



Pulse current test considerations for contacts

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Problem

- Users of contacts under transient pulse loading conditions need to assess performance during design phase of system and during operation
- Pulse testing of contacts can generate a wide variety of responses and results for critical parameters like
 - Current handling capability
 - Contact temperature rise
-
- Interpretation of measurements depends on
 - Test parameters
 - Test environment
 - Instrumentation
 - Test methods



Objective

- Identify potential pitfalls in pulse current testing
 - Instrumentation
 - Measurement techniques
 - Test specimen
- Provide some guidelines for performance assessment



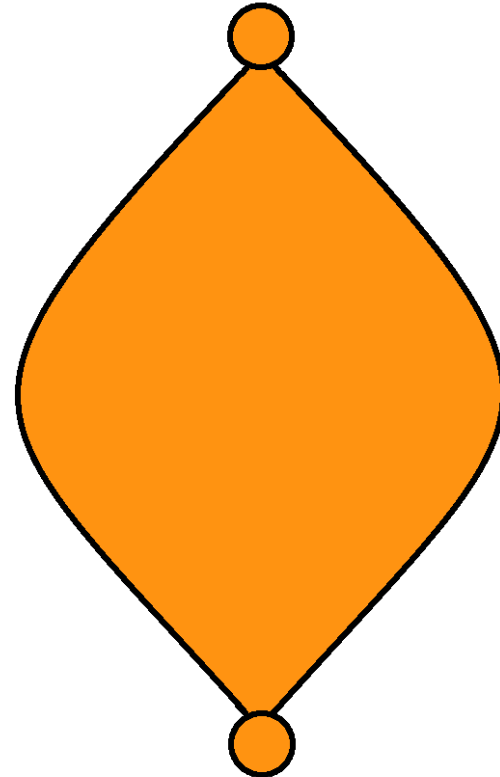
Approach

- Examine contact construction and basic parameters
- Utilize knowledge gained from actual test to establish simple models and procedures
- Engage computer simulations to demonstrate impact of test environment and parameters
 - SPICE circuit simulator
 - ANSYS HFSS field modeler
 - 2.5D modeler for thermal problems



Contact design

- Important parameters
 - Electrical resistance
 - Thermal resistance
 - Thermal mass
- Cooling mechanisms
 - Conduction
 - Convection
 - Radiation



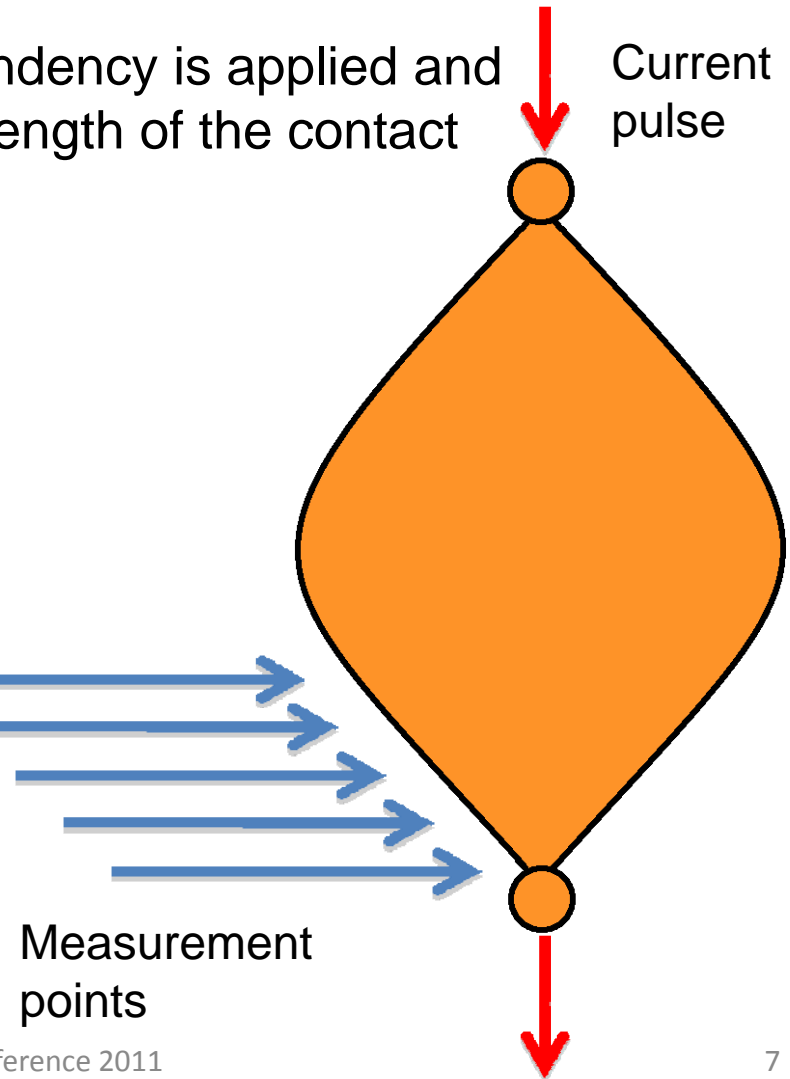
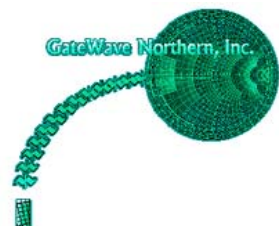
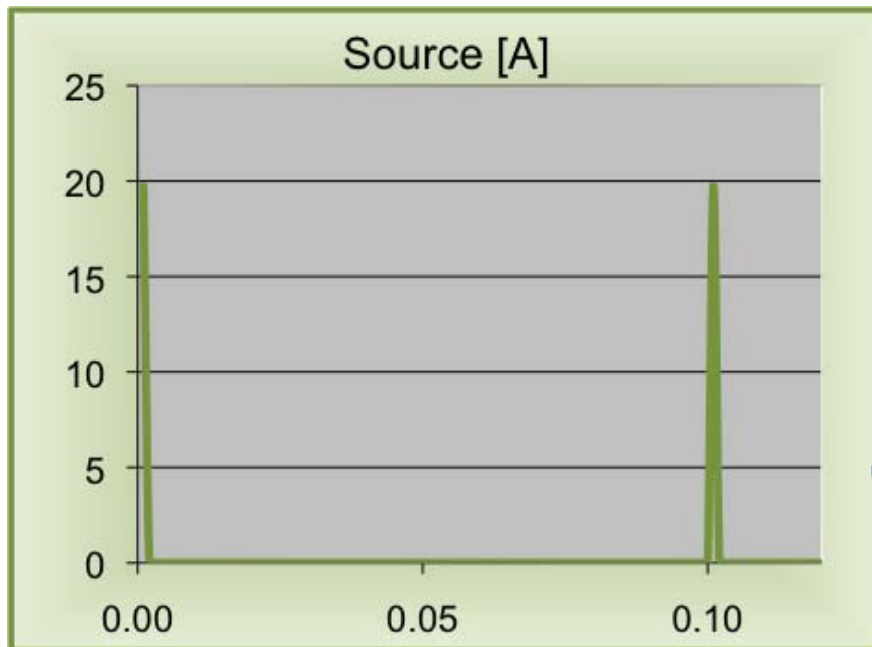
Operating parameters

- What a contact may be subjected to:
 - DC (steady state) current
 - AC (alternating / RF) current
 - Short term loads
 - Spikes from malfunctions
 - Ambient temperature
- Consequences of exceeding design envelope
 - Parameter changes
 - Bulk
 - Surface
 - Premature (longer term) wear/failure
 - Immediate failure



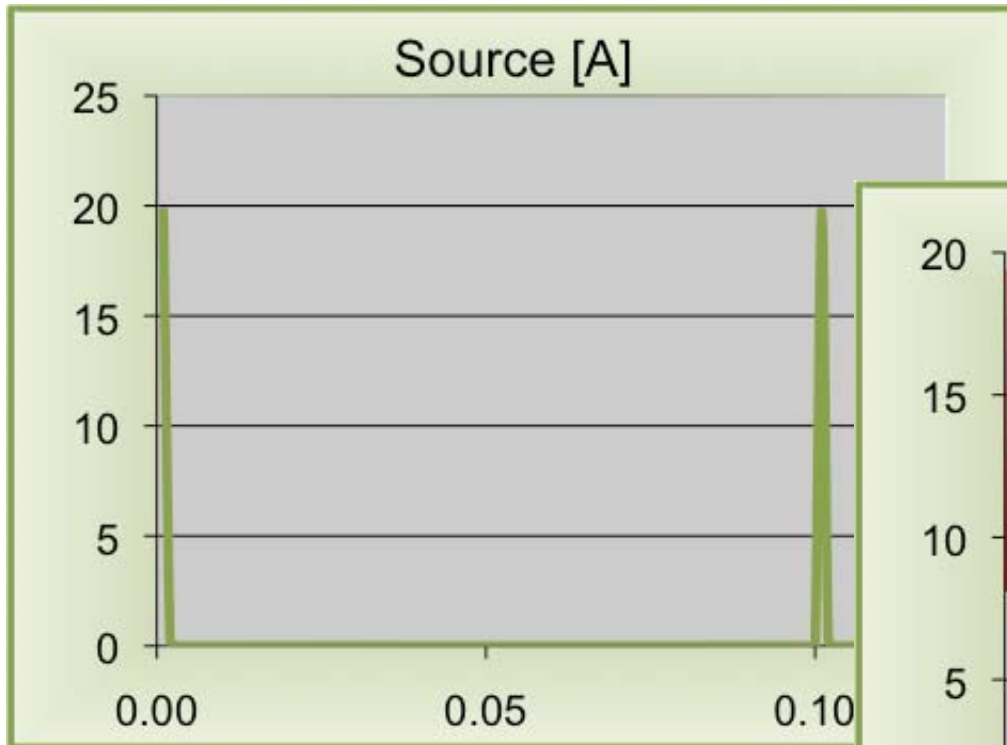
Pulse Operation

- Current with a particular time dependency is applied and temperature is monitored along the length of the contact

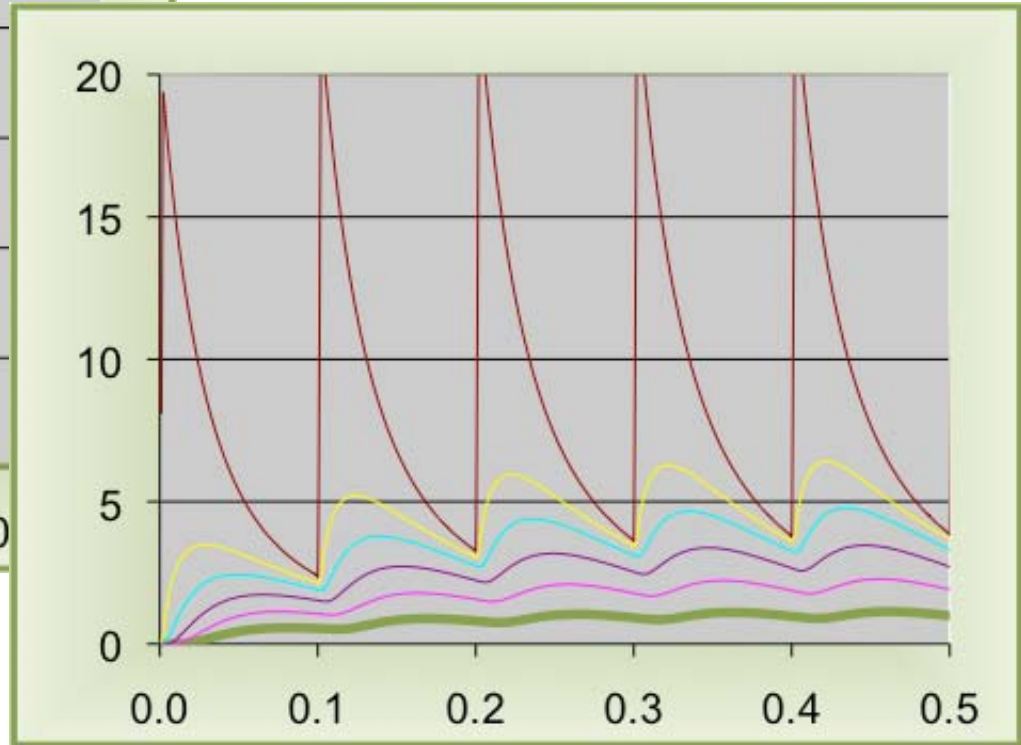


Simulated short pulse response

- A short pulse causes only a slight temperature rise in the contact center

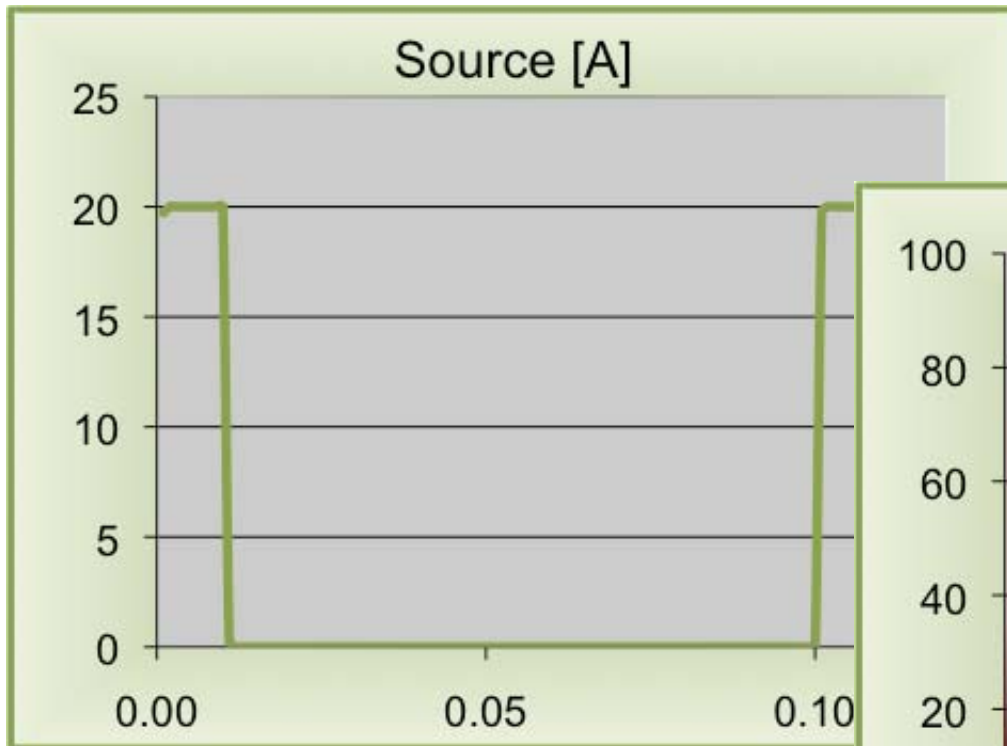


20A 100 ms 1% duty cycle
dT [C] as a function of time [s]

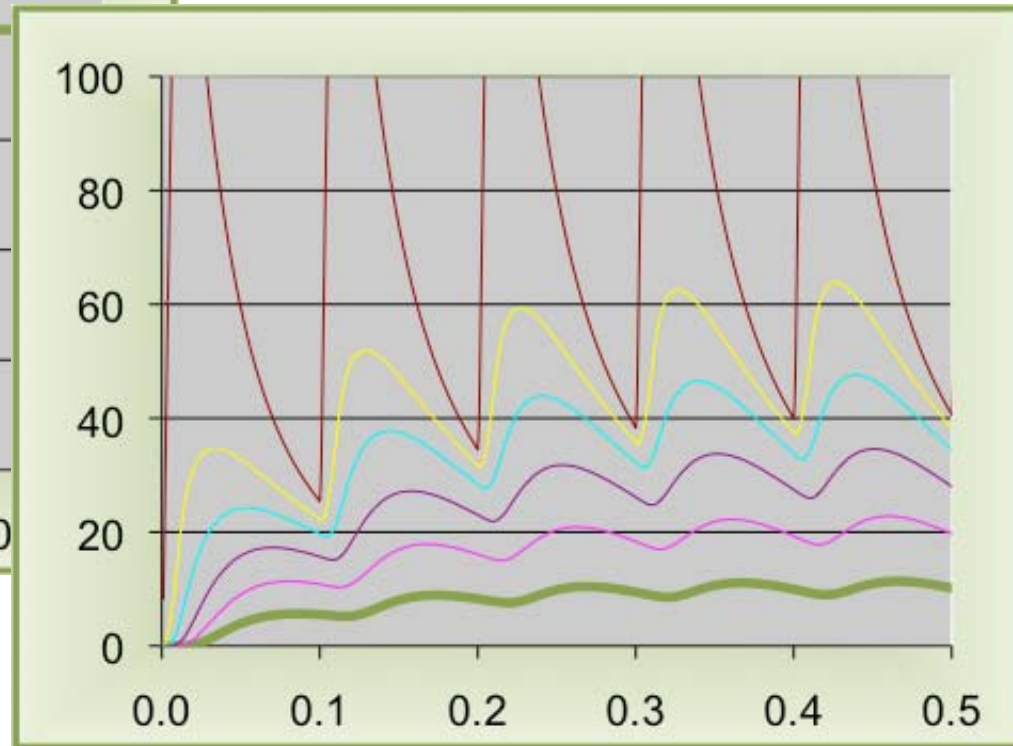


Simulated longer pulse response

- Higher duty cycle leads to higher temperatures

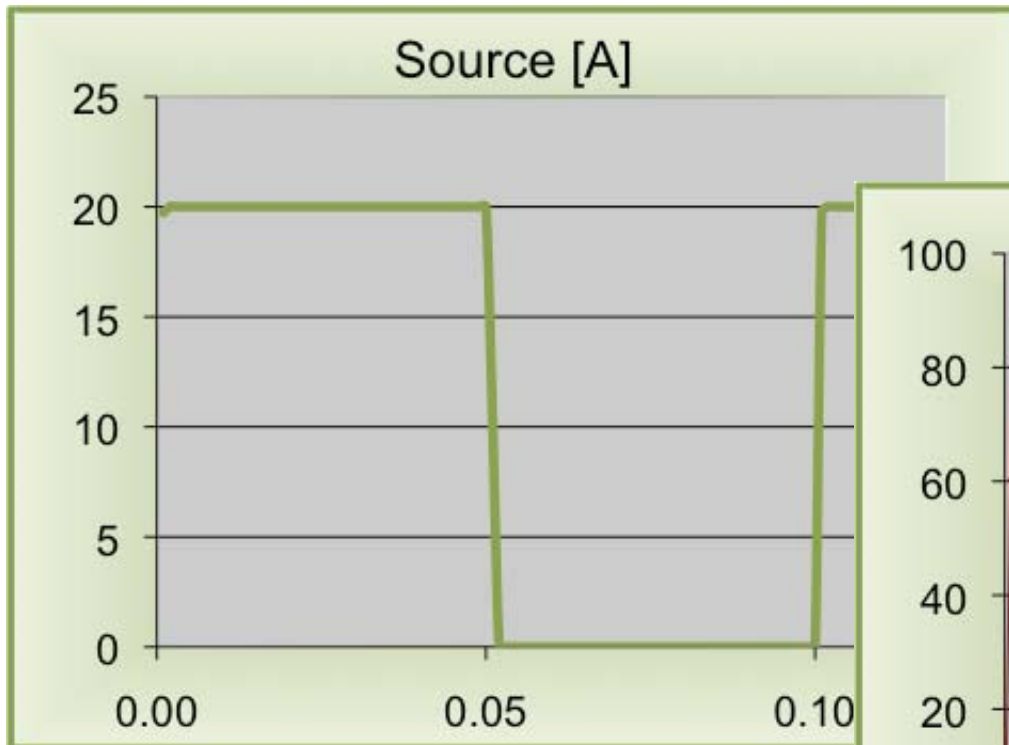


20A 100 ms 10% duty cycle
dT [C] as a function of time [s]

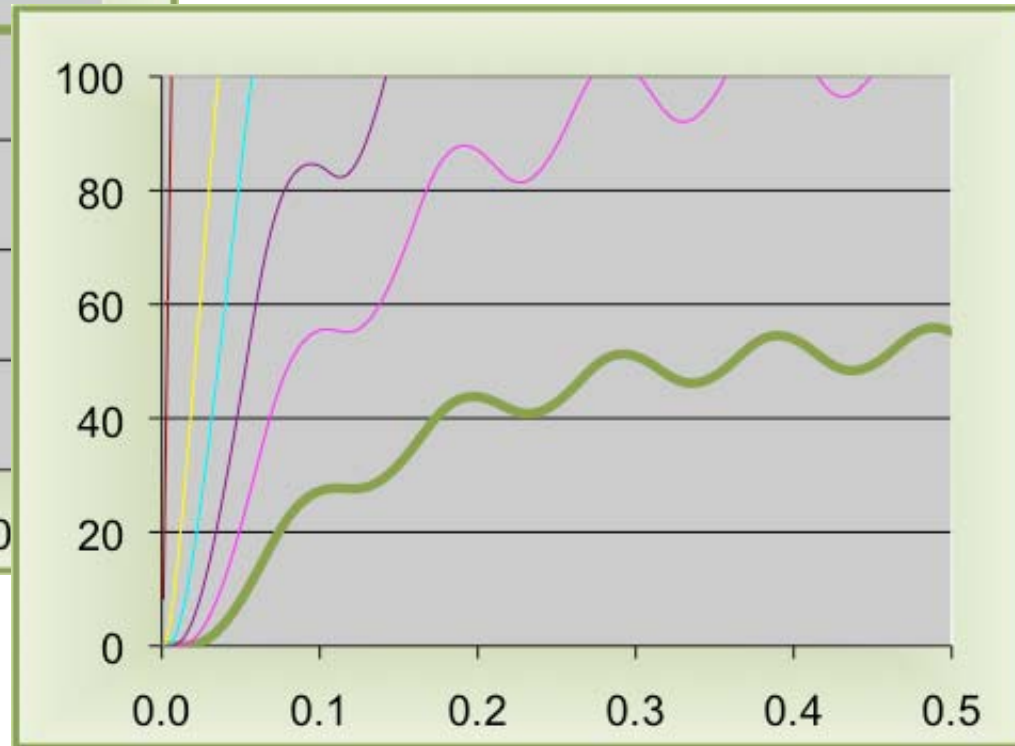


Simulated square pulse response

- Test would lead to destruction of contact near ends

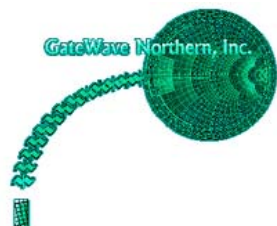
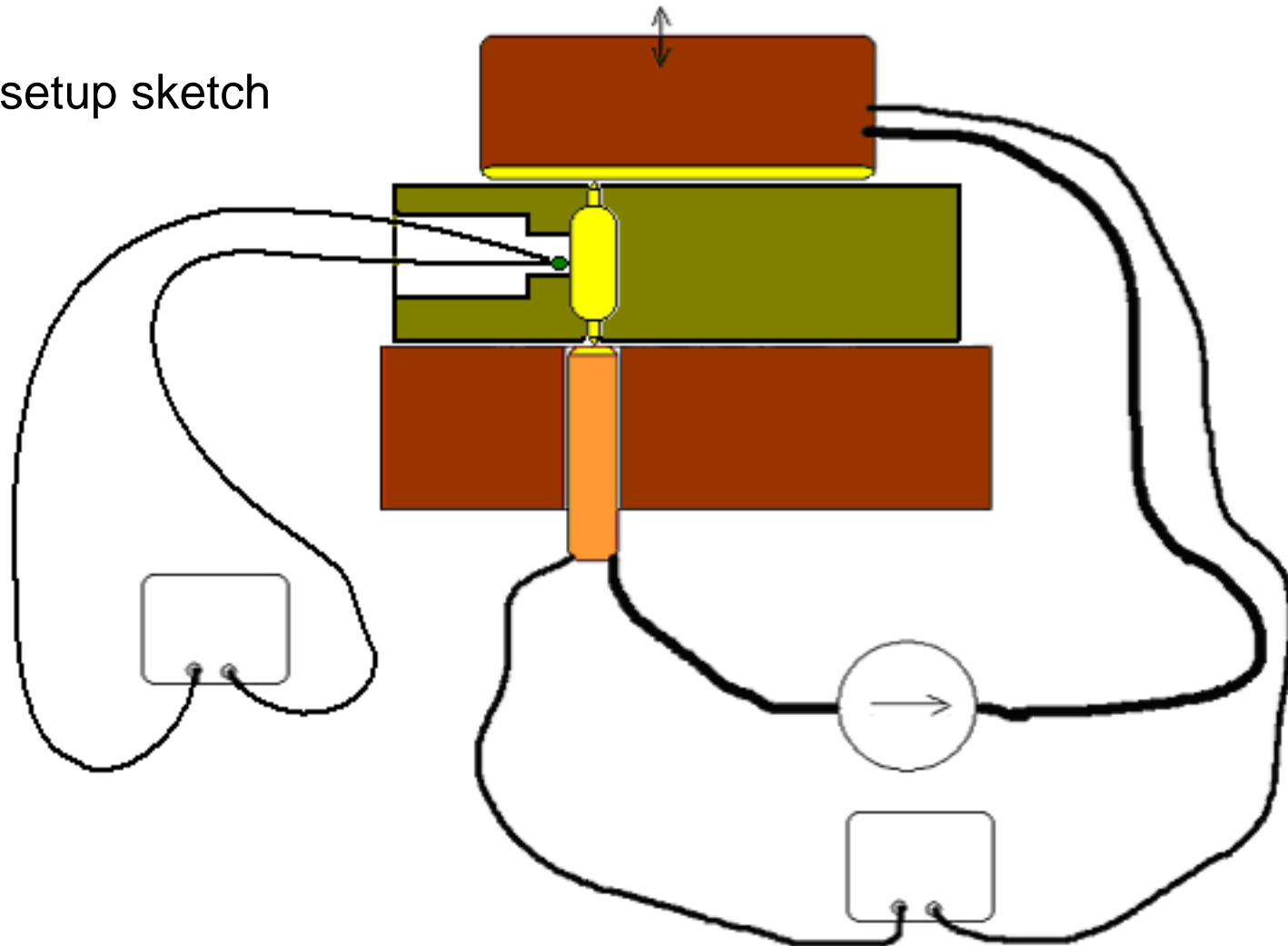


20A 100 ms 50% duty cycle
dT [C] as a function of time [s]



Setup

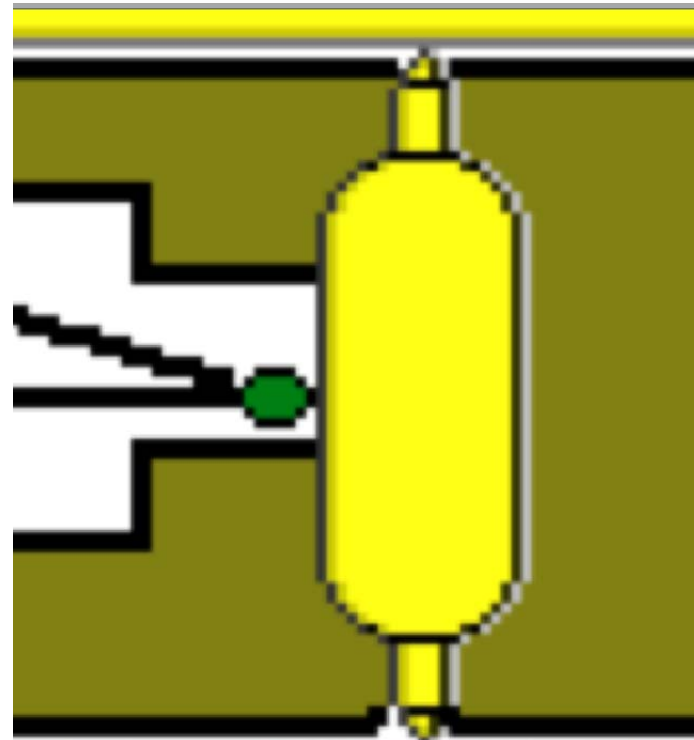
- Typical test setup sketch



Setup

- Temperature sensor detail

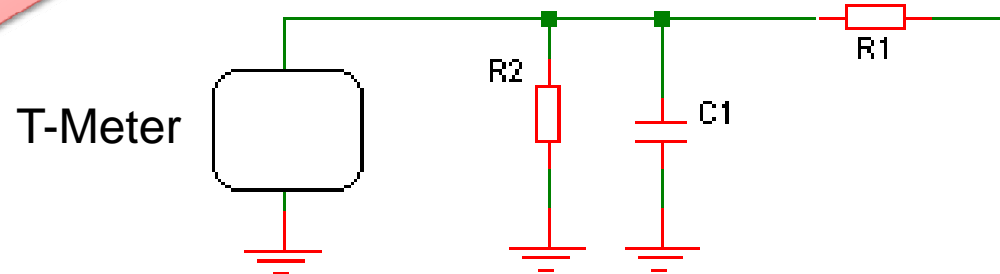
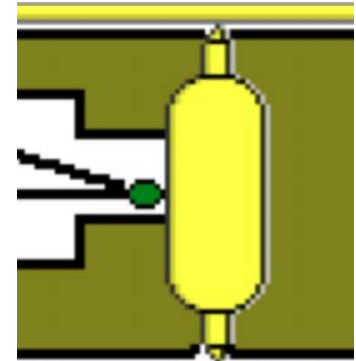
- ✓ Narrowing at contact point to T-sensor combined with thermal mass of sensor plus cables causes time lag.
- ✓ Cables conduct heat away in steady state and cause offset from proper value.



Setup analysis

- Equivalent circuit

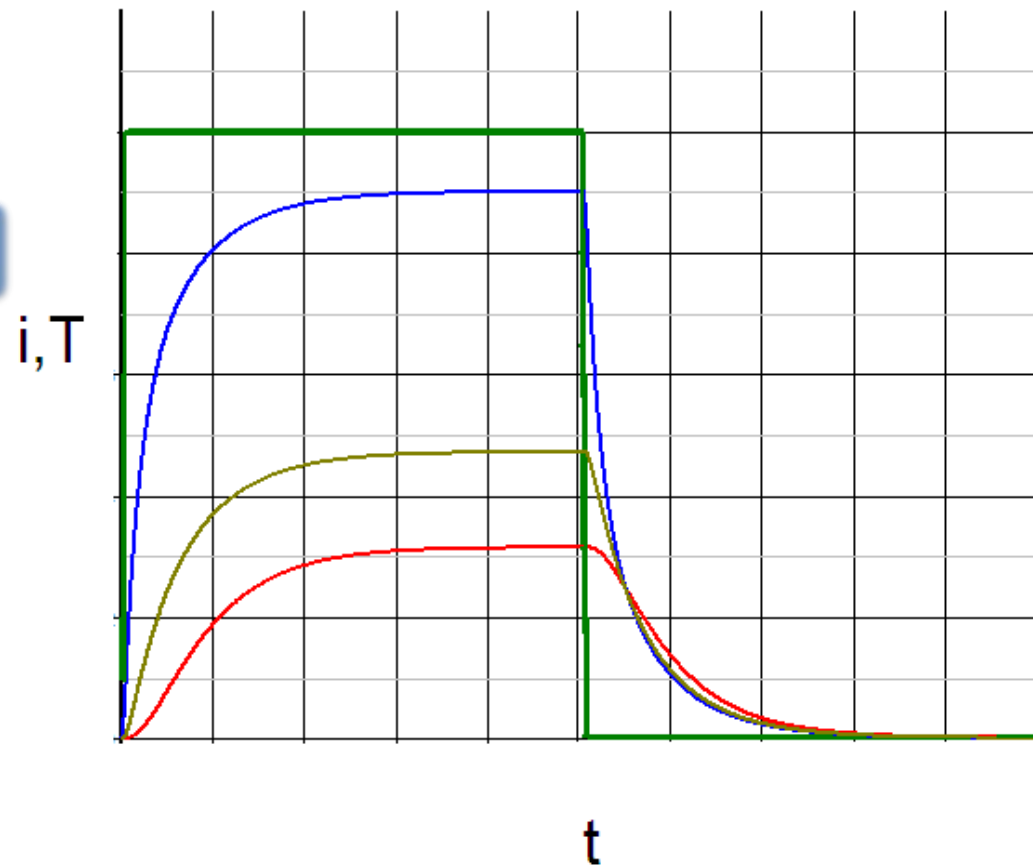
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Impact of pulse parameters

- After a finite time contact temperature reaches steady state

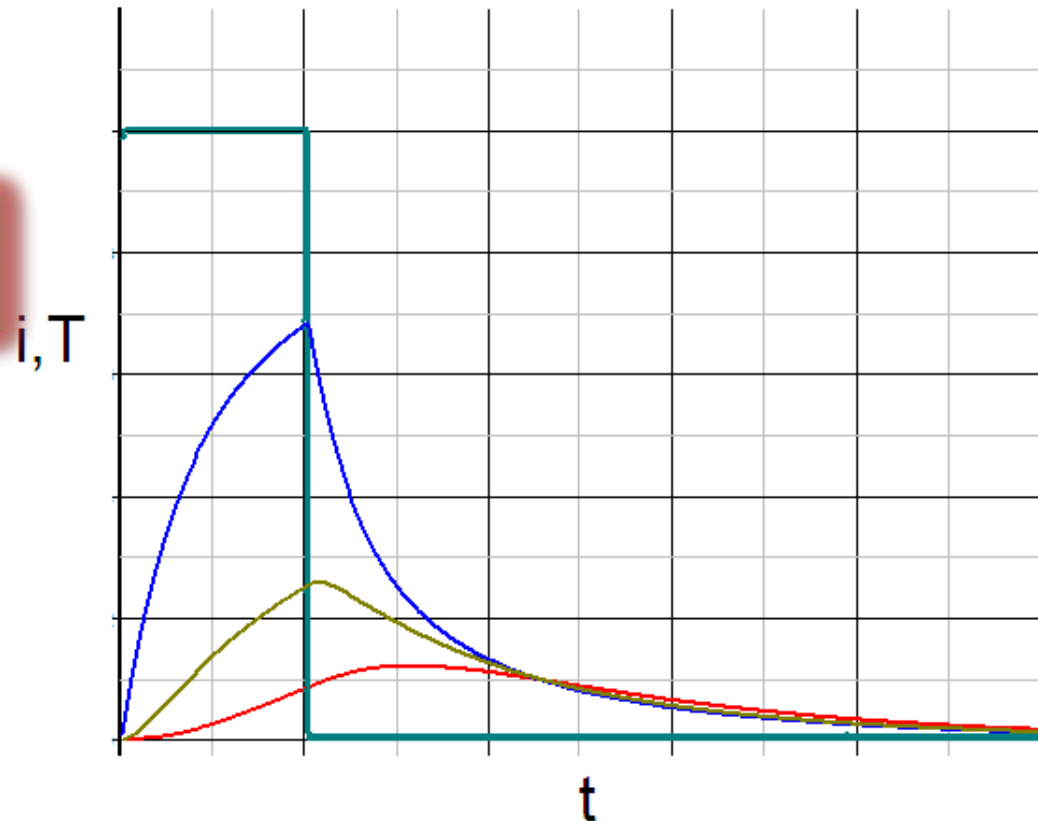
There is a small amount of lag.



Shorter pulse

- Contact does not reach thermal steady-state

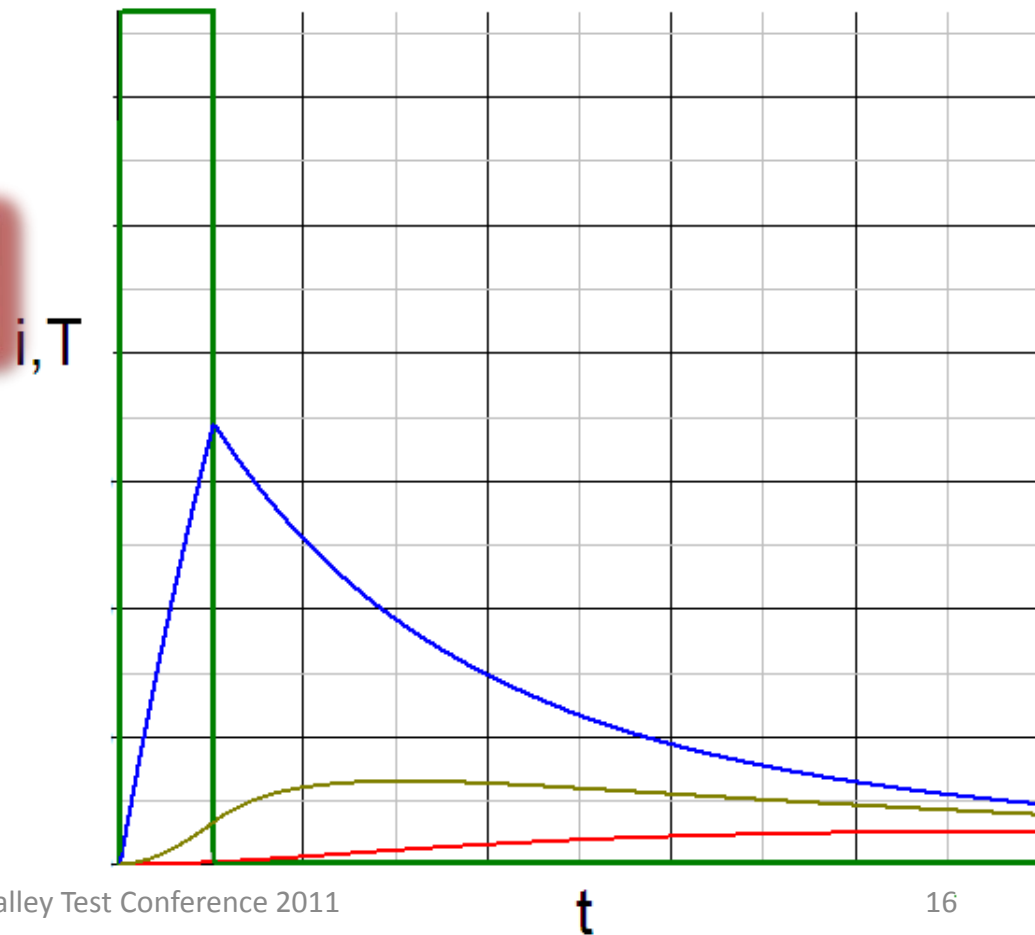
Instrumentation timing becomes an issue.



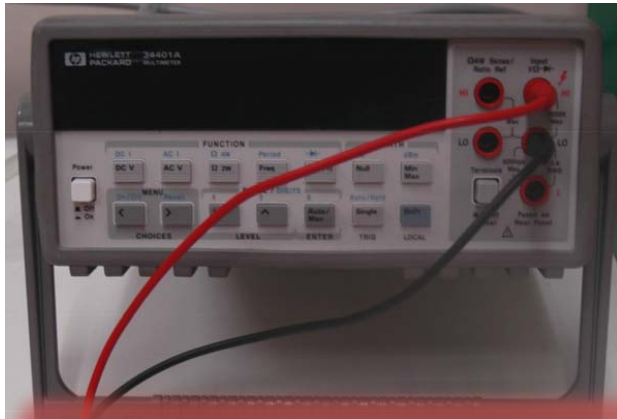
Very short pulse

- Pulse length very short compared to thermal time constants

Instrumentation timing is critical.



Instrumentation timing



Source: Wikipedia

- “Free-standing” DMMs and thermocouple meters can most likely not be properly timed to acquire data at the right time.
- Simple windows based acquisition systems do not give reliable timing.
- An ‘integrated’ system approach with proper component characterization is the preferred solution.



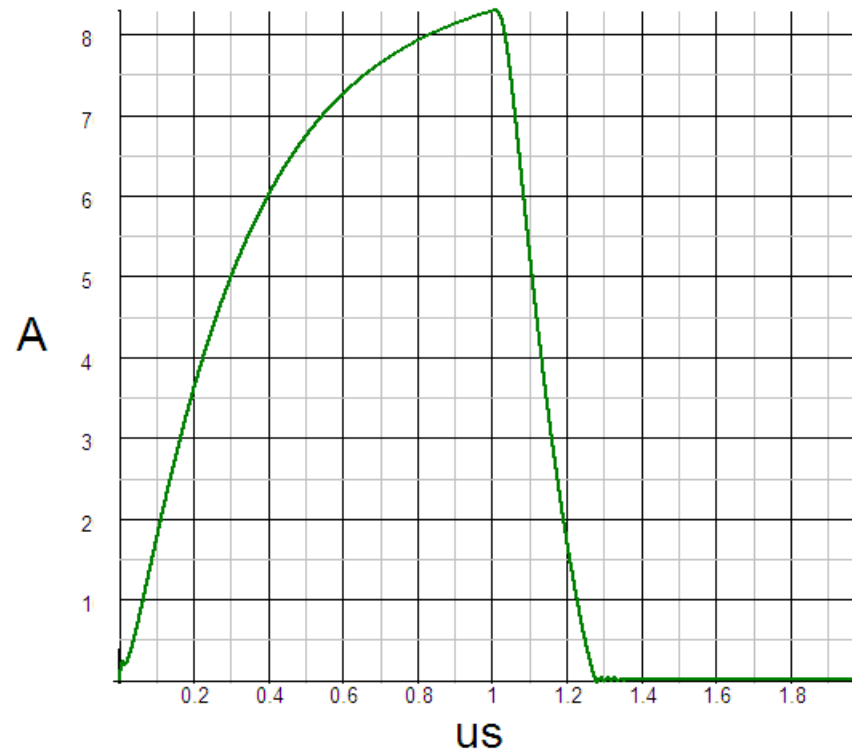
Sources

- Commercial high current pulse generators
 - Likely well characterized
 - Output voltage can reach very high levels
 - May not be suitable for driving near short circuit as required in contact testing
 - Load, i.e. test specimen, must be very close to source
- Custom design
 - Drive circuit can be made part of test fixture/setup
 - Source characteristics difficult to assess or unknown
 - Potential for catastrophic failure is higher



Source impedance

- When driving from a 'real' source it's internal impedance and properties must be taken into account:

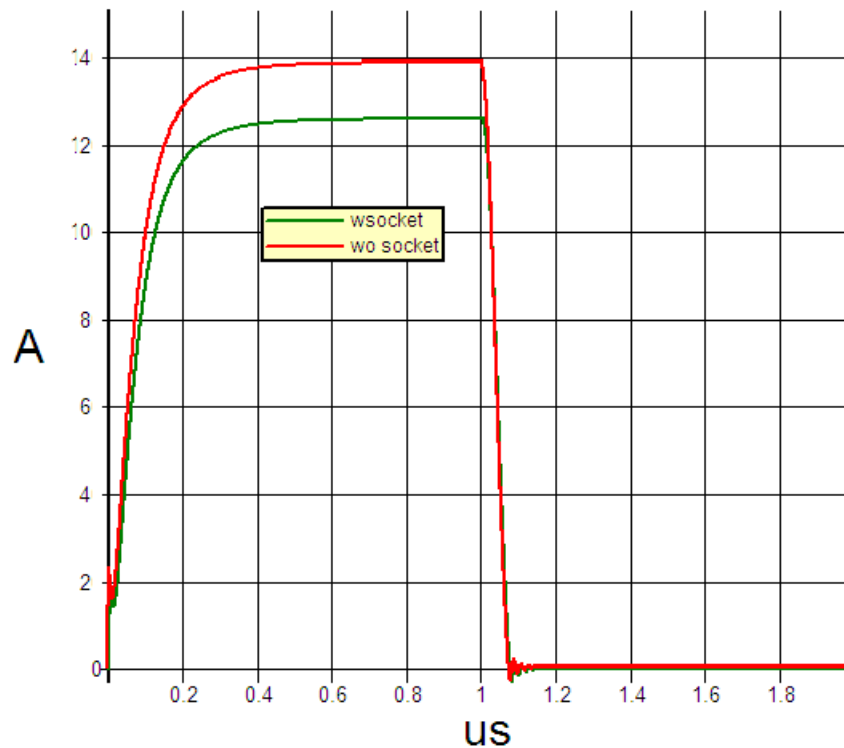


Finite pulse risetime and internal source impedance results in a reduced current during actual test (nominal 10 A)



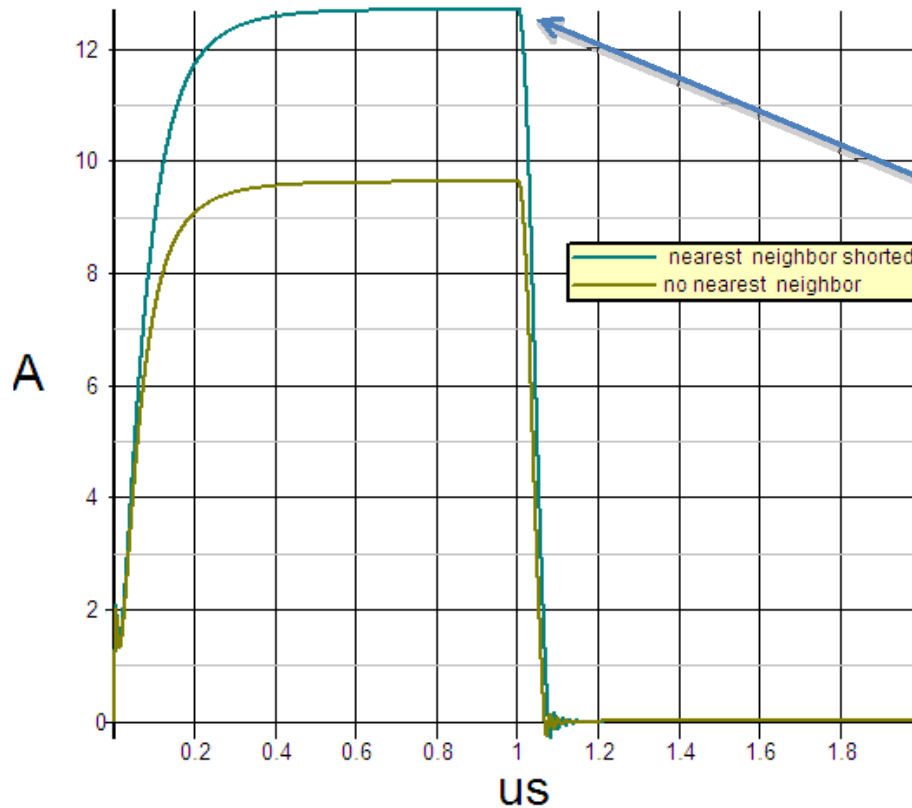
Calibration

- Since source impedance is not infinite for high speed sources amplitude errors can occur when contact resistance varies / changes:



Test configuration

- Allowing multiple conductors to participate in return path can lead to configuration dependent results:

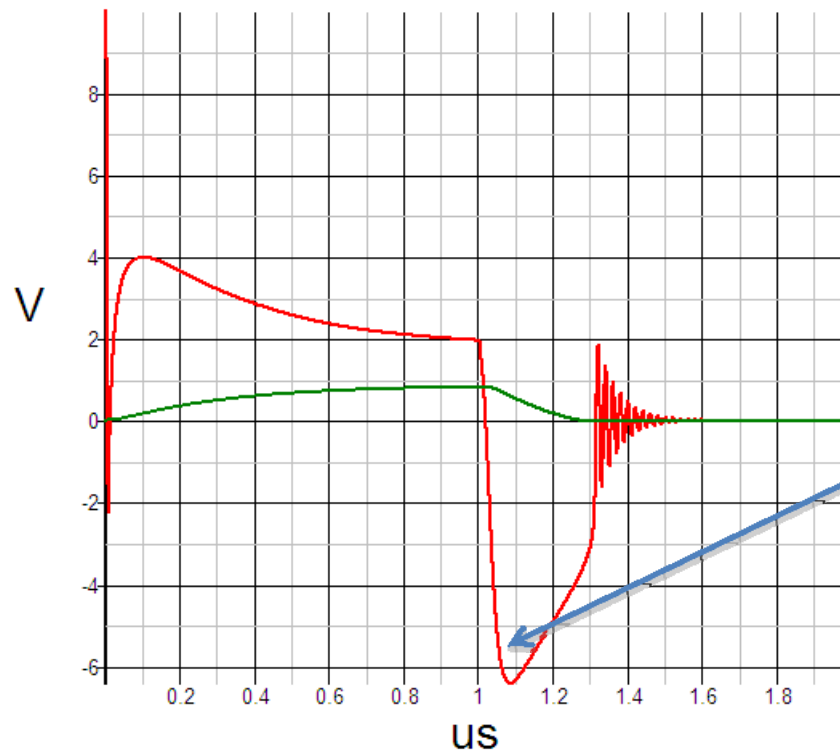


Lower return path resistance causes higher test current



Circuit specifics

- Turn-on/off transients cause voltage excursions at the source terminals. This in turn can affect proper operation and calibration:

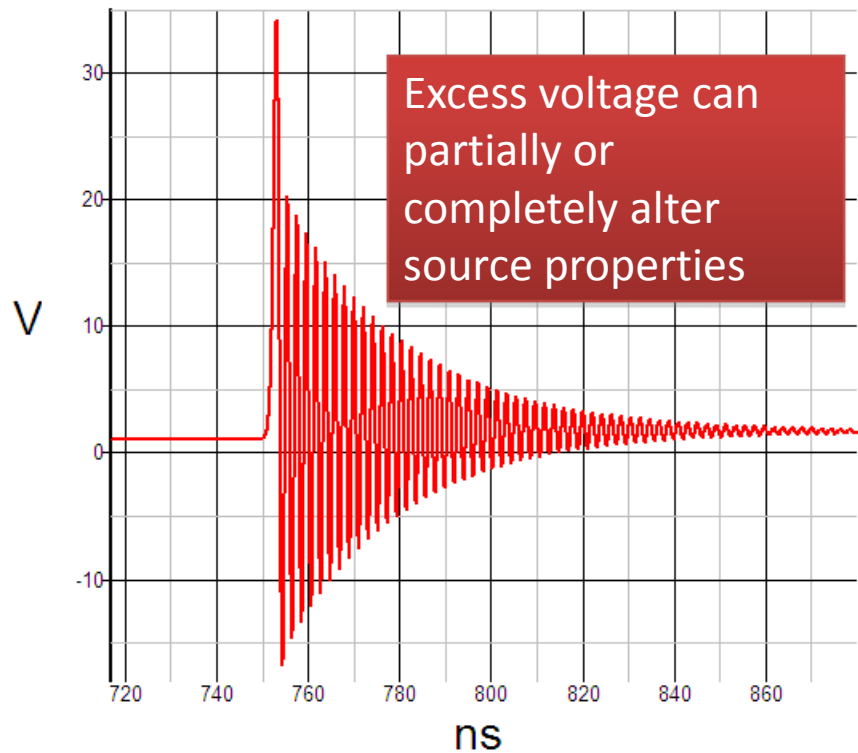
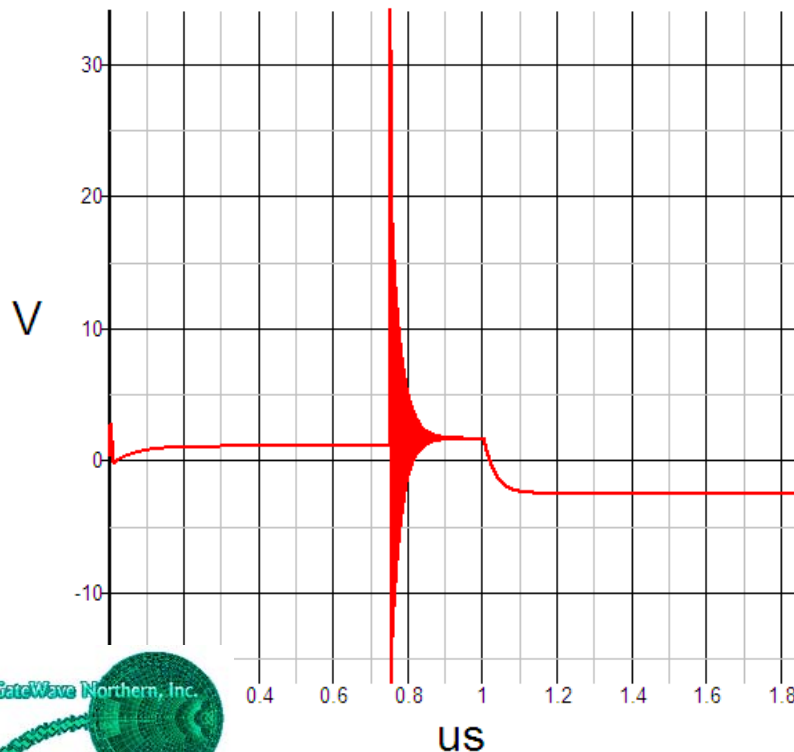


A large negative voltage spike (inductive load !) occurs during fast source signal turn-off



Contact failure

- When contact burns open, large transients can (and will) occur:



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Conclusion

- Pulse test requires accurate knowledge of system time constants
 - Source
 - Load
 - Thermal time constants of specimen
 - Instrumentation
- Assessment of maximum current capability is not straightforward
 - Measurement point for highest temperature rise may not be accessible
 - A force based criterion may be more descriptive measure

