
- Scan tool… (Only really if the car is coding)
- DVOM…
- Test Light…

- LAB SCOPE
- A lab scope is the most versatile tool out there for capturing electrical intermittents of ANY kind. Period.

Diag Nation

18

Because lab scopes allow us to physically measure voltage, amperage and pressure, we can watch signal, power and ground activity on the circuit and monitor the signal's behavior. The lab scope is really nothing more than a "Visual Voltmeter". To be able to observe and measure any circuit this way allows us to run the system into duplication and record the failure definitively. The lab scope is the best friend of a tech chasing an intermittent condition.

Why Use a Lab Scope?

- Multi-channel scopes allow us to hook up to multiple circuits at once to monitor different circuits during the duplication of the problem.
- Lab Scopes allow us to watch a suspect circuit or device's BEHAVIOR, which is critical to see when trying to capture an intermittent.
- Interpreting circuit BEHAVIOR can cut hours off diagnostic time.
- Most techs pin out just the signal return circuit when looking for a problem, or the feedback circuit.
- A better strategy is to pin out ALL the wires on the sensor, motor, relay or device you are testing.

Diag Nation

Multi-channel scopes allow us to hook up to multiple circuits at once to monitor different circuits during the duplication of the problem.
Lab Scopes allow us to watch a suspect circuit or device's BEHAVIOR, which is critical to see when trying to capture an intermittent.
Interpreting circuit BEHAVIOR can cut hours off diagnostic time.
Most techs pin out just the signal return circuit when looking for a problem, or the feedback circuit.
A better strategy is to pin out ALL the wires on the sensor, motor, relay or device you are testing.

Duplication Techniques

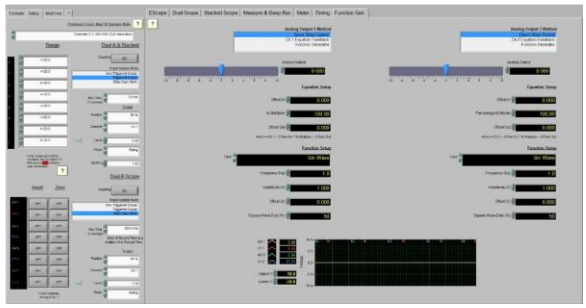
- Techniques we can use to simulate conditions on a circuit, motor, sensor, device or component are ***only limited by our lack of thinking***, experiments and willingness to create or engineer a solution.
- Tools used to induce an intermittent are often creative, or just re-purposed:
- Heat Gun
- Choke Gun or Cold Air Gun (Venturi Gun)
- Spray Bottle
- Replacement Loads: Headlamp, Motor, Etc…
- Signal Generator

Diag Nation

← 20 →

Techniques we can use to simulate conditions on a circuit, motor, sensor, device or component are ***only limited by our lack of thinking***, experiments and willingness to create or engineer a solution.
Tools used to induce an intermittent are often creative, or just re-purposed:
Heat Gun
Choke Gun or Cold Air Gun (Venturi Gun)
Spray Bottle
Replacement Loads: Headlamp, Motor, Etc…
Signal Generator

Tools of Trickery…



Diag Nation

When it comes to tracking and solving intermittents, whether mechanical or electrical (And often these are inter-related) The technician is only limited to his own ability to create a test strategy to capture the condition. He or she is limited only by his imagination and creativity to re-purpose, create, duplicate environments and use un-conventional tools and thought to “trick” or even force the vehicle into acting up WHILE we have it in front of us.

Circuit Monitoring Techniques

- Sometimes it is helpful to watch both voltage behavior AND amperage behavior together at the same time while diagnosing an intermittent.
- Being able to see what is happening with the current can help us to isolate a bad component quickly or identify a wiring or connection issue.
- Since current, resistance and voltage are ***inextricably*** related via Ohm's Law, we can make use of these measurements to ***narrow our focus*** to a corroded wire or bad component quickly and accurately.

Diag Nation

It is almost always helpful to watch both voltage behavior AND amperage behavior together at the same time while diagnosing an intermittent.
Being able to see what is happening with the current can help us to isolate a bad component quickly or identify a wiring or connection issue.
Since current, resistance and voltage are ***inextricably*** related via Ohm's Law, we can make use of these measurements to ***narrow our focus*** to a corroded wire or bad component quickly and accurately. If we use a combination of current, supply voltage and voltage drop, we can see the entire picture as we duplicate the fault.

Rules of Thumb

- **In a Typical Automotive Circuit…**

- When the voltage stays the same in the circuit:
- ***Current goes up*** as resistance ***goes down.***
- ***Current goes down*** as resistance ***goes up***.

- Loose or corroded connections increase resistance, causing low current.
- Shorted loads (or wires) decrease resistance, causing high current.

DiagNation

In a Typical Automotive Circuit…

When the voltage stays the same in the circuit:
Current goes up as resistance ***goes down.***
Current goes down as resistance ***goes up***.

Loose or corroded connections increase resistance, causing low current.
Shorted loads (or wires) decrease resistance, causing high current.

Good ‘Ol Trusty OHM’s LAW…

- Ohms Law forms the basis for understanding electricity flow and electrical system characteristics, whether a simple circuit, or deep inside the computer itself.
- Ohm’s Law is a basic building block for electronics and computer engineers, so to understand how to use it in diagnostics is key to being accurate and not wasting time testing in circles.

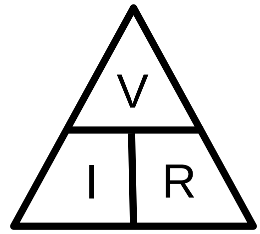
- Ohm’s Law states: V (Voltage) = I (Current) X R (Resistance)
- We can use this Law to provide direction in diagnosis.
- It is a GOOD PRACTICE to memorize and apply Ohm’s Law.

Diag Nation

Ohms Law forms the basis for understanding electricity flow and electrical system characteristics, whether a simple circuit, or deep inside the computer itself.
Ohm’s Law is a basic building block for electronics and computer engineers, so to understand how to use it in diagnostics is key to being accurate and not wasting time testing in circles.
Ohm’s Law states: V (Voltage) = I (Current) X R (Resistance)
We can use this Law to provide direction in diagnosis. By doing this we can often avoid unnecessary testing by letting the circuit tell us what is wrong.
It is a GOOD PRACTICE to memorize and apply Ohm’s Law in your daily diagnostics.

Ohm’s Law Triangle:

- To solve for any unknown in the equation:
- Cover what you want to solve for with your finger
- Perform the math on the remaining data



- Math done above and below the horizontal line is by **DIVISION**
- Math done to the right and left of vertical line is by **MULTIPLICATION**

Diag Nation

To solve for any unknown in the equation:
Cover what you want to solve for with your finger
Perform the math on the remaining data

Math done above and below the horizontal line is by **DIVISION**
Math done to the right and left of vertical line is by **MULTIPLICATION**
Example: What is amperage in the circuit? **12 Volts divided by 5.2 Ohms = 2.3 Amps**
Example: What is voltage in the circuit? **3.3 Amps X 4.2 Ohms = 13.86 Volts**
Example: What is resistance in the circuit? **13.86 Volts divided by 1.7 Amps = 8.15 Ohms**

Example:

- A **normally operating 12V circuit** with the load drawing a current of 3.5A = Circuit Operating Resistance of ***3.43 Ohms***.
- Anything ***EXCEEDING 3.43 Ohms*** in the circuit is *UNWANTED* Resistance. This could be in the load itself, or in the wiring.
- Anything ***UNDER 3.43 ohms*** in the circuit may be a partially or fully shorted or worn load - or wire.

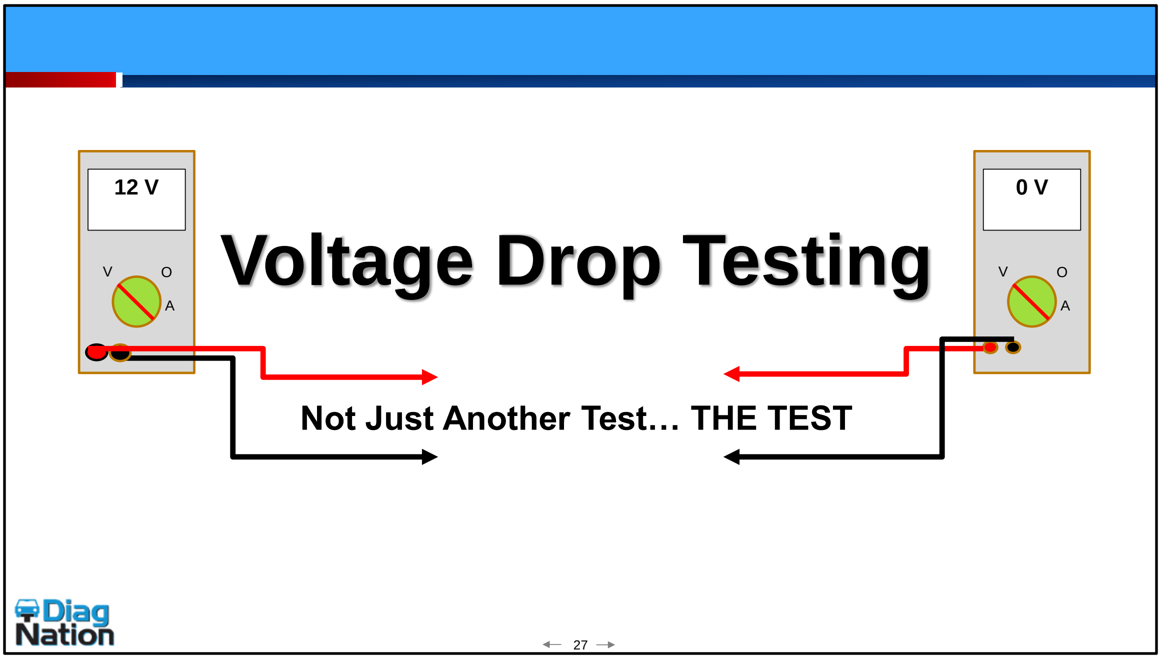
Diag Nation

26

A **normally operating circuit** with 12V with load drawing a current of 3.5A = Circuit Operating Resistance of 3.43 Ohms.

Anything **EXCEEDING** 3.43 Ohms in the circuit is UNWANTED Resistance. This could be in the load itself, or in the wiring.

Anything **UNDER** 3.43 ohms in the circuit may be a shorted or worn load - or wire.



Voltage Drop Testing

Voltage Drop Testing

- Voltage drop is probably the most under-used diagnostic technique, and yet it is the most powerful or isolating a problem in a circuit that runs a load.
- Continuity testing can be deceiving, because if we check a wire and the Ohmmeter "beeps" and displays 0.1 Ohms, we are ASSUMING that the wire or circuit is ok... But is it?
- What if we had a 12 strand wire, and 11 strands were broken?
- The Ohmmeter would still beep, and ***<u>would still show no resistance issues</u>*** at 0.1 Ohm.
- The problem is, that wire can no longer carry **CURRENT**, and the load will not run.
- In addition, the circuit AND load will now begin to heat up.

DiagNation

← 28 →

Voltage drop is probably the most under-used diagnostic technique, and yet it is the most powerful or isolating a problem in a circuit that runs a load.
Continuity testing can be deceiving, because if we check a wire and the Ohmmeter "beeps" and displays 0.1 Ohms, we are ASSUMING that the wire or circuit is ok... But is it?
What if we had a 12-strand wire, and 11 strands were broken?
The Ohmmeter would still beep and ***<u>would still show no resistance issues</u>*** at 0.1 Ohm.
The problem is, that wire can no longer carry ***CURRENT***, and the load will not run.
In addition, the circuit (wire) and load will now begin to heat up.

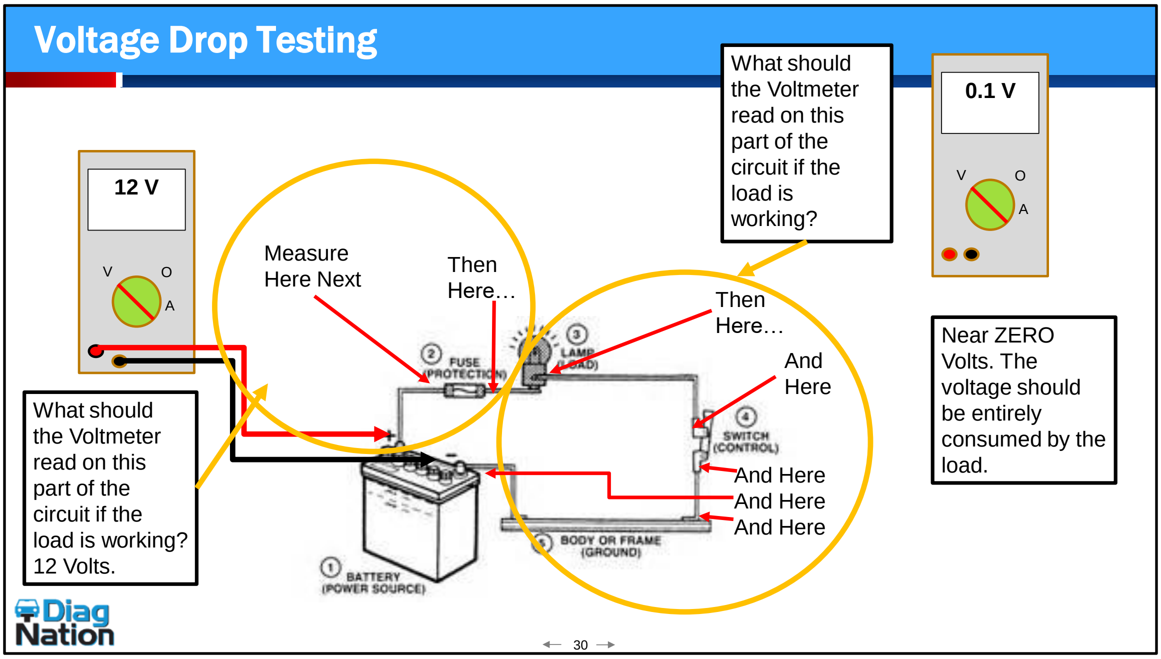
Voltage Drop Testing

- There are 2 main methods to perform voltage drop testing.
- One method involves chasing the circuit at each circuit break and across the load from positive to ground in the circuit
- The other method splits the system at the load, and the meter leads are reversed to test the ground side of the circuit.
- As long as you are measuring and interpreting correctly, either method or a combination of both is fine.
- Any circuit being voltage dropped ***must have current flowing*** and the load must be applied.

Diag Nation

← 29 →

There are 2 main methods to perform voltage drop testing.
One method involves chasing the circuit at each circuit break and across the load from positive to ground in the circuit
The other method splits the system at the load, and the meter leads are reversed to test the ground side of the circuit.
As long as you are measuring and interpreting correctly, either method or a combination of both is fine.
Any circuit being voltage dropped must have current flowing and the load must be applied.



Graphic showing test path for typical voltage drop test.

Voltage Drop Rules of Thumb:

- All Gages of Wiring or Battery Cables: 0.2v or 200mv
- Relays and Switches: 0.3v or 300mv
- Connectors: 0.0v or 0.0mv (No Drop)
- Ground Drop: 0.1v or 100mv
- TOTAL CIRCUIT DROP ALLOWABLE: 0.6 Volts
- The Rule of Thumb is that any given circuit can get in trouble with anything exceeding a .5V drop.

DiagNation

Voltage Drop Rules of Thumb:

All Gages of Wiring or Battery Cables: 0.2v or 200mv

Relays and Switches: 0.3v or 300mv

Connectors: 0.0v or 0.0mv (No Drop)

Ground Drop: 0.1v or 100mv

TOTAL CIRCUIT DROP ALLOWABLE: 0.6 Volts

The Rule of Thumb is that any given circuit can get in trouble with anything exceeding a .5V drop.

An Advanced example

DC H-Bridge Automotive Motor and Solenoid Driver Chip with ***Integrated*** MOSFET Drivers

Throttle Motors and other Inductive Loads Driven by Chipsets

- How many times have we replaced that ETM more than once to find it still intermittently defaults?
- In an ***OVERWHELMING*** number of cases, voltage supply, pin tension, bad grounds or corrosion in connectors is the cause of this.
- Many times, an intense intermittent ghost diagnostic can be avoided if we focus on what the logic doesn't like.
- ***Sometimes we have to research things the OEM will not publish.***

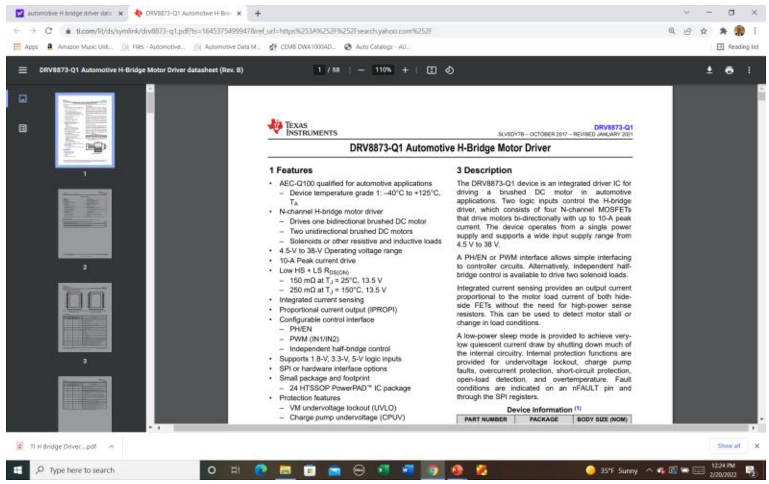
- The answer, therefore, can almost ALWAYS be isolated by studying the data and ***electrical BEHAVIOR*** on input or output circuits, which can be analyzed with a scope waveform.

Diag Nation

How many times have we replaced that ETM more than once to find it still intermittently defaults?
In an OVERWHELMING number of cases, voltage supply, pin tension, bad grounds or corrosion in connectors is the cause of this.
Many times, an intense intermittent ghost diagnostic can be avoided if we focus on what the logic doesn't like.
Sometimes we have to research things the OEM will not publish.

The answer, therefore, can almost ALWAYS be isolated by studying the data and ***electrical BEHAVIOR*** on input or output circuits, which can be analyzed with a scope waveform.

Data Sheets Provide Golden Nuggets of Unobtanium Information



34

A Data Sheet for any modulized control chip can provide diagnostic clues the OEM doesn't provide in schematics or service information. Specifically, voltage, current and other chip specifications can be extremely helpful, for example, reading the protection features for the chip clearly explains trigger parameters and logic responses to these problems. Many Integrated Automotive control chips (Integrated meaning drivers built into the chip itself) that drive inductive loads will have robust chip protection schemes for situations where the driver can be destroyed by the "loss of inductive control" within the circuit.

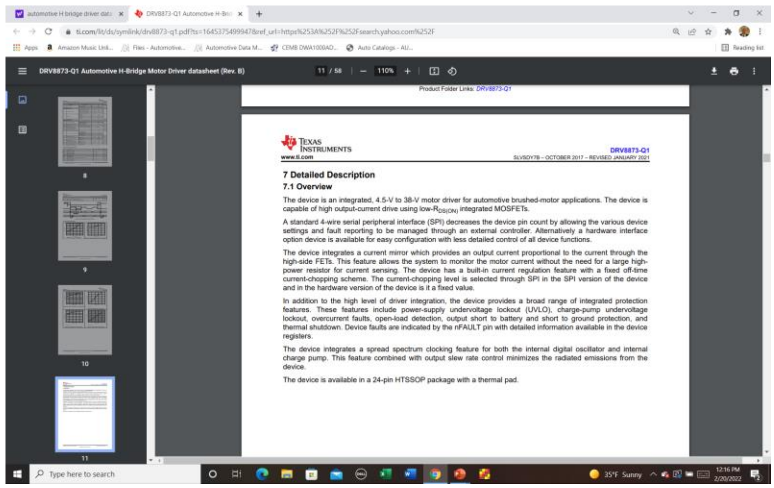
As a rule of thumb, most ALL of these control chips' data sheets will describe in detail what the chip will do when a fault occurs.

Almost every one calls out 4 common things that cause chip resets:

(1) Undervoltage Condition: (Causes UVLO Lock out, this is where the throttle no longer works, for example)
(2) Undercurrent Condition: (Same, default lockout)
(3) Overvoltage Condition: (Same, default lockout)
(4) Overcurrent Condition: (Same, default lockout)

This behavior can often clearly explain the driver's description of the problem. (Starts right up when towed in!)

Data Sheet “Detailed Description” The How and the Why

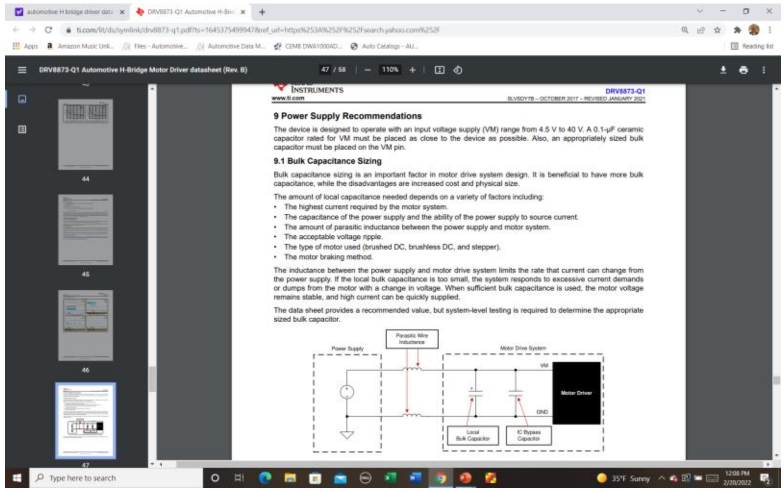


Diag Nation

← 35 →

The detailed description here is a great example of those protection statements and provide valuable information to understanding “Ghost” complaints. The “Detailed Description” section lays out the theory of operation, the explanation of what the chip does. The subsequent information provides all critical operating characteristics, protection defaults and specs.

Data Sheet Lays Out Circuit Configuration and Theory



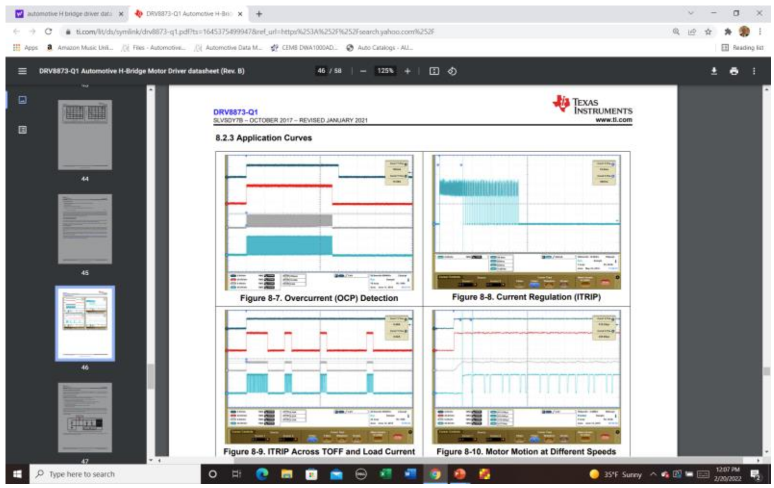
Diag Nation

36

Here we can see the importance of understanding the ***SIGNATURES*** of certain components, such as the capacitors seen in this TI Chipset Data Sheet.

If we look at our real-world case study, there is gold in the understanding of this particular ***SIGNATURE***. In many cases, being able to interpret the physical signatures of electrical behavior allows the technician to (A) "See" the problem where it would otherwise be missed, and (B) interpret whether the fault is external to the wiring, or internal logic-style electrical behavior.
The example here would be identifying a capacitive discharge signature of the output waveform.

Data Sheets Show Scope Shots of Expected Performance



← 37 →

A data sheet will also (typically) provide expected performance and scope waveforms to show key points of performance at these fault trigger points and show typical operating characteristics.

In many cases, research on this level can provide understanding of the circuit theory and function, as well as the fault conditions and module behaviors.

IC Chip Reset Criteria for Driving Inductive Output Loads

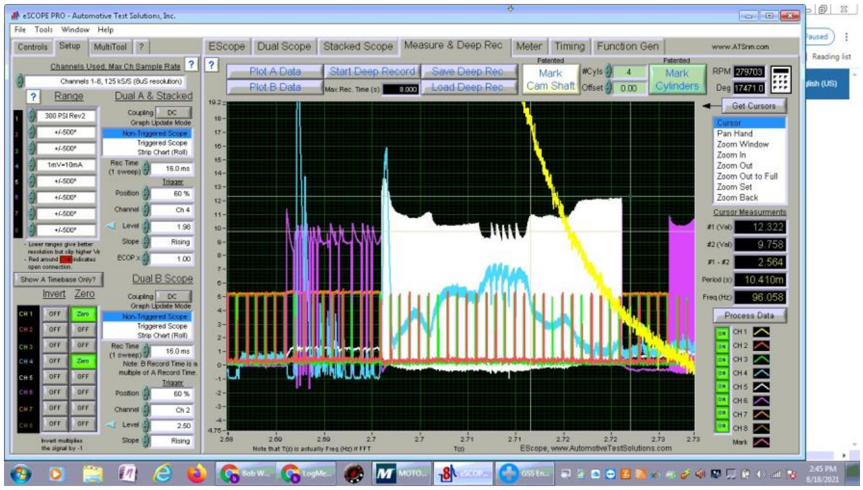
- Data Sheets provide the critical information NOT stated in OEM service information.
- These are clues as to the expected behavior in the chip in certain conditions.
- These provide HUGE clues for tracking down and even understanding the nature of your intermittent fault.
- The main 4 chip resets occur DUE TO THE FOLLOWING:
- **UVLO (Under Voltage Lock Out)**
- **UCLO (Under Current Lock Out)**
- **OVLO (Over Voltage Lockout)**
- **OCLO (Over Current Lock Out)**

Diag Nation

38

Data Sheets provide the critical information NOT stated in OEM service information.
These are clues as to the expected behavior in the chip in certain conditions.
These provide HUGE clues for tracking down and even understanding the nature of your intermittent fault.
The main 4 chip resets occur DUE TO THE FOLLOWING:
UVLO (Under Voltage Lock Out)
UCLO (Under Current Lock Out)
OVLO (Over Voltage Lockout)
OCLO (Over Current Lock Out)
NOTE: Each chip will state the automatic reset parameters, these (if you are aware) can be proven during the fault.

Chip Reset Sequence Caught on the Scope – BMW Fuel Pump



Diag Nation

← 39 →

Here is a shot of a vehicle having a major control problem with voltage (In WHITE) and the reaction of the control chip when this motor was shorting. The (BLUE) trace is set up to view current LEAKAGE, (Not level), which can be detected in the white voltage overlay. As the motor heats up and shorts, we can see the reaction in the voltage, as well as the chip trying to cycle the fault. The next page shows what the chip does during this reset. Remember, that current should be right around ZERO during this test, as the current clamp is around all the power wires for the motor. According to KCL, the algebraic sum of all currents into and out of a node should equal ZERO. When measuring this way, the BLUE trace you see rise up on the white is the motor showing its short (leakage) which quickly throws this BMW into a TIZZY.

Diag Nation

Using the Lab Scope as a Gnarly Intermittent Capture Tool

Let the Scope do the Work for You!

Let the Scope Do It All For You At Once:

- Multiple channels monitored at different points in the circuit.
- Use math channels and alarms to monitor for the fault as you drive or wiggle.
- Characterizing or modeling your circuit when NOT faulting provides “Spec-less” setup to catch the fault.
- The ability to store this data is awesome for intermittents.

Diag Nation

← 41 →

Let the scope do the work for you!

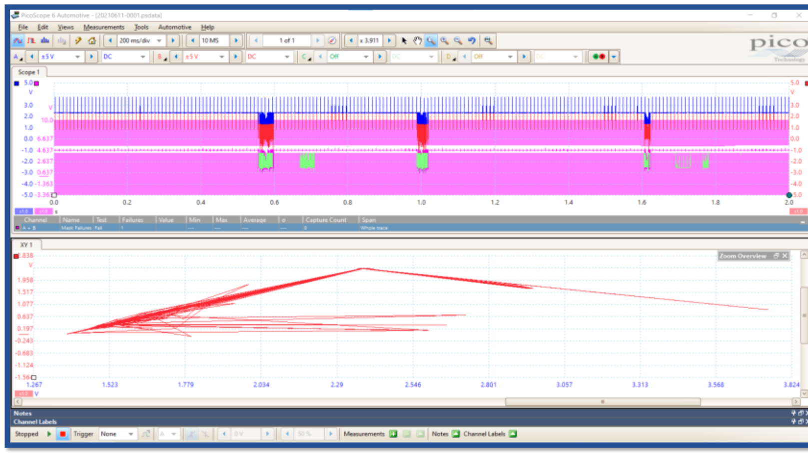
Multiple channels monitored at different points in the circuit.

Use math channels and alarms to monitor for the fault as you drive or wiggle.

Characterizing or modeling your circuit when NOT faulting provides “Spec-less” setup to catch the fault.

The ability to store this data is awesome for intermittents.

Mask, Alarm, Math Channel & XY View All Together



Mask, Alarm, Math Channel & XY View All Together

Mask, Alarm, Math Channel & XY View All Together

Diag Nation

← 43 →

Now, we are using some imagination. We are looking at an **XY view of a high-speed CAN-C network that has an intermittent open in CAN-C low**. We are utilizing several different advanced features of PicoScope at the same time. We are using a combination of **masks**, **alarms**, **scope** and **XY view**. This CAN failure would not be a good candidate for serial decoding because it is a short to ground that we have.

We can easily see the breaking of the mask in several locations on this screen. One of the benefits of this style of testing is that we can now zoom in on one of those events and see exactly what happened to our CAN-C network. The top screen capture represents a deep zoom magnification of one of the failure areas of our mask. By using the measurement **rulers**, we can see that the **CAN-C negative channel B**, in **RED**, is reaching almost exactly to a full ground while **channel A CAN-C positive** in **BLUE**, is only going down to 1.4 volts. Therefore, we can see that it is our **CAN-C negative** that is shorting to ground. Because high-speed CAN-C runs a parallel resistance of 60 ohms between the two wires when channel B shorted to ground, it also pulled down channel A, but not as far.

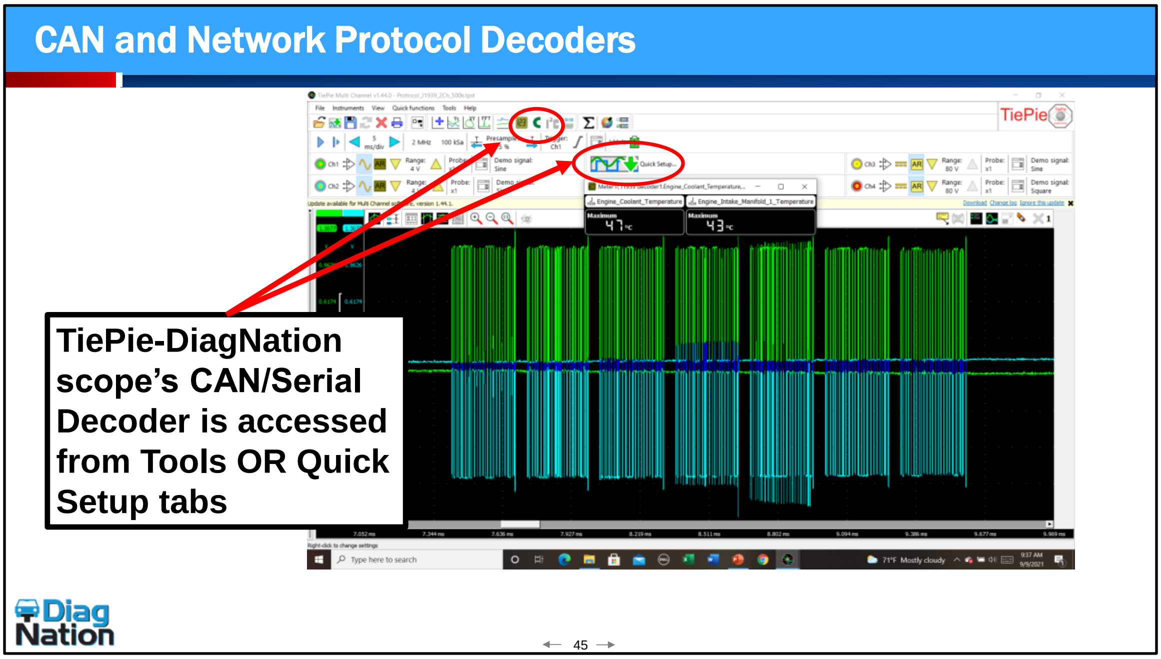
Advanced Lab Scope Functions Section.

Slide is of the new, TiePie Engineering-DiagNation 250mHz Automotive scope with 1G/S Sampling Rate.

Wifi Scope, no wires to the computer!

Add 4 scope modules, make 8, 12, 16 channels and manage them on the same screen.

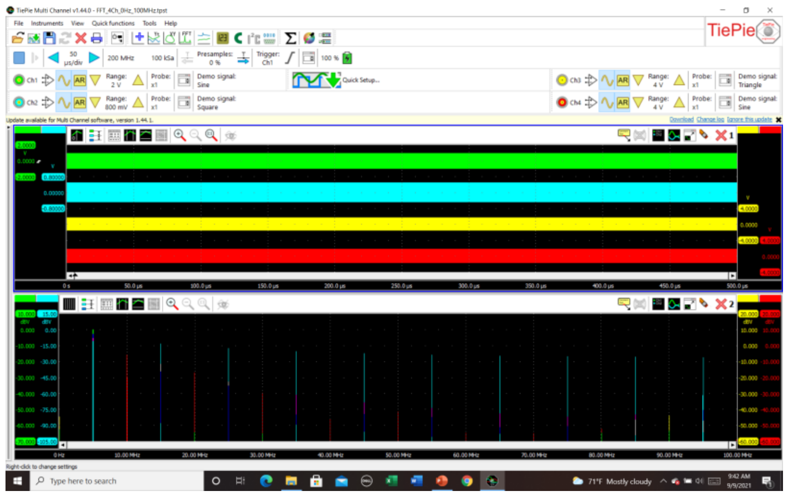
See the details at: https://diagnation.com/product/automotive-diagnostics-kit-adk610004dw/



Pico, TiePie and several others offer dedicated Comms Protocol Analyzers. These are GREAT tools for finding and decoding network issues. These decoders will typically provide the module id, packet tracking and data extraction needed to isolate a network issue related to the data packets and faults such as error-outs, CRC failures, etc.

The artform of using these tools successfully is known ad “De-Bugging” the platform.

Live Spectrum Analyzer and FFT Waveform Converter



Diag Nation

← 46 →

The live (Or file converted in some cases) FFT Spectrum analyzer allows technicians to diagnose, "see" and measure signals in the sub-sonic, audio, ultrasonic and RF frequency ranges. Using these tools requires some "pre-requisite" studies into the world of capturing (Coupling) RF signals to the scope and study on RF electricity but can be SUPER handy to use in the RF world we live in today. Remote Fobs, GPS and Radio antennas, ultrasonic park assist sensors, radar, Bluetooth and in-vehicle Wi-Fi can all be diagnosed with a spectrum analyzer.
It is even handy to convert waveforms from the electrical domain to see frequency drops and interference otherwise missed by electrical waveform analysis.

Math Channels, Masks and Alarms

- For advanced scoping functions such as Math, Masks and Alarms, consult your scope's user manual.
- Not all scopes provide all these features, but most scopes will accommodate the basic tools shown here.
- Math channels allow us to perform basic to advanced math calculations on our waveforms, calculate things like running circuit resistance, power calculations, solve for impedance, reactance, susceptance, phase angle and other engineering equations for solving circuits.

Diag Nation

For advanced scoping functions such as Math, Masks and Alarms, consult your scope's user manual.
Not all scopes provide all these features, but most scopes will accommodate the basic tools shown here.

Math channels allow us to perform basic to advanced math calculations on our waveforms, calculate things like running circuit resistance, power calculations, solve for impedance, reactance, susceptance, phase angle and other engineering equations for solving circuits.

Math Channels, Masks and Alarms

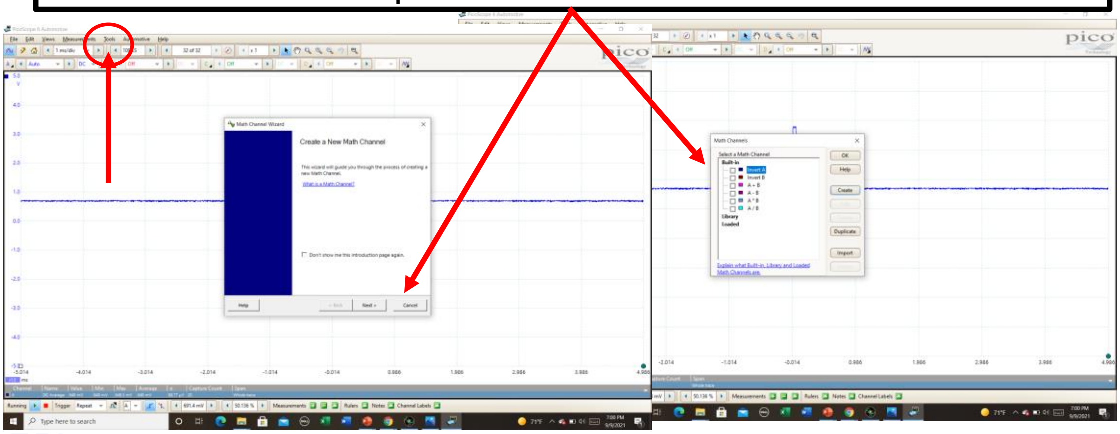
- Masks allow us to “paint” an area inside or outside of the waveform’s expected normal operation parameters.
- When monitoring the circuit under test, the mask provides a clear visual that the signal, power or ground has glitched, dropped or otherwise been affected.
- When masks are combined with audible alarms, as the input signal intrudes on the mask, an alarm alerts the technician to the fault.
- Some scopes like the TiePie Engineering scope can assign an audible alarm in the audio frequency spectrum to monitor a running signal, who’s frequency and pitch will change when the fault occurs.
- This is an incredible handy tool for diagnosing.

Diag Nation

Masks allow us to “paint” an area inside or outside of the waveform’s expected normal operation parameters.
When monitoring the circuit under test, the mask provides a clear visual that the signal, power or ground has glitched, dropped or otherwise been affected.
When masks are combined with audible alarms, as the input signal intrudes on the mask, an alarm alerts the technician to the fault.
Some scopes like the TiePie Engineering scope can assign an audible alarm in the audio frequency spectrum to monitor a running signal, who’s frequency and pitch will change when the fault occurs.
This is an incredible handy tool for diagnosing.

PicoScope 6 Math Channels Access

Access Pico's Math Channels from the TOOLS Dropdown, both preset basic and advanced math functions are there. Also provided is the Math Channel Wizard.

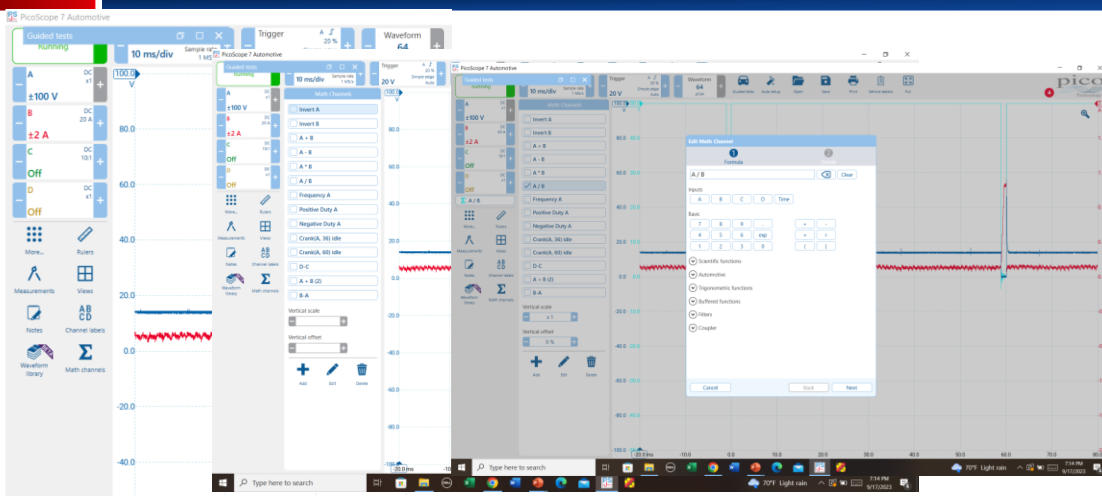


Diag Nation

49

Picoscope 6 Math Channel Drop Down Location

Pico 7 Math Channels

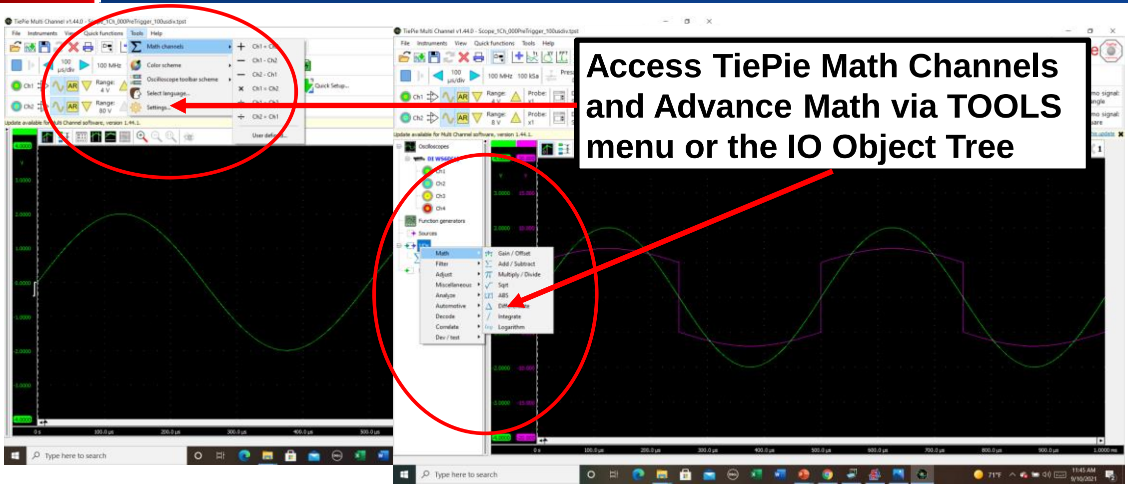


Diag Nation

← 50 →

Picoscope 7 Math Channel Pathway

DiagNation TiePie Scope Math Channels

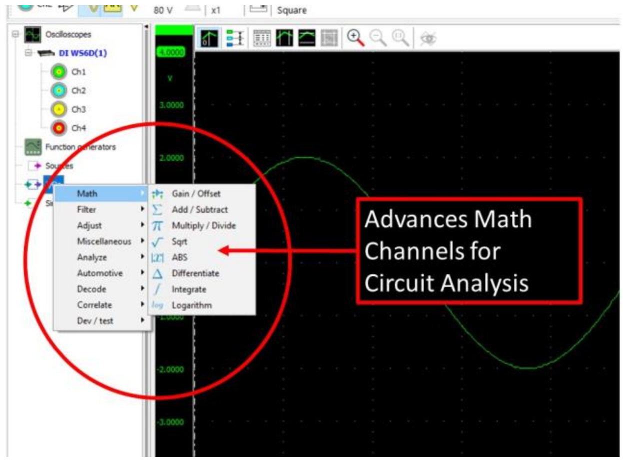


Diag Nation

← 51 →

TiePie Scope Math Channel Navigation

TiePie Scope Advanced Math Channel Section



Advanced Math Channels on the TiePie Scope

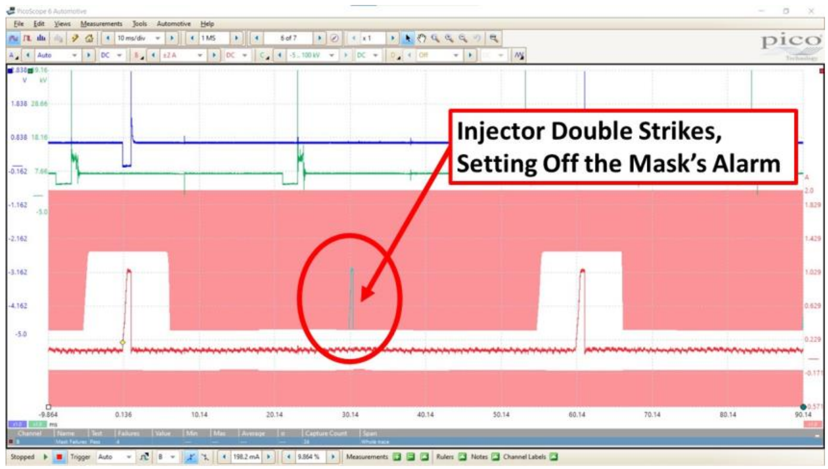
Mask Setup for Signal Drop or Circuit Glitch

Normal operation, no MASK intrusions yet.

← 53 →

In this capture, we can see that the mask (PINK) has been set up to ***NOT* trigger** on normal operation, but any substantive deviation from the normal operation of the circuit shall be captured and identified. Note how the mask is painted (smartly) with about 500mv of space around the waveform, to account for any NORMAL voltage fluctuations or drop activity in the circuit.

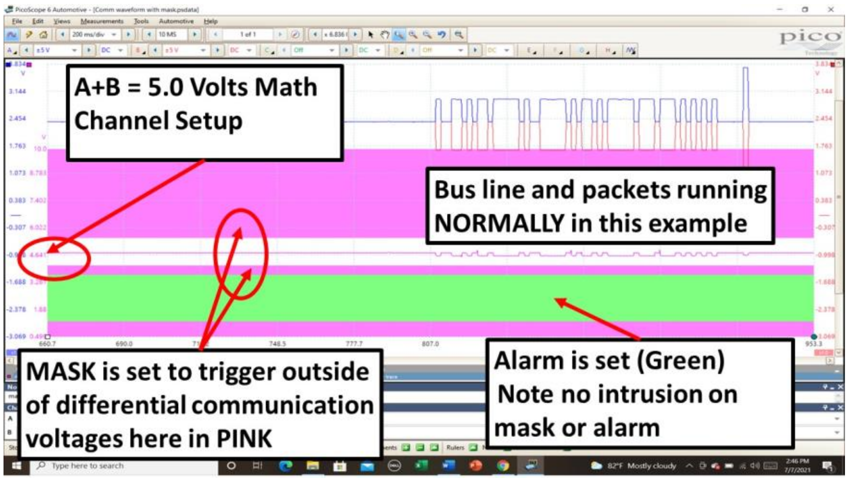
The Mask Un-Masks the Problem!



Diag Nation

In this screenshot, Adam catches what he was going after, and had suspected. The injector double striking OUT of firing order sequence due to partial short in injector circuit. Caught with a well thought out strategy and application of **Masks and Alarms**.

A Gnarly Math Combo for Locating a Rouge Node on the Bus



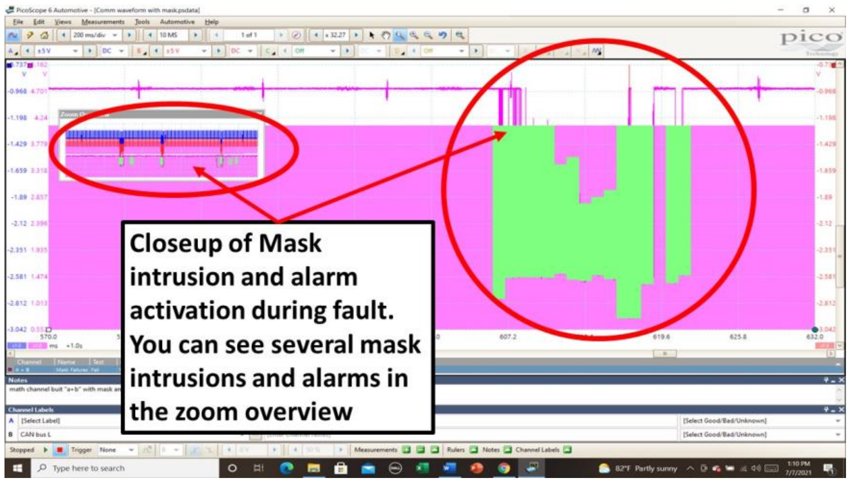
Diag Nation

In this more complex setup to capture a network fault, the **Masks and Alarms** are set for intrusion, but also, a cool trick built into this fault capture was the summing of the CAN circuits to 5V, then masking the summed signal for any variation. The next slide shows the vehicle in the captured node fault condition.

When properly thought out, constructed and deployed, these advanced scope functions can be set up to successfully trigger or catch ANY intermittent fault involving electricity, whether signaling, power delivery or communications and actuations. Powerful diagnostics here.

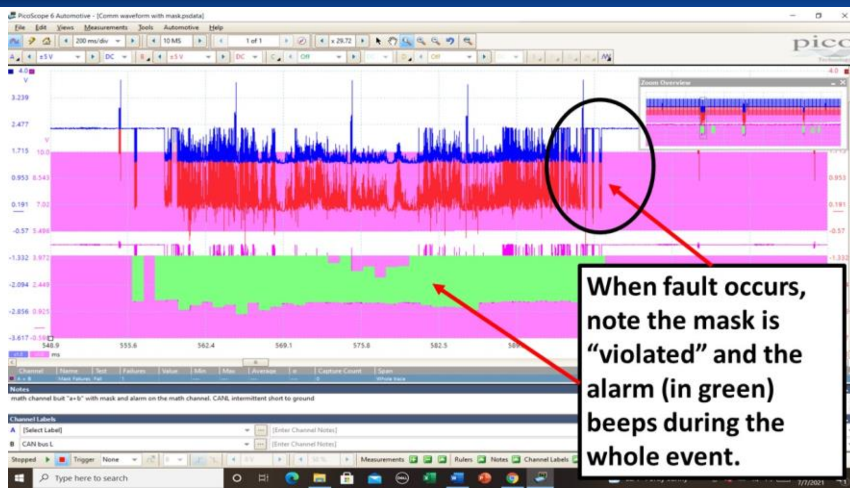
We recommend you begin to explore these tools and hone your skills. The future demands it!

Closeup of the Math Channel's Mask Intrusion



In this capture, we can see that the summed differential math channel monitor picks up the fault several times (See the inset zoom overview upper left)

CAN Node Fault NAILED!

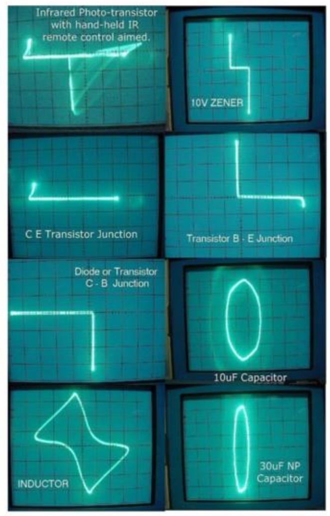


Diag Nation

In this capture, a well thought out diagnostic approach strategy and set up has captured the fault. Here, you can see the Mask intrusions. (Green) and the alarms are undoubtedly ringing away here.

X-Y Mode: Phase Control Circuit Visuals

This image shows Lissajou patterns acquired in **X-Y mode**. Lissajous are analyzed to measure the phase relationship between current and voltage in a circuit when controlled by different components



Internet Image Attributed to:
Pinterest/Michael Hagood's Curve Tracer

Diag Nation

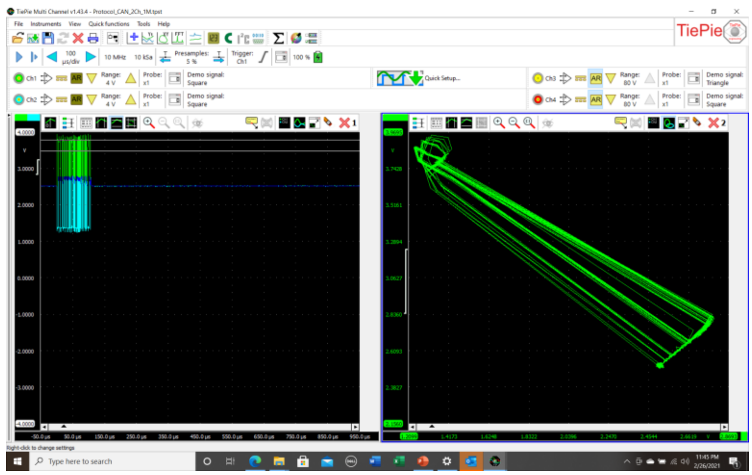
This image shows Lissajou patterns acquired in X-Y mode.

Lissajous are analyzed to measure the phase relationship between current and voltage in a circuit when controlled by different components.

When you switch the scope to X-Y Mode, the horizontal axis (X or Time) of the electronic signal input is not being controlled by the internal scope control, but by the signal attached to channel 2. The vertical axis of the (Y or input signal amplitude) axis is now determined by the input signal attached to channel 1. In this way, when 2 points of an oscillating or inductive circuit are observed, the actual phase angle of the current and voltage through the tank circuit can be observed visually.

This is used heavily in the engineering and diagnosis of modern micro-control and transistor/driver circuits and helps us understand how different components affect the control of current flow. We can study these things and become more proficient at reading the waveforms when we are diagnosing any inductive automotive components and circuits.

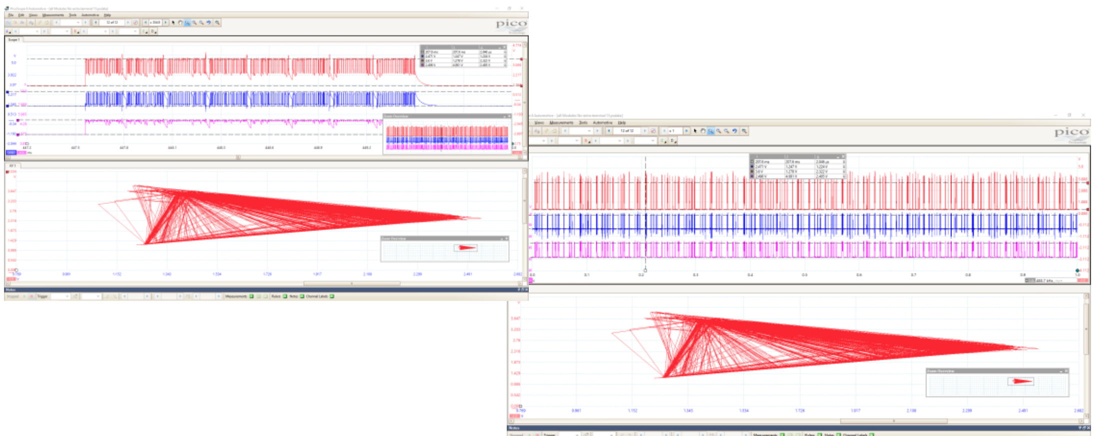
CAN Bus Twisted Pair Resonance in X-Y Mode



Diag Nation

Here, the CAN Bus is being tested for the CAN Node's magnetic resonance (viewing phase angle of electricity on the balanced, terminated bus pair).
Each thin line in the X-Y graph on the right, represents an individual node transmitting and receiving the differential signal.
This is a GREAT way to view the health of the bus.
If it only shows a "muddy" straight line, then one or both terminator resistors are out.
Further CAN and Flexray testing techniques using this methodology are under development at DiagNation's lab, stay tuned.

Lack of Terminal 15 Power to Modules w/XY and A+B Math

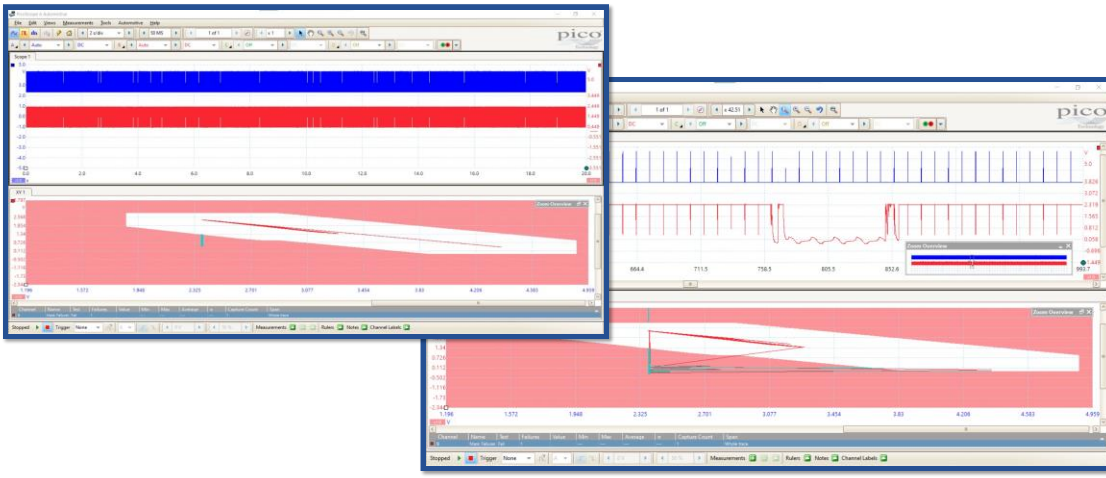


Diag Nation

← 60 →

Lack of terminal 15 power example.

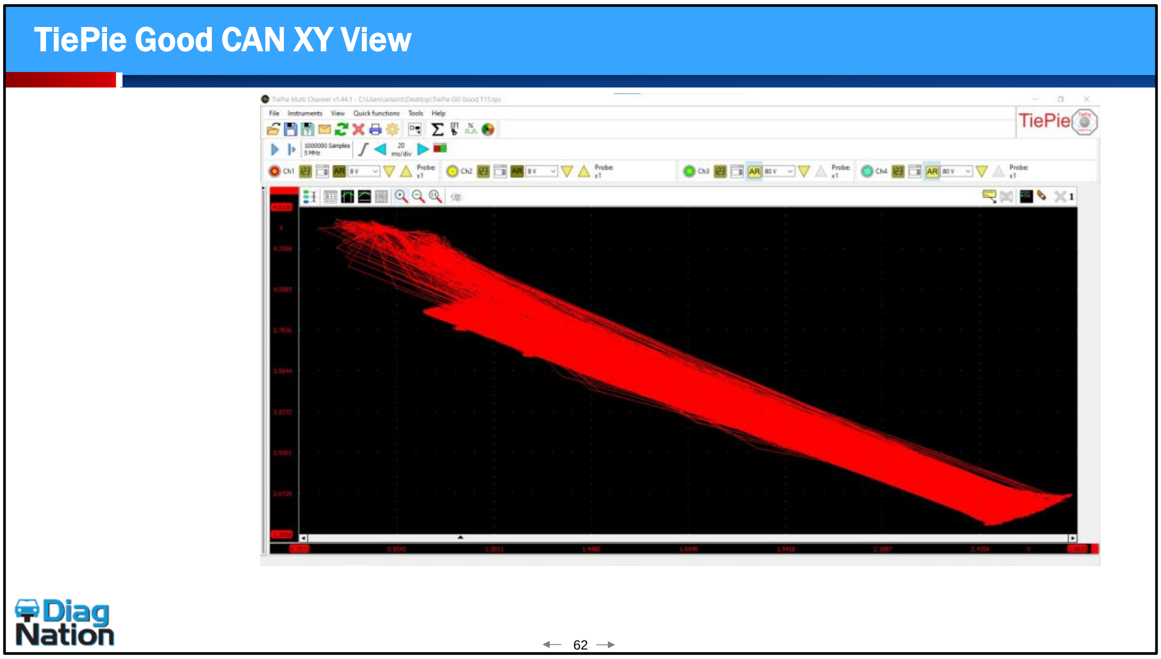
Example of XY View Utilizing a Mask/Alarm of HS-CAN-C



Diag Nation

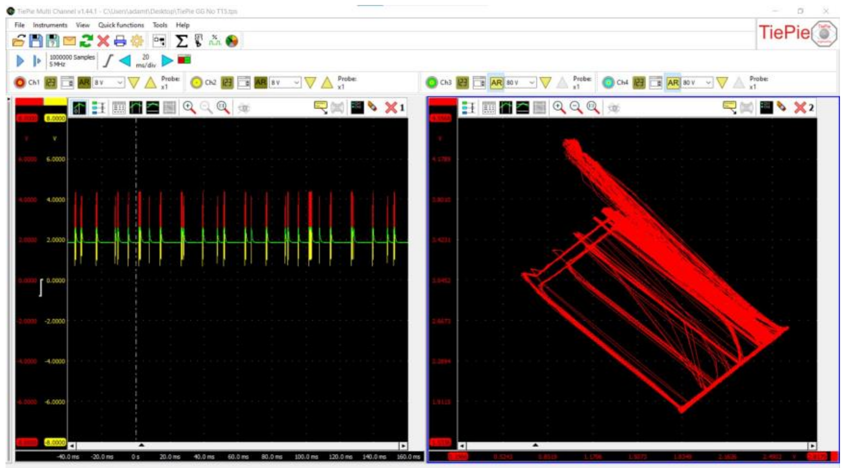
← 61 →

We're looking at an **XY view of a high-speed CAN-C network that has an intermittent open in CAN-C low**. We are utilizing several different advanced features of PicoScope at the same time. We are using a combination of **masks**, **alarms**, **scope** and **XY view**. The result is that with the masks and the XY view, we can easily pick out the failure in the circuit in the second capture. So now we can see how obvious the XY view shows a communication error. The use of multiple advanced Pico functions can really enhance your diagnostic routine like it has in this intermittent open in the CAN-C low circuit.



In this X-Y view of the terminated bus line, you can see the rectangle-shaped characteristic of the bus when fully powered. This is a visual indicator that the bus termination is (1) there and (2) working. The termination resistors provide a balanced antenna for the modules to broadcast on, by providing control of signal reflection and transmitter ringing. Watch what happens on the next slide, when CKT 15, (Key on Power) is missing from the bus.

TiePie Scope XY View No Terminal 15



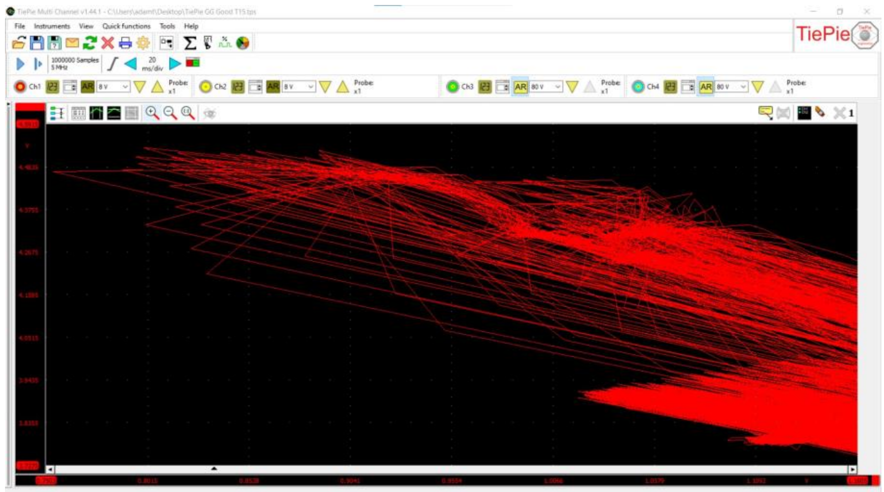
Diag Nation

This screen capture is the same vehicle with the CKT 15 (Key-on power) missing. Note what VISUALLY happens to the X-Y waveform when parts of the bus remain unpowered.

The un-powered nodes provide a voltage divider that looks like a ladder. As each chunk of modules powers up, the waveform begins to take on it’s single rectangle characteristics again. ***This is an amazingly quick and visual look at the electrical health of the bus at a glance.***

TiePie scopes are the “next step-up” for analyzing electrical behavior on our vehicles. These scopes have some of the fastest sample rates and storage capabilities available in automotive based scopes. In another unique option is the ability to latch scope interfaces together in a daisy chain and have more channels available.

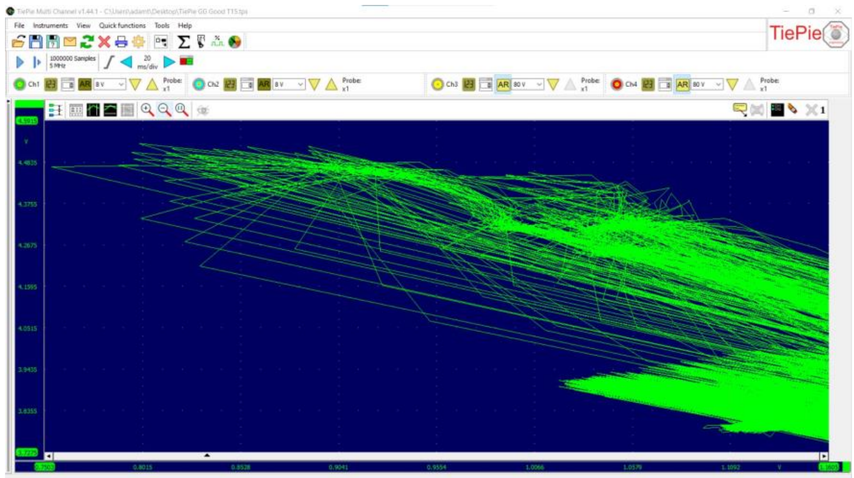
Terminating Resistors Viewed in X-Y Mode



Diag Nation

This screenshot is a closeup of the terminator at the end of the waveform. You can observe the electrical resonance of the data being “pushed” through the termination. When a node goes rogue, it’s electrical characteristics are altered under operation, which becomes clearly visible in this resonant X-Y view. A GREAT bus health check and module isolation tool indeed.

Seattle Seahawks Fan’s View of Terminators in X-Y Mode



A rabid Seattle Seahawks Fan’s view of the previous screen capture in X-Y mode on the TiePie Scope.

A Case of the Severe Hiccups…

… A Driveability Problem?

Diag Nation

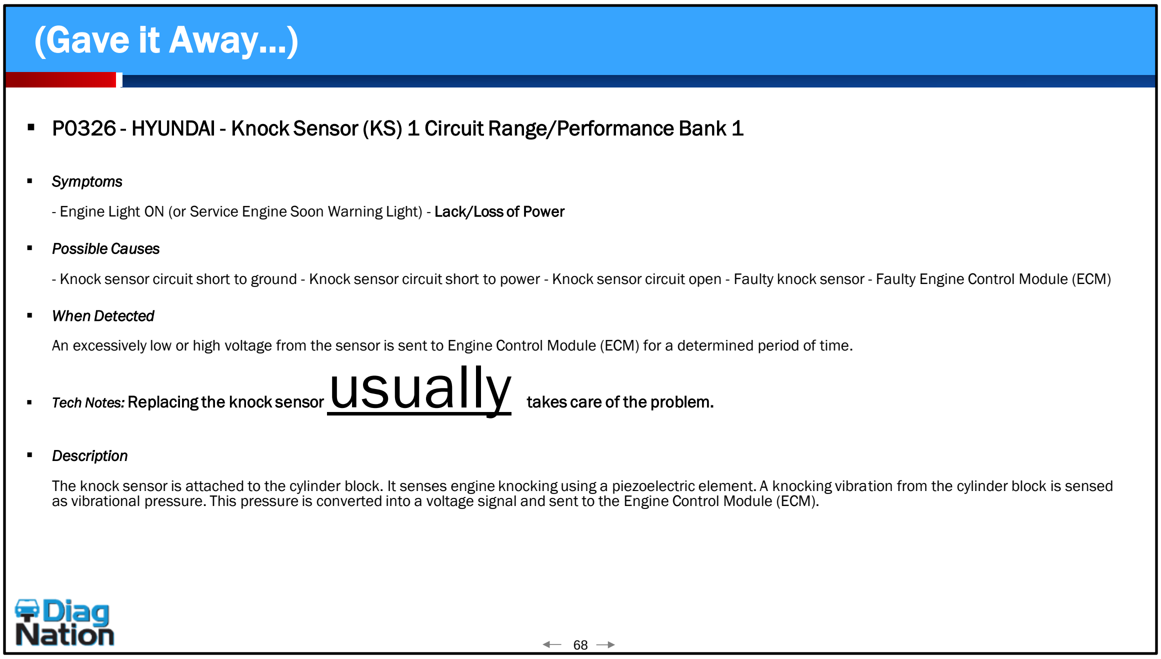
2014 AnyCar - Intermittent Fall-On-Face Power Loss

- **39,000 Miles:**
- **Intermittent *<u>Severe</u>* Lack of Power on Acceleration, MIL On.**
- Vehicle came to shop with a **knock sensor code and lean code**,
- Knock sensor was replaced by dealer ***<u>twice</u>***, the PCM had been re-flashed.
- Vehicle had a ***<u>SEVERE</u>*** drop-out power loss on acceleration, ran OK otherwise, but had a bad idle shake as well.
- Customer stated the vehicle had been back the dealer *three times*, and condition was never resolved.

Diag Nation

← 67 →

39,000 Miles:
Intermittent *<u>Severe</u>* Lack of Power on Acceleration, MIL On.
Vehicle came to shop with a **knock sensor code and lean code**,
(Knock sensor was replaced by dealer ***<u>twice</u>***, the PCM had been re-flashed.)
Vehicle had a ***<u>SEVERE</u>*** drop-out power loss on acceleration, ran pretty decent otherwise, but had pretty bad idle shake as well.
Customer stated the vehicle had been back to Hyundai dealer three times, and condition was never resolved.



P0326 - HYUNDAI - Knock Sensor (KS) 1 Circuit Range/Performance Bank 1

Symptoms: Engine Light ON (or Service Engine Soon Warning Light) - **Lack/Loss of Power**

Possible Causes: Knock sensor circuit short to ground - Knock sensor circuit short to power - Knock sensor circuit open - Faulty knock sensor - Faulty Engine Control Module (ECM)

When Detected: An excessively low or high voltage from the sensor is sent to Engine Control Module (ECM) for a determined period of time.
Description: The knock sensor is attached to the cylinder block. It senses engine knocking using a piezoelectric element. A knocking vibration from the cylinder block is sensed as vibrational pressure. This pressure is converted into a voltage signal and sent to the Engine Control Module (ECM).

Setup and Inspection:

- Inspection and test drive: Fuel trims were adding 18% at idle
- Fuel trims started **subtracting** during wide open throttle pulls.
- Noticed that within seconds of snap throttle, knock sensor immediately (But BRIEFLY) would pull back timing almost 30 degrees, then suddenly return to normal.
- Each time the car was accelerated a certain way, when RPMs got into the 1,800-2,000 RPM range, this knock sensor signal would occur.
- In the middle of acceleration, the car would fall out, but power would come roaring back as you drove through 2,000 to higher RPMs.

Diag Nation

← 69 →

Inspection and test drive: Fuel trims were adding 18% at idle
Fuel trims started **subtracting** during wide open throttle pulls.
Noticed that within seconds of snap throttle, knock sensor immediately (But BRIEFLY) would pull back timing almost 30 degrees, then suddenly return to normal.
Each time the car was accelerated a certain way, when RPMs got into the 1,800-2,000 RPM range, this knock sensor signal would occur.
In the middle of acceleration the car would fall out, but power would come roaring back as you drove through 2,000 to higher RPMs.

What the Heck is Wrong With This Car?

- No pinging or detonation was observed during any of the road tests
- Dealer had done all of the obvious already, IE: Sensor, Re-Flash, etc…
- Shop had run through the usual lean code diagnostic, smoked intake for vacuum leaks, but no problems were discovered. Low pressure fuel supply was ok, and high pressure parameters for pressure control and pulse width looked within spec as well.
- Were are assuming based on history and Dealer ROs that they had done the same… 3 times.
- Nobody seems to be able to solve this one… WHY?

Diag Nation

← 70 →

No pinging or detonation was observed during any of the road tests

Dealer had done all of the obvious already, IE: Sensor, Re-Flash, etc…

Shop had run through the usual lean code diagnostic, smoked intake for vacuum leaks, but no problems were discovered. Low pressure fuel supply was ok, and high pressure parameters for pressure control and pulse width looked within spec as well.
Were are assuming based on history and Dealer ROs that they had done the same… 3 times.
Nobody seems to be able to solve this one… WHY?

Let's Have a Look…

The knock sensor was definitely ringing strong as we approached 1800 RPM on initial acceleration and gets much worse as revs build through 2000 RPM. Then, on deceleration the problem suddenly settles down…

Diag Nation

Scope capture showing the repeated ringing of the knock sensor during testing.

I See Waveforms….

When this ringing was occurring, **the scan tool indicated *__30 degrees__* of ignition retard.**

The customer was definitely feeling SEVERE power loss…

Look at how the PCM is messing with the timing, the darker yellow lines (Coil) that match the Knock Sensor ringing.
This is where the 30 degrees retard occurred.

Diag Nation

← 72 →

Note the knock sensor "ringing" each time the vehicle was accelerated through the affected RPM range.

The FIX?

- We identified the activity on the knock sensor and set out to find out **WHY**.
- We installed the Steelman Chassis Ears at 4 points of the engine, each side front, and each side back.
- Within seconds, we "heard" the problem.
- On the back side, front of the engine, the rear AC Compressor bracket was cracked, and was grounding on the engine block when the serpentine belt was loaded during acceleration. Resonance was terrible at 2000 RPM.
- The broken piece of bracket was removed, the remaining piece isolated with rubber… Road test: FIXED! (Of course, a new bracket was ordered and installed after the fact…)

Diag Nation

← 73 →

We identified the activity on the knock sensor, and set out to find out **WHY**.
We installed the Steelman Chassis Ears at 4 points of the engine, each side front, and each side back.
Within seconds, we "heard" the problem.
On the back side, front of the engine, the rear AC Compressor bracket was cracked, and was grounding on the engine block when the serpentine belt was loaded during acceleration. Resonance was terrible at 2000 RPM.
The broken piece of bracket was removed, the remaining piece isolated with rubber… Road test: FIXED! **(Of course, a new bracket was ordered and installed after the fact…)**

Modeling to Fix a Customer Complaint

- From time to time, a really difficult and problematic vehicle lands in our bay.
- When it comes to the build of the car and specifications, we know that service information can be very scant, or even impossible to find on certain systems and in certain carlines.
- We can either waste huge amounts of time trying to perform conventional testing (Scanners, etc…) with no information, OR,
- We can learn the art form of characterizing the system you are working on.

DiagNation

← 74 →

From time to time, a really difficult and problematic vehicle lands in our bay.
When it comes to the build of the car and specifications, we know that service information can be very scant, or even impossible to find on certain systems and in certain carlines.
We can either waste huge amounts of time trying to perform conventional testing (Scanners, etc…) with no information, OR,
We can learn the art form of characterizing the system you are working on.

Characterizing System Performance

- ABS: If we had a repeat wheel speed sensor code setting, we could scope all 4 wheel speed sensors to characterize what the good wheels looked like, and quickly see the wheel that is not working right.
- Circuit Performance: We can even use the art of characterization to observe a circuit when operating properly, so when the intermittent occurred, we would quickly see what went wrong.
- Injectors (Misfire) By characterizing the known good injectors against the suspected bad one, we can play "one of these things is not like the other" and most of the time, identify the problem without the assistance of wiring schematics, specs, etc… the "time wasters".

Diag Nation

ABS: If we had a repeat wheel speed sensor code setting, we could scope all 4 wheel speed sensors to characterize what the good wheels looked like, and quickly see the wheel that is not working right.
Circuit Performance: We can even use the art of characterization to observe a circuit when operating properly, so when the intermittent occurred, we would quickly see what went wrong.
Injectors (Misfire) By characterizing the known good injectors against the suspected bad one, we can play "one of these things is not like the other" and most of the time, identify the problem without the assistance of wiring schematics, specs, etc… the "time wasters".

Characterizing System Performance

- Ignition Coils: Measuring the KV, burn-time and current ramp of the coil and comparing this to other coils on the car allows us to see control problems, no fuel in cylinder, shorted coils and more.
- Trying to depend on specs can be a big waste of time, because most “specs” don’t tell us HOW the circuit should perform.
- Example: there are no “specs” for proper burn-time, dwell time, current limiting, etc… just “known guidelines”.
- Learning how to characterize the system you are working with may seem like burning time, but almost ALWAYS leads to the source of the problem!

Diag Nation

Ignition Coils: Measuring the KV, burn-time and current ramp of the coil and comparing this to other coils on the car allows us to see control problems, no fuel in cylinder, shorted coils and more.
Trying to depend on specs can be a big waste of time, because most “specs” don’t tell us HOW the circuit should perform.
Example: there are no “specs” for proper burn-time, dwell time, current limiting, etc… just “known guidelines”.
Learning how to characterize the system you are working with may seem like burning time, but almost ALWAYS leads to the source of the problem!

Case Study: 2013 Chevy Impala With Repeat ABS codes

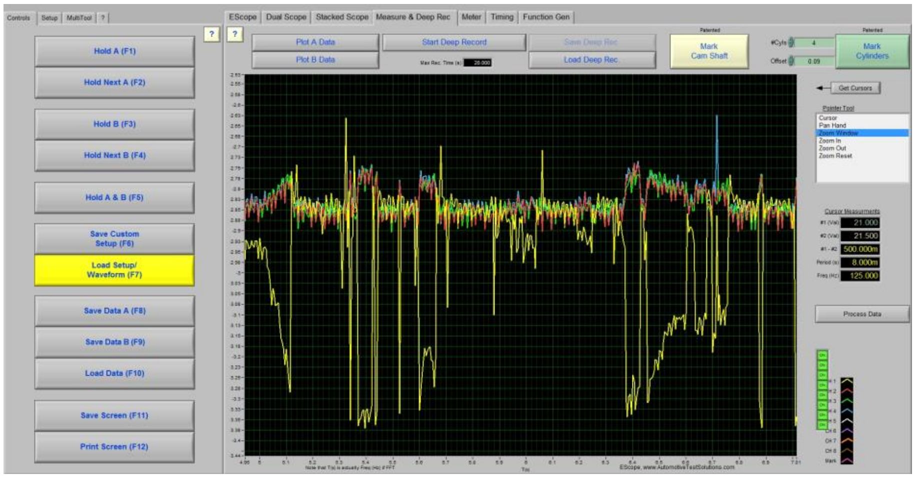
- This vehicle was at one of our support account's shops. They were in desperation to get this car fixed and had done lots of "work" to the car to get the DTC to stop setting.
- This included:
- Wheel Speed Sensor Replacement (X3)
- Axle (Reluctor ring)
- Hub (Maybe the hub was out and an air gap problem?)
- The next guess was going to be the EBTCM, but this was where we were asked to get involved.

Diag Nation

← 77 →

This vehicle was at one of our support account's shops. They were in desperation to get this car fixed and had done lots of "work" to the car to get the DTC to stop setting.
This included:
Wheel Speed Sensor Replacement (X3)
Axle (Reluctor ring)
Hub (Maybe the hub was out and an air gap problem?)
The next guess was going to be the EBTCM, but this was where we were asked to get involved.

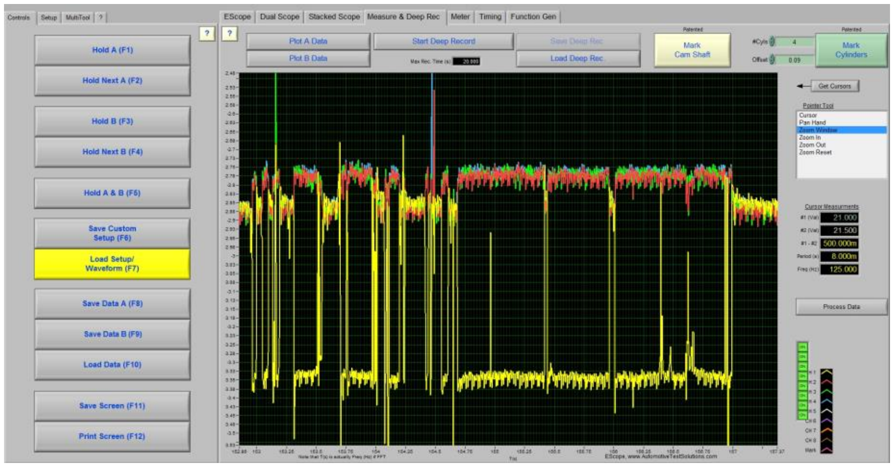
A Lab Scope Road Test Captures the Problem



Diag Nation

A scope capture of the Impala’s ABS wheel speed sensor circuits under way during the road test. On right hand turns, this would show up…

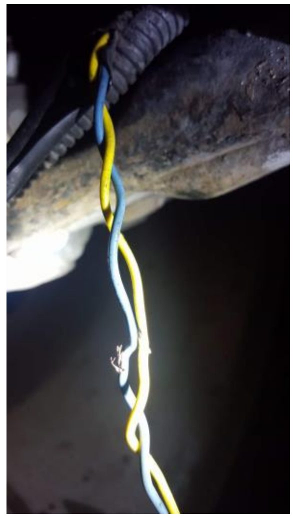
Waveform Captured on Lift While Manipulating Harness



← 79 →

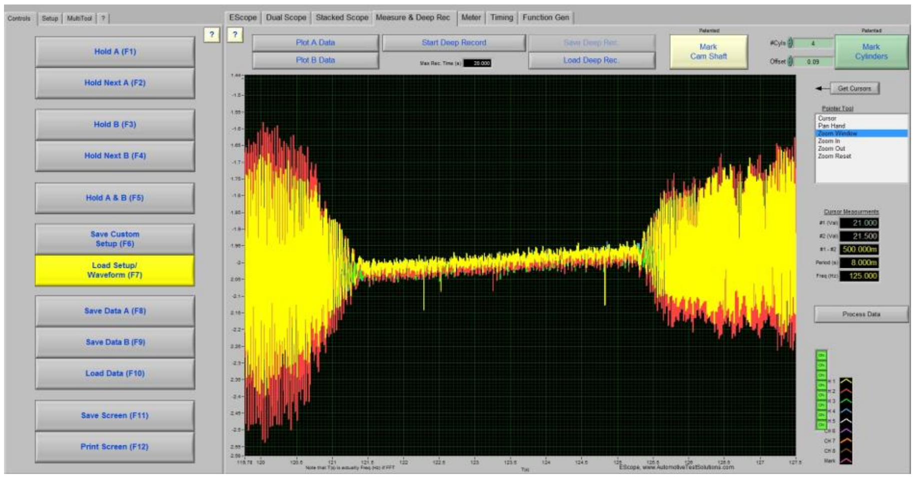
Having heard the whole tale of woe from the techs involved with this car, we hooked a scope up to all 4 wheel speed sensors and drove the vehicle. The previous capture plus this capture have nailed the problem while it was acting up. The "mystery" ABS wheel speed code was solved with a wire harness repair.

Cause of the Intermittent ABS Problem on 2013 Impala



The lesson learned here is that sometimes when faced with a car that comes back over and over, it is good to wire up all affected circuits on your scope and go for a ride. The techs in this case were not operating the vehicle into the condition, and were “assuming” defective parts. Between the 3 sensors, axle/reluctor and hub, the “barrel of the “Parts Cannon” was smoking red on this one.

2013 Impala ABS Problem Fixed



Now, one can observe the wheel speed sensors all speeding up and slowing down at the same frequency.
You can see the Impala's ABS in action. During multiple starts, stops, bumps and hard left and right turns, the signal remained steady after the wiring repair. No light and the DTC has not reset.

The Drop Head... Drops a Cylinder Instead!

Case Study:

2012 Rolls Royce Phantom Drop Head Convertible

Engine: BMW N73 V-12 Bi-Turbo GDI, 4 Bank Control, 2 DMEs, 8 - O_2 Sensors

Intermittent Cylinder 7 Misfire. Several repair attempts

Observations: *BEAUTIFUL Car. WOW.*

DiagNation

← 82 →

2012 Rolls Royce Drop Head V12 Bi-Turbo

- Car came in setting a misfire code in Cylinder 7.
- The usual coil swaps and spark plug replacements were performed.
- When swapping coils, the misfire ***DID NOT*** follow.
- There is negative – I mean ***<u>ZERO</u>*** service information available on this car, but we were able to get hold of an internet document on the operation of the N73 BMW Gasoline Direct Injection fuel control system from Bosch.
- This was not much help, so we went to work on the car.
- First test was a running compression test because the misfire was staying with #7.
- **NOTE: An important diagnostic tip is to *<u>START here</u>* with the mechanical waveform before chasing electronics on ALL Gasoline Direct Injected vehicles!**

Diag Nation

← 83 →

Car came in setting a misfire code in Cylinder 7.
The usual coil swaps and spark plug replacements were performed.
When swapping coils, the misfire ***DID NOT*** follow.
There is negative – I mean ***<u>ZERO</u>*** service information available on this car, but we were able to get hold of an internet document on the operation of the N73 BMW Gasoline Direct Injection fuel control system from Bosch.
This was not much help, so we went to work on the car.
First test was a running compression test because the misfire was staying with #7.
NOTE: An important diagnostic tip is to *<u>START here</u>* with the mechanical waveform before chasing electronics on ALL Gasoline Direct Injected vehicles!

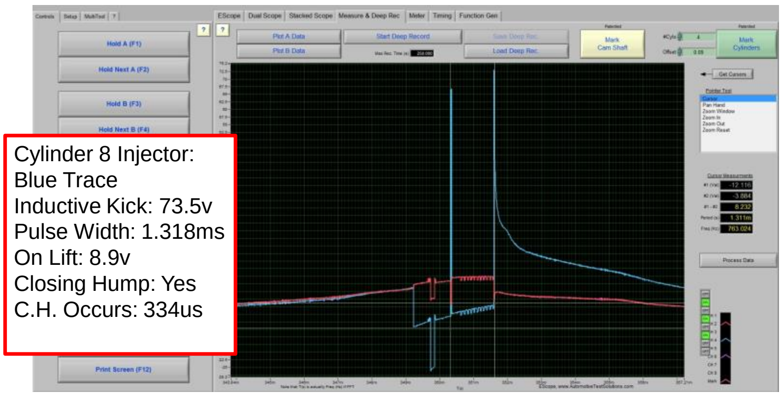
Setup on the Drop Head

- We did three things here to start:
- Looked at the engine data while running, specifically looking for adaptations in the fuel controls. There was an adaptation of 0.88 Lambda, indicating RICH command on Bank 3 (The bank with Cyl 7), the other banks were all 1.0 Lambda.
- First step was to set up the scope to capture the running compression in-cylinder waveform and ignition coils for cam and ignition timing reference.
- Secondary setup was to capture four injectors for the same cylinders.
- Ran the engine several times for Compression and Injector waveform captures, then performed ***<u>in-depth analysis</u>*** of the signals.

Diag Nation

We did three things here to start:
Looked at the engine data while running, specifically looking for adaptations in the fuel controls. There was an adaptation of 0.88 Lambda, indicating RICH command on Bank 3 (The bank with Cyl 7), the other banks were all 1.0 Lambda.
First step was to set up the scope to capture the running compression in-cylinder waveform and ignition coils for cam and ignition timing reference.
Secondary setup was to capture four injectors for the same cylinders.
Ran the engine several times for Compression and Injector waveform captures, then performed ***<u>in-depth analysis</u>*** of the signals.

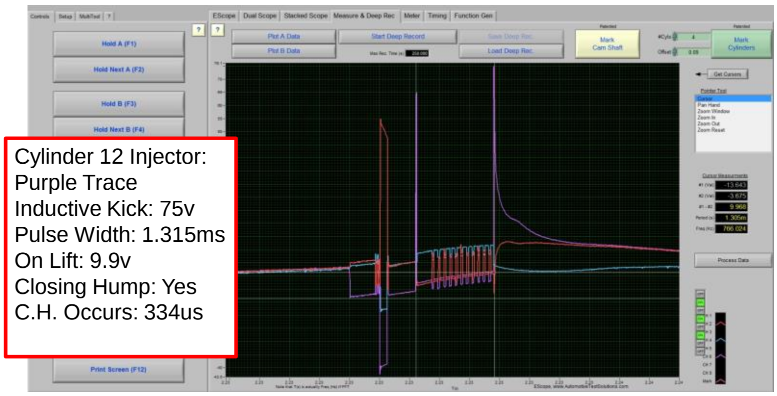
2014 Rolls Drop Head Cylinder 8 Injector



← 85 →

Cylinder 8 Injector:
Blue Trace
Inductive Kick: 73.5v
Pulse Width: 1.318ms
On Lift: 8.9v
Closing Hump: Yes
C.H. Occurs: 334us

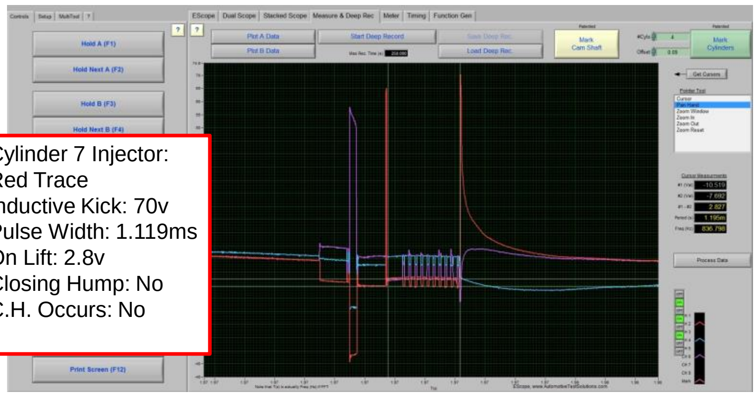
2014 Rolls Drop Head Cylinder 12 Injector



Diag Nation

Cylinder 12 Injector:
Purple Trace
Inductive Kick: 75v
Pulse Width: 1.315ms
On Lift: 9.9v
Closing Hump: Yes
C.H. Occurs: 334us

2014 Rolls Drop Head Cylinder 7 Injector



Cylinder 7 Injector:
Red Trace
Inductive Kick: 70v
Pulse Width: 1.119ms
On Lift: 2.8v
Closing Hump: No
C.H. Occurs: No

Diag Nation

Cylinder 7 Injector:
Red Trace
Inductive Kick: 70v
Pulse Width: 1.119ms
On Lift: 2.8v
Closing Hump: No
C.H. Occurs: No

Modeling Helps Us to Nail the Problem!

- We modeled the mechanical waveforms against **four** of the 12 cylinders, including the misfiring #7. **(One from each of the 4 banks)**
- The mechanical waveforms were all ***identical***, good compression, nice clean gas exchange, there was no mechanical issue with Cyl 7.
- What is left, Injector or some sort of intake leak maybe, right?
- Problem is, it takes better than ***15 hours*** to do an injector in this car.
- I'm sure the injector was cheap too. (And easy to get to…LOL)
- The shop owner wanted to ***KNOW*** that injector was bad before doing all that work…

DiagNation

← 88 →

We modeled the mechanical waveforms against **four** of the 12 cylinders, including the misfiring #7. **(One from each of the 4 banks)**
The mechanical waveforms were all ***identical***, good compression, nice clean gas exchange, there was no mechanical issue with Cyl 7.
What is left, Injector or some sort of intake leak maybe, right?
Problem is, it takes better than **15 hours** to do an injector in this car.
I'm sure the injector was cheap too. (And easy to get to…LOL)
The shop owner wanted to ***KNOW*** that injector was bad before doing all that work…

Case Study: The Bummin BMW, 2013 M5

- **This car was having its fourth visit to the shop for an ABS light.**
- The vehicle was setting the RF Wheel Speed Sensor DTC.
- The car had a ghost… it was a very intermittent condition with no apparent set patterns.
- Out of nowhere, the ABS light would come on and set the DTC.
- The customer was less than pleased about the third and fourth visits.

DiagNation

89

2013 BMW M5 ABS Issue Case Study
This car was having its fourth visit to the shop for an ABS light.
The vehicle was setting the RF Wheel Speed Sensor DTC.
The car had a ghost… it was a very intermittent condition with no apparent set patterns.
Out of nowhere, the ABS light would come on and set the DTC.
The customer was less than pleased about the third and fourth visits.

The Bummin BMW 2013 M5

- The shop had replaced the sensor twice, first with Aftermarket, then an OEM - BMW sensor.
- The RF reluctor ring had been replaced.
- The tires were the same make, size and had the same pressure.
- A road test with a scan tool showed both sensors working fine
- A continuity test had been done on the 2 sensor wires back to the module.

Diag Nation

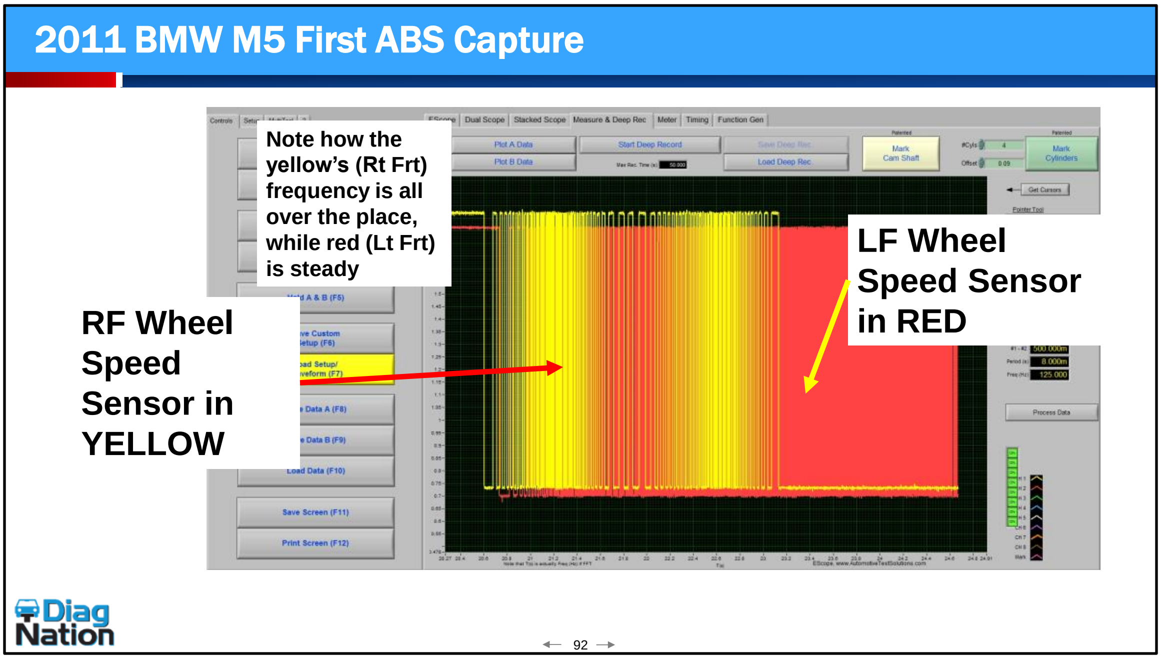
The shop had replaced the sensor twice, first with Aftermarket, then an OEM - BMW sensor.
The RF reluctor ring had been replaced.
The tires were the same make, size and had the same pressure.
A road test with a scan tool showed both sensors working fine
A continuity test had been done on the 2 sensor wires back to the module.

Preparing to Catch a Ghost…

- We installed the scanner and pulled up ABS data, clearing codes first.
- Once the (4) wheel speed sensors were pinned out, we put the scope on the front seat and took the beast for a ride.
- After driving the car for quite some time, we pulled into a parking lot to get a coffee, and BAM! On comes the light. (After hitting a bump…)
- We analyzed the capture, and found that the RF wheel was signaling, but was losing and gaining frequency, while the LF remained speed-steady.
- We also noticed that circuit voltage was a 300mv off of the other sensor circuit's voltage.
- Hmmm…

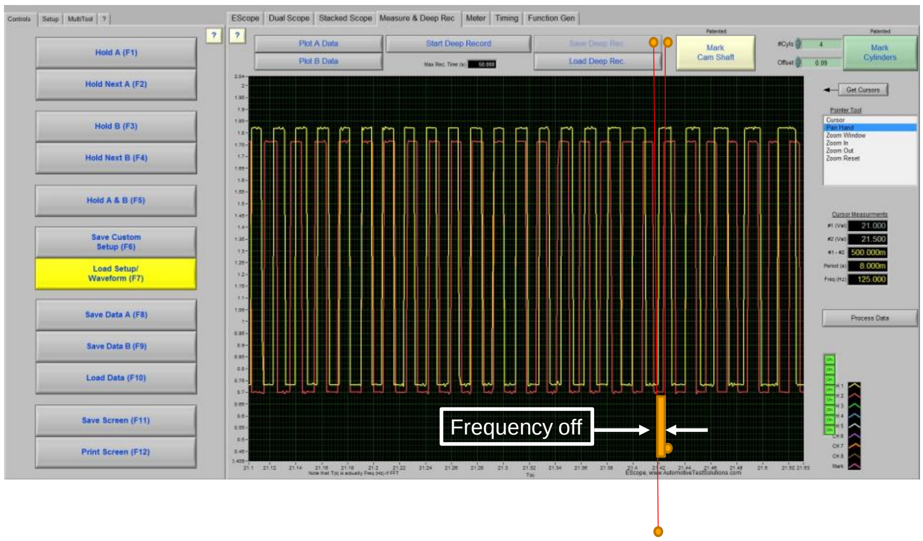
Diag Nation

We installed the scanner and pulled up ABS data, clearing codes first.
Once the 4 wheel speed sensors were pinned out, we put the scope on the front seat and took the beast for a ride.
After driving the car for quite some time, we pulled into a parking lot to get a coffee, and BAM! On comes the light. (After hitting a bump…)
We analyzed the capture, and found that the RF wheel was signaling, but was losing and gaining frequency, while the LF remained speed-steady.
We also noticed that circuit voltage was a 300mv off of the other sensor circuit's voltage.
Hmmm…



Scope capture showing the Yellow Channel (RF Wheel Speed Sensor) is dropping signal while the red signal to the LF Wheel remains steady.

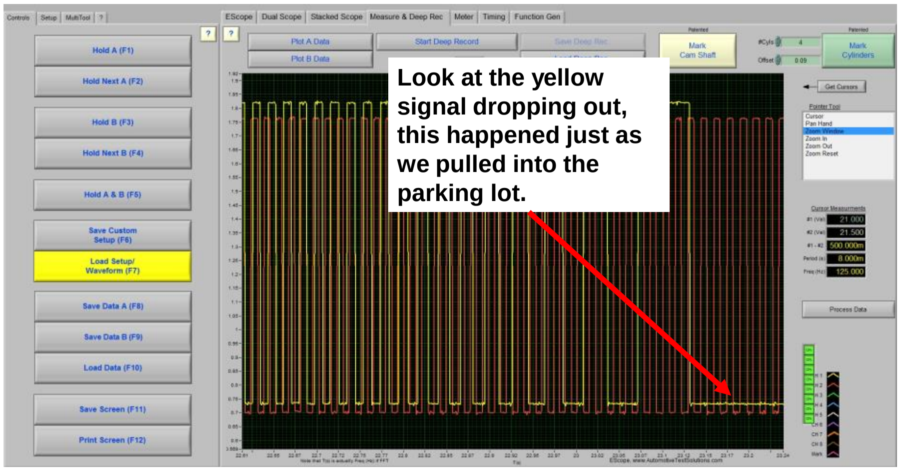
M-5 ABS Right Front Wheel Speed Problem



Diag Nation

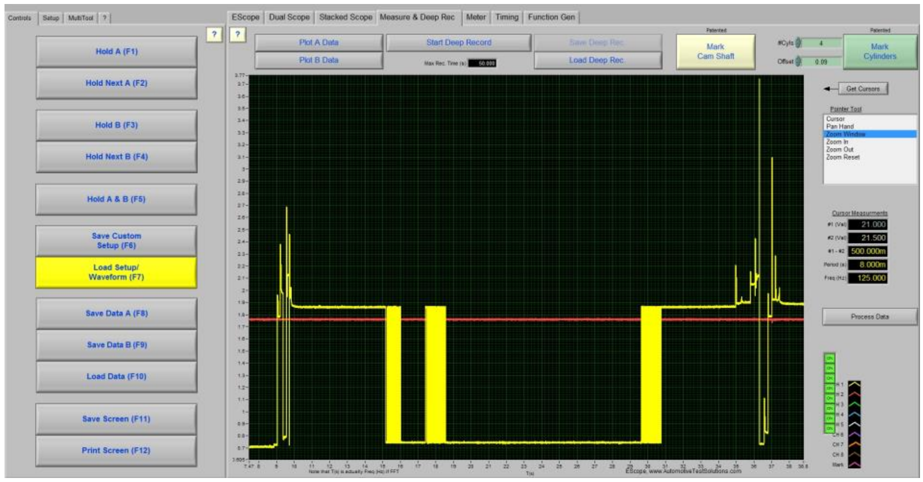
On this close-up of the ABS front speed sensor circuits, we can see the frequency or timing problem these sensors have going on when the car acts up. The frequency of each wheel speed sensor should match, given that the wheels are all spinning at the same speed while driving. The fact that the Right Front is so far off is a concern.

Dropout of RF Wheel Speed Signal (Yellow Trace)



Operating the vehicle into the problem helps us to see which portion of the signal, power or ground circuit is causing the problem. Here you can see the RF sensor physically dropping to zero volts and staying there.

BMW M-5 ABS Module Tap Test… AHA!



Diag Nation

← 95 →

Once back from our road test, we performed wiring wiggle-test and a tap test of the ABS module. This tap test quickly showed us where the problem was in this car.

The FIX… The BMW is Bummin No More…

- After capturing the failure on the scope with a tap test, we took the module off the ABS Block.
- After some creative surgery on the plastic cover, we removed the potting material and located a cracked edge board circuit in the module about 1/8” in from the connector, where it goes through the seal.
- We repaired the connection on the board and reassembled.
- After installation, we cleared codes and drove the car, 3 people for a total of about two hours, bumpy roads and all.
- Next day road test went well, ***FIXED***.

Diag Nation

After capturing the failure on the scope with a tap test, we took the module off the ABS Block.
After some creative surgery on the plastic cover, we removed the potting material and located a cracked edge board circuit in the module about 1/8” in from the connector, where it goes through the seal.
We repaired the connection on the board and reassembled.
After installation, we cleared codes and drove the car, 3 people for a total of about two hours, bumpy roads and all.
Next day road test went well, ***FIXED***.

Class Summary:

- There are many methods and tricks we can deploy to capture and solve electronics problems and **gnarly intermittents.**
- We covered several methodologies for approaching intermittents, including techniques for duplication or inducing the problem and how to get creative with that.
- We introduced the concept of **characterizing a system or problem**, and provided several case studies where this single methodology was what led to the fix, ***WITHOUT wasted time*** on schematics and specs.
- **We hope you enjoyed the class, THANK YOU for your TIME!**

Diag Nation

← 97 →

There are many methods and tricks we can deploy to capture and solve electronics problems and intermittents.
We covered several methodologies for approaching intermittents, including techniques for duplication or inducing the problem and how to get creative with that.
We covered the importance of **Voltage Drop Testing**, **Relay Testing**, and many **Rules of Thumb** were provided in the book along the way.
We introduced the concept of **characterizing a system or problem**, and provided several case studies where this single methodology was what led to the fix, ***WITHOUT wasted time*** on schematics and specs.
We hope you enjoyed the class, THANK YOU for your TIME!

Questions

DiagNation Thanks You for Attending!

E-mail Gary any questions to **gsmith@diagnation.com**

For Remote Technical Assistance and Programming,
Call the DiagNation Support Desk at (775)-GET-DIAG

We hope you enjoyed the class! If you did, please tell your friends!

Please SHARE our DiagNation Facebook page and help us spread the word!

DiagNation