The Unhappy Motorcycle Speedometer Troubleshooting Case History

Bonus Presentation Available, See Page 3

Lee Hill, ***MSEE***

Founding Partner – SILENT Solutions LLC & GmbH

lhill@silent-solutions.com

www.silent-solutions.com

Amherst, New Hampshire

+1 (603) 578-1842

Member Adjunct Faculty	**Worcester Polytechnic Institute, Worcester, Massachusetts, USA**
EMC course instructor	**University of Oxford, England**

WPI — SILENT Solutions for your noisy world. — Missouri S&T — University of Oxford

Instructor Biography

Lee Hill is Founding Partner of SILENT Solutions LLC, an independent electromagnetic compatibility (EMC) and RF design firm he established in 1992. Besides providing EMC design review and troubleshooting services, Lee is also a member of adjunct faculty at Worcester Polytechnic Institute (WPI) where he teaches graduate courses in EMC. He is also an EMC class instructor at the University of Oxford (England), and for the IEEE EMC Society's annual Global University program and EMC Fundamentals workshop. In past years Lee was also an EMC course instructor for UC Berkeley Extension as well for Hewlett Packard and Agilent Technologies. Previously Lee was Principal EMC and Systems Engineer at Digital Equipment Corporation's Workstation Systems Engineering Group in Palo Alto, CA. In 2017 Lee founded SILENT Solutions GmbH in Munich, Germany.

Lee received the Master of Science Degree in Electrical Engineering & Electromagnetics with highest honors from the University of Missouri-Rolla, (now Missouri University of Science and Technology). He is an inventor of three US patents for EMI control in electronic systems, and provides expert witness services for patent litigation.

In the past fifteen years he has been a frequent featured speaker at IEEE EMC Society fundraising events in cities throughout the US including Santa Clara, Seattle, Portland, Chicago, Milwaukee, Dallas/Fort Worth and Detroit. He has also provided technical presentations to Society chapters in Los Angeles, San Diego, Santa Clara, Boston, Austin, Colorado Springs, Pittsburgh, and Orange County, CA. He served a term as an IEEE EMC Society Distinguished Lecturer from 1994-1996.

Lee has over twenty-five years of experience in the EMC design and retrofit of complex electronic systems. He has been teaching short courses on EMC design and troubleshooting for twenty years. Lee consults and teaches worldwide, and has presented classes in Taiwan, Singapore, Mexico, Norway, Canada, South Korea, France, Germany and United Kingdom. He has completed a three-year term on the Editorial Review Board of Printed Circuit Design Magazine.. He is an avid father, runner, motorcyclist, table tennis player and Amateur Radio operator, and has served as an officer on the board of directors of several non-profits.

Lee is past member of the IEEE EMC Society Board of Directors (2004-2007). From 1999-2006 he chaired the IEEE EMC Society's Distinguished Lecturer Program, and served as Co-Technical Chair of the 2003 IEEE Symposium on EMC in Boston, MA. In 1999 Lee received a Certificate of Appreciation from the EMC Society for significant contributions to education through his annual participation in the Demonstrations and Experiments portion of annual IEEE EMC Symposia.

SILENT

Thank You!   Free Bonus Technical Presentation Available

Dear Demystifying EMC 2020 Attendee:

Randal and I would like to thank you again for taking time out from work to attend Lee's presentation(s) this year.

Please let us know if you would like to bring a SILENT EMC course to your work location. We offer intensive two, three, and four day format EMC courses for electrical hardware designers, PCB designers, mechanical engineers, and EMC engineers.
We have delivered these courses around the world to companies that develop a wide variety of electronic products and systems.

If you would like to receive a free bonus technical presentation from SILENT, please just follow this link, Bonus Presentation then enter your name and email, and we'll send you an updated pdf copy of Lee's very popular talk "Mastering the Details of EMI Suppression Ferrites."

This bonus presentation discusses the performance characteristics and high frequency EMI suppression ferrites and important considerations for practical applications. When this talk is given live, Lee includes a hardoware demonstration of the effect of DC bias on a ferrite's impedance, using a network analyzer, power supply, and bias network. Lee has given this presentation throughout the US, Germany, and at DeMystifying EMC 2019 at Silverstone in the UK.

Warm Regards,

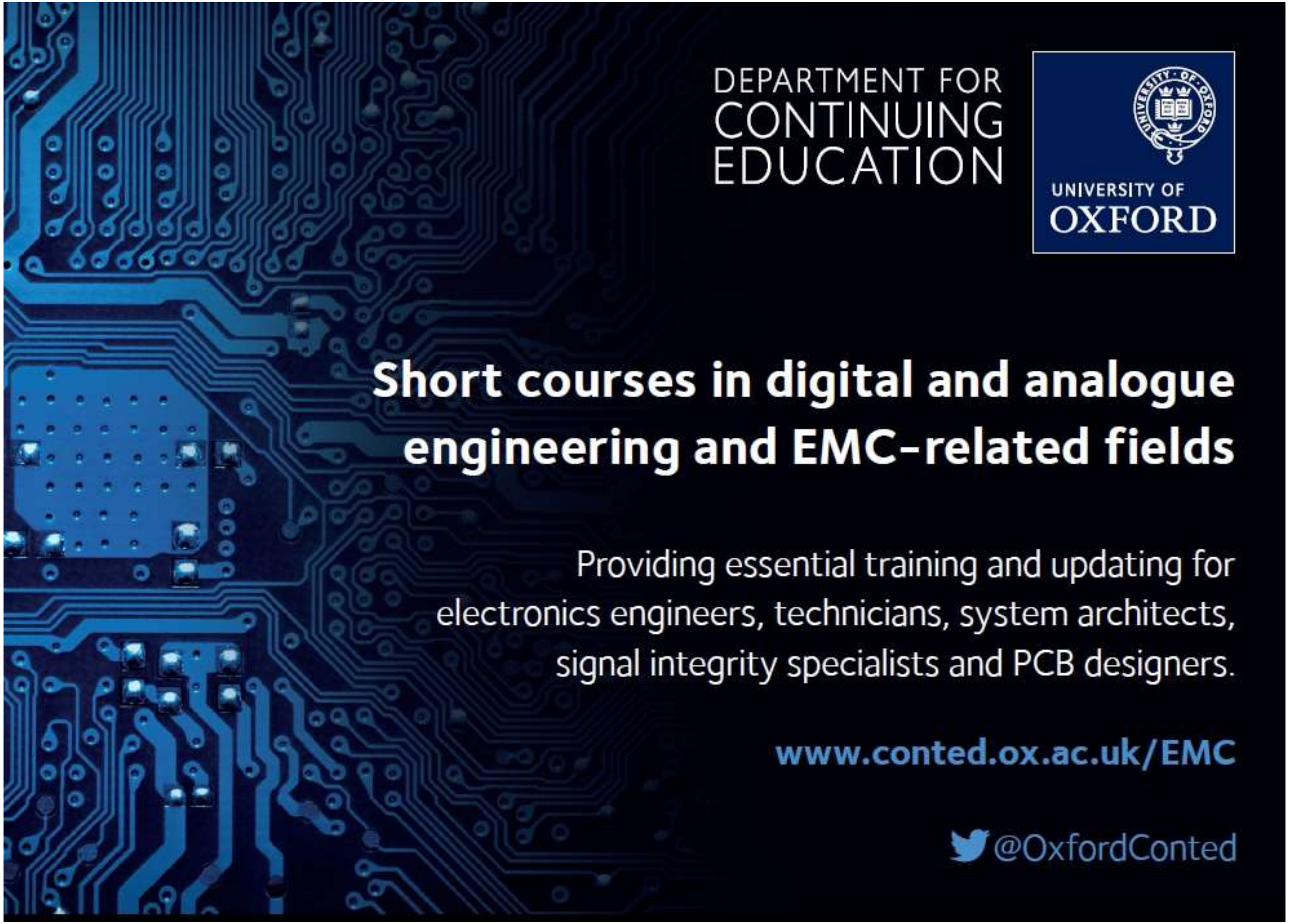
Lee Hill

Randal Vaughn

SILENT Training Events - Europe 2020

Please get in touch and visit with me if you are traveling to one of these cities in 2020
Find more info at www.silent-solutions.com

EMV, Cologne, Germany	***March 2020***
Posnań, Poland	***May 5-9, 2020***
University of Oxford, England	***June 2020***
IEEE Symposium on EMC, SI+PI	***July 2020 (Reno, Nevada)***
SILENT EMC Courses	***May, October 2020 (Boston, Silicon Valley)***
Dresden, Germany	***October 2020***


DEPARTMENT FOR
CONTINUING
EDUCATION
UNIVERSITY OF
OXFORD
Short courses in digital and analogue
engineering and EMC-related fields
Providing essential training and updating for
electronics engineers, technicians, system architects,
signal integrity specialists and PCB designers.
www.conted.ox.ac.uk/EMC
@OxfordConted

2020 summer courses

HIGH-SPEED DIGITAL, ANALOGUE AND EMC ENGINEERING

Applying Practical EMI Design and Troubleshooting Techniques

9 – 10 JUNE

Tutor: Lee Hill, SILENT Solutions LLC & GmbH, USA & Germany

Advanced Printed Circuit Board Design for EMI & Signal Integrity

9 AND 11 JUNE

Tutor: Lee Hill, SILENT Solutions LLC & GmbH, USA & Germany

Mechanical Design for EMC

9 AND 12 JUNE

Tutor: Lee Hill, SILENT Solutions LLC & GmbH, USA & Germany

Mastering High Speed Serial I/O Technology

22 – 24 JUNE

Tutor: Ransom Stephens, Signal Integrity Specialist

Resetting Your Signal Integrity Knowledge

24 – 26 JUNE

Tutor: Dr Istvan Novak, Senior Principal Engineer, Oracle

Making Successful Power Distribution Designs

29 JUNE – 1 JULY

Tutor: Dr Istvan Novak, Senior Principal Engineer, Oracle

www.conted.ox.ac.uk/EMC

EMC Words of Wisdom

"A rough estimate of the dominant EMI problem is more useful than a precise calculation of a negligible problem"

Dr. Thomas Van Doren, Professor Emeritus,
Missouri University of Science and Technology

"EMC is the study of what is NOT on the schematic"

Source unknown

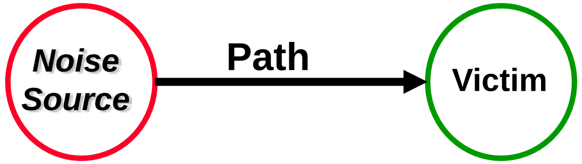
The Unhappy Motorcycle Speedometer

The Unhappy Motorcycle Speedometer

Radiated Immunity
Conducted Emissions
Radiated Emissions
ESD
Conducted Immunity
Power Bus Filtering
Self-Interference

Collect information from customer

Use the Noise Model, create a guess = "hypothesis"



Fix the problem with a solution based on the guess

Dear Customer: What KIND of Solution Would you Like?"

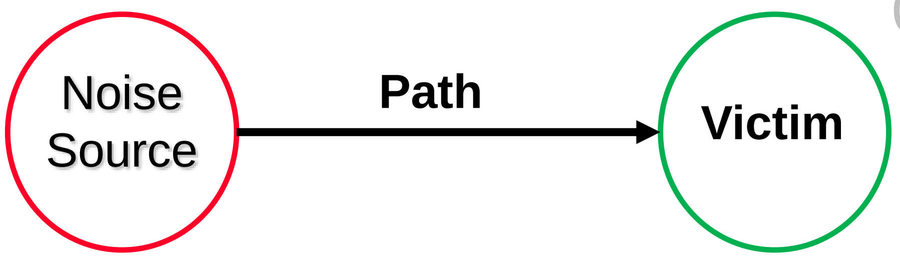
A. Bike Retrofit at Local Bike Dealer- Fix motorcycle at customer's location or repair shop

B. Bike Retrofit at Factory– Fix motorcycle at motorcycle factory AFTER motorcycle is built

C. Part Factory Retrofit - Fix specific parts at motorcycle factory BEFORE motorcycle is built

D. Redesign specific parts so that a new motorcycle is ok. It works well without any "extra" "fixes" or "pieces"

Noise Model



Radiated Immunity
Conducted Emissions
Radiated Emissions
ESD
Conducted Immunity
POWER BUS FILTERING
Self–Interference

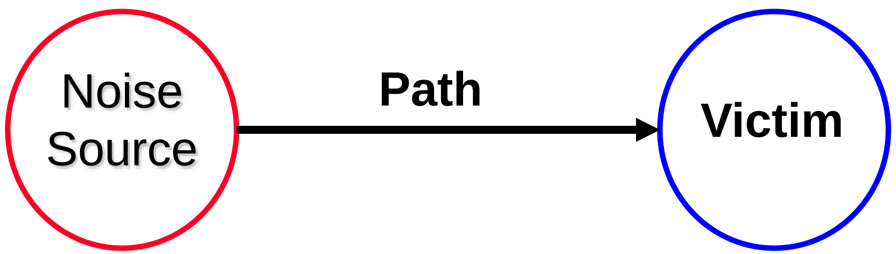
Noise problem = “Self - Interference”
Let’s view it as an “Immunity Problem”, at the speedometer

Information from the customer:

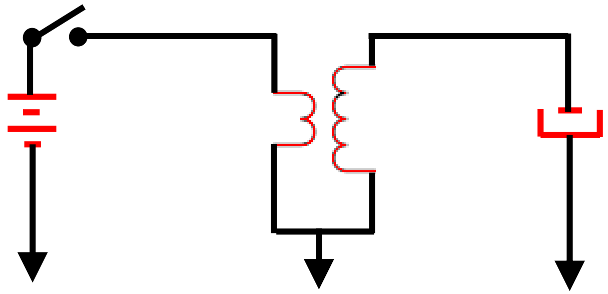
What is the noise source?

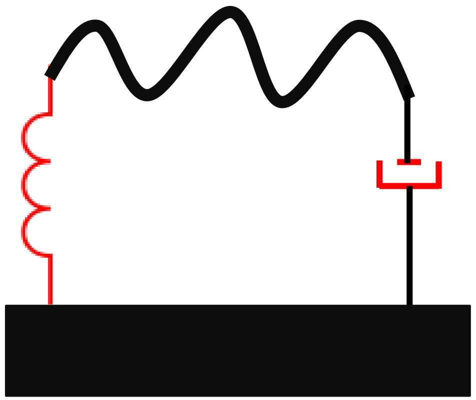
What is the victim?

Describe the Source and Victim Circuits

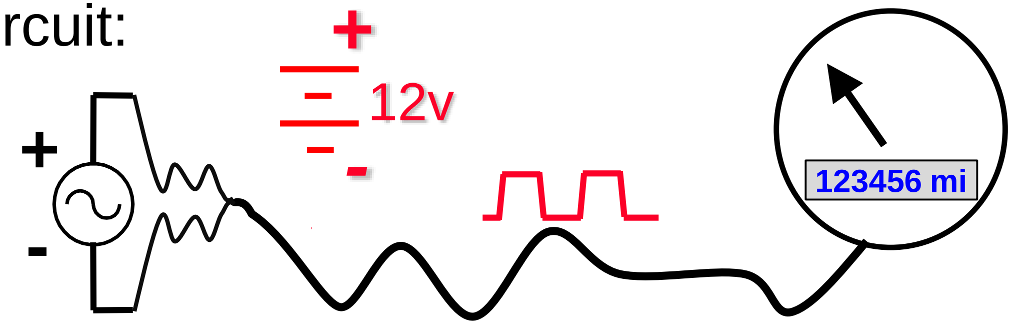


Noise Source Circuit:





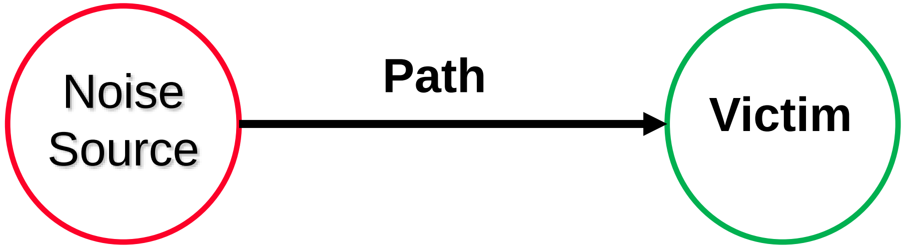
Noise Victim Circuit:



Which Noise Paths are Possible?

Path	Dependence on Distance	Dependence on Frequency	Electrical Source	Physical Features
Radiative				
Conducted				
Capacitive				
Inductive				

Determine Noise Path By “Process of Elimination”



1) Use observations, simple calculations, simple experiments to prove that 1 or 2 of the 4 paths are NOT possible for this PARTICULAR noise problem.

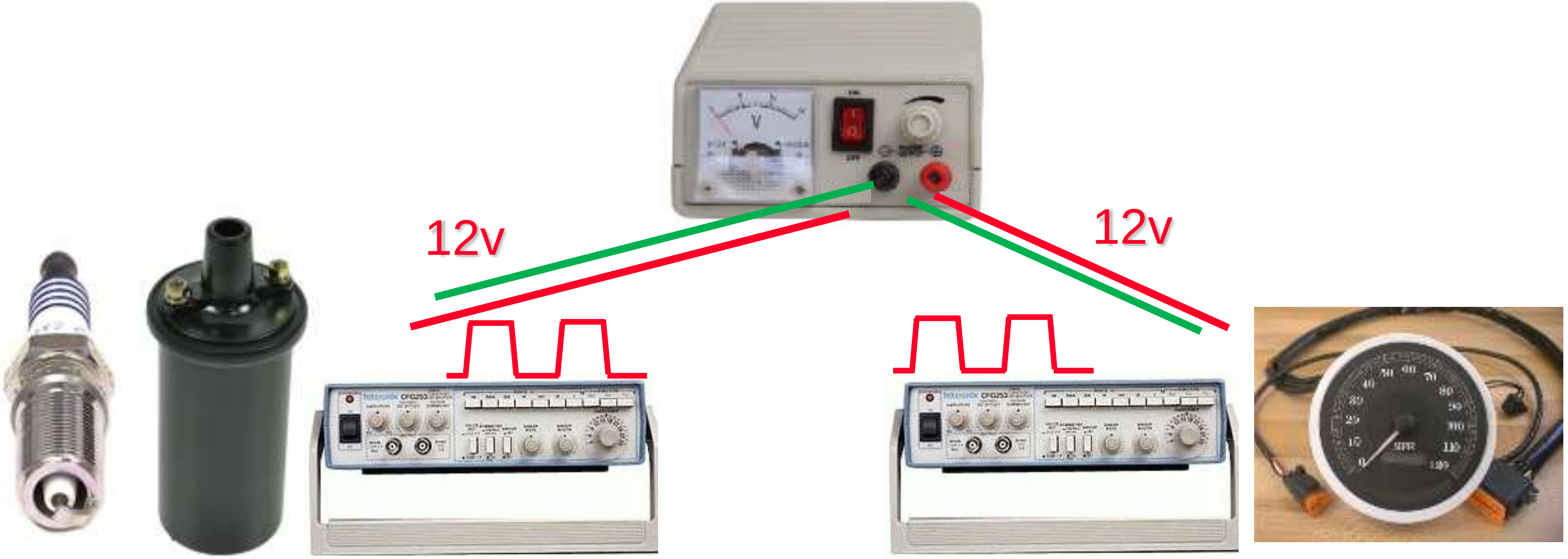
Conductive? Radiative? Inductive? Capacitive?

2) This reduces the number of possible paths that we should use for our noise model.

Let's Try to Eliminate at Least 1 Path

1) When I arrive at the speedometer company, they have already simplified the system.

2) Which of the 4 noise paths is EASY to try to eliminate?
How do I do that here?



Can We Eliminate One More Path From Consideration?

All 3 of the remaining paths depend on distance between source and victim

We can better understand many noise problems if we study the effect of changing the distance between source and victim, or by studying the “normal” distance between source and victim.

We can usually eliminate __________ coupling as a possibility if we can prove that separation distance between source and victim is _________ than noise wavelength

Can We Eliminate One More Path?

Repeating - We can usually eliminate ___________ coupling as a possible path IF we can prove that separation distance between source is victim is __________ than noise wavelength

To find the noise wavelength, we need to measure or calculate the noise ________________.

Is the noise signal periodic or aperiodic? Sinusoidal or non-sinusoidal?

Other parameters ___________________

Try to Make Some Conclusions

How can I understand WHICH physical part of the circuit is responding to noise?
This is VERY important, near-field coupling is very sensitive to |separation distance|

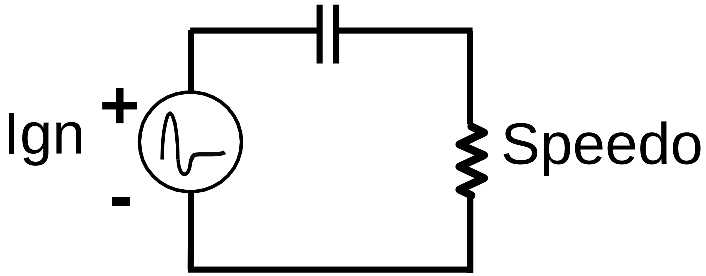
Step 1: I move the speedometer DISPLAY close to the ignition coil, cable and spark plug
Step 2: I move the speedometer CABLE close to the ignition coil, cable and spark plug…..

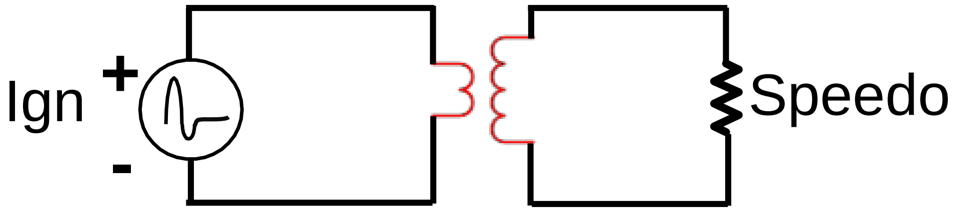
This observation makes sense. The electric or magnetic noise FIELD STRENGTH is MUCH larger AT THE VICTIM where these two objects are very close together on the motorcycle.
Is the problem capacitive or inductive?

Recall capacitive coupling requires big ____________ and big ________
Inductive coupling requires big ______________and big ____________

Can We Eliminate One More Path?

The two remaining paths are then ____________ and _____________





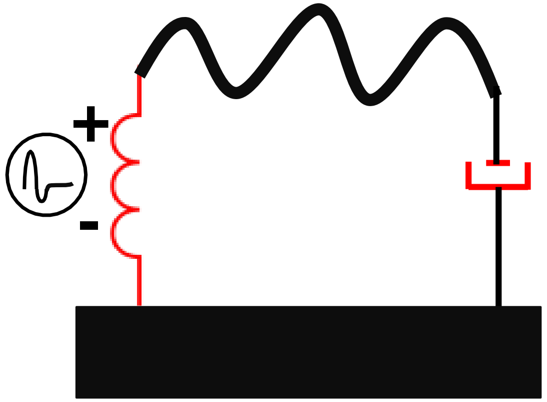
Remember: Our lumped element noise model won't work at (higher) frequencies where the largest physical dimensions of the source and victim get close to (noise wavelength)/4.

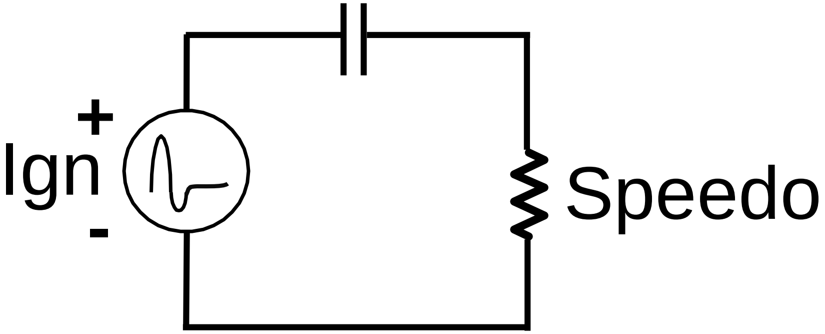
BUT, IF near-field noise coupling occurs over small physical areas, where small parts of the source and victim circuits are close together…THEN we can STILL use a near-field model at "HIGH" frequencies.


Analyze the Source Circuit
Does it Favor L or C Coupling?

What s typical ignition system di/dt?
What ignition system dv/dt?

Ok, then the noise path is probably ____________________

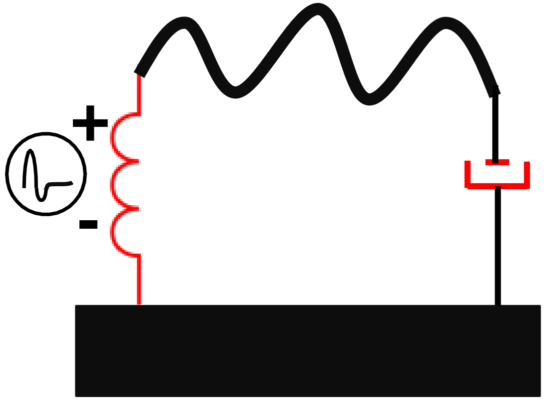


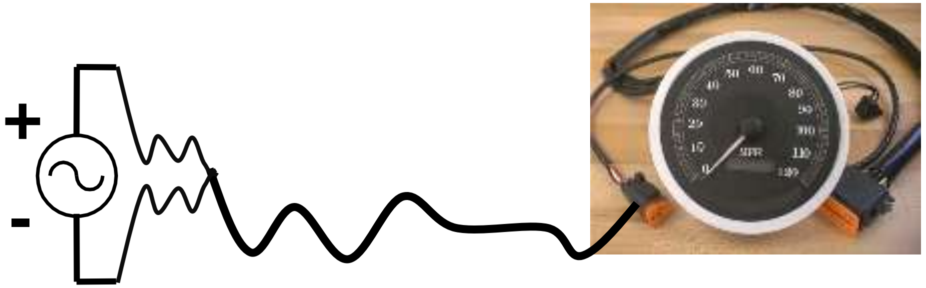


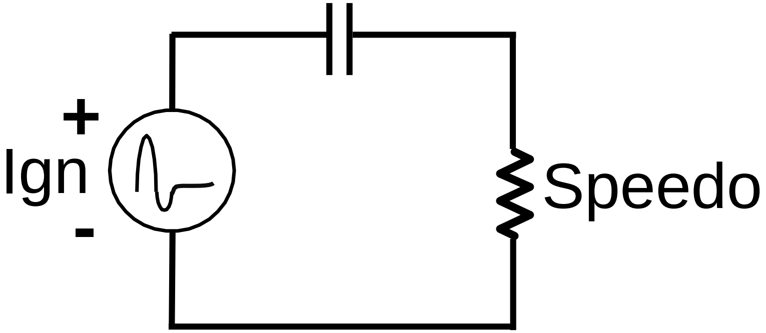
Solutions For L Coupling, C Coupling

Typical solutions for magnetic (inductive) coupling in this example would be:

Typical solutions for electric (capacitive) coupling in this example would be:





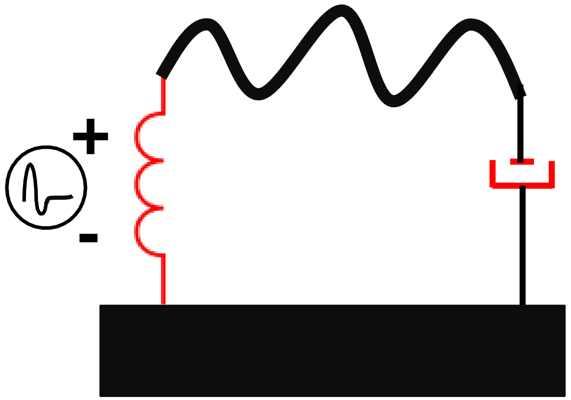


SILENT

Alternate Solution?

Bonus Question:

1) Would adding “resistive spark plugs” and/or “resistive ignition wire” help to solve the noise problem?



SILENT

Summary

- The “Noise Model” is the best thing we have to help us troubleshoot and solve electrical noise problems.

- Eliminate (“rule out”) as many paths as possible by observation and experiment.

- Modify 1 of the source’s 2 “electrical driving functions”.
  If big change in di/dt causes noise to decrease, then suspect _________.

- If big change in dv/dt causes noise to decrease, then suspect ___________.

- Change the position of either the source or the victim. If noise problem stays the same, then suspect ___________ to be the path.
  If the noise problem does not change, then suspect that __________ is NOT the path.

The Unhappy Motorcycle Speedometer Troubleshooting Case History

Bonus Presentation Available, See Page 3

Lee Hill, ***MSEE***

Founding Partner – SILENT Solutions LLC & GmbH

lhill@silent-solutions.com

www.silent-solutions.com

Amherst, New Hampshire

+1 (603) 578-1842

Member Adjunct Faculty	**Worcester Polytechnic Institute, Worcester, Massachusetts, USA**
EMC course instructor	**University of Oxford, England**

WPI SILENT Solutions for your noisy world. Missouri S&T University of Oxford