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# Pulse Test of Firing Capacitor Characteristics

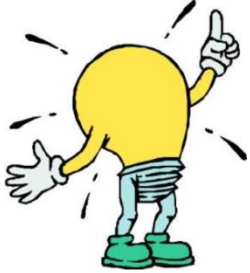
**NDIA Fuze Conference**  
**Baltimore, MD**  
**7-9 July 2015**



# Insight

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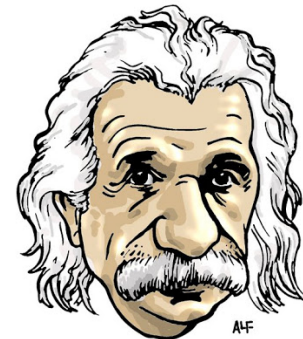


**Generally I'm not known for being too bright,**

**But, a Google search can make you an instant genius !**

Google

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# Source of Technique

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**A Web search turned up a “Technical TidBit” on the referent web site  
“Measuring Capacitor Self-Inductance and ESR”**

**The purpose was to measure inductance and ESR  
with regards to the capacitors’ pulse performance as a  
bypass capacitor in a digital circuit or its ability to  
shunt current in an ESD role.**

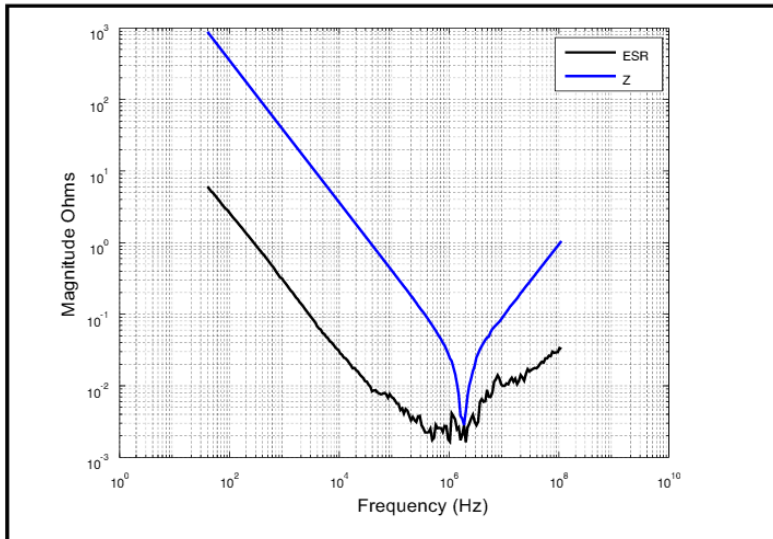
**High Frequency Measurements Web Page  
Douglas C. Smith  
URL: [www.dsmith.org](http://www.dsmith.org)**





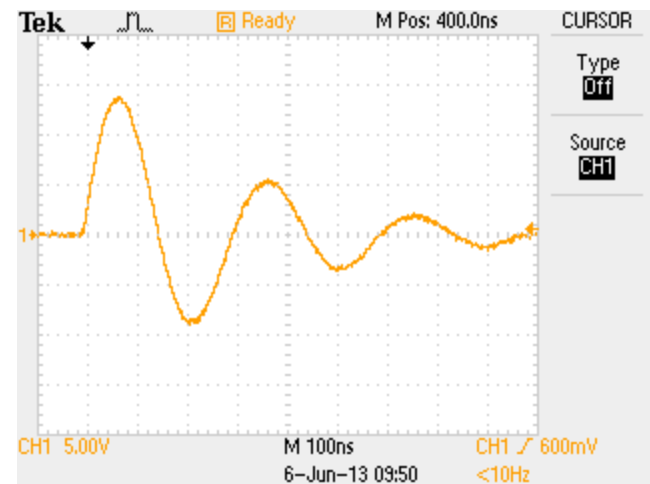
# New Application

Z and ESR C1210C475M5R1C



**Most capacitor data is given at AC.  
Some data is DC but not pulse.**

**When we perform a ringdown test,  
We are looking for peak amperes,  
inductance, and resistance.**

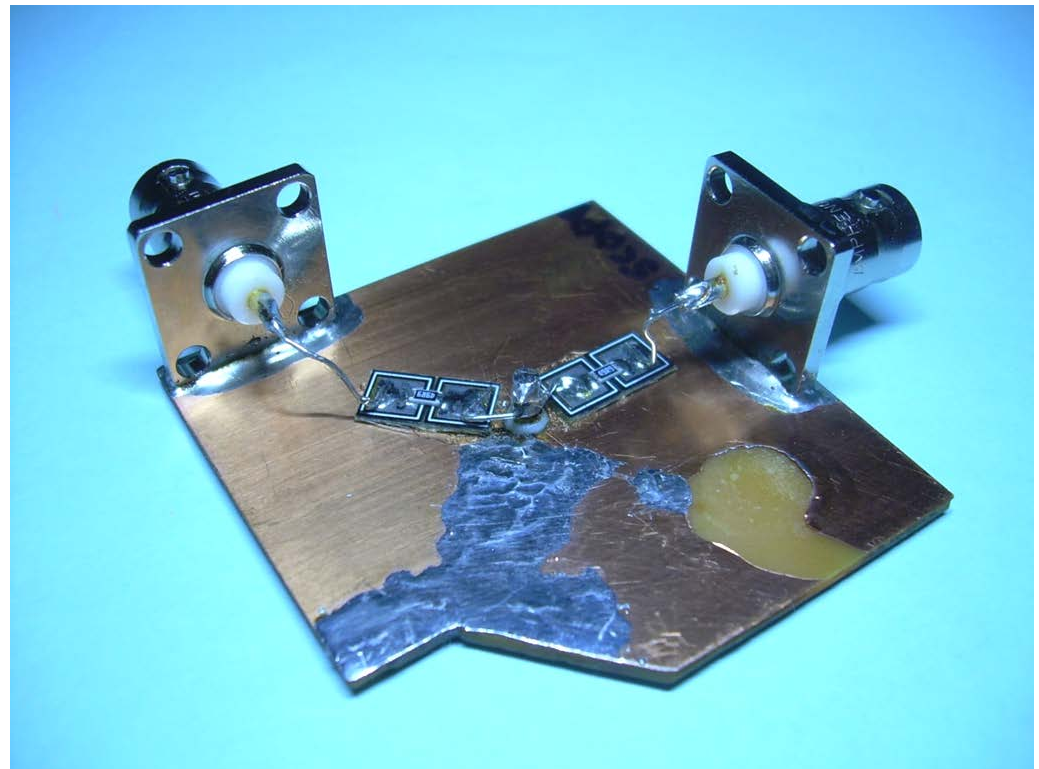




# Pulse Testing

So, can we do pulse testing, and how does it relate to ringdown data?

**Doug Smith Fixture**



**New Test Fixture**

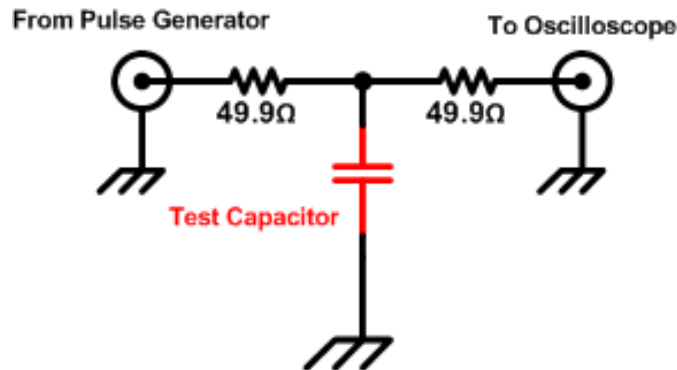


# Test Set-Up

**Pulse Generator**  
1  $\mu$ sec pulse  
2.5 volt amplitude  
50  $\Omega$  source



**Oscilloscope 100 MHz or Better**  
5 mv / div, 10 nS / div-typical  
Dependant on inductance, etc.

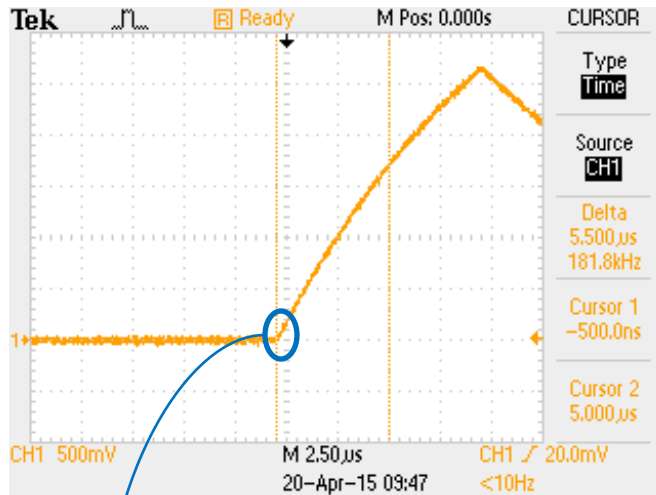


**Use 50 ohm coax cables**  
with BNC connectors, ~ 2 Ft  
and equal lengths.

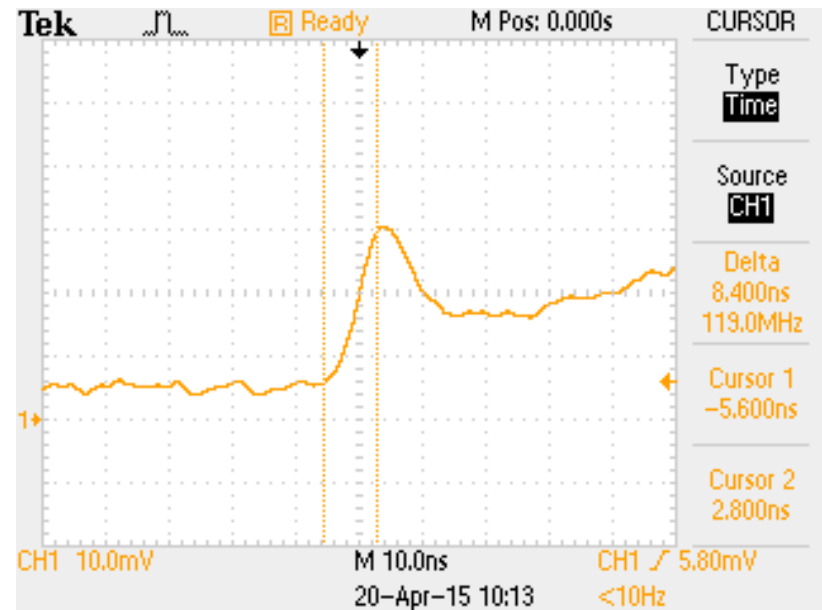


# What Do We See?

## Typical Capacitor Charge Waveform



If we zoom in, this is what we see !

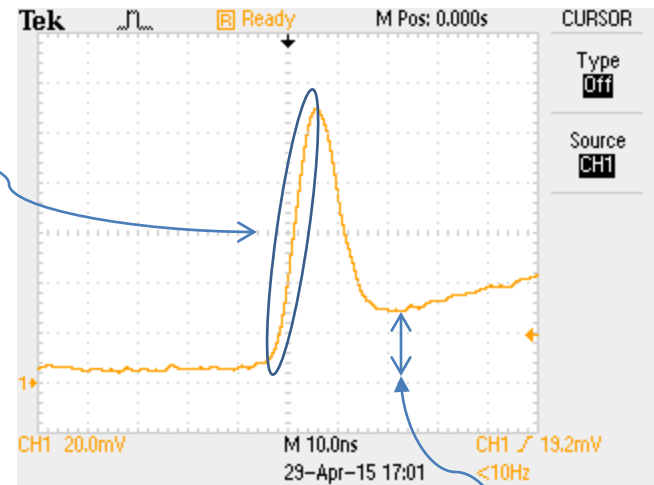
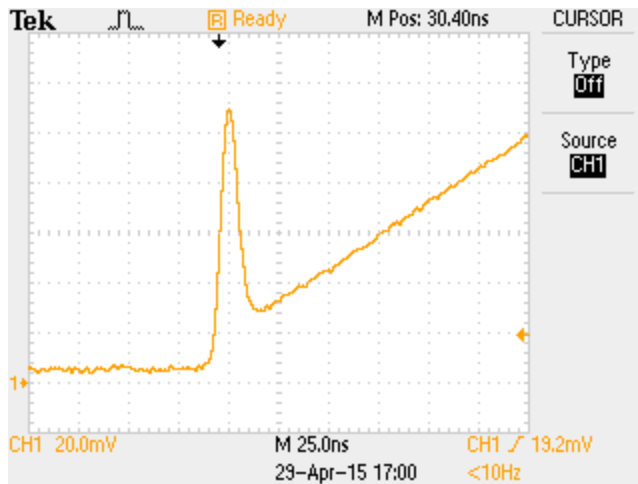




# What Does That Waveform Represent?

Parasitic Inductance of Capacitor,

$$L = \frac{E}{\left(\frac{di}{dt}\right)}$$



ESR of Capacitor,

$$R = \frac{E}{I}$$

Since we use a 2.5 volt pulse into a 50 ohm resistor, current,  $I$  ( $di$ ) is 50 mA





# Testing

Like a Kid with a new toy, I started testing all kinds of stuff!



## Capacitors

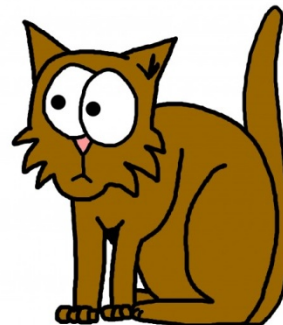
- NovaCap
- Wright
- Poly Film
- High voltage ceramic
- Regular chip ceramic

## CVRs

- Barrel
- Clamp (Stripline)

## Resistors

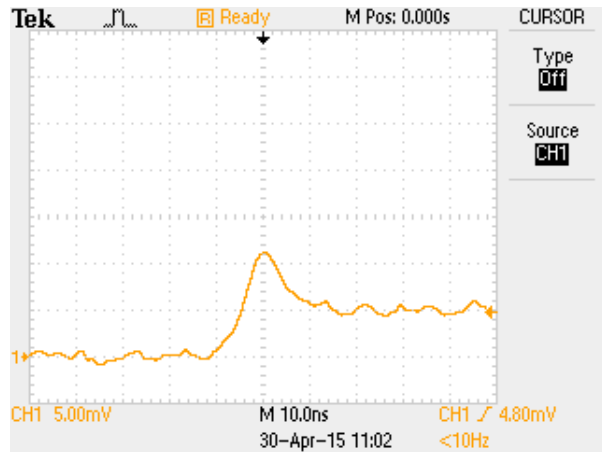
## Inductors



But, not the cat

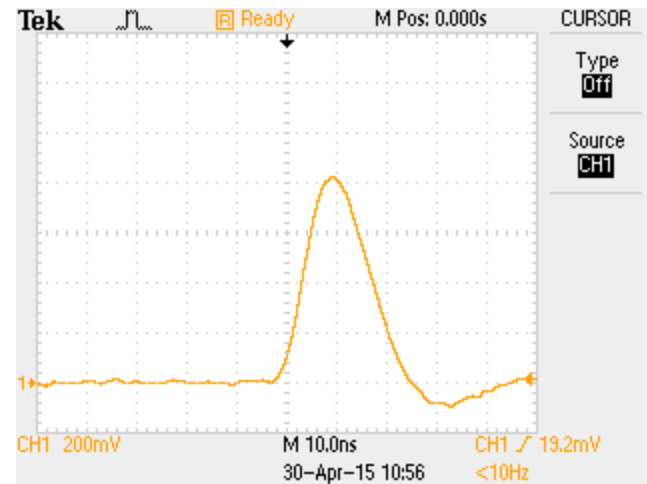


# General Parts



**Surface Mount Resistor, .10 Ohms  
Measured L=2.2 nH, R=100.73 mΩ**

**Molded RF Inductor 220 nH  
Measured 186 nH**





# Firing Capacitors

## Summary of Pulse Test vs. Ring Down in Freddie Fireset

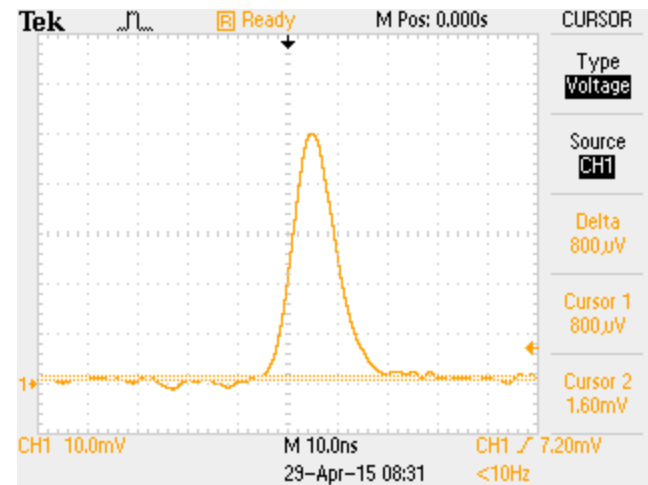
Pulse Test		Ring Down	
NovaCap 3640R144K152P		$I_{PEAK}$	2544 A
L=	1.530 nH	L=	13.72 nH
R=	126 mΩ	R=	42.31 mΩ
Wright SMN6964TR		$I_{PEAK}$	2035 A
L=	4.115 nH	L=	16.49 nH
R=	213 mΩ	R=	65.74 mΩ
Vishay PolyFilm ?		$I_{PEAK}$	1487 A
L=	13.65 nH	L=	35.52 nH
R=	237 mΩ	R=	65.74 mΩ



# Barrel CVR Measurement



**Pulse Measurement Data:**  
**L=9.259 nH, R=15.9 mΩ**



**CVR Resistance is .005087 Ω,  
At 50 mA,  $E \approx 258 \mu\text{V}$ .**

**Not likely to measure that on my scope!**

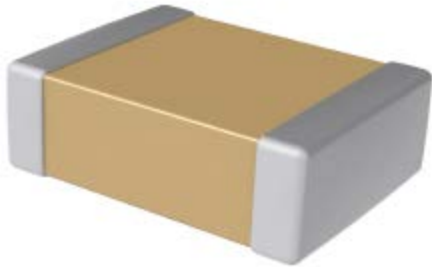
**But, it could also imply 10 mΩ of Fixture Resistance.**

**Clamp CVR is  $\sim 2$  nH less**



# A Potential Firing Cap ?

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**Kemet C2225C104KFRACTU**

**0.1  $\mu$ F, 1.5 KV**

**High Voltage X7R Dielectric, 500 – 3,000 VDC  
(Commercial & Automotive Grade)**

**Pulse Data: L=1.49 nH, 130 m $\Omega$**

**So I put two in parallel, must be twice as good, right?**

**2 in Parallel, Pulse Data: L=1.02 nH, 94 m $\Omega$**

**Well, not quite!**

**Have not performed ring down yet. Most all data sheets say X7R material not suitable for pulse applications. Need to run that to ground.**



# Summary

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- ▶ The test method may have value in testing potential capacitors and measuring other components
- ▶ There appears to be a correlation between pulse inductance and performance
- ▶ There is a weak correlation between pulse ESR and performance



# Questions?

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