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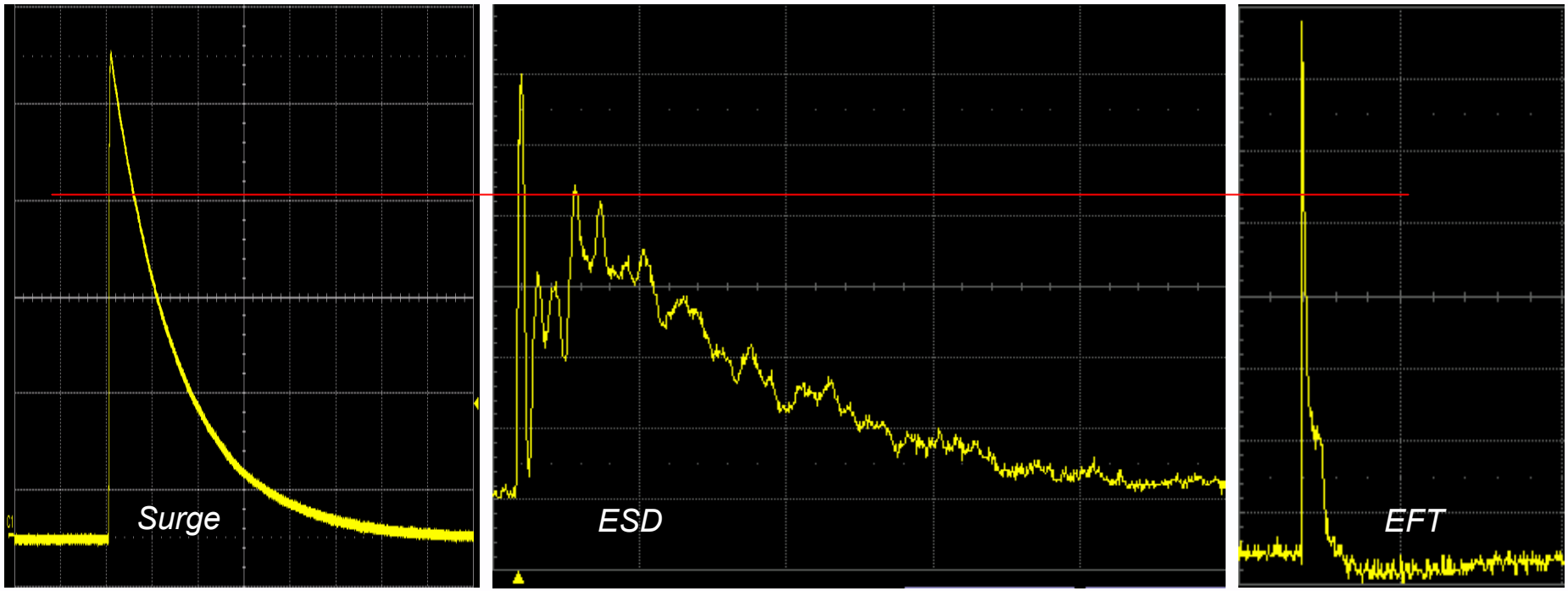
EMC Pulse Measurement

and Custom Thresholding



Contents

- EMC measurement requirements
- How thresholds affect pulse measurement definitions and why standard pulse parameters will not work for EMC pulses
- Measurement thresholds for ESD pulses
- Sequenced acquisition for EFT (Electrical Fast Transient) pulses
- Parameter limiters applied to filter EMC pulse statistics
- Custom measurements

EMC Measurement Requirements

4 Quadrants of EMC/ESD Testing

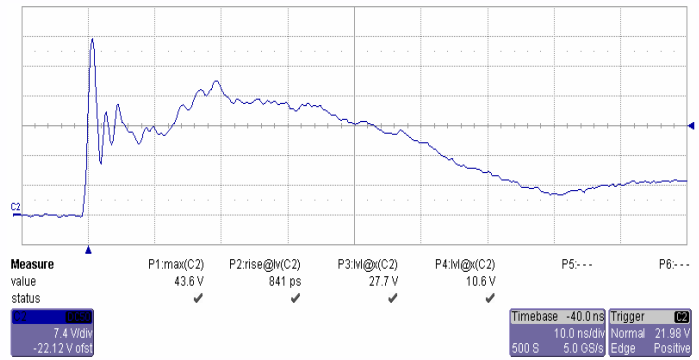
Radiated Emissions Will the EUT create emissions that interfere with the operation of other products?	**Conducted Emissions** How much noise voltage is injected back into the mains by the EUT?
Radiated Immunity Will the EUT be susceptible to emissions from other devices, either through the air or via cables?	**Conducted Immunity** Will the EUT be susceptible to transients generated by switching of capacitive or inductive components?

EUT = Equipment Under Test

- Oscilloscopes used for
  - Radiated Immunity
  - Conducted Immunity
- "Pulsed EMI tests:
  - ESD (Electrostatic Discharge)
  - EFT (Electrical Fast Transient)
  - Surge

Test Requirements

- Generate a Burst, Surge, or ESD pulse (for example, with an ESD gun)
- Verify the pulse shape(s) from the generator with an oscilloscope before each test
  - Rise Time
  - Fall Time
  - Width
- Ensure that the DUT still operates correctly during test, for example:
  - Automotive engine control unit still transmits proper messages
  - Telecom board serial data messages are uncorrupted
  - Consumer electronics item still functions
- ESD Standards:
  - IEC 61000-4, EN 61000-4, ITU, UL, FCC, Telcordia, ANSI, Bellcore, Proprietary (Military, Automotive), etc.
  - The majority of Immunity Testing follows the IEC 61000 (CE Mark)

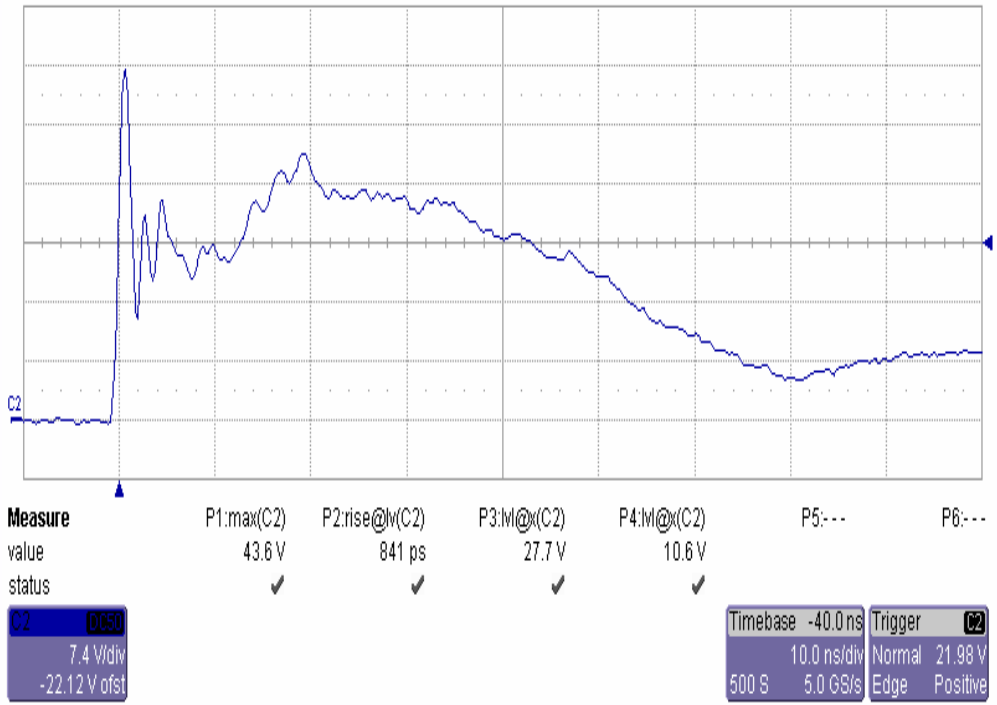


CE

ESD Testing – Electrostatic Discharge

Measurement Steps

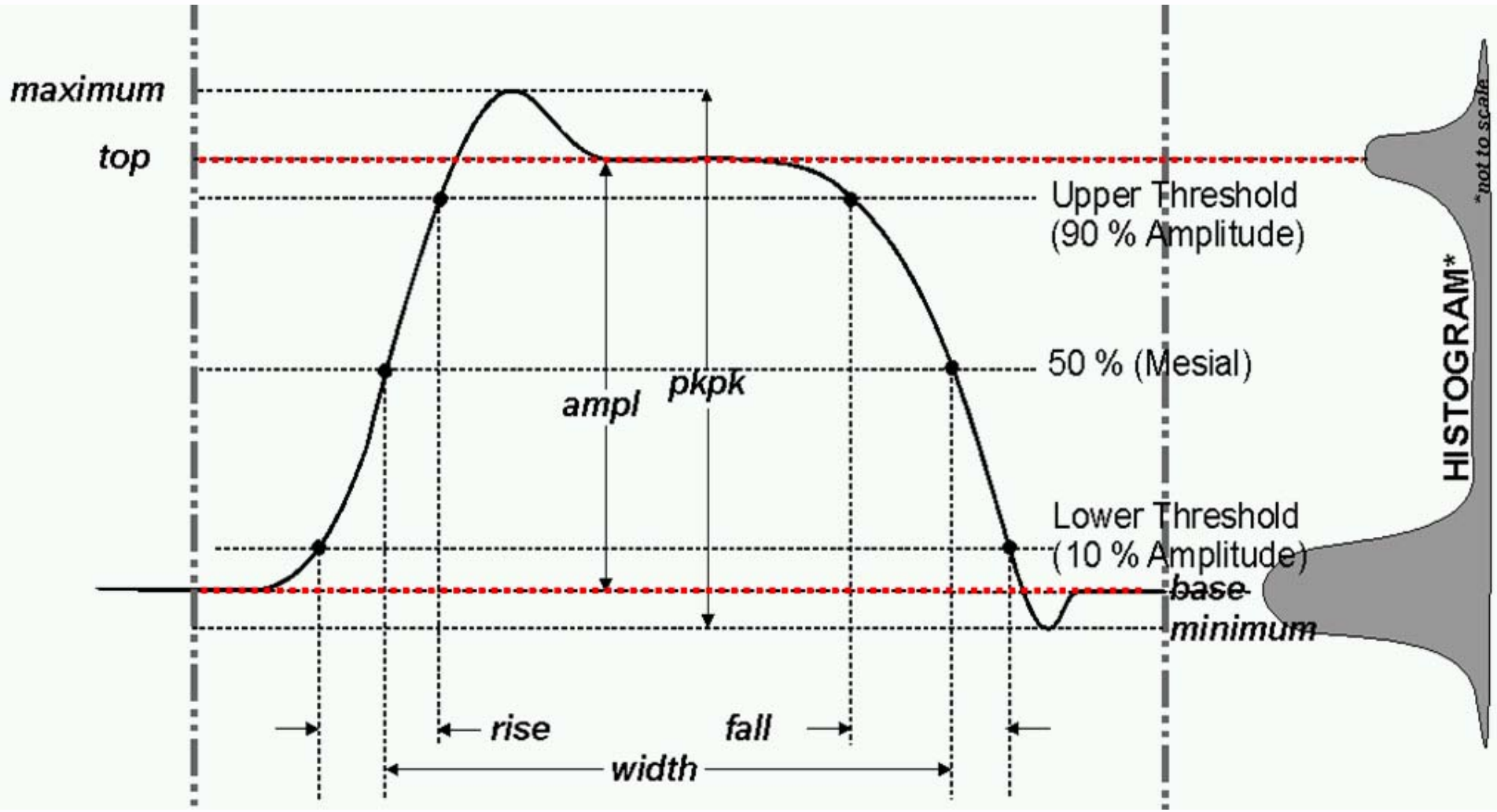
- Pulse Characteristics
  - T_{rise} = 0.7 to 1.0 ns
  - T_{fall} = 0.7 to 1.0 ns
- Measurement Needs
  - Capture a Single Pulse
  - Measure one pulse, verify rise time for positive pulses, verify fall time for negative pulses
  - 1 GHz, 2 GHz, or 3 GHz+ scope depending on standard specification



How is risetime defined on this ESD pulse? 10%-90% risetime is only meaningful if 0% and 100% levels exist and have been defined on the pulse.

Pulse Measurement Definitions

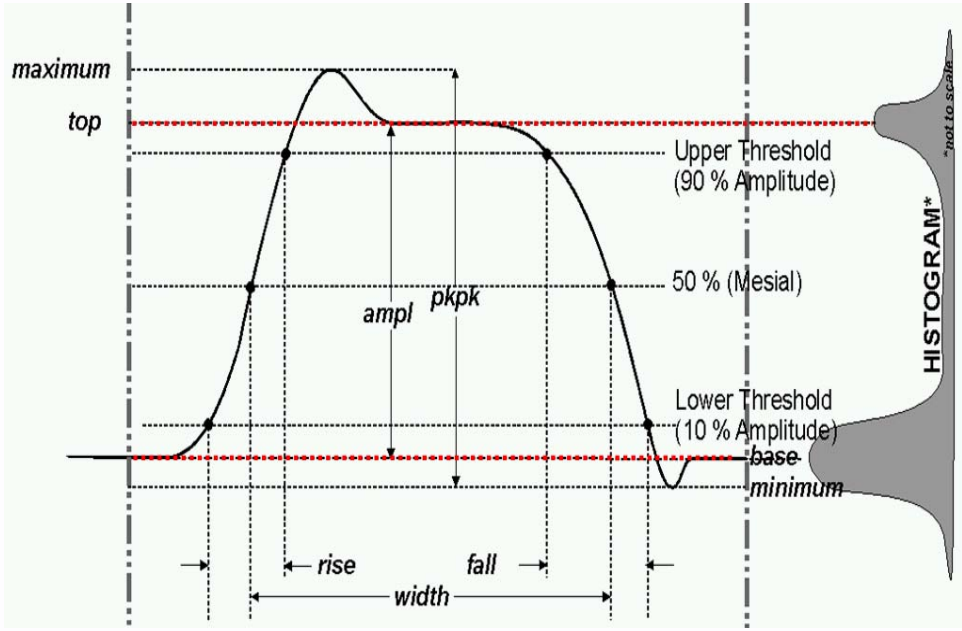
IEEE Standard Pulse Definitions
How Oscilloscopes Measure Pulse Parameters



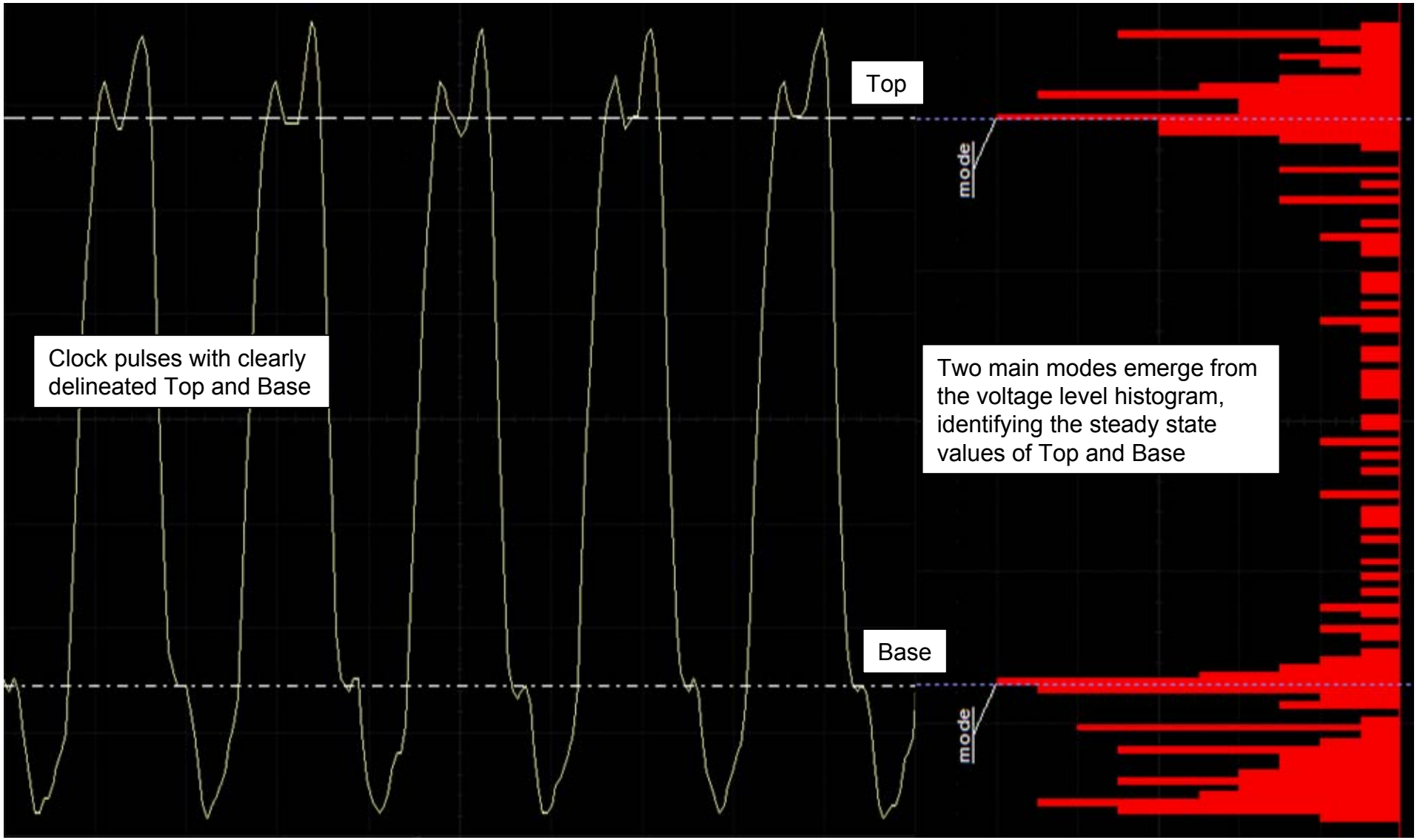
Oscilloscopes determine pulse parameters from Top and Base values

IEEE Pulse Definitions
How Pulse Measurements Are Determined

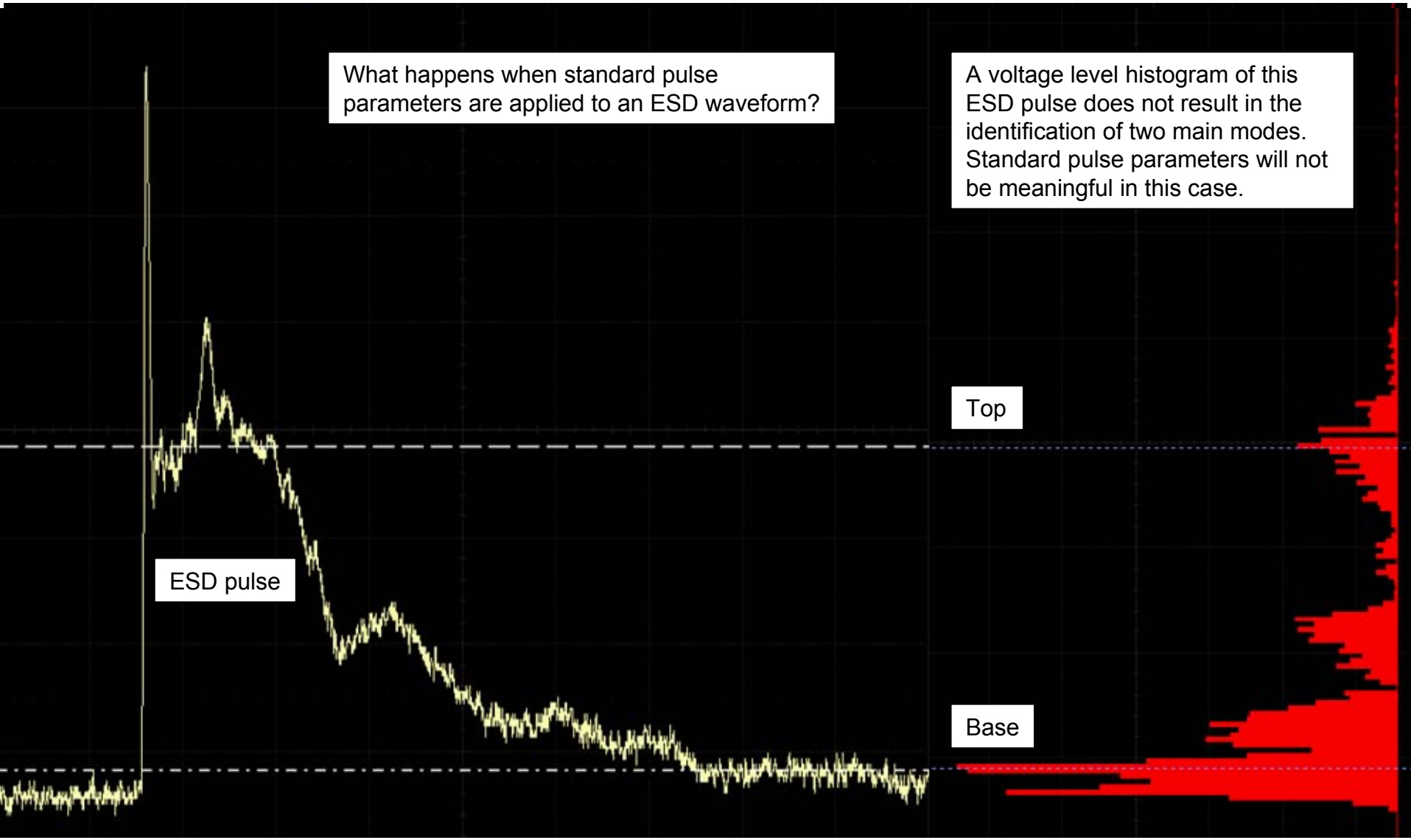
- Pulse measurement definitions are defined by the IEEE Std 181-2003 "IEEE standard on transitions, pulses, and related waveforms"
- Oscilloscopes conform to the IEEE pulse measurement definitions, and Top and Base are determined statistically based on the two modes of a voltage level histogram.
- Top and Base form the 100% and 0% reference levels which are used for measurements such as amplitude, risetime, falltime, period, frequency, width, duty cycle, overshoot, and virtually every timing measurement.
- Top and Base must first be calculated correctly in order for timing and amplitude measurements to produce the correct measurement result.



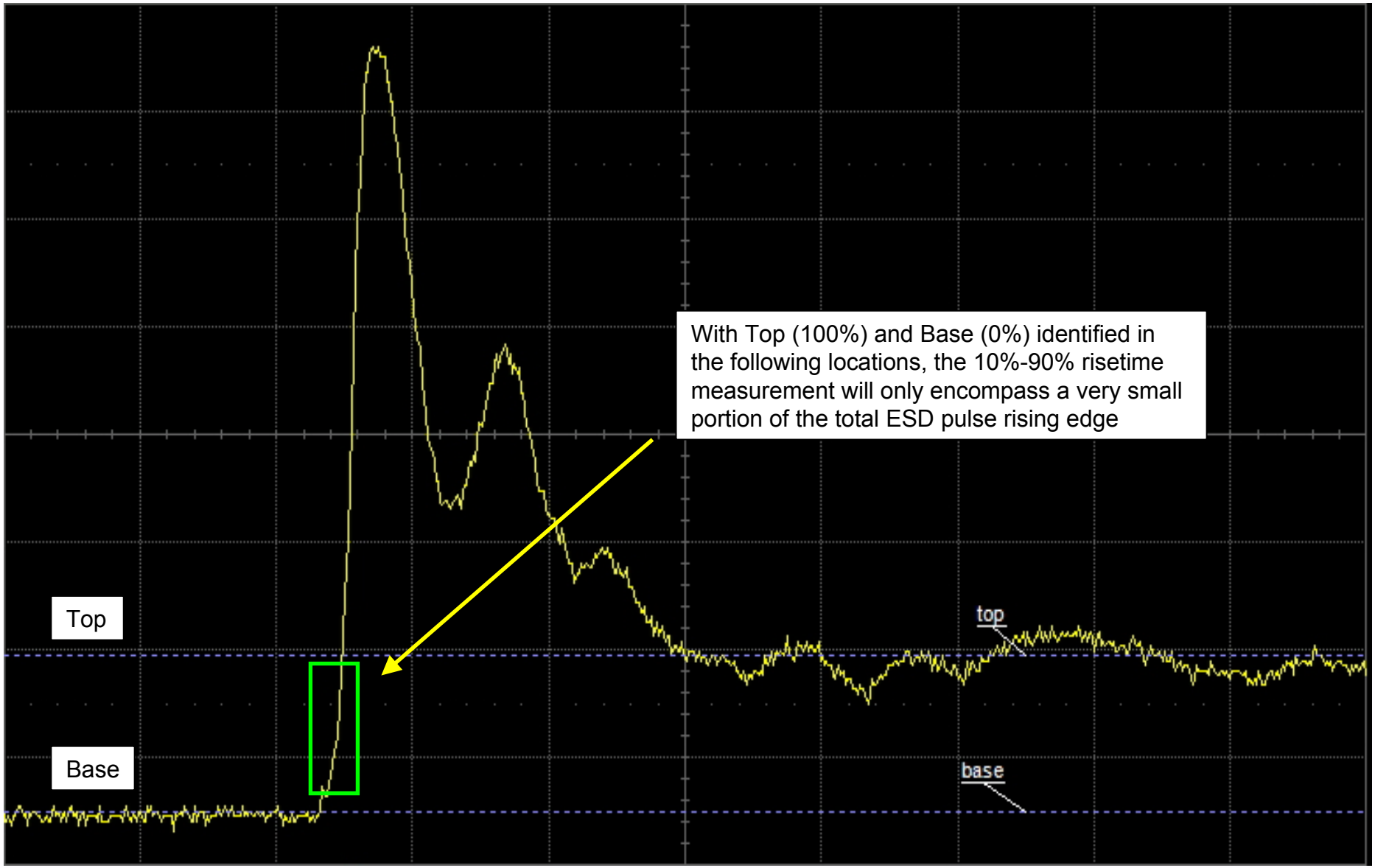
Clock Top and Base correctly determined from voltage histogram



ESD Top and Base are not meaningful for pulse measurements



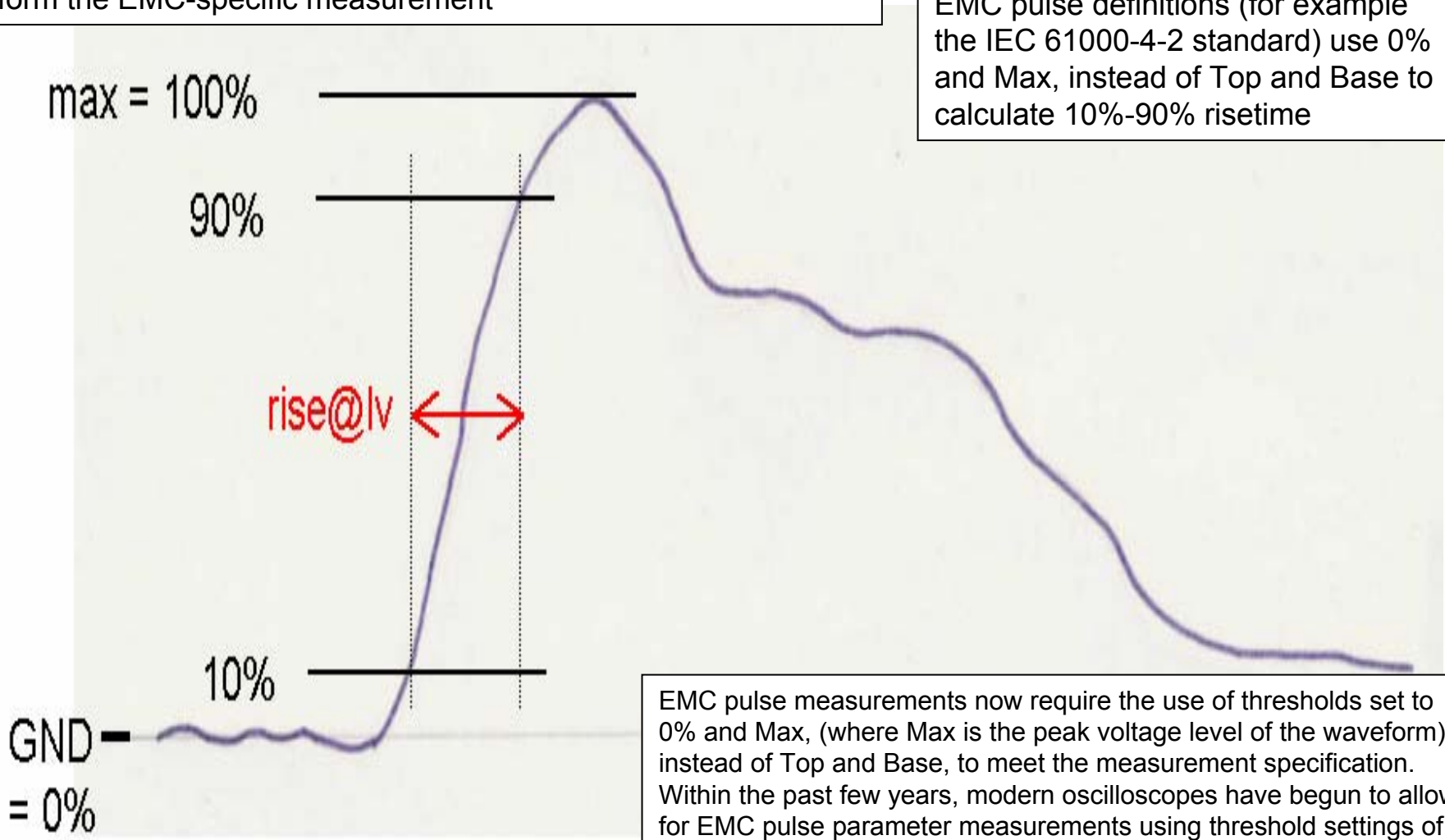
ESD Top and Base are not meaningful for pulse measurements



EMC Risetime Definitions use 0% and Max

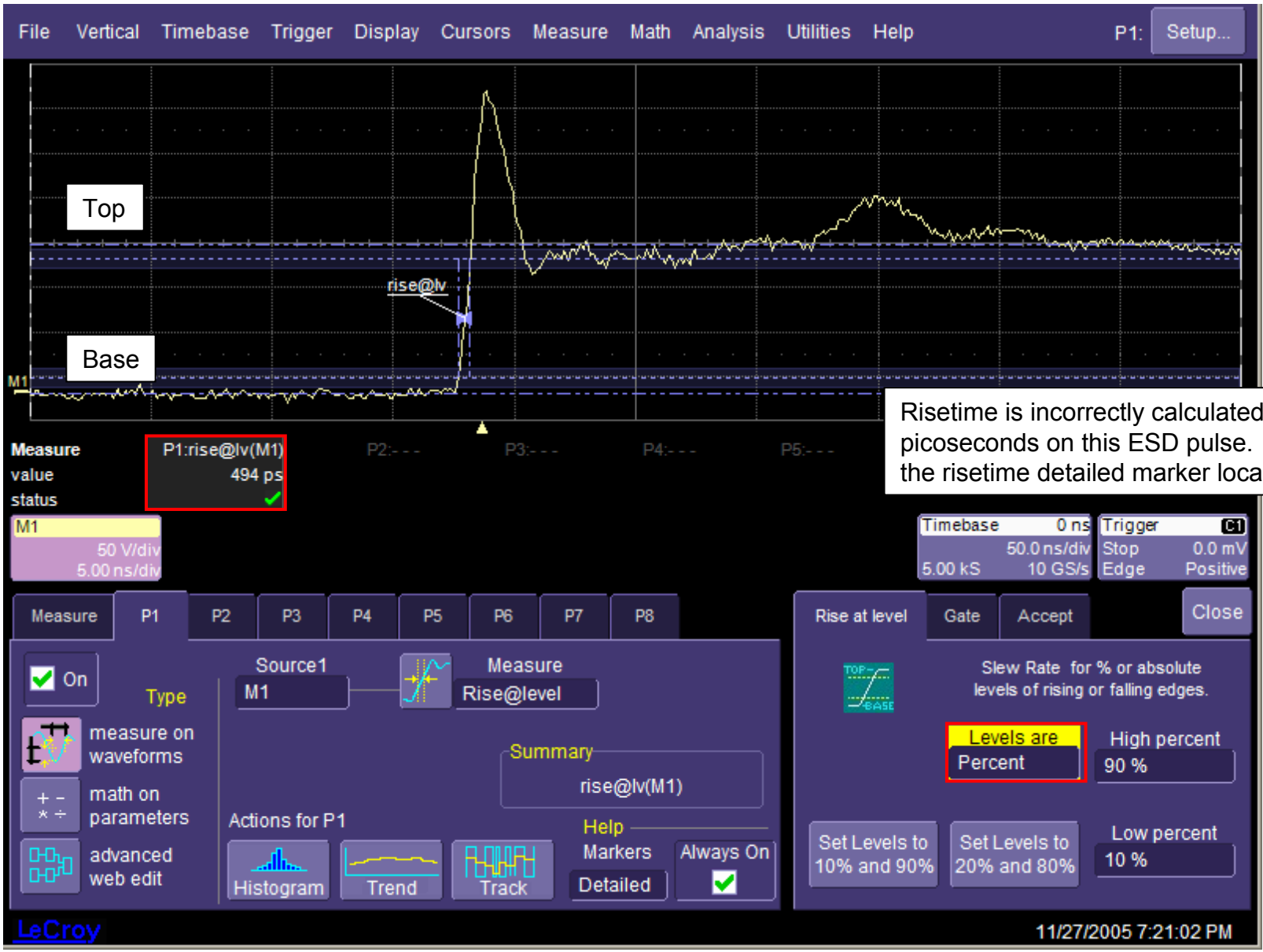
An oscilloscope must use 0% and Max thresholds in order to perform the EMC-specific measurement

Differing from IEEE pulse definitions, EMC pulse definitions (for example the IEC 61000-4-2 standard) use 0% and Max, instead of Top and Base to calculate 10%-90% risetime



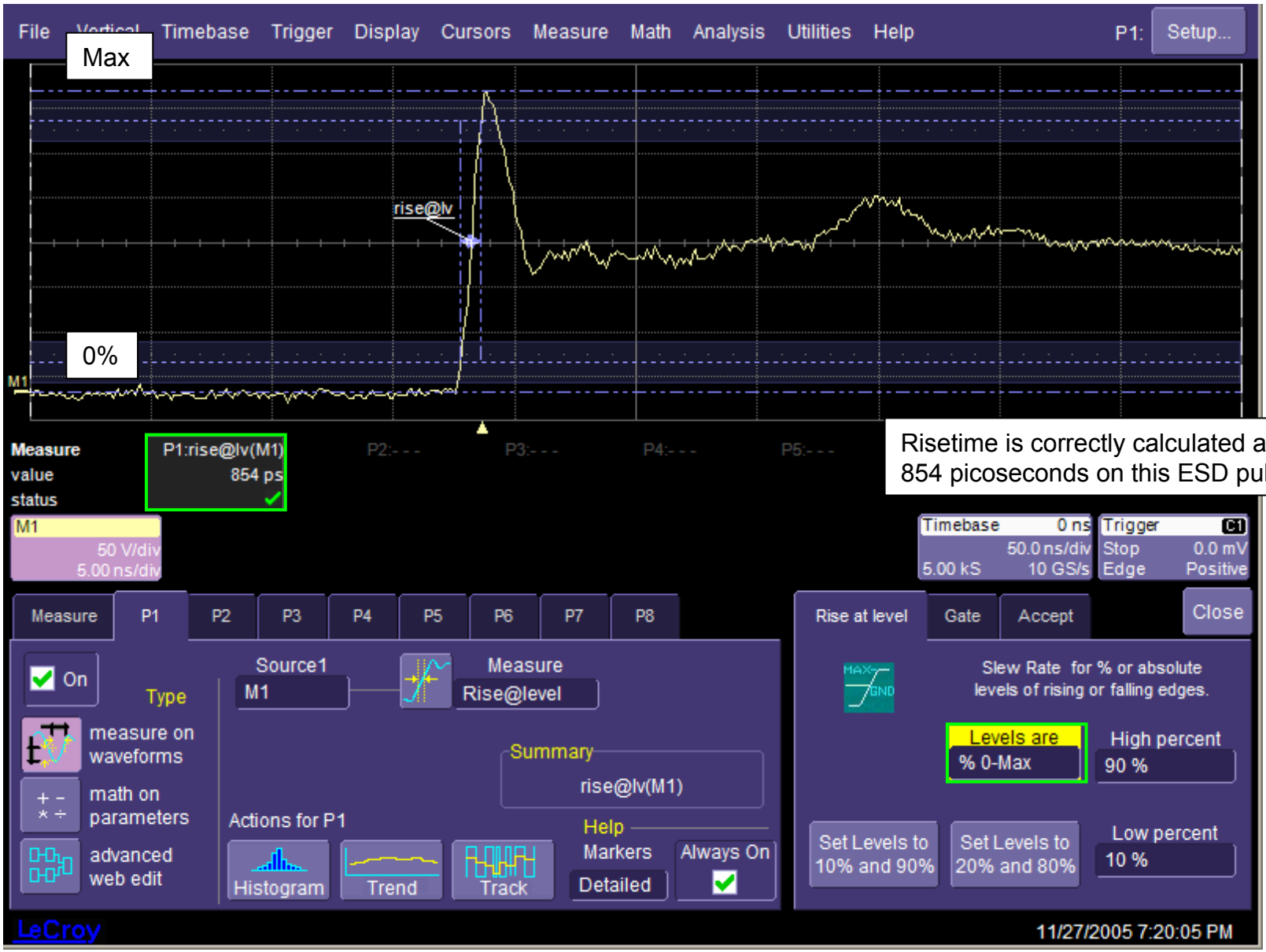
EMC pulse measurements now require the use of thresholds set to 0% and Max, (where Max is the peak voltage level of the waveform), instead of Top and Base, to meet the measurement specification. Within the past few years, modern oscilloscopes have begun to allow for EMC pulse parameter measurements using threshold settings of peak-to-peak, 0% to Max, and 0% to Min along with the standard absolute or percent levels.

Risetime calculated using standard IEEE pulse parameter definitions



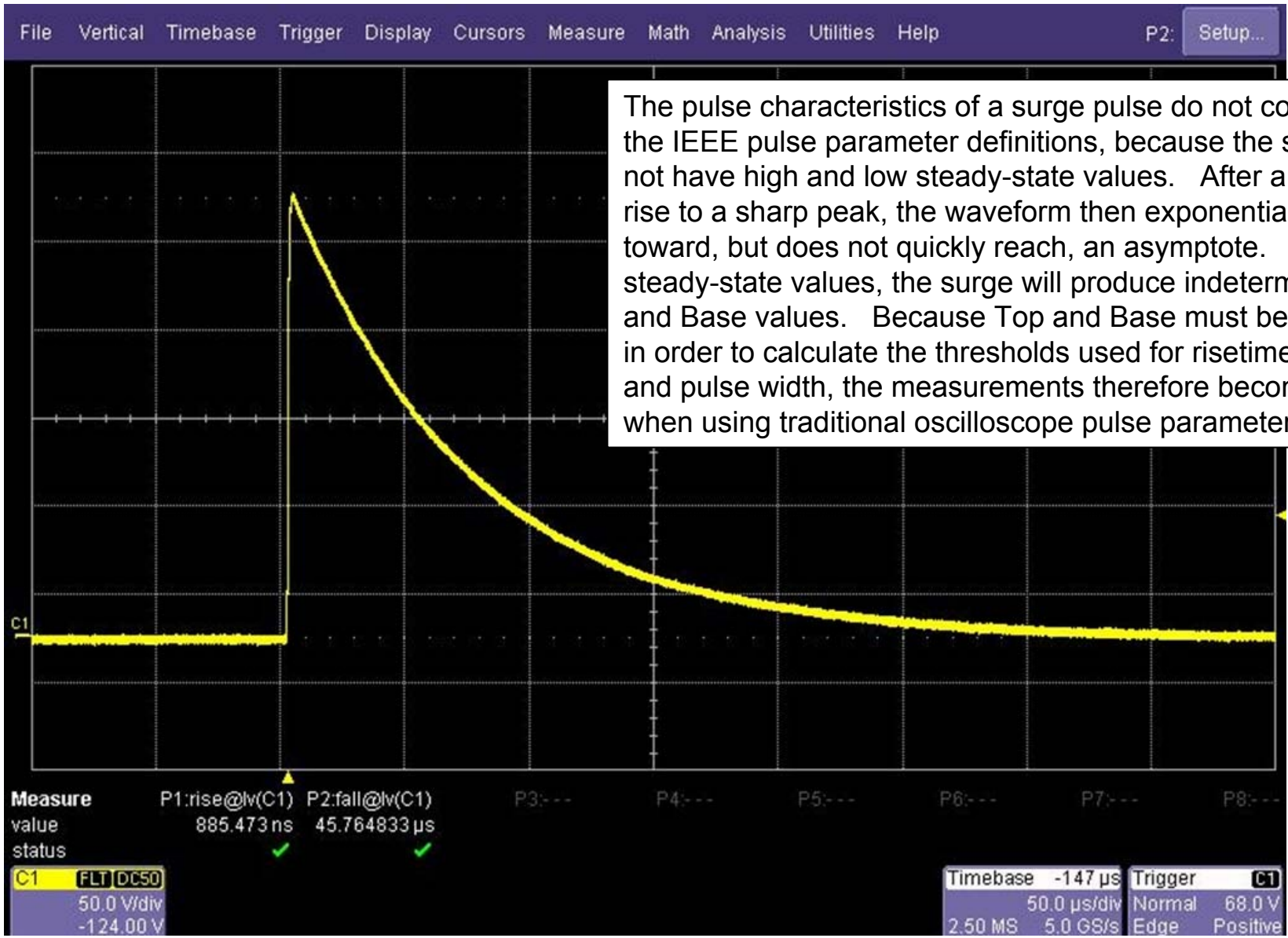
Risetime is incorrectly calculated as 494 picoseconds on this ESD pulse. Note the risetime detailed marker location.

Risetime calculated using EMC thresholds



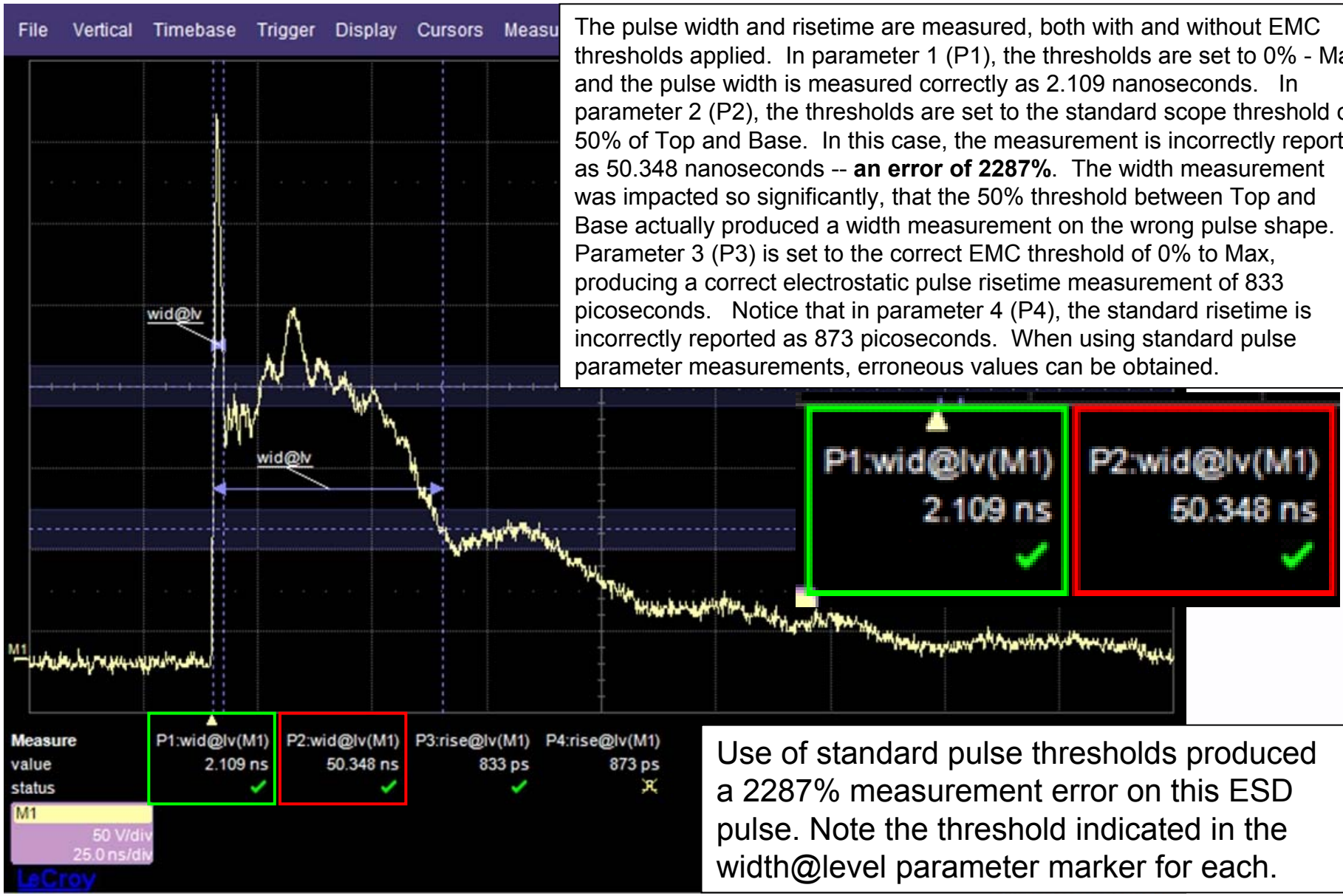
Risetime is correctly calculated as 854 picoseconds on this ESD pulse

A Surge pulse does not have a clearly-defined Top and Base



The pulse characteristics of a surge pulse do not conform to the IEEE pulse parameter definitions, because the surge does not have high and low steady-state values. After a fast linear rise to a sharp peak, the waveform then exponentially decays toward, but does not quickly reach, an asymptote. With no steady-state values, the surge will produce indeterminate Top and Base values. Because Top and Base must be determined in order to calculate the thresholds used for risetime, falltime, and pulse width, the measurements therefore become invalid when using traditional oscilloscope pulse parameters.

Standard and EMC thresholds for ESD pulse width



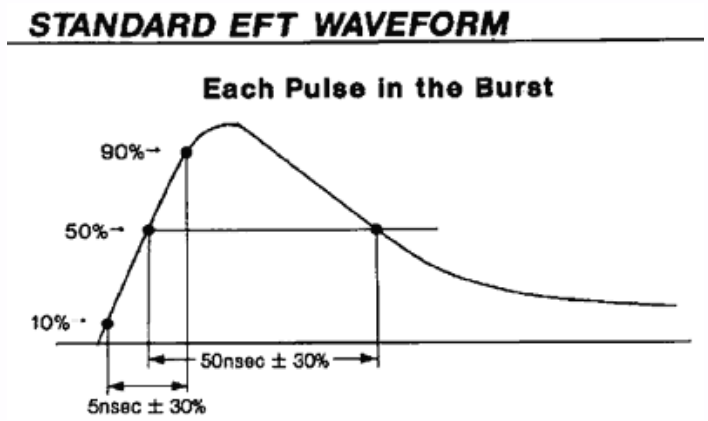
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- **an error of 2287%**. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.

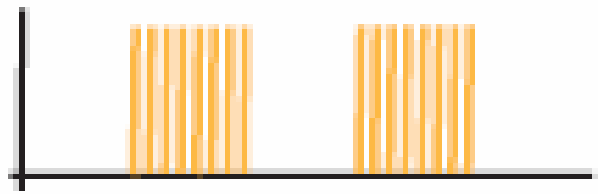
Use of standard pulse thresholds produced a 2287% measurement error on this ESD pulse. Note the threshold indicated in the width@level parameter marker for each.

EFT Testing – Electrical Fast Transient

Measurement Steps

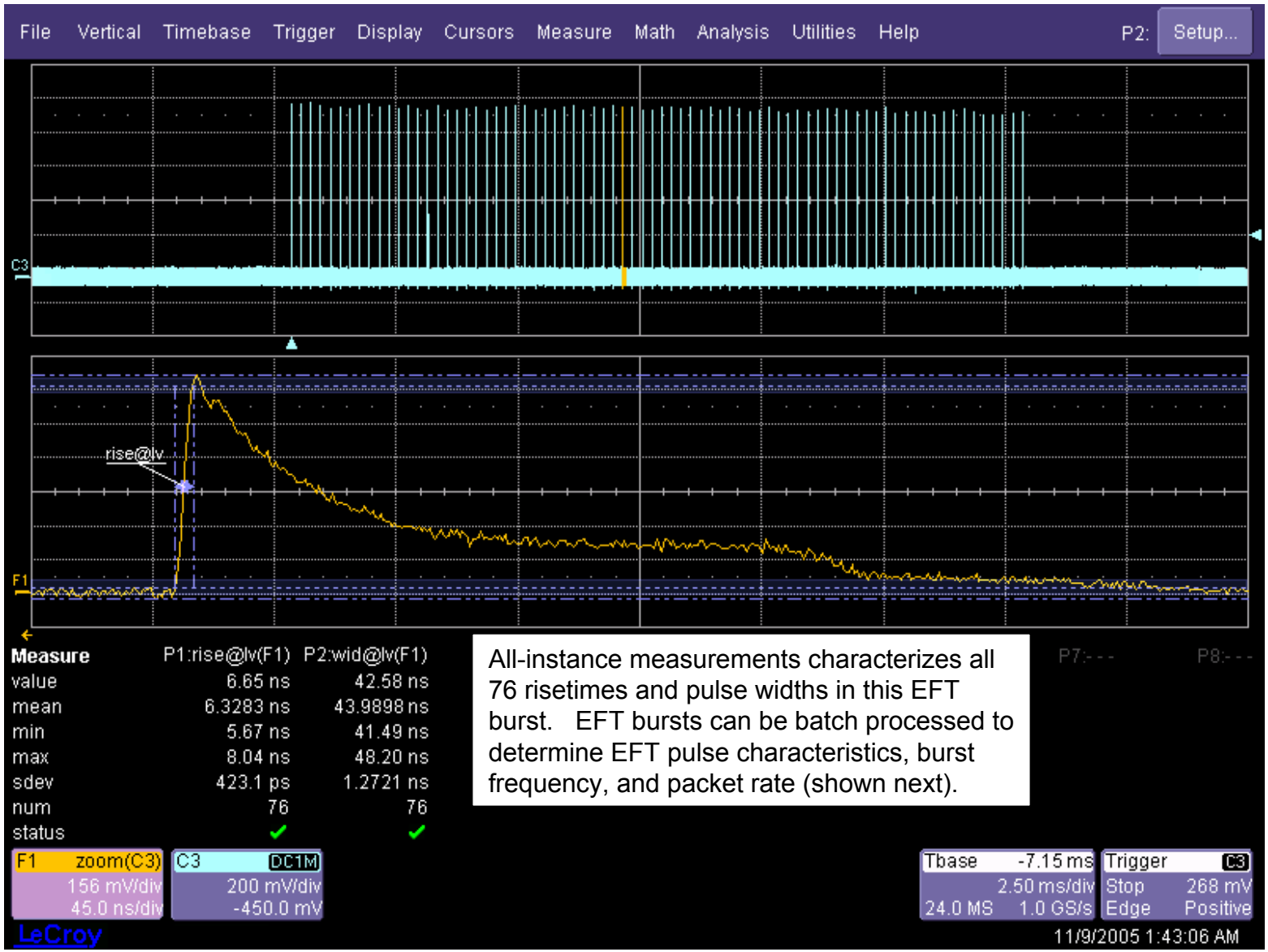
- Pulse Characteristics
  - T_{rise} = 5ns
  - T_{fall} = 50ns
  - Burst of many 5x50 pulses
- Measurement Needs
  - Capture 2ms of burst
  - Measure one pulse, verify shape (rise, fall, width)
  - Measure burst frequency (10-100 kHz)
  - Measure Capture time of burst packet (2ms)
  - Measure burst packet rate (300ms)





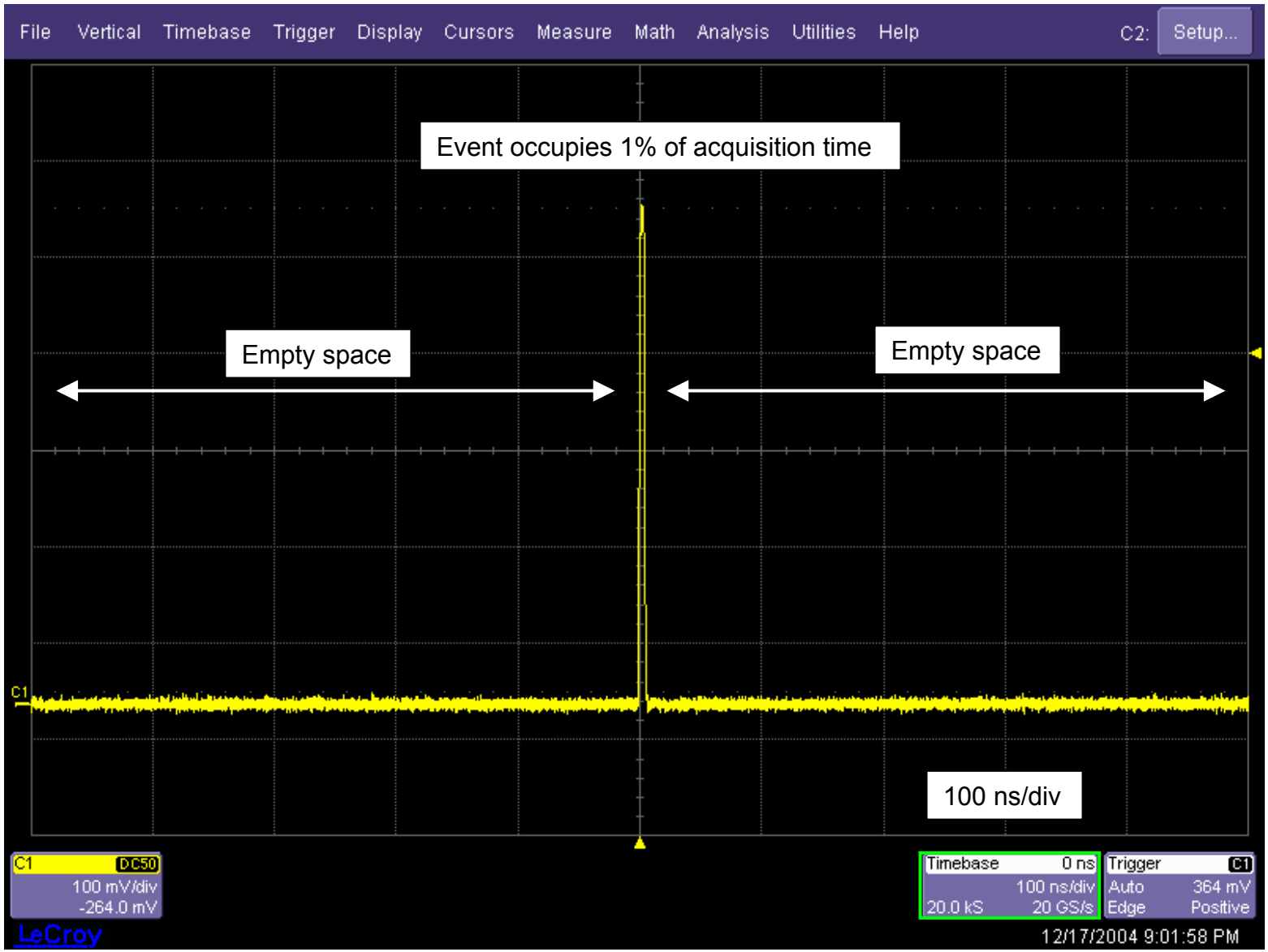
EFT Testing – Electrical Fast Transient

Measurement Statistics

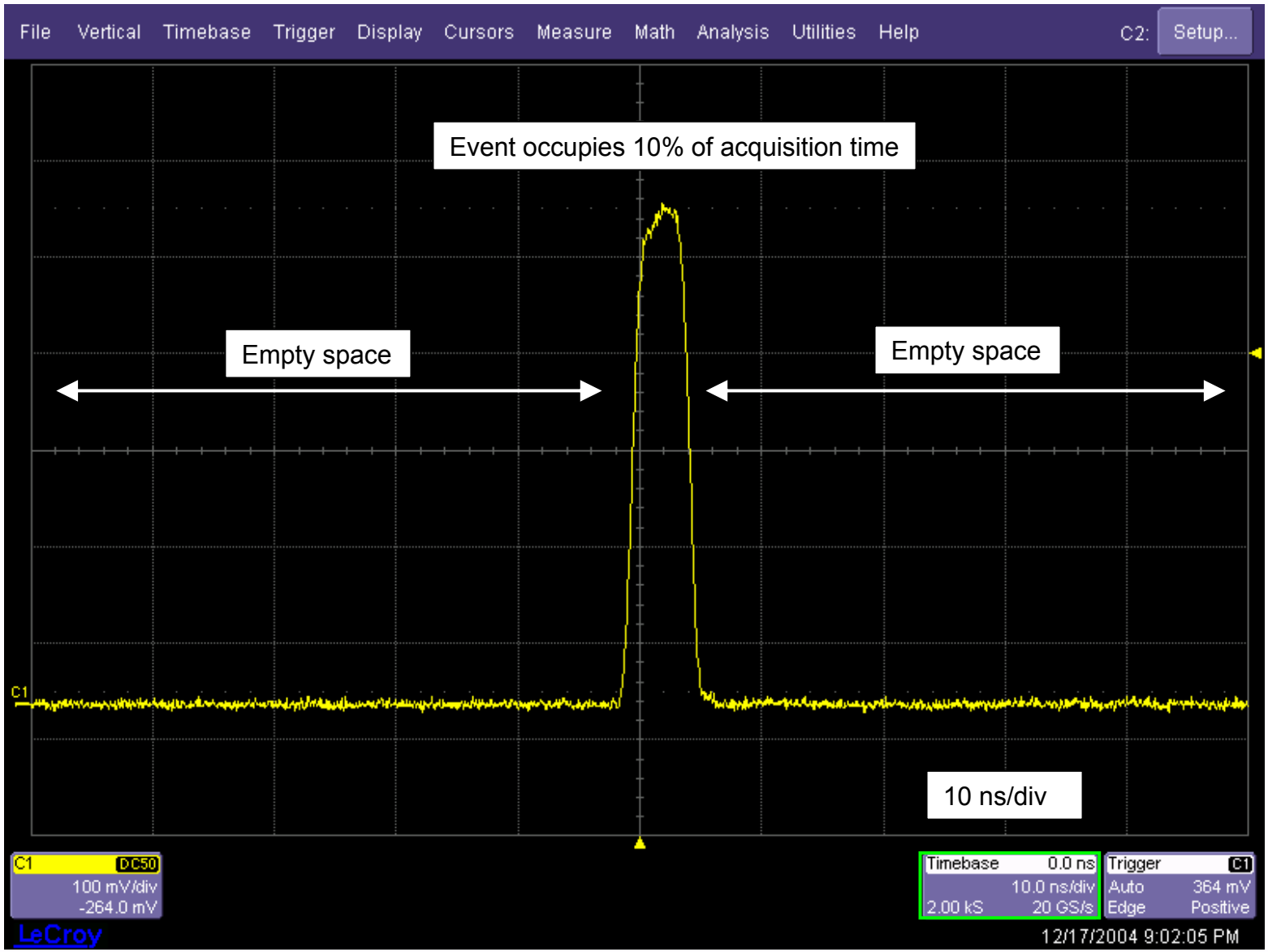


All-instance measurements characterizes all 76 risetimes and pulse widths in this EFT burst. EFT bursts can be batch processed to determine EFT pulse characteristics, burst frequency, and packet rate (shown next).

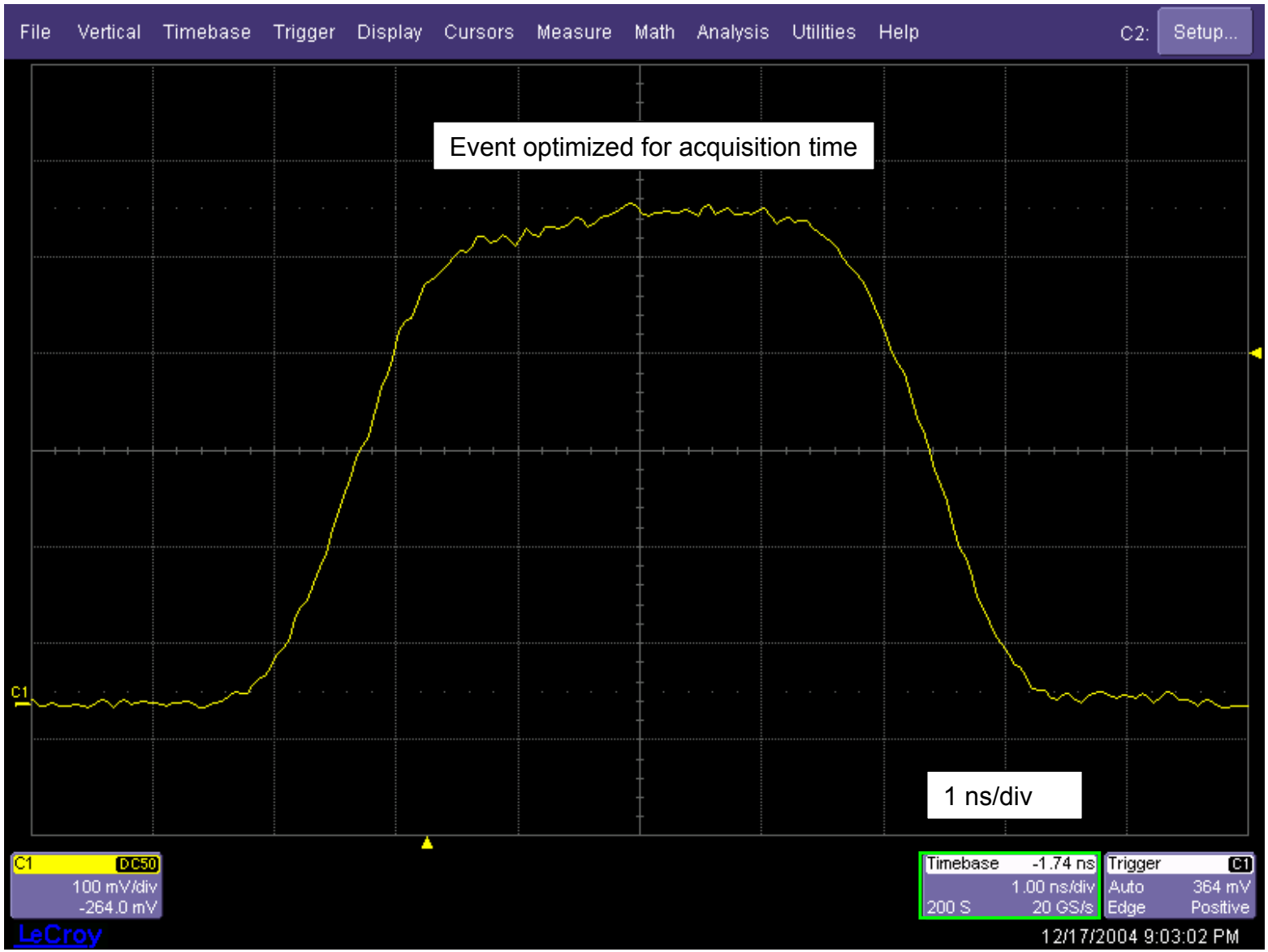
Maximizing Acquisition Memory for Events



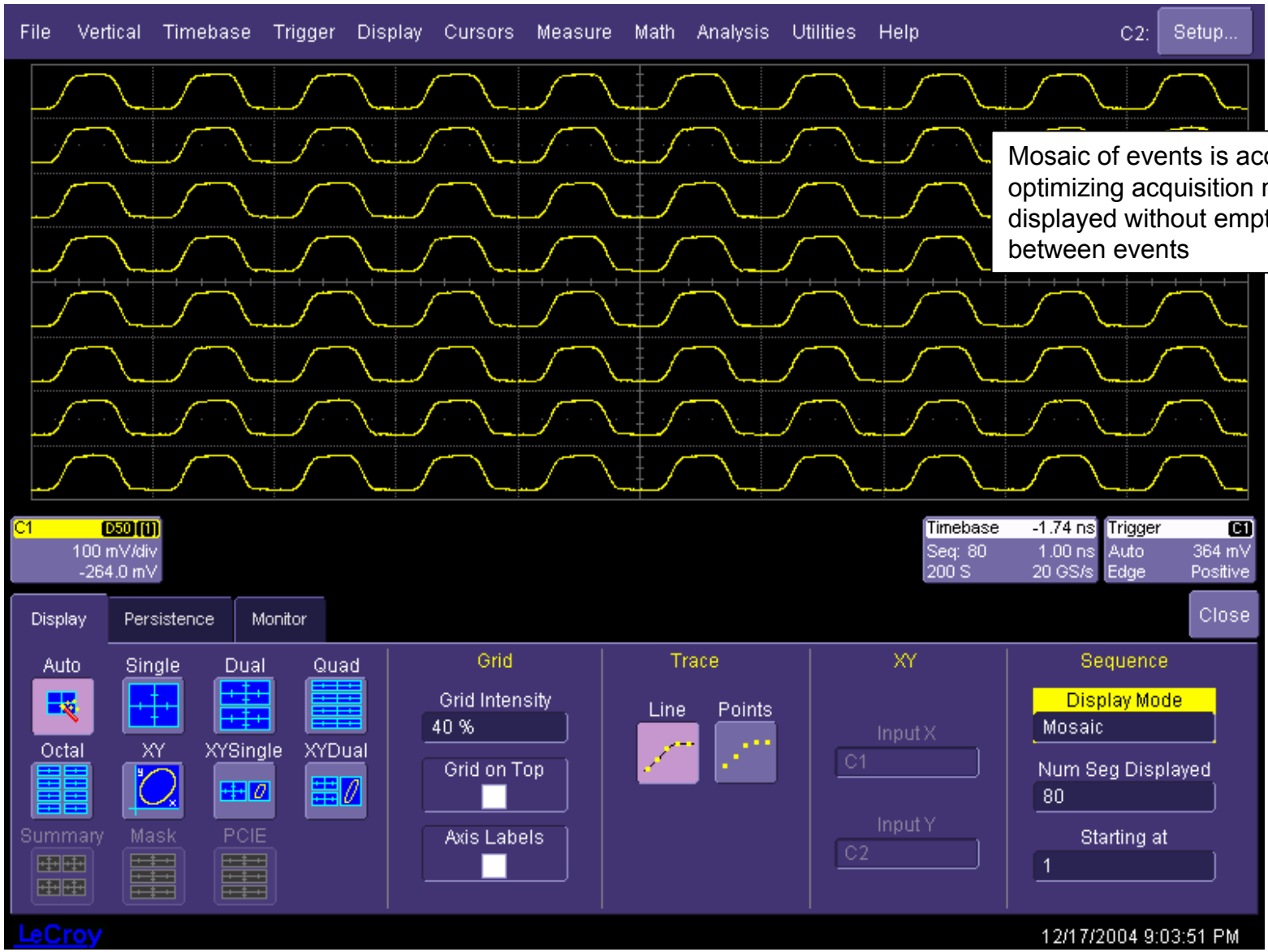
Maximizing Acquisition Memory for Events



Maximizing Acquisition Memory for Events

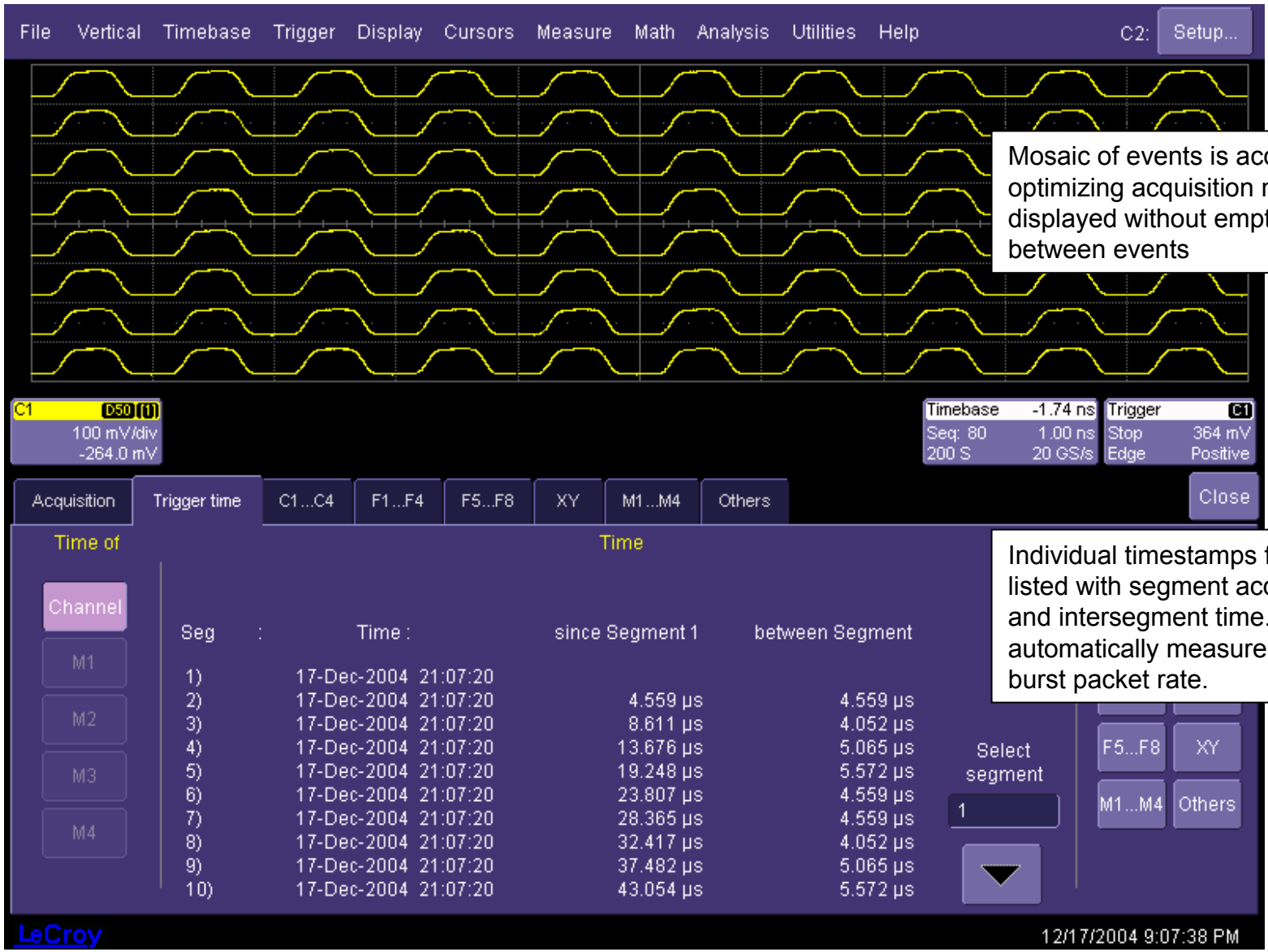


Maximizing Acquisition Memory for Events



Mosaic of events is acquired while optimizing acquisition memory, and displayed without empty spaces between events

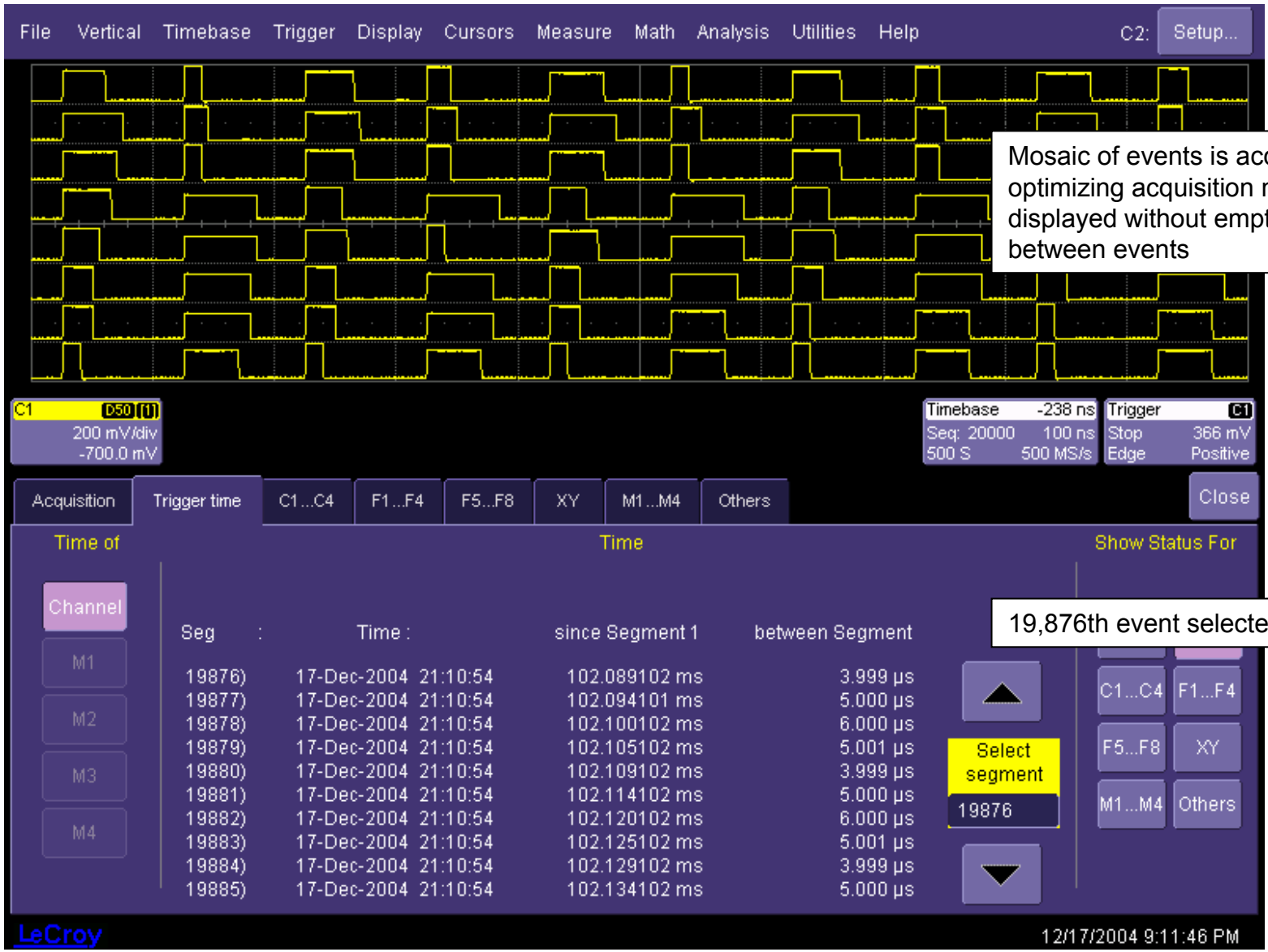
Maximizing Acquisition Memory for Events



Mosaic of events is acquired while optimizing acquisition memory, and displayed without empty spaces between events

Individual timestamps for each event listed with segment acquisition time and intersegment time. This will automatically measure the EFT burst packet rate.

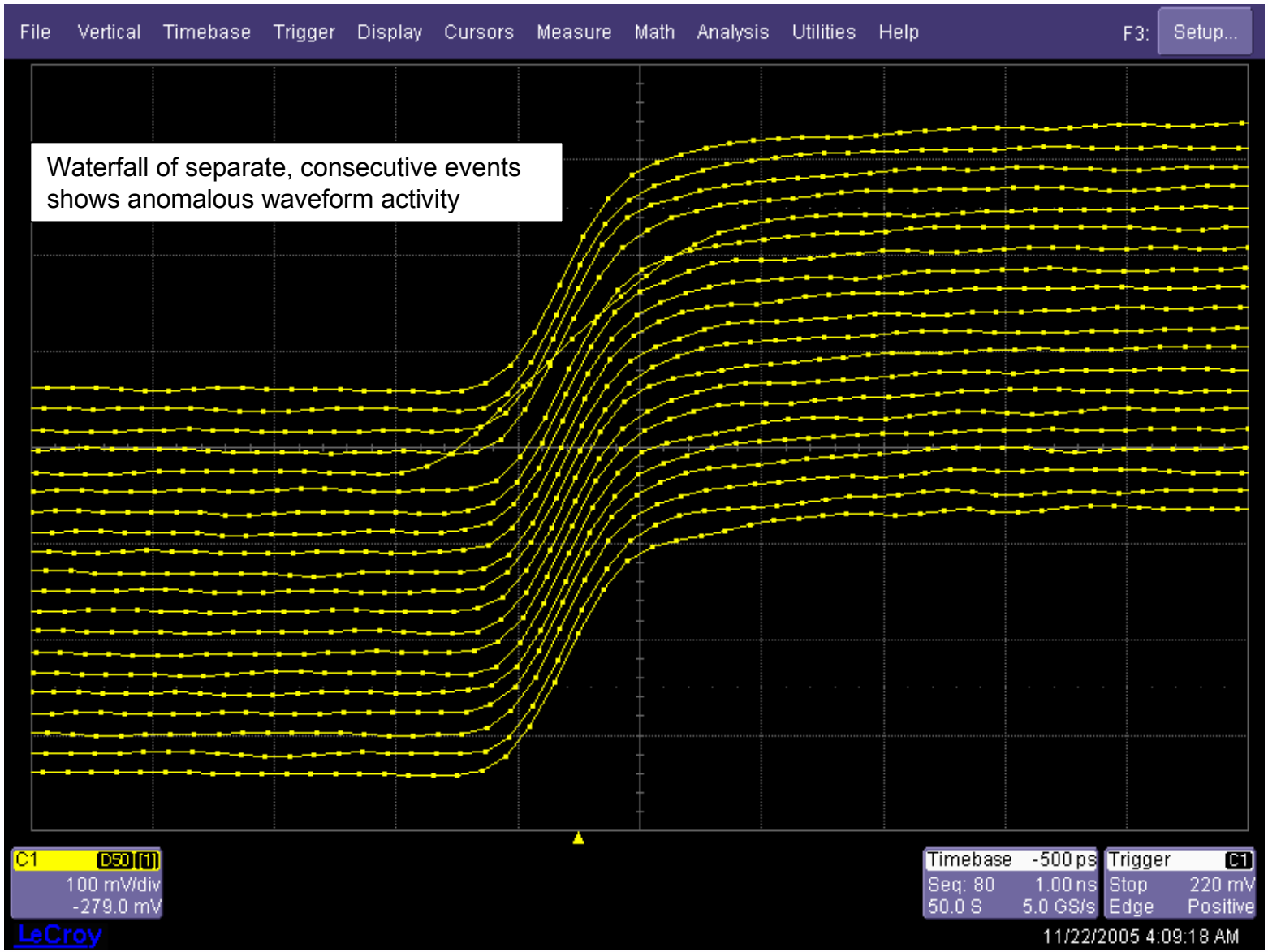
Maximizing Acquisition Memory for Events



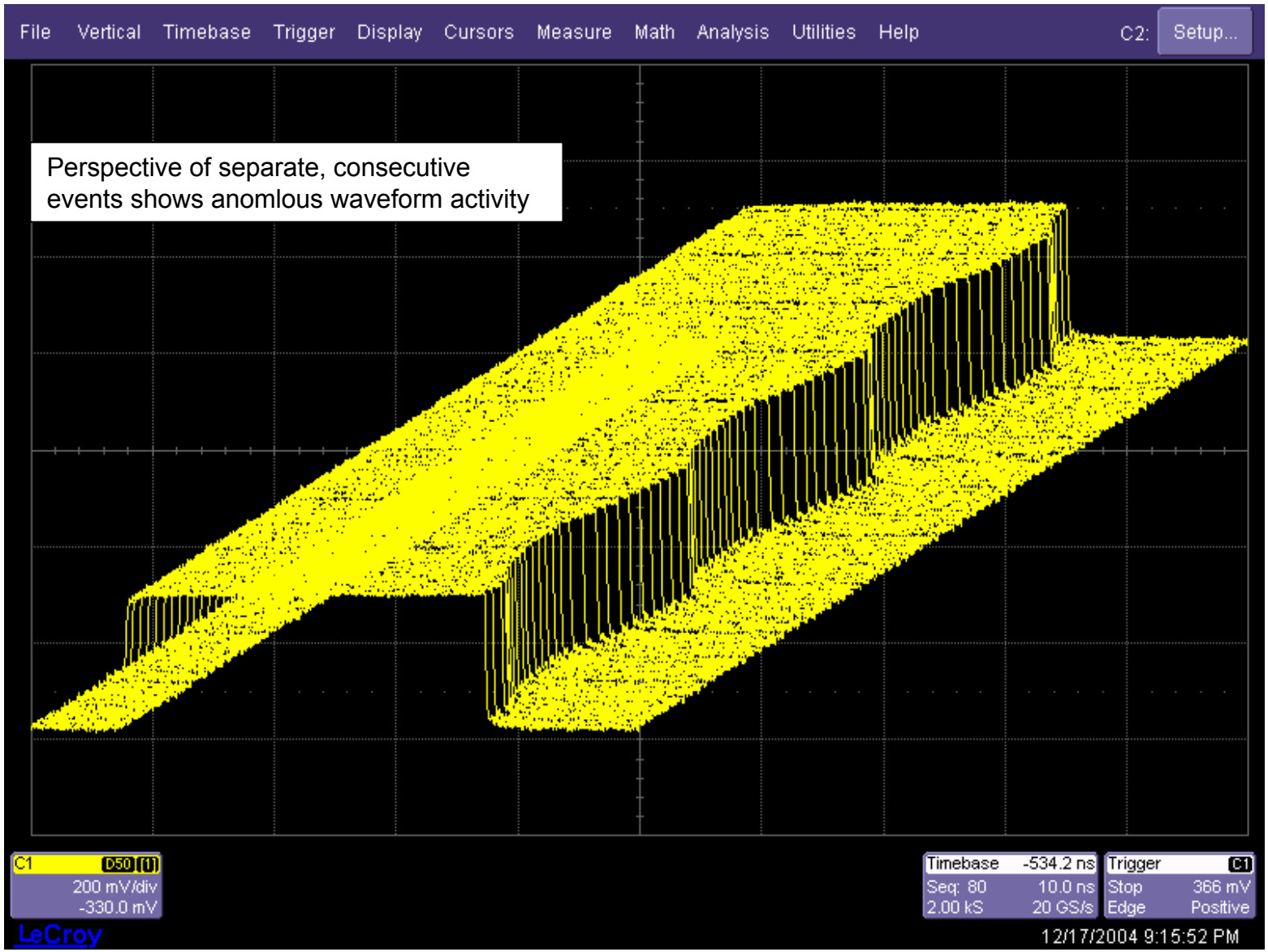
Mosaic of events is acquired while optimizing acquisition memory, and displayed without empty spaces between events

19,876th event selected

Sequence Waterfall shows anomaly

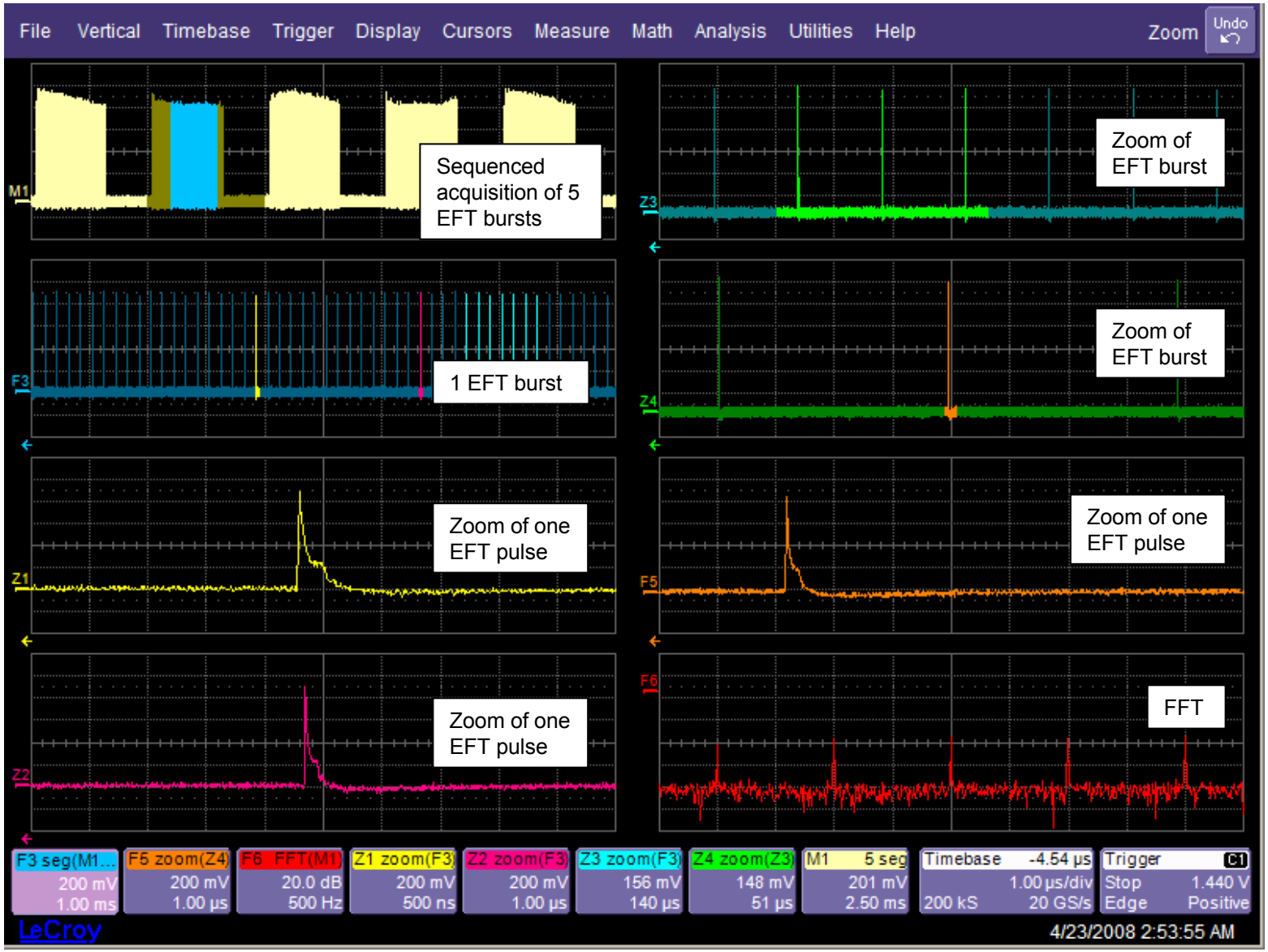


Sequence Perspective shows contour of acquired pulses

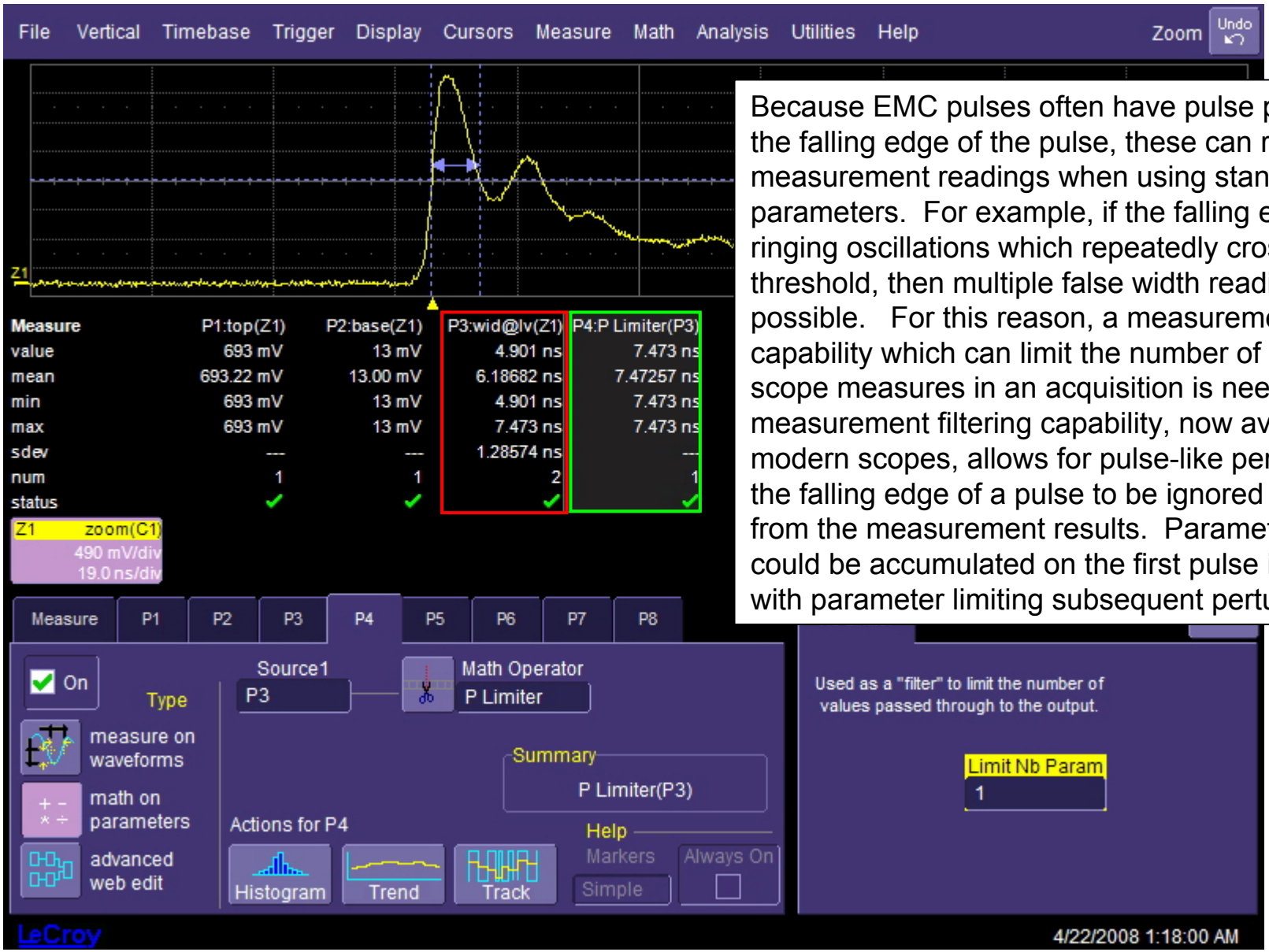


EFT Testing – Electrical Fast Transient

Sequence Mode and Octal Grid

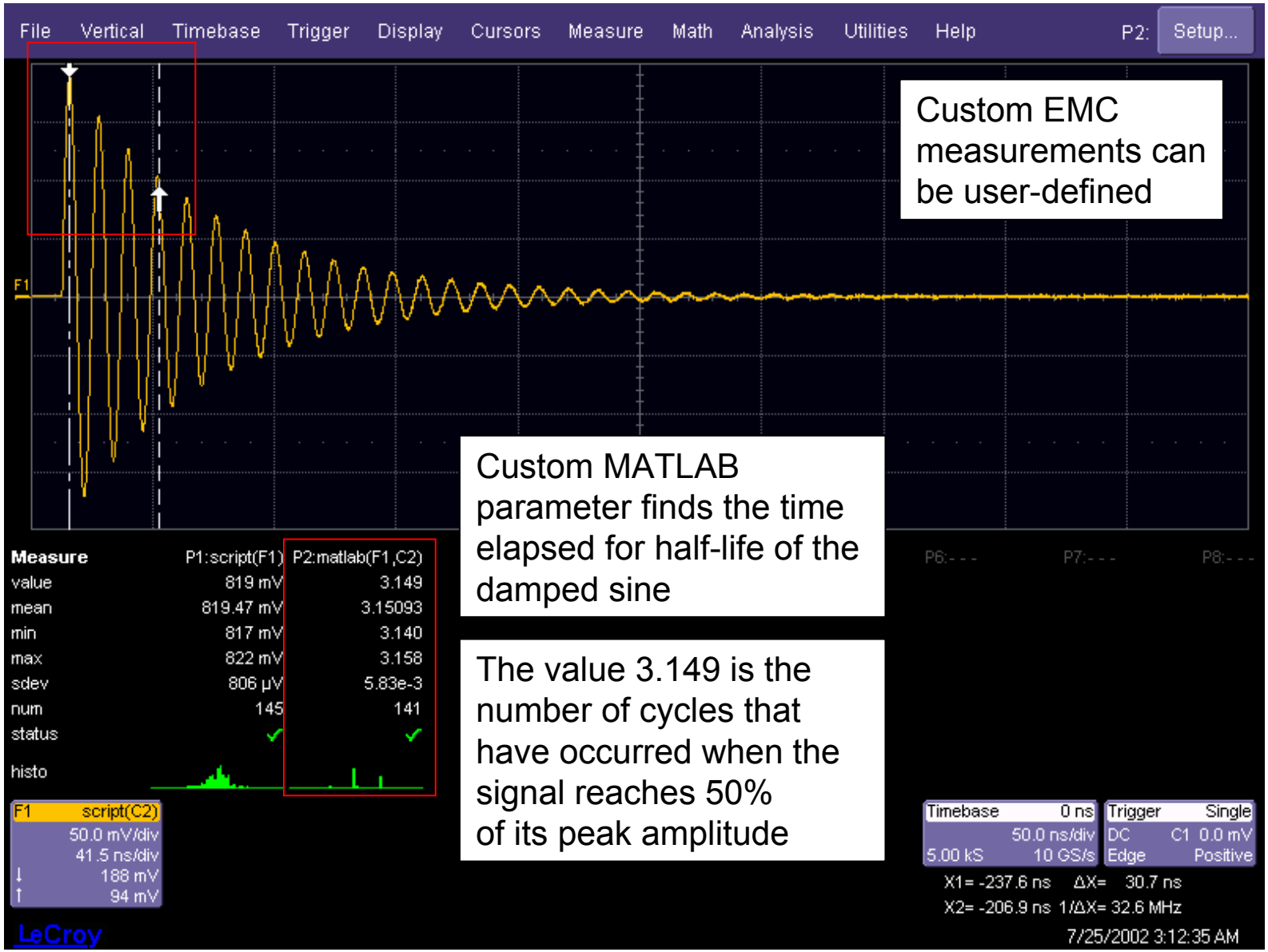


Parameter limiting technique for ESD width measurement

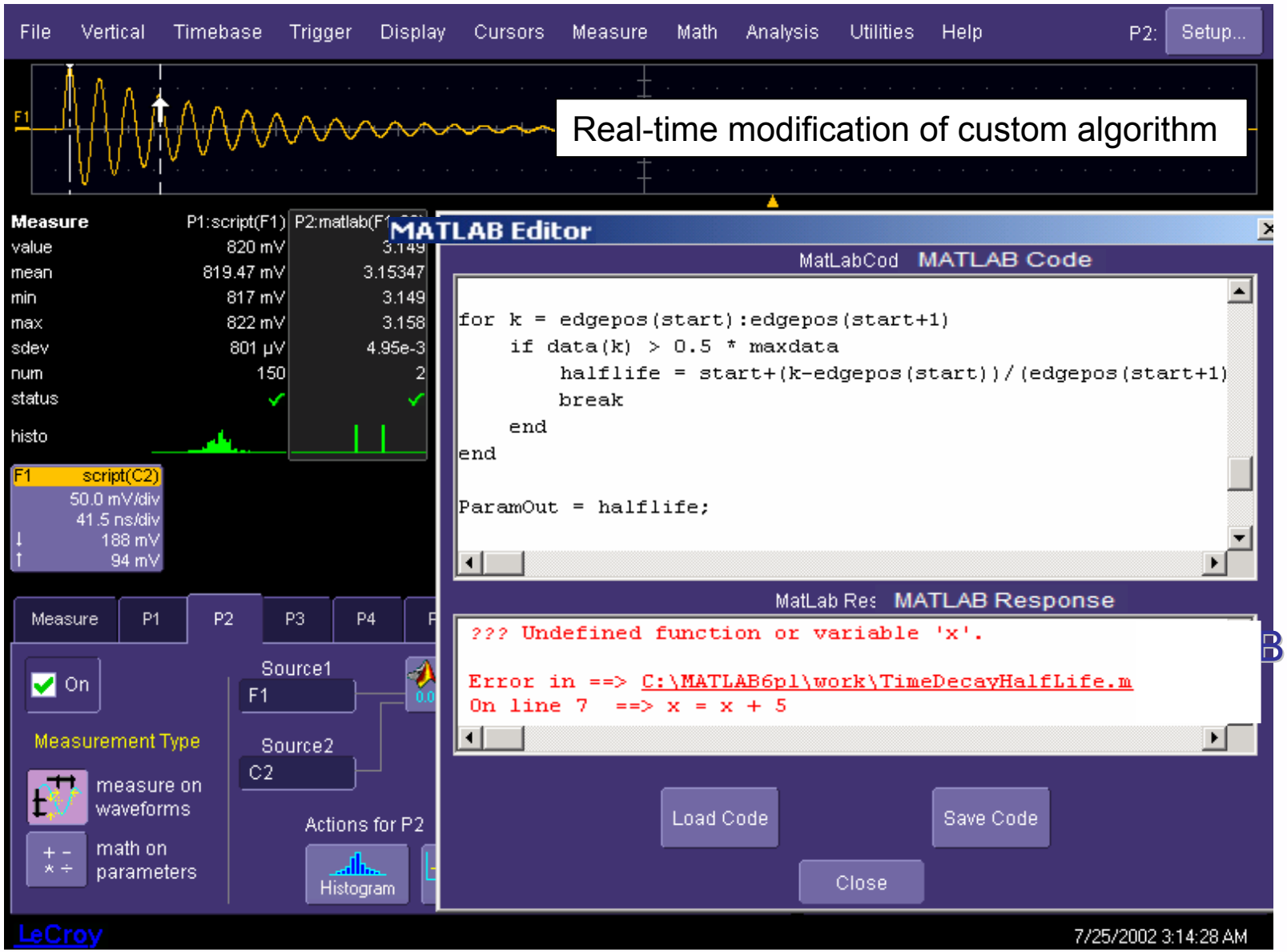


Because EMC pulses often have pulse perturbations on the falling edge of the pulse, these can result in false measurement readings when using standard parameters. For example, if the falling edge had ringing oscillations which repeatedly crossed the threshold, then multiple false width readings would be possible. For this reason, a measurement filtering capability which can limit the number of pulses the scope measures in an acquisition is needed. This measurement filtering capability, now available on modern scopes, allows for pulse-like perturbations on the falling edge of a pulse to be ignored and excluded from the measurement results. Parameter statistics could be accumulated on the first pulse in conjunction with parameter limiting subsequent perturbations.

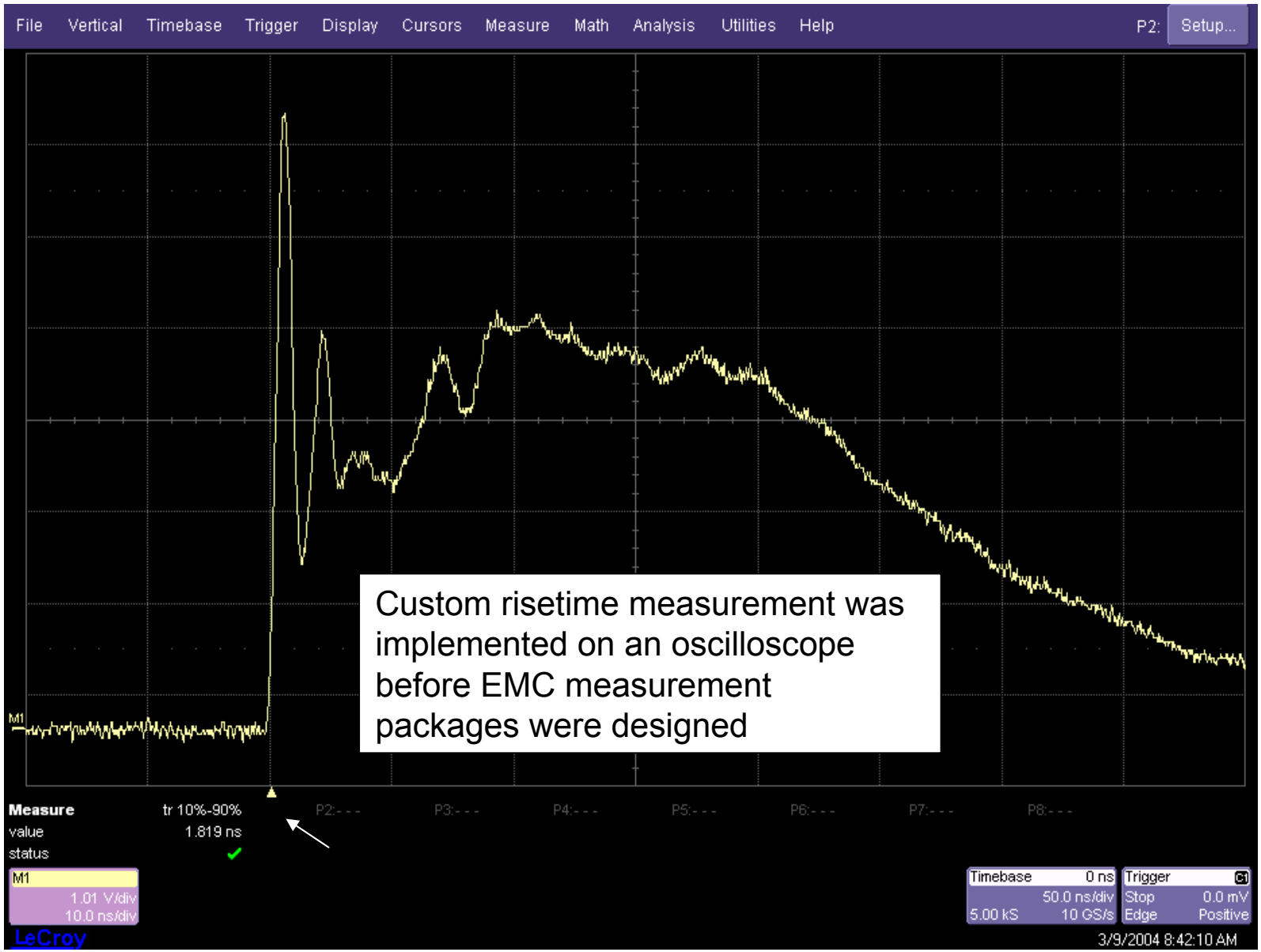
Inline Custom Measurement



Real-Time Modification of Custom Measurement



EMC Risetime Custom Definition



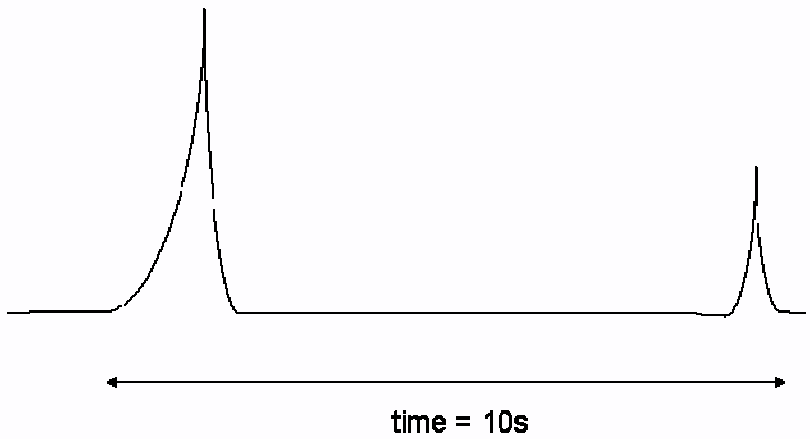
Summary

- EMC/ESD test specifications require verification of rise times, fall times, pulse widths and pulse shapes
- Standard oscilloscope pulse parameter measurements are based on IEEE pulse definitions
- EMC engineers use different pulse definitions which oscilloscopes are not designed to use
- Non-standard measurement setups are required to perform accurate pulse parameter measurements of electrostatic discharge, electrical fast transients, and surges.
- Selecting the correct measurement threshold can make a significant difference in the measurement accuracy of these signals.

Reference Slides

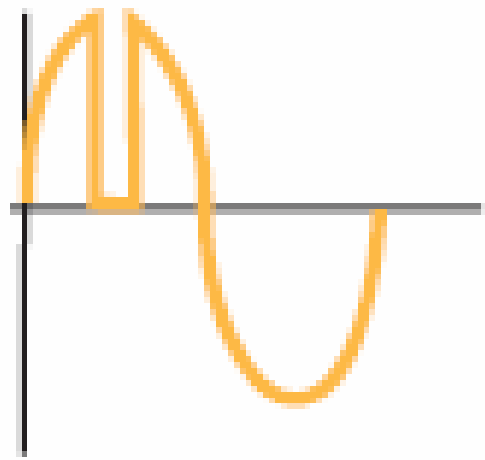
Transient Testing (Automotive)

- Pulse Characteristics
  - Capacitive load dump
  - Inductive kickback/spike (back EMF from motor turn off)
- Measurement Needs
  - Capture Time – longer the better:
    - Relay bounce (μs to ms)
    - Transient time
      - μs (motor)
      - ns (FET switch)
    - Measure 50-100 MHz transient
    - 10s capture = 2Mpts at 100 MHz Sample Rate



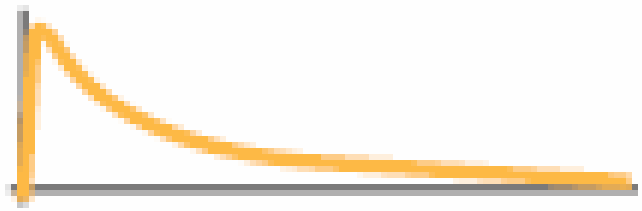
Dropout and Interrupt Testing

- Monitor AC or DC voltage line with oscilloscope during EMC testing
- Verify that dropout or interrupt occurred, and that device under test was unaffected



Surge Testing

- Pulse Characteristics
  - T_{rise} = typically 1.2 to 10 μs
  - T_{fall} = typically 20 to 10,000μs
- Measurement Needs
  - Capture a Single Pulse
  - Measure one pulse, verify rise and fall time




File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
P1:
Setup...
Standard scope measurements revert to peak-to-peak if Top and Base are not found. (Compare risetime value below to risetime value in next slide.)
rise@lv
M1
Measure
value
status
P1:rise@lv(M1)
896 ps
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
P7:- - -
P8:- - -
M1
50 V/div
25.0 ns/div
Timebase 0 ns
50.0 ns/div
5.00 kS 10 GS/s
Trigger C1
Stop 0.0 mV
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Rise@level
Summary
rise@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Rise at level
Gate
Accept
Close
Slew Rate for % or absolute levels of rising or falling edges.
Levels are
Percent
High percent
90 %
Set Levels to 10% and 90%
Set Levels to 20% and 80%
Low percent
10 %
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File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
P1:
Setup...
Standard scope measurements revert to peak-to-peak if Top and Base are not found. (Compare risetime value below to risetime value in previous slide.)
rise@lv
M1
Measure
value
status
P1:rise@lv(M1)
854 ps
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
P7:- - -
P8:- - -
M1
50 V/div
25.0 ns/div
Timebase 0 ns
50.0 ns/div
5.00 kS 10 GS/s
Trigger C1
Stop 0.0 mV
Edge Positive
Measure P1 P2 P3 P4 P5 P6 P7 P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Rise@level
Summary
rise@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Rise at level
Gate
Accept
Close
Slew Rate for % or absolute levels of rising or falling edges.
Levels are
% 0-Max
High percent
90 %
Set Levels to 10% and 90%
Set Levels to 20% and 80%
Low percent
10 %
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File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
P1:
Setup...
Effect of thresholds on the Width measurement of this ESD pulse
wid@lv
M1
Measure
value
status
P1:wid@lv(M1)
13.246 ns
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
P7:- - -
P8:- - -
M1
50 V/div
25.0 ns/div
Timebase 0 ns
50.0 ns/div
5.00 kS 10 GS/s
Trigger C1
Stop 0.0 mV
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Width@level
Summary
wid@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Width at Level
Gate
Accept
Close
Time between two transitions of opposite slope at a specified level. (Slope specified for 1st transition)
Level is
% 0-Max
Percent level
50 %
Find level
Slope
Pos
Hyst. Type
Divisions
Hysteresis
500 mdiv
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File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
P1:
Setup...
Effect of thresholds on the Width measurement of this ESD pulse
wid@lv
M1
Measure
value
status
P1:wid@lv(M1)
23.084 ns
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
P7:- - -
P8:- - -
M1
50 V/div
25.0 ns/div
Timebase 0 ns
50.0 ns/div
5.00 kS 10 GS/s
Trigger C1
Stop 0.0 mV
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Width@level
Summary
wid@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Width at Level
Gate
Accept
Close
Time between two transitions of opposite slope at a specified level. (Slope specified for 1st transition)
Level is
Percent
Percent level
50 %
Find level
Slope
Pos
Hyst. Type
Divisions
Hysteresis
500 mdiv
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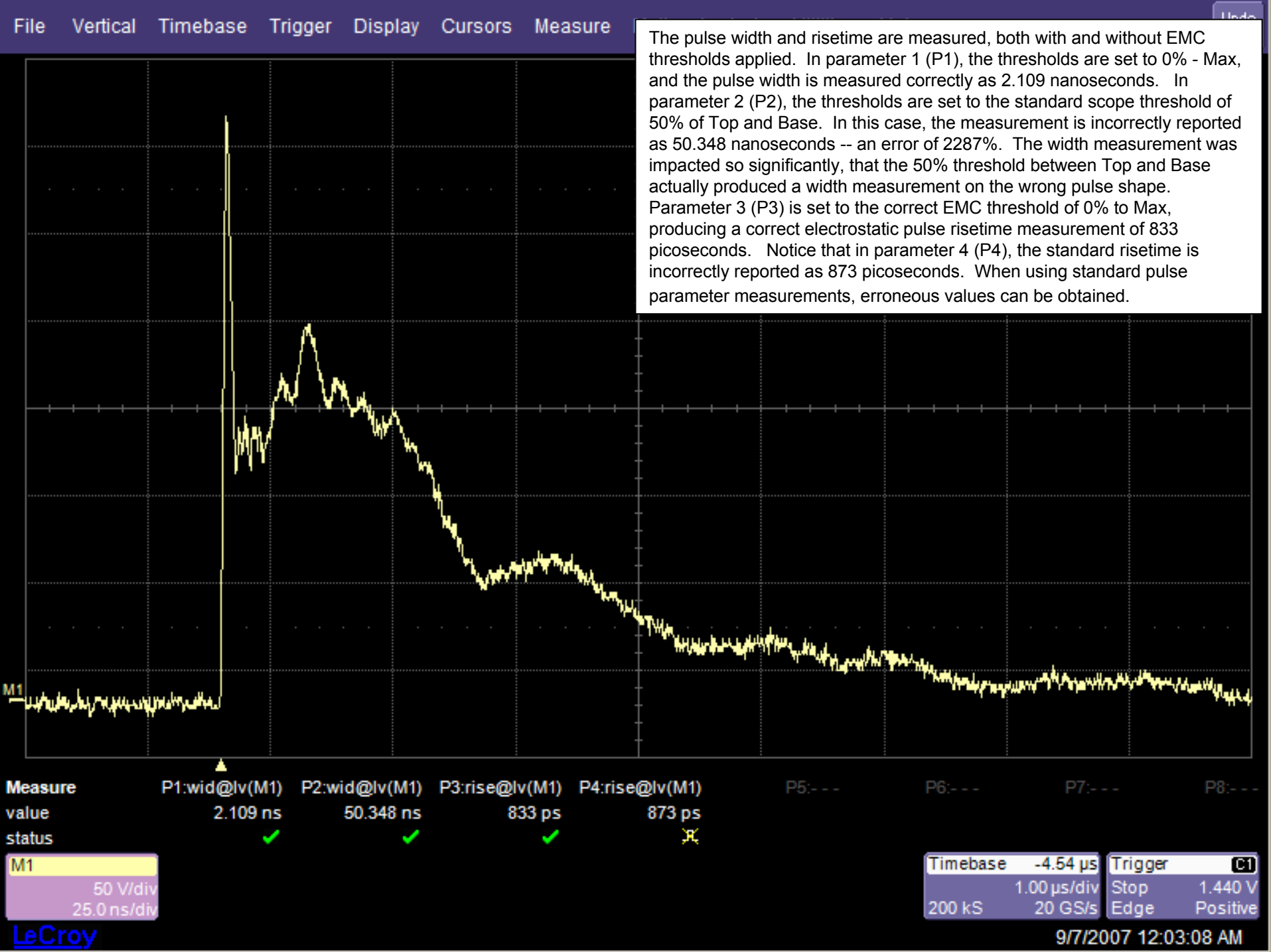
File Vertical Timebase Trigger Display Cursors Measure Math Analysis Utilities Help
P1:
Setup...
Effect of thresholds on the Width measurement of this ESD pulse
wid@lv
M1
Measure
value
status
P1:wid@lv(M1)
83.106 ns
P2:- - -
P3:- - -
P4:- - -
P5:- - -
P6:- - -
P7:- - -
P8:- - -
M1
50 V/div
25.0 ns/div
Timebase 0 ns
50.0 ns/div
5.00 kS 10 GS/s
Trigger C1
Stop 0.0 mV
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Width@level
Summary
wid@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Width at Level
Gate
Accept
Close
Time between two transitions of opposite slope at a specified level. (Slope specified for 1st transition)
Level is
Absolute
Absolute level
52.2 V
Find level
Slope
Pos
Hyst. Type
Divisions
Hysteresis
500 mdiv
LeCroy
11/27/2005 7:25:19 PM


File
Vertical
Timebase
Trigger
Display
Cursors
Measure
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- an error of 2287%. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.
wid@lv
wid@lv
M1
Measure
P1:wid@lv(M1)
P2:wid@lv(M1)
P3:rise@lv(M1)
P4:rise@lv(M1)
P5:- - -
P6:- - -
P7:- - -
P8:- - -
value
2.109 ns
50.348 ns
833 ps
873 ps
status
M1
50 V/div
25.0 ns/div
Timebase -4.54 µs
1.00 µs/div
200 kS 20 GS/s
Trigger C1
Stop 1.440 V
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Width@level
Summary
wid@lv(M1)
Actions for P1
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Width at Level
Gate
Accept
Close
Time between two transitions of opposite slope at a specified level. (Slope specified for 1st transition)
Level is
% 0-Max
Percent level
50 %
Find level
Slope
Pos
Hyst. Type
Divisions
Hysteresis
500 mdiv
LeCroy
9/7/2007 12:01:38 AM


File
Vertical
Timebase
Trigger
Display
Cursors
Measure
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- an error of 2287%. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.
wid@lv
wid@lv
M1
Measure
P1:wid@lv(M1)
P2:wid@lv(M1)
P3:rise@lv(M1)
P4:rise@lv(M1)
P5:- - -
P6:- - -
P7:- - -
P8:- - -
value
2.109 ns
50.348 ns
833 ps
873 ps
status
M1
50 V/div
25.0 ns/div
Timebase -4.54 µs
1.00 µs/div
200 kS 20 GS/s
Trigger C1
Stop 1.440 V
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Width@level
Summary
wid@lv(M1)
Actions for P2
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Width at Level
Gate
Accept
Close
Time between two transitions of opposite slope at a specified level. (Slope specified for 1st transition)
Level is
Percent
Percent level
50 %
Find level
Slope
Pos
Hyst. Type
Divisions
Hysteresis
500 mdiv
LeCroy
9/7/2007 12:01:57 AM


File Vertical Timebase Trigger Display Cursors Measure
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- an error of 2287%. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.
rise@lv
M1
Measure
P1:wid@lv(M1)
P2:wid@lv(M1)
P3:rise@lv(M1)
P4:rise@lv(M1)
P5:- - -
P6:- - -
P7:- - -
P8:- - -
value
2.109 ns
50.348 ns
833 ps
873 ps
status
M1
50 V/div
25.0 ns/div
Timebase -4.54 µs
1.00 µs/div
200 kS 20 GS/s
Trigger C1
Stop 1.440 V
Edge Positive
Measure P1 P2 P3 P4 P5 P6 P7 P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Rise@level
Summary
rise@lv(M1)
Actions for P3
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Rise at level
Gate
Accept
Close
Transition time for % or absolute levels of all rising edges
Levels are
% 0-Max
High percent
90 %
Set Levels to 10% and 90%
Set Levels to 20% and 80%
Low percent
10 %
LeCroy
9/7/2007 12:02:27 AM


File
Vertical
Timebase
Trigger
Display
Cursors
Measure
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- an error of 2287%. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.
rise@lv
M1
Measure
P1:wid@lv(M1)
P2:wid@lv(M1)
P3:rise@lv(M1)
P4:rise@lv(M1)
P5:- - -
P6:- - -
P7:- - -
P8:- - -
value
2.109 ns
50.348 ns
833 ps
873 ps
status
M1
50 V/div
25.0 ns/div
Timebase -4.54 µs
1.00 µs/div
200 kS 20 GS/s
Trigger C1
Stop 1.440 V
Edge Positive
Measure
P1
P2
P3
P4
P5
P6
P7
P8
On
Type
measure on waveforms
math on parameters
advanced web edit
Source1
M1
Measure
Rise@level
Summary
rise@lv(M1)
Actions for P4
Histogram
Trend
Track
Help
Markers
Detailed
Always On
Rise at level
Gate
Accept
Close
Transition time for % or absolute levels of all rising edges
Levels are
Percent
High percent
90 %
Set Levels to 10% and 90%
Set Levels to 20% and 80%
Low percent
10 %
P4 Status: Not a pulse.


File Vertical Timebase Trigger Display Cursors Measure
The pulse width and risetime are measured, both with and without EMC thresholds applied. In parameter 1 (P1), the thresholds are set to 0% - Max, and the pulse width is measured correctly as 2.109 nanoseconds. In parameter 2 (P2), the thresholds are set to the standard scope threshold of 50% of Top and Base. In this case, the measurement is incorrectly reported as 50.348 nanoseconds -- an error of 2287%. The width measurement was impacted so significantly, that the 50% threshold between Top and Base actually produced a width measurement on the wrong pulse shape. Parameter 3 (P3) is set to the correct EMC threshold of 0% to Max, producing a correct electrostatic pulse risetime measurement of 833 picoseconds. Notice that in parameter 4 (P4), the standard risetime is incorrectly reported as 873 picoseconds. When using standard pulse parameter measurements, erroneous values can be obtained.
M1
Measure
P1:wid@lv(M1)
P2:wid@lv(M1)
P3:rise@lv(M1)
P4:rise@lv(M1)
P5:- - -
P6:- - -
P7:- - -
P8:- - -
value
2.109 ns
50.348 ns
833 ps
873 ps
status
M1
50 V/div
25.0 ns/div
Timebase -4.54 µs
1.00 µs/div
200 kS 20 GS/s
Trigger C1
Stop 1.440 V
Edge Positive
LeCroy
9/7/2007 12:03:08 AM