



14IND08 EIPow



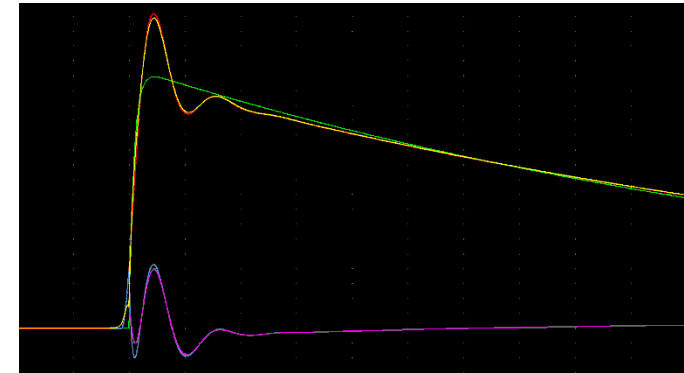
Why measure lightning impulse?

- HV equipment is subjected to several types of electric stress in service
- Factory testing used to prove withstand
- Voltage and waveshape crucial to obtain consistent results
- Test waveshape loosely similar to natural lightning
- Close to a century's experience of on-site performance and tests performed ensure reliable results



Challenges in measuring lightning impulse

- High voltage dividers cannot be regarded as ideal
- Digitizers must capture both waveform and peak voltage accurately
- Digitizer requirements
 - Moderately fast response
 - Very fast settling
 - High resolution
 - Linearity under dynamic conditions
 - Reasonably low internal noise



Standard digitizers and Lightning impulse

- Development of digitizers seems to favour fast step response and high sampling rates
- The specific needs of LI on fast settling and high resolution are not automatically met
- Present requirement in IEC 61083-1 on DC static non-linearity does not constitute a problem
- Clean step response and good dynamic linearity are however i focus



Sony Tektronix 390 AD from 1982
Still used in LI measurements
Newer digitizers are only somewhat better



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Resolution vs sampling rate

- LI requires at least
 - 12 bit resolution
 - 100 Msamples/s
 - Distinct step response
- A number of high-end oscilloscopes and transient recorders investigated
- Step response most crucial
- Industri "standard"
 - GSamples/s and 8 bit or
 - >12 bit and < 100 Msamples/s
 - Fast step response for 10/90 %



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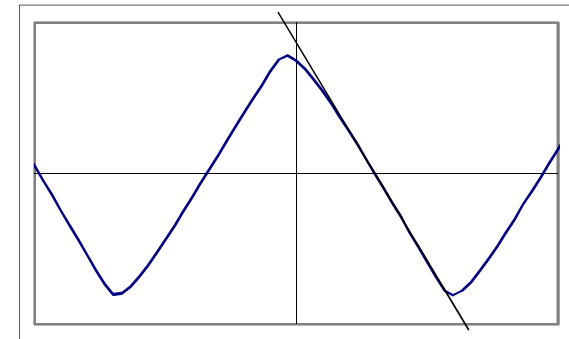


Calibration for DC linearity

- Was a concern in early days
- Verification measurement very time consuming
- Few, if any, digitizers have exhibited problems
- It is recommended to regard manufacturer's specification as sufficient proof

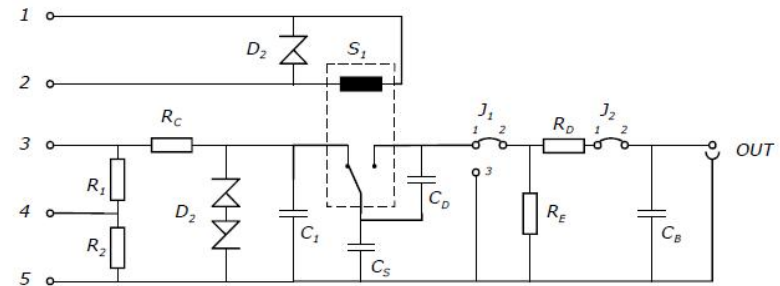
Calibration for dynamic non-linearity

- Important test to show that also changing signals are well reproduced
- The test standard suggests using a triangular wave and verifying that equal number of samples obtain in each code bin
 - Few wave generators are known to be as good as the digitizers
 - Sine wave can be characterised for distortion but number of samples per bin will be unequal – must compare to an expected distribution



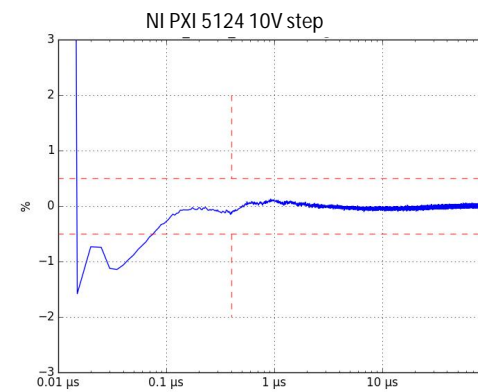
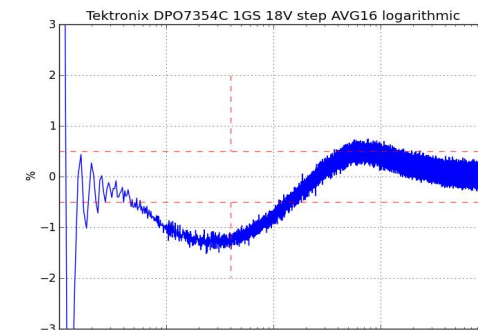
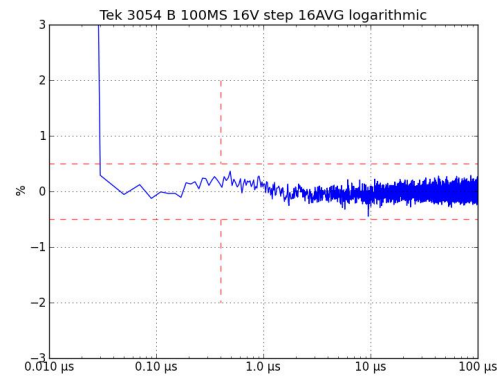
Calibration for impulse time parameters

- Calculable impulse calibrator
 - Traceable to calibrations of DC voltage, resistance and capacitance (J. Hällström)
- Step response and convolution
 - Traceable via characterisation of step generator stability after step
 - Uses convolution strategy as defined in IEC60060-2
- Agreement within a few 1/10%
- (peak voltage assumed to be defined by DC)



Outcome?

- Modern oscilloscopes often have indistinct step
- NI-5124 digitizer card passes tests
- Thus very few options available!





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