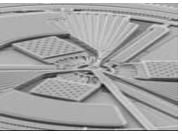
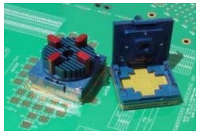
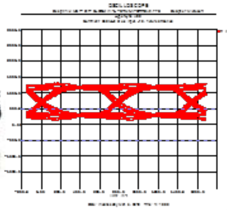
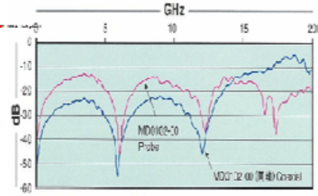







Pulse current test considerations for contacts

Gert Hohenwarter
GateWave Northern, Inc.
g.hohenwarter@gatewave.com

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

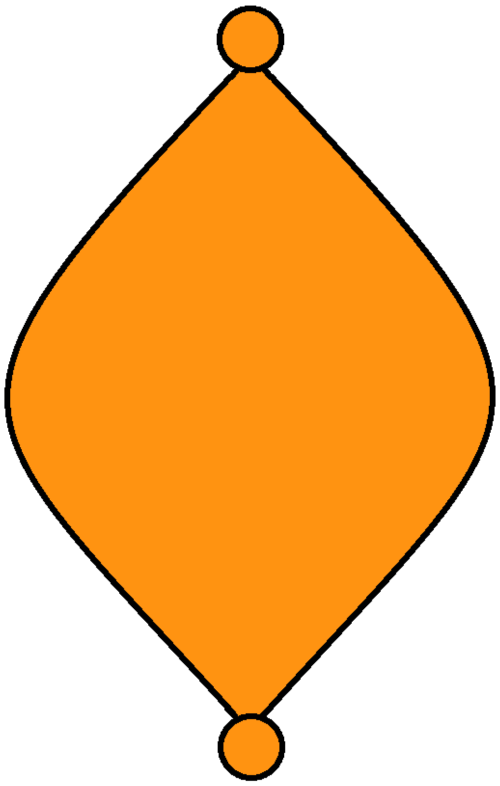
- Utilize knowledge gained from actual test to establish simple models and procedures

- 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



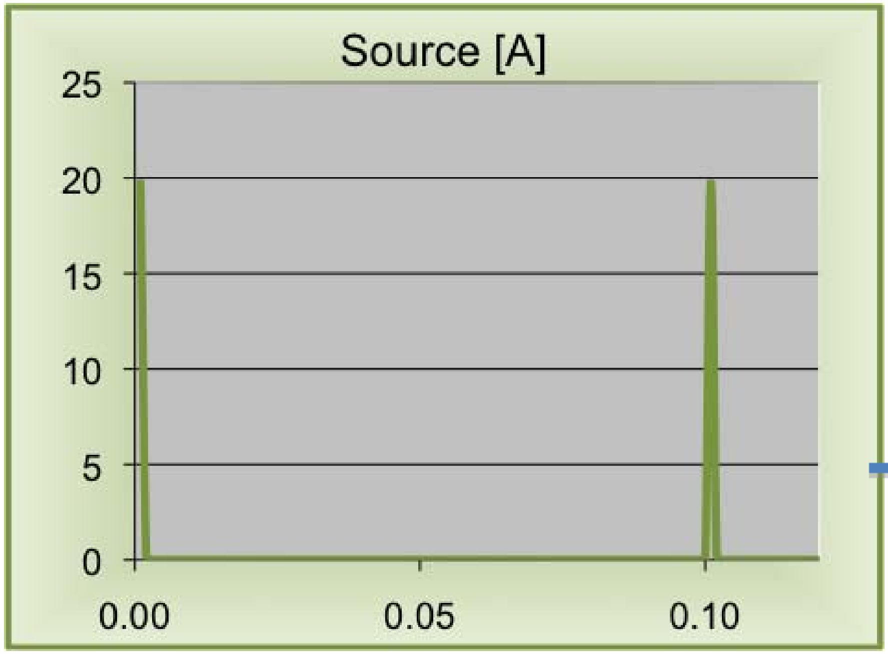
Operating parameters

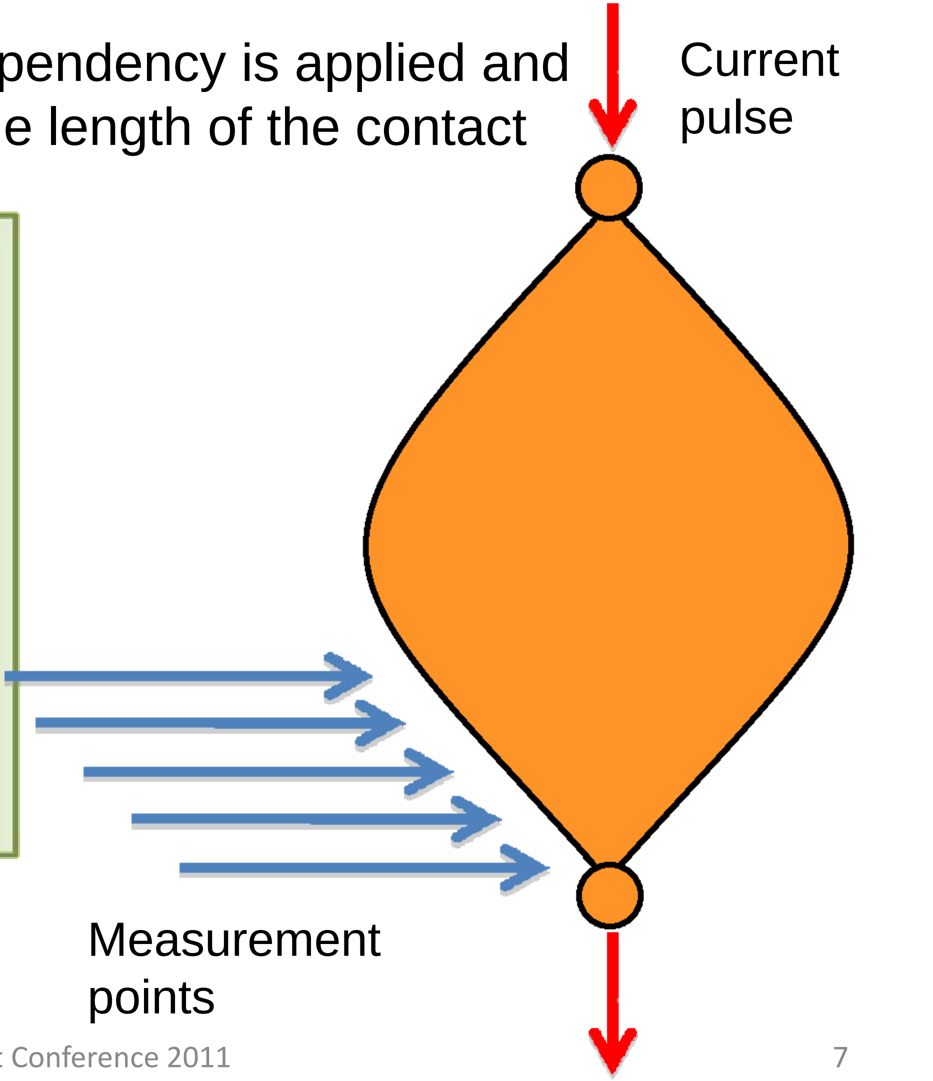
- What a contact may be subjected to:
  - DC (steady state) current
  - AC (alternating / RF) current
  - Short term loads
  - Spikes from malfunctions
  - Ambient temperature

- Consequences of exceeding design envelope
  - Parameter changes
    - Bulk
    - Surface
  - Premature (longer term) wear/failure
  - Immediate failure

Pulse Operation

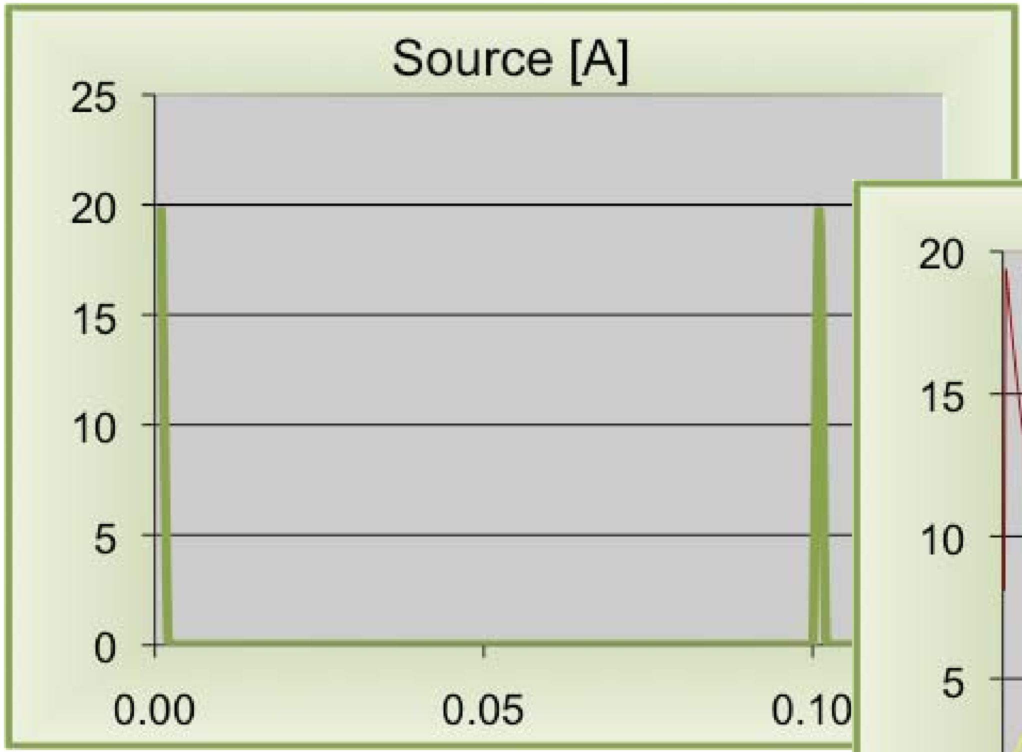
- Current with a particular time dependency is applied and temperature is monitored along the length of the contact



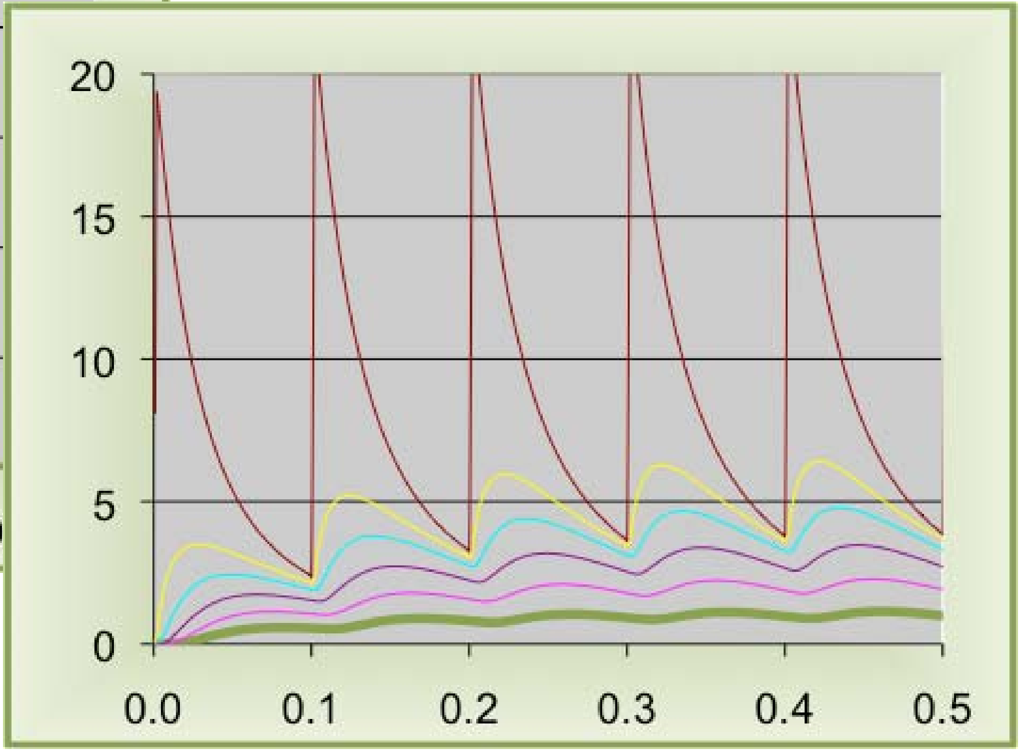


Simulated short pulse response

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

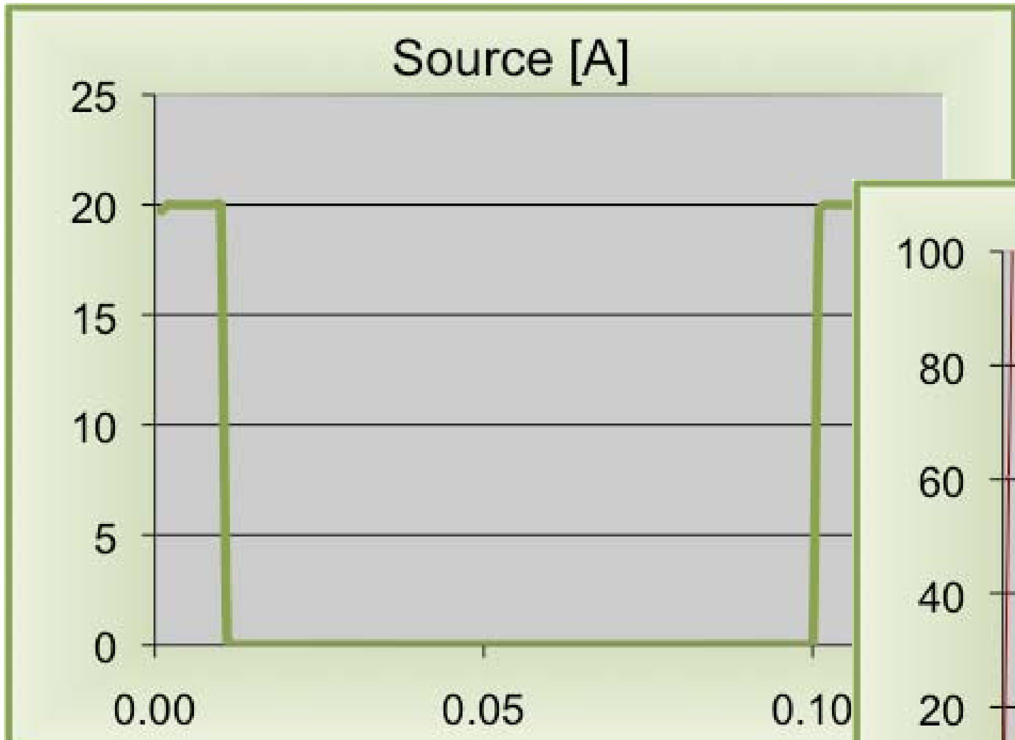


20A 100 ms 1% duty cycle
dT [C] as a function of time [s]

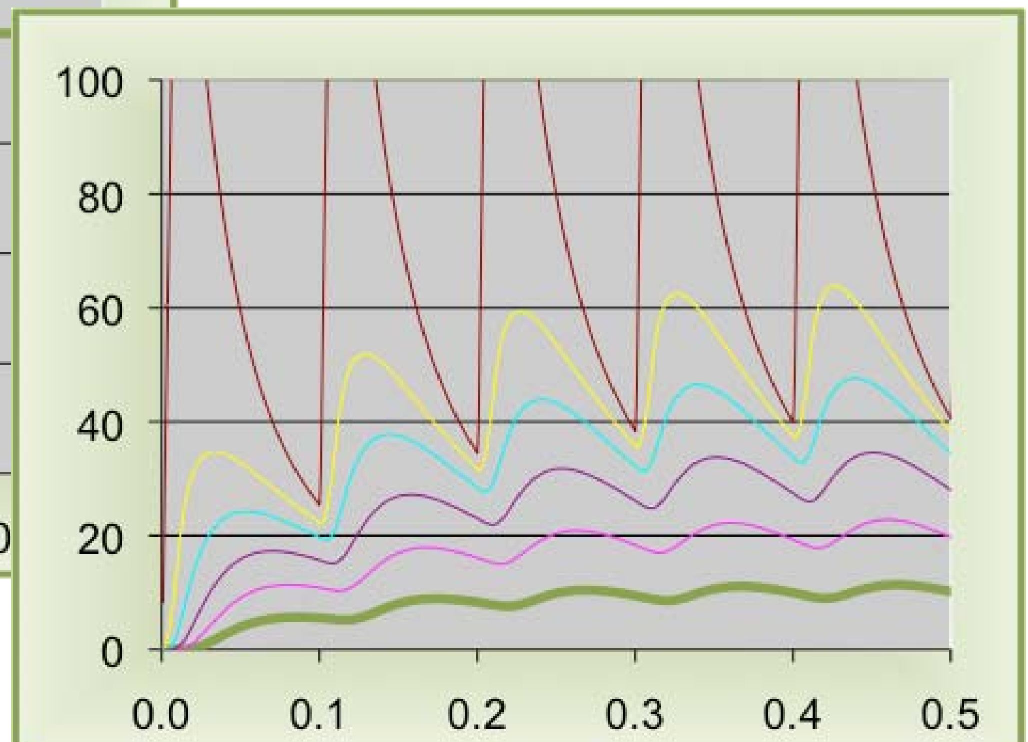


Simulated longer pulse response

- Higher duty cycle leads to higher temperatures

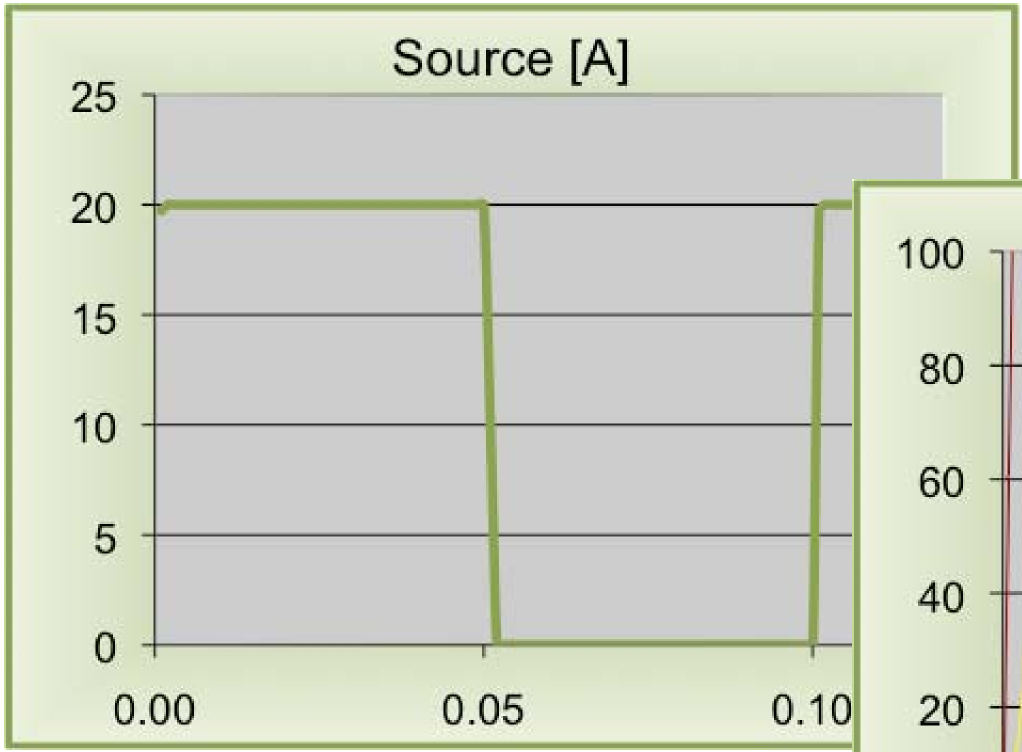


20A 100 ms 10% duty cycle
dT [C] as a function of time [s]

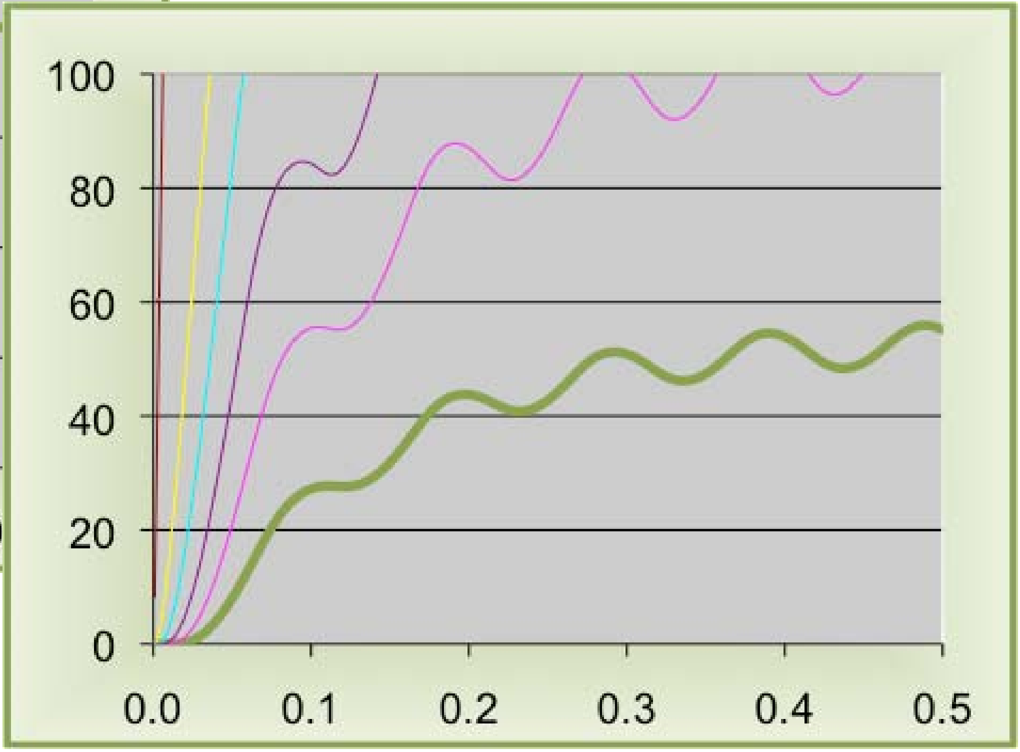


Simulated square pulse response

- Test would lead to destruction of contact near ends

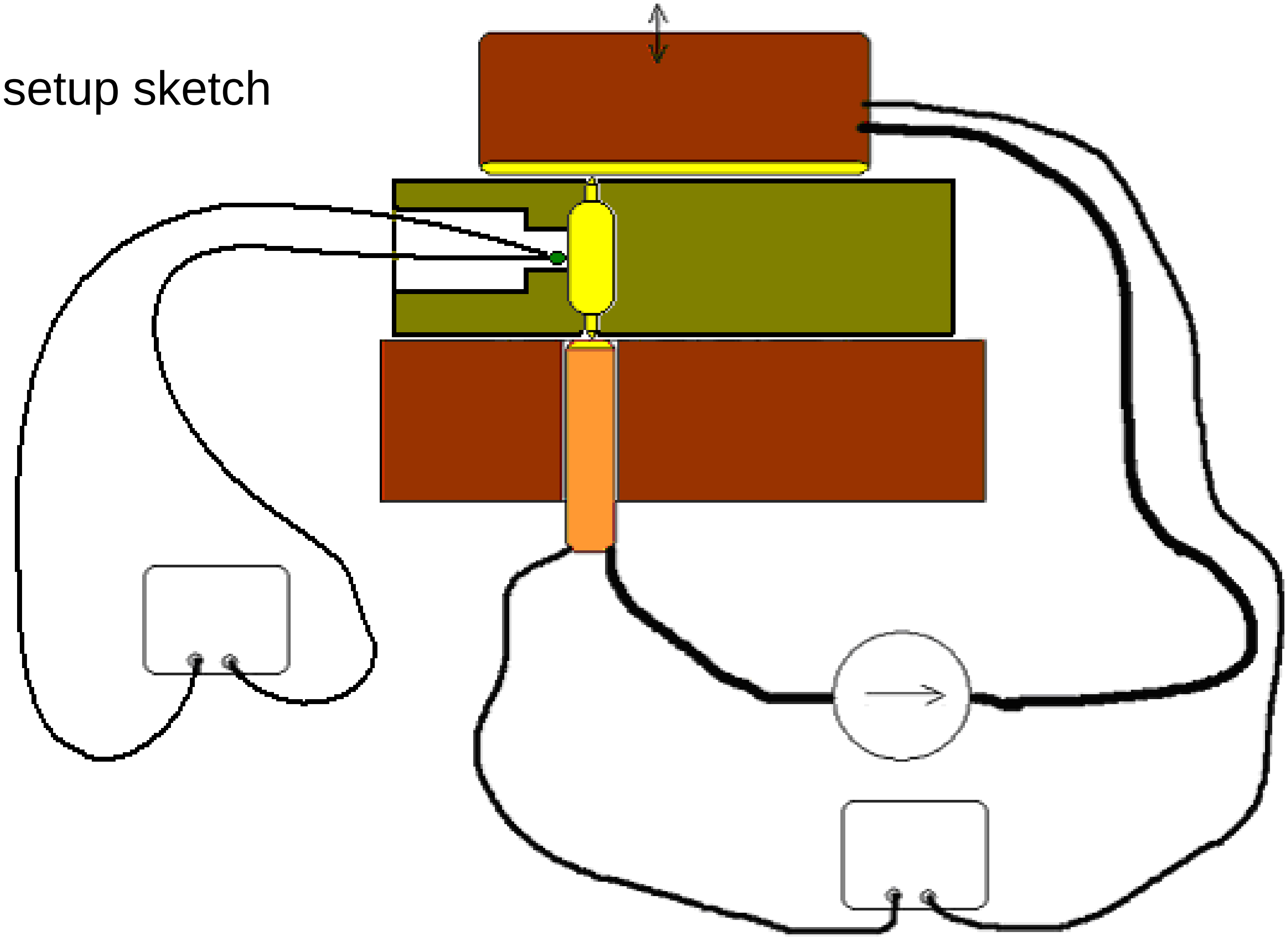


20A 100 ms 50% duty cycle
dT [C] as a function of time [s]



Setup

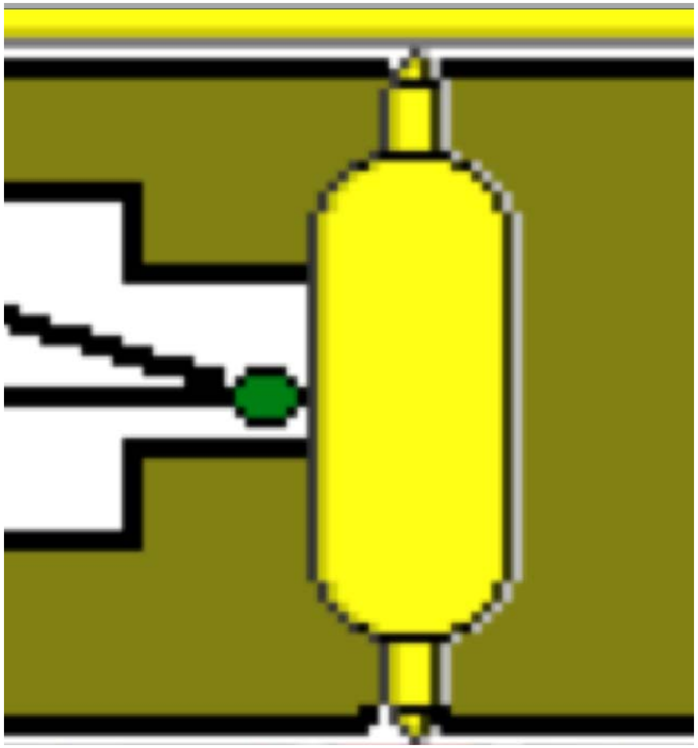
- Typical test setup sketch



Setup

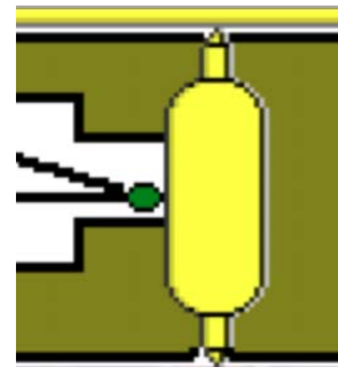
- Temperature sensor detail

✓ 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.

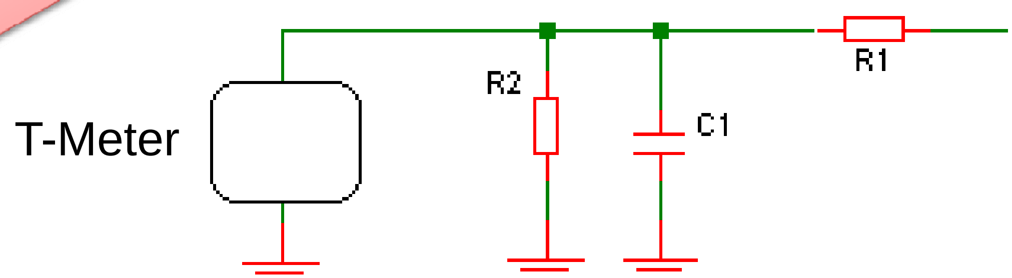


Setup analysis

- Equivalent circuit



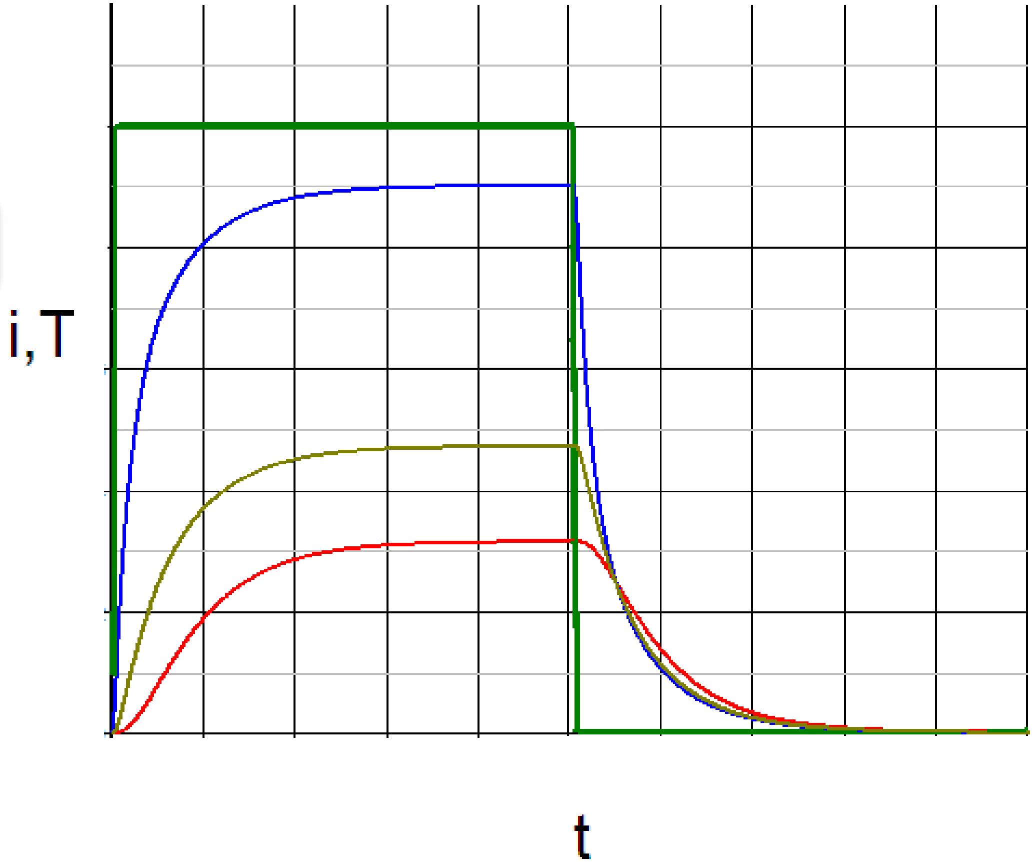
✓ Narrowing at contact point to T-sensor combined with thermal mass of sensor plus cables causes time lag.
✓ Cables conduct heat away in steady state and cause offset from proper value.



Impact of pulse parameters

- After a finite time contact temperature reaches steady state

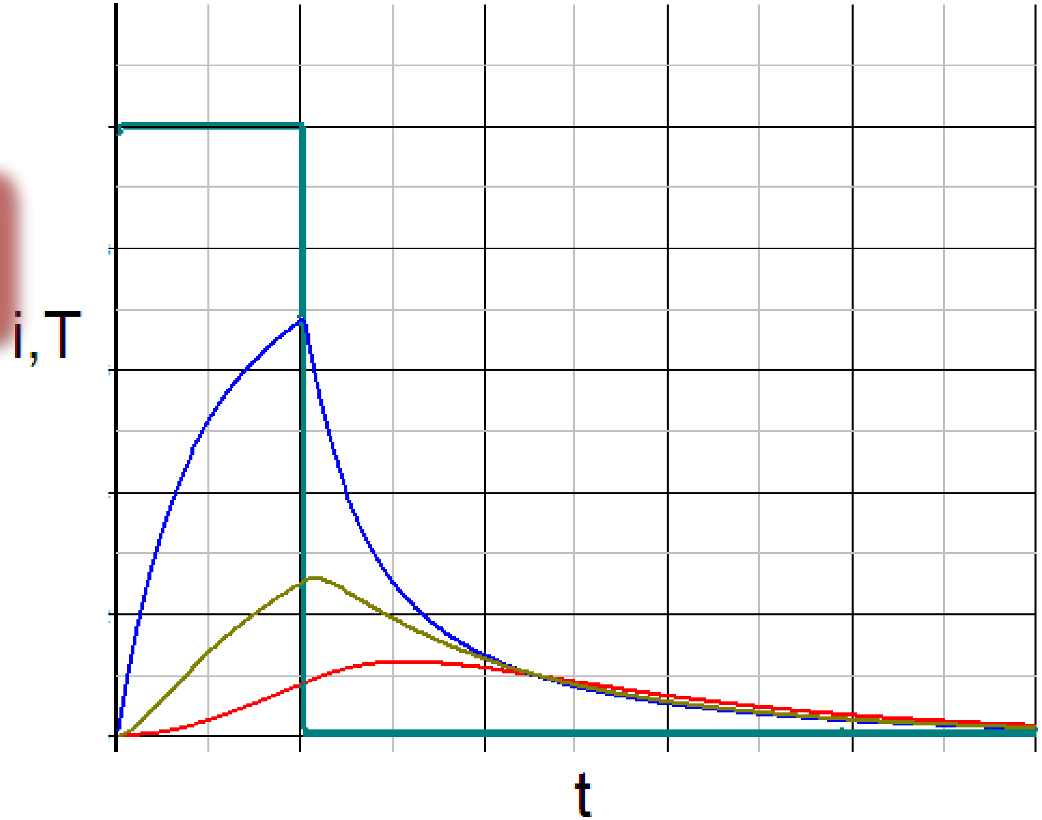
There is a small amount of lag.



Shorter pulse

- Contact does not reach thermal steady-state

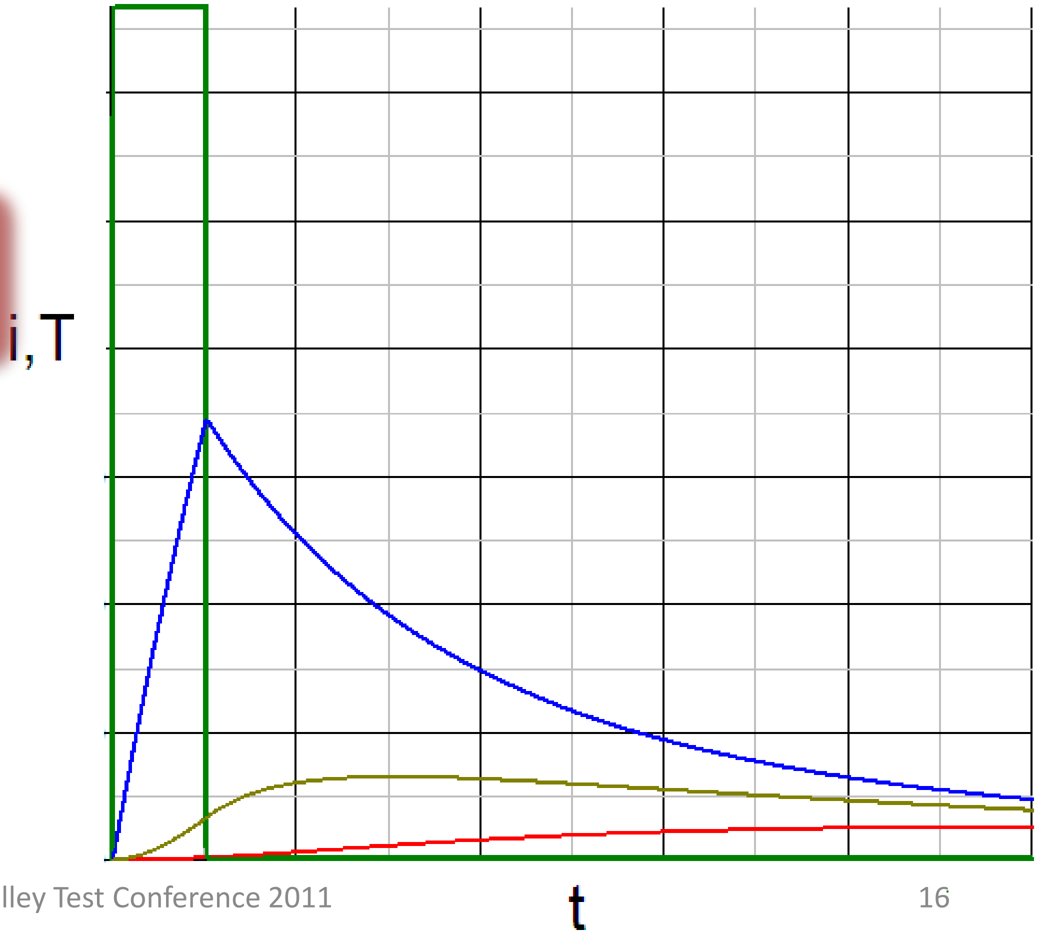
Instrumentation timing becomes an issue.



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.

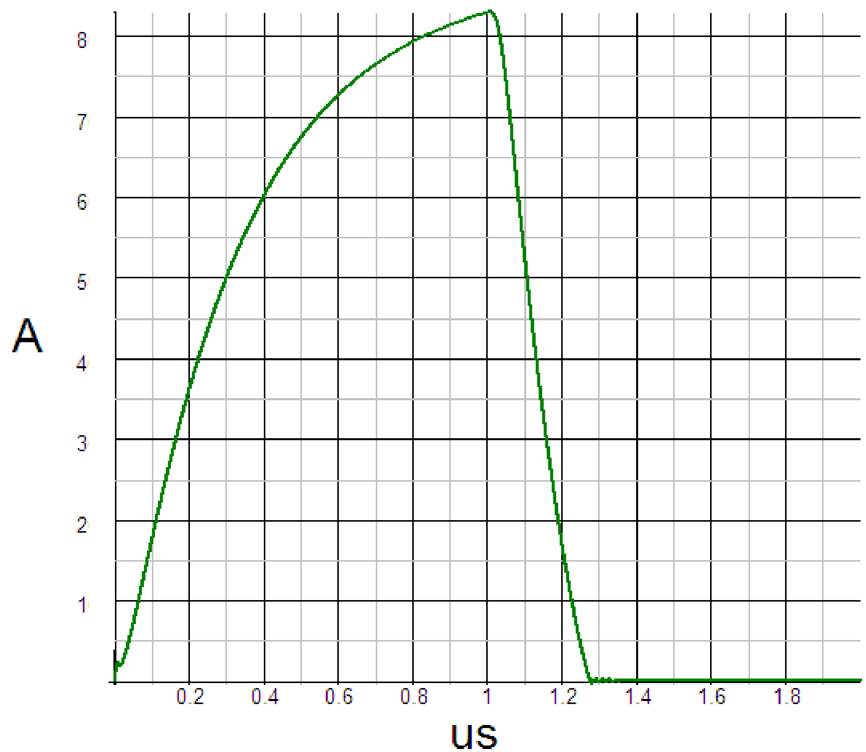
Sources

- 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

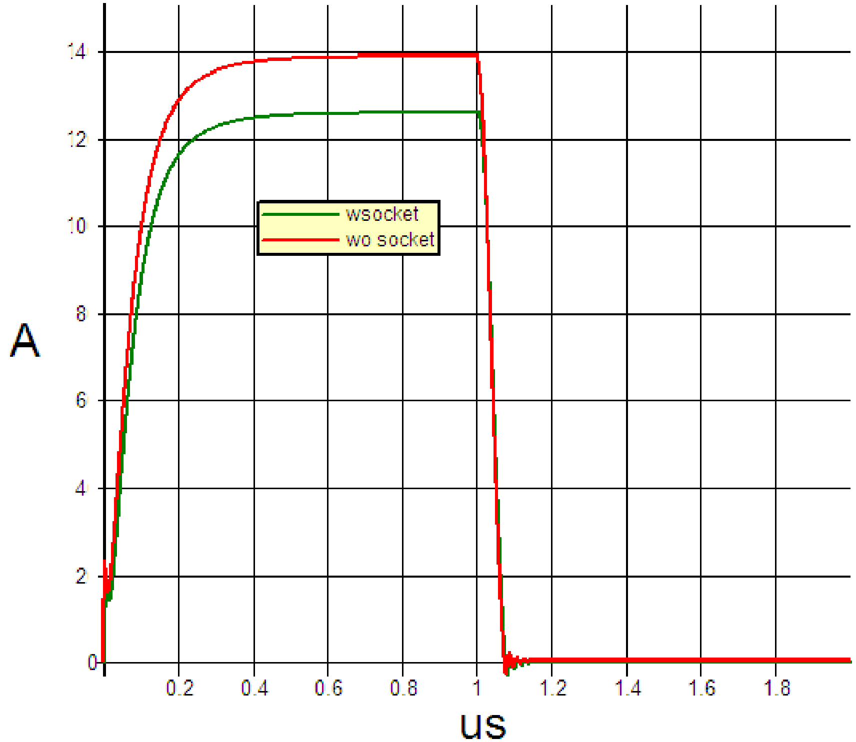
• When driving from a ‘real’ source it’s internal impedance and properties must be taken into account:



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

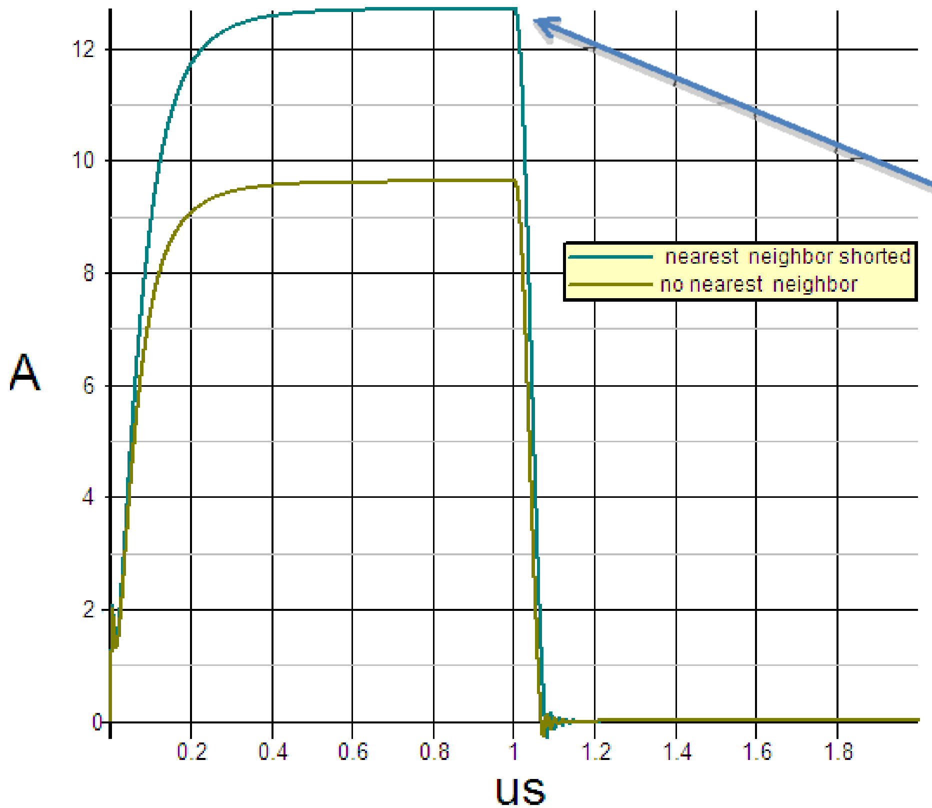
Calibration

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



Test configuration

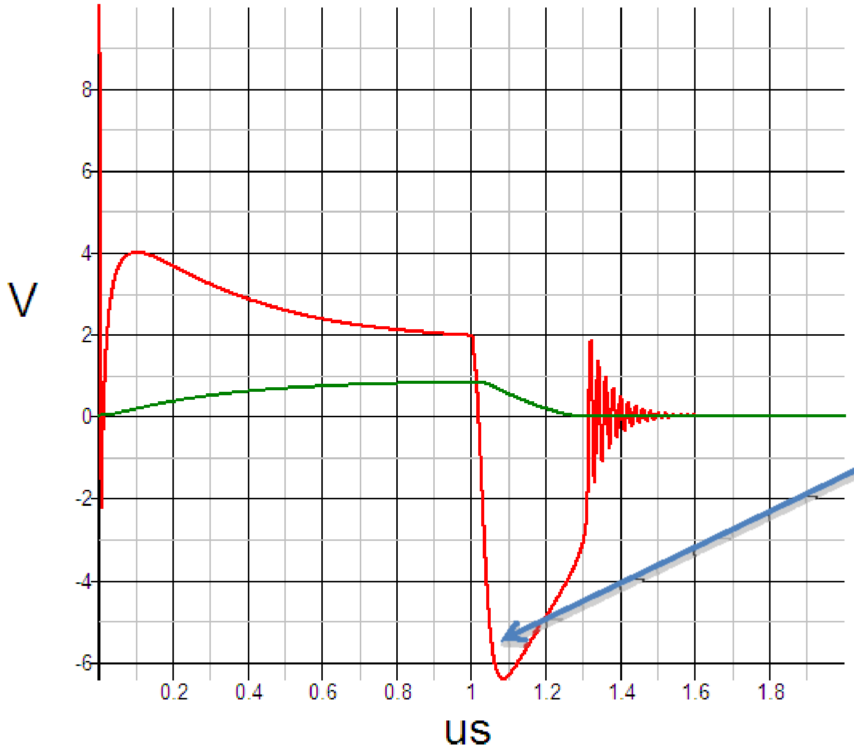
- Allowing multiple conductors to participate in return path can lead to configuration dependent results:



Lower return path resistance causes higher test current

Circuit specifics

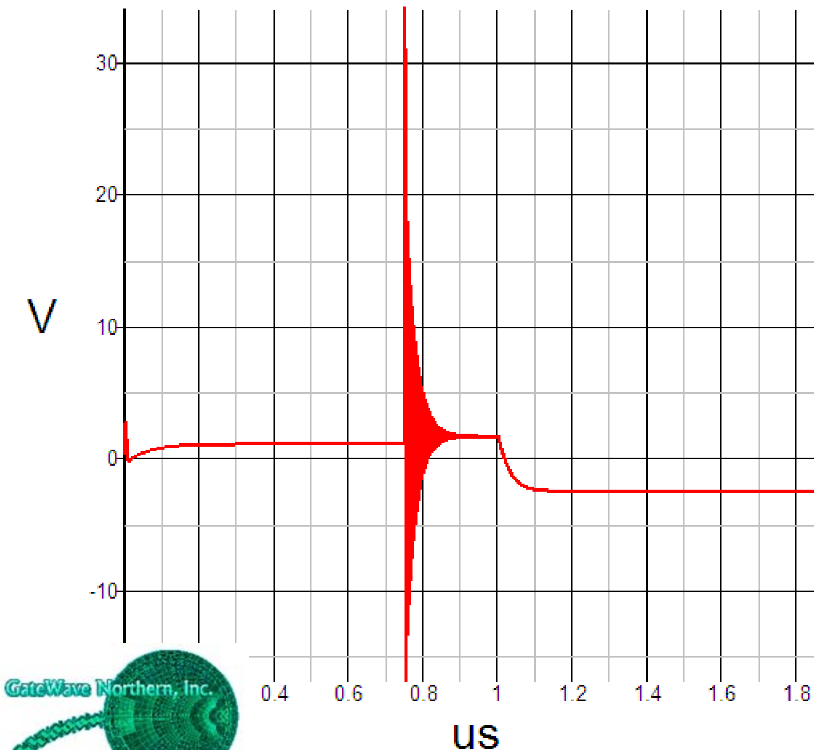
• Turn-on/off transients cause voltage excursions at the source terminals. This in turn can affect proper operation and calibration:

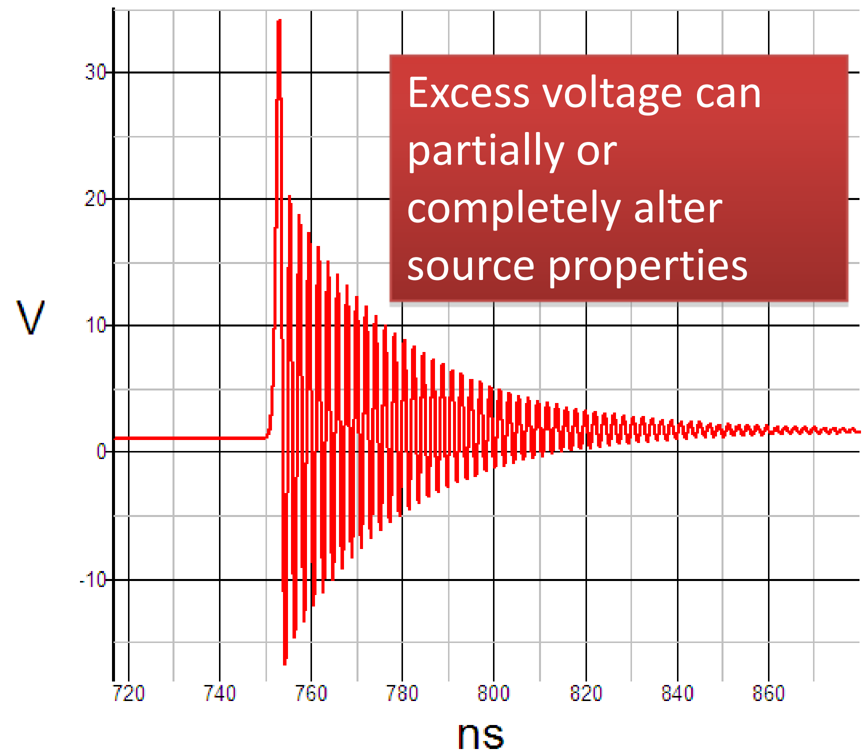


A large negative voltage spike (inductive load !) occurs during fast source signal turn-off

Contact failure

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





GateWave Northern, Inc.

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