EMC LIVE 2018
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State-of-the-art Testing According to CISPR 14-1

Discontinuous Disturbances Testing

EMC LIVE 2018

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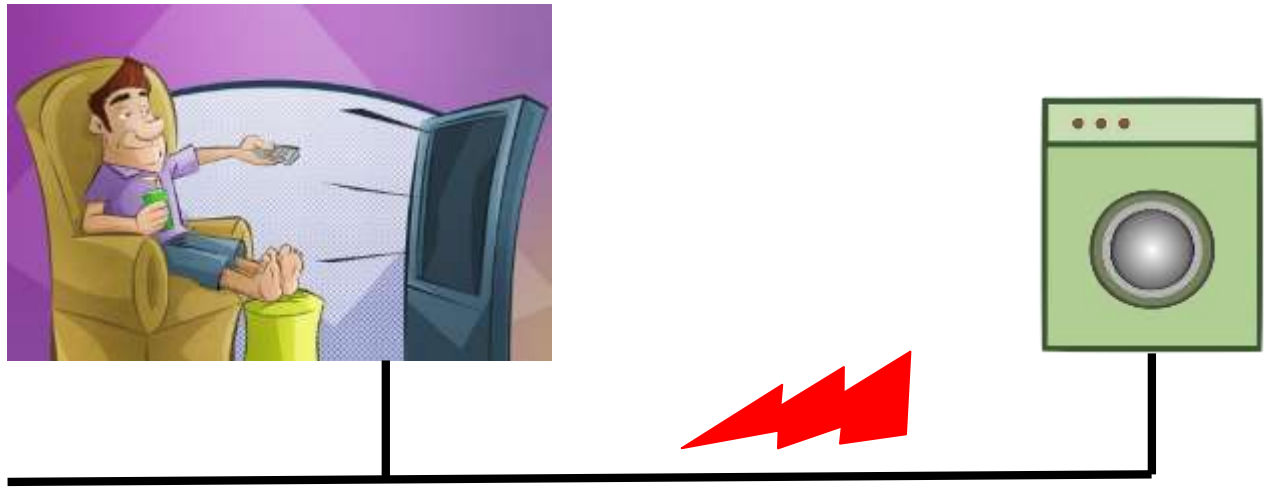
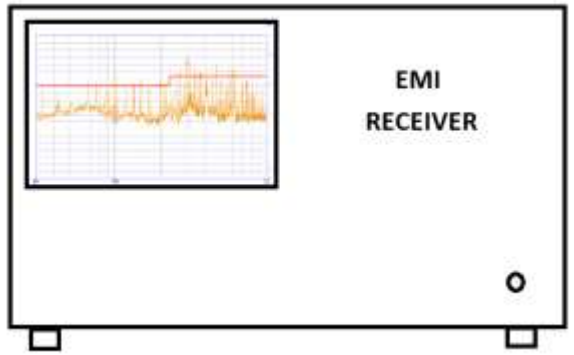
EMI conducted disturbances

Described by EMC Standards (CISPR, IEC/EN, MIL etc.) as **unwanted radio frequency disturbances that propagate via the mains or other power supply lines**



EMI continuous conducted disturbances

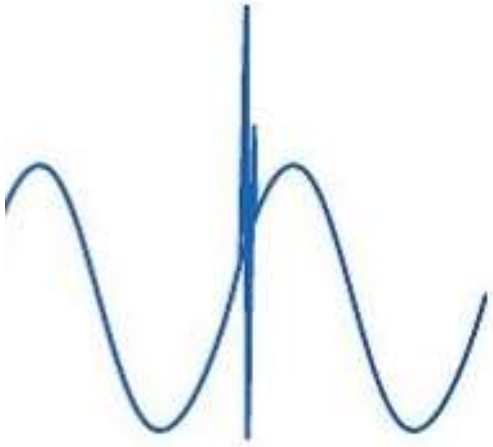
Continuous

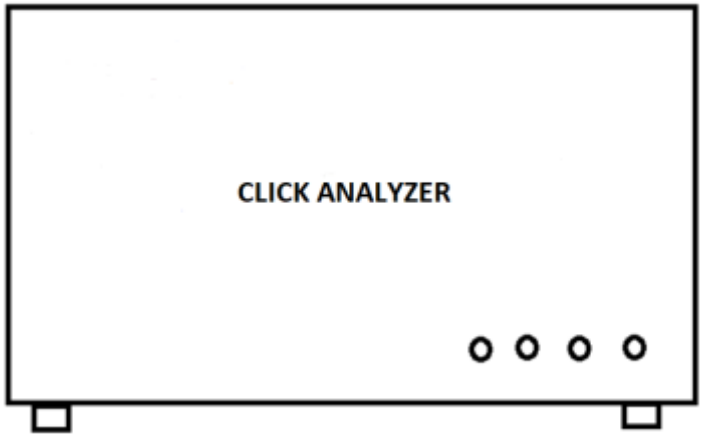


Compare the frequency components amplitude to Standard Limits

In the shortest possible time

EMI discontinuous conducted disturbances





Severity of discontinuous disturbances not only depends on their amplitude.
How frequently they happen, the so called «**Click Rate**», defines the Click Limit

CISPR 14-1, EN55014-1 PRODUCT STANDARD

Emissions testing (conducted and radiated) of:

- Household appliances or similar, even for use in working places such as offices, shops, farms…
- Electric tools
- Similar apparatus such as motor driven electro-medical, toys, entertainment machines, vending machines…

Conducted Discontinuous Disturbances Test

Measurement of **CLICKS** on selected EUTs like not only washing machines, coffee machines, dryers or refrigerators etc…

… more in general, on every appliance equipped with Switching Components, for both residential and Industrial environments.

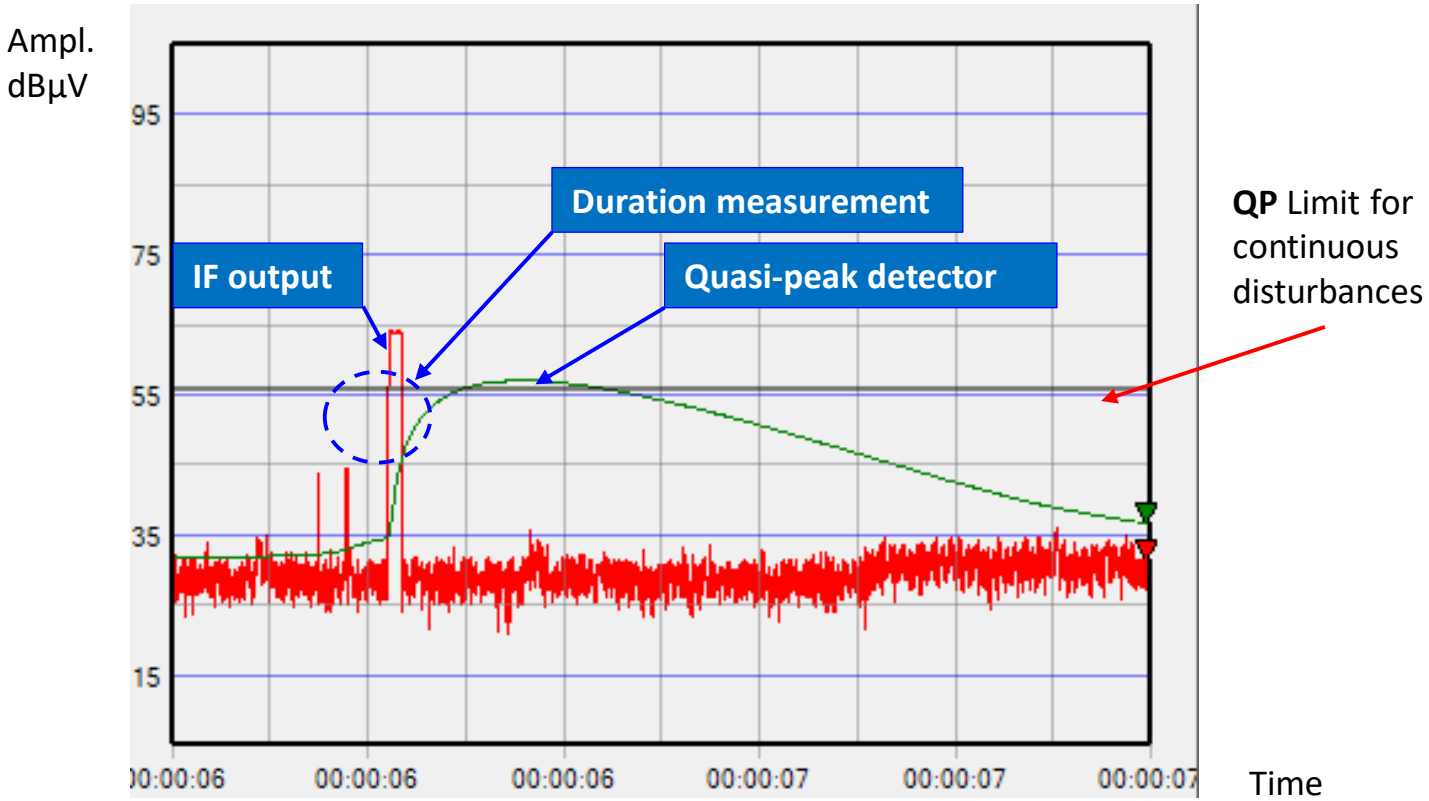
Of course, besides continuous and radiated, the reference standard provides the **«click» definition** as well as the **click measurement procedure**.

CLICK definition

Click
a disturbance having an amplitude exceeding the QP Limit, which duration is ≤ 200ms and is separated from a subsequent disturbance by at least 200ms

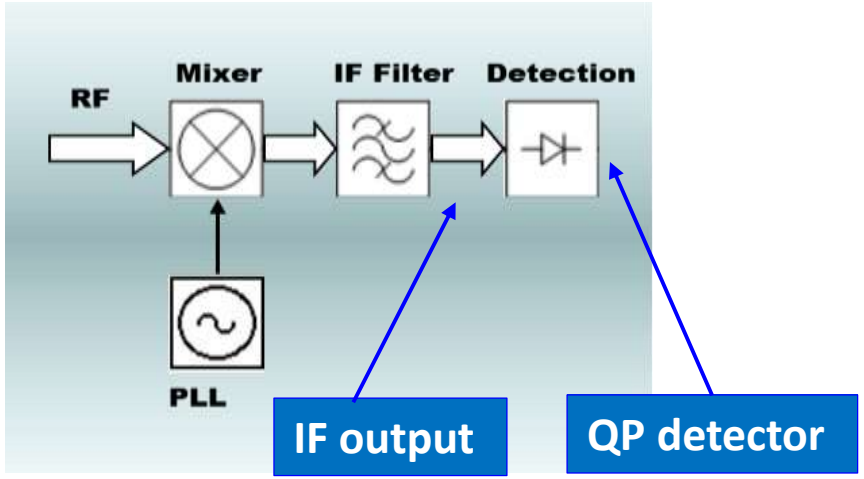
Duration is defined as the time the signal (IF) overcomes the reference level corresponding to the QP Limit

IF is the intermediate frequency output of a measuring receiver

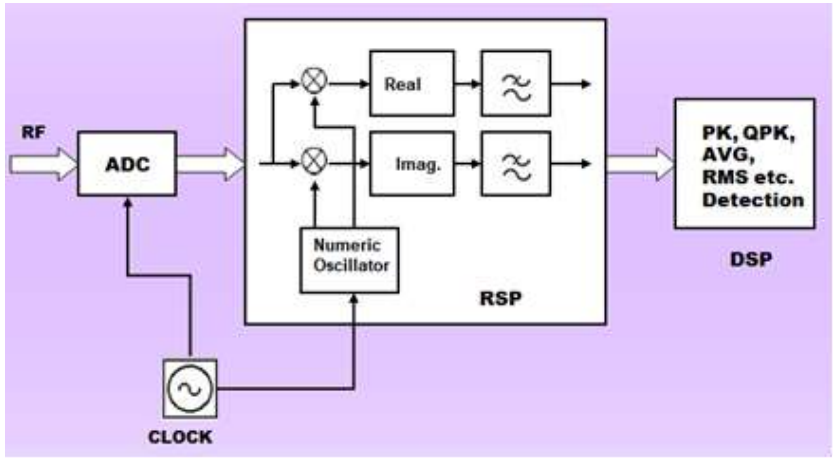


What does “IF output” mean?

Old CISPR 14-1 standard date back to the **heterodyne** receiver technology:
IF = Intermediate Frequency



Modern digital receivers emulate frequency conversion, RBW filters, detectors etc. or use FFT
A virtual IF output is generated for the purpose



First Run: Defining the click limit Lq

Lq depends on how many clicks are generated in a unit of time.

The click test starts counting clicks for an amount of time significant for a statistical assessment of the **Click Rate (N)**

How long is the **Minimum Observation Time (T)** to define the Click Rate?

- Time to count 40 clicks
- 2 hours (if the count not yet reached 40 clicks)
- More than 2 hours for EUTs which function is based on operating cycles (1 cycle if longer than 2 hours or multiple complete cycles to excede 2 hours in total).

Click Rate calculation:

$$N = n_1 / T$$

Where n_1 = number of clicks in the Minimum Observation Time

Discontinuous disturbance is a long lasting test

Alternate method for defining the Click Rate

For specific devices listed in CISPR 14-1:

Counting of Switching Operation (n_2) independent of whether clicks are observed or not.

Switching Operations:
opening or closing of a mechanical or electronic switch or contact
Are used to control the operation of a device
Can occur at a random or pre-determined rate

Example:

Type of equipment	Factor f
Refrigerators, freezers	0.5
Irons	0.66
Electro-mechanical office machines	1.00

Click Rate calculation:

$$N = n_2 \times f / T$$

Where n_2 = number of switching operations in the Minimum Observation Time

If Click Rate ≥ 30 it must be assessed by counting clicks

Defining the Click Limit (Lq)

Once the Click Rate has been assessed (after, maybe, 2 hours) we can define the Click Limit to be used for our measurement:

For a time period corresponding to the Minimum Observation Time used for the Rate assessment, we will be going to check how many clicks excede the Click Limit (Lq)

Click Limit Lq: Limit for Discontinuous Disturbance, derived from the Q-Peak Limit for Continuous Disturbance increased by a value depending on the click rate N*

(a kind of relaxation offset)

*** For N<0,2: Lq = L+44 dB**

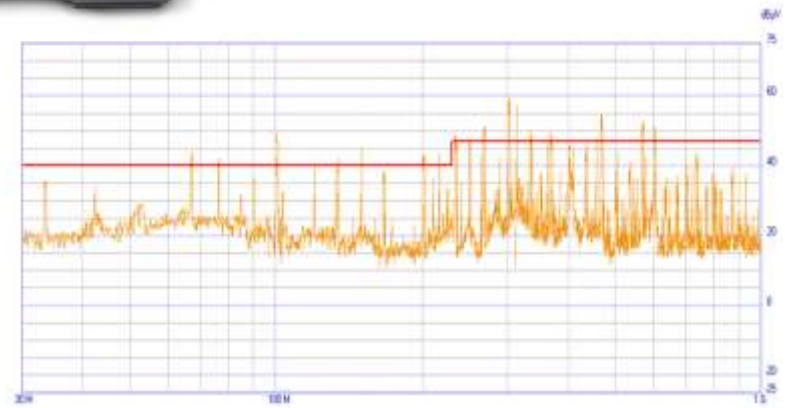
Click Limit calculation:

$$Lq = L + 20 \log (30/N)$$

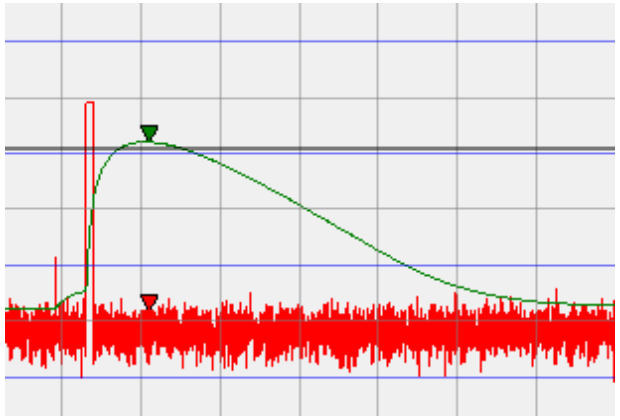
Where L is the QP limit for continuous disturbances.

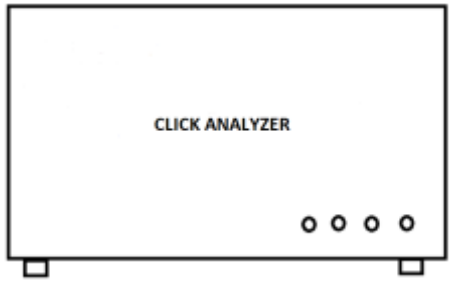
Different disturbances different meters

Continuous



Discontinuous
«Clicks»





Compare the frequency components amplitude to Limits
High speed measurement if Time Domain (FFT)

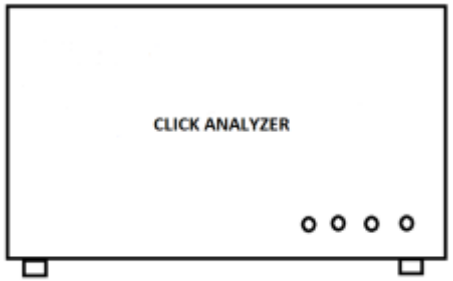
Sophisticated time-amplitude analysis on fixed frequencies.
IT can last 2 hours for each frequency

Frequencies for click analysis

Discontinuous disturbances are impulsive signals that provide a wide band noise whose effect can be well represented by few frequencies in the range of interest:

- **150 kHz** (entire process)
- **500 kHz** (entire process)
- **1.4 MHz** (Limit calculation, final evaluation)
- **30 MHz** (Limit calculation, final evaluation)

Click Rate and Click Limit must be assessed at **150 Khz** and **500 kHz**.
Click Rate assessed at 500 kHz is deemed to be representative of higher frequencies too



4 channel click analyzers save time!

Second Run: Upper Quartile Method

Known information:

- Observation Time at 150 kHz and 500 kHz
- Number of Clicks counted during the observation time
- Click Limit Lq for each of the 4 frequencies

Take a new measurement for the entire observation time at each frequency and check how many clicks excede the Click Limit Lq:

- If not more than 25% of click counted before: **Pass**
- If more than 25% of click counted before: Non-Compliant, **Fail**.

2 or even 8 hours more testing

CISPR 14-1 Click Measurement Example

Standard used: EN 55014-1, f = 150 kHz and Limit L= 66 dBµV

- 1) First run: count of 40 clicks (n) in 50 minutes (T)
  - Click rate N = 40/50 = 0.8
  - Offset = 20 Log (30/N) = 32 dB
- 2) The new Click limit is Lq = L+Offset = 66+32 = 98 dBµV
- 3) Second run: With the upper quartile method the maximum clicks allowed are: 25% of 40 = 10 clicks
- 4) *Using the new limit the EUT will fail the test if will count more then 10 clicks higher than 98 dBµV (with Qpeak)*

Exceptions

For specific disturbance characteristics:

May change the measurement process flow

May require the storage of any detail of preceding disturbances

- 1 - Individual switching operations (not considered)
- 2 - Combination of disturbances in a time frame less than 600 ms (1 click)
  - One time only in the minimum observation time or EUT operating cycle
- 3 - Instantaneous switching (E.U.T. compliant)
  - Click Rate (N) ≤ 5; no click longer than 20ms; duration ≤ 10 ms for at least 90% of clicks
- 4 - Separation less than 200 ms (2 clicks)
  - Click Rate (N) < 5; two disturbances ≤200 ms; separation < 200 ms
  - Click Rate (N) still < 5 after applying the exception

Basic information provided by the click analyzer

- Number of click (n)
- Observation Time (T)
- Click Rate (N)
- Click Limit (Lq)
- Number of clicks ≤ 10 ms
- Number of clicks > 10 ms and ≤ 20 ms
- Number of clicks > 20 ms and ≤ 200 ms
- Duration of “Other than click”
- Exceptions
- Pass/Fail

Example of click test report form

Lq Calculation										
Frequency MHz	Limit dBµV	<=10ms	<=20ms	<=0.2s	From Exception E4	Other than click ms	Total Clicks	Time min.	N rate	+Lq dB
0.15	56.0	0	8	0	0	0	8	3.0	2.7	21.0
0.50	56.0	0	7	0	0	0	7	3.0	2.3	22.2
1.40	56.0	0	7	0	0	0	7	3.0	---	22.2
30.00	56.0	0	7	0	0	0	7	3.0	---	22.2

Final Test Report										
Frequency MHz	Limit Quartile dBµV	<=10ms	<=20ms	<=0.2s	From Exception E4	Other than click ms	Total Clicks	Time min.	Max Click Allowed	Pass Fail
0.15	77.0	0	0	0	0	0	0	3.0	2	Pass
0.50	78.2	0	0	0	0	0	0	3.0	1	Pass
1.40	78.2	0	0	0	0	0	0	3.0	1	Pass
30.00	78.2	0	0	0	0	0	0	3.0	1	Pass

Doubts on application of the Upper Quartile Method

Two different approaches are adopted by different test equipment manufacturers:

- **2 Rates – 2 Quartiles**

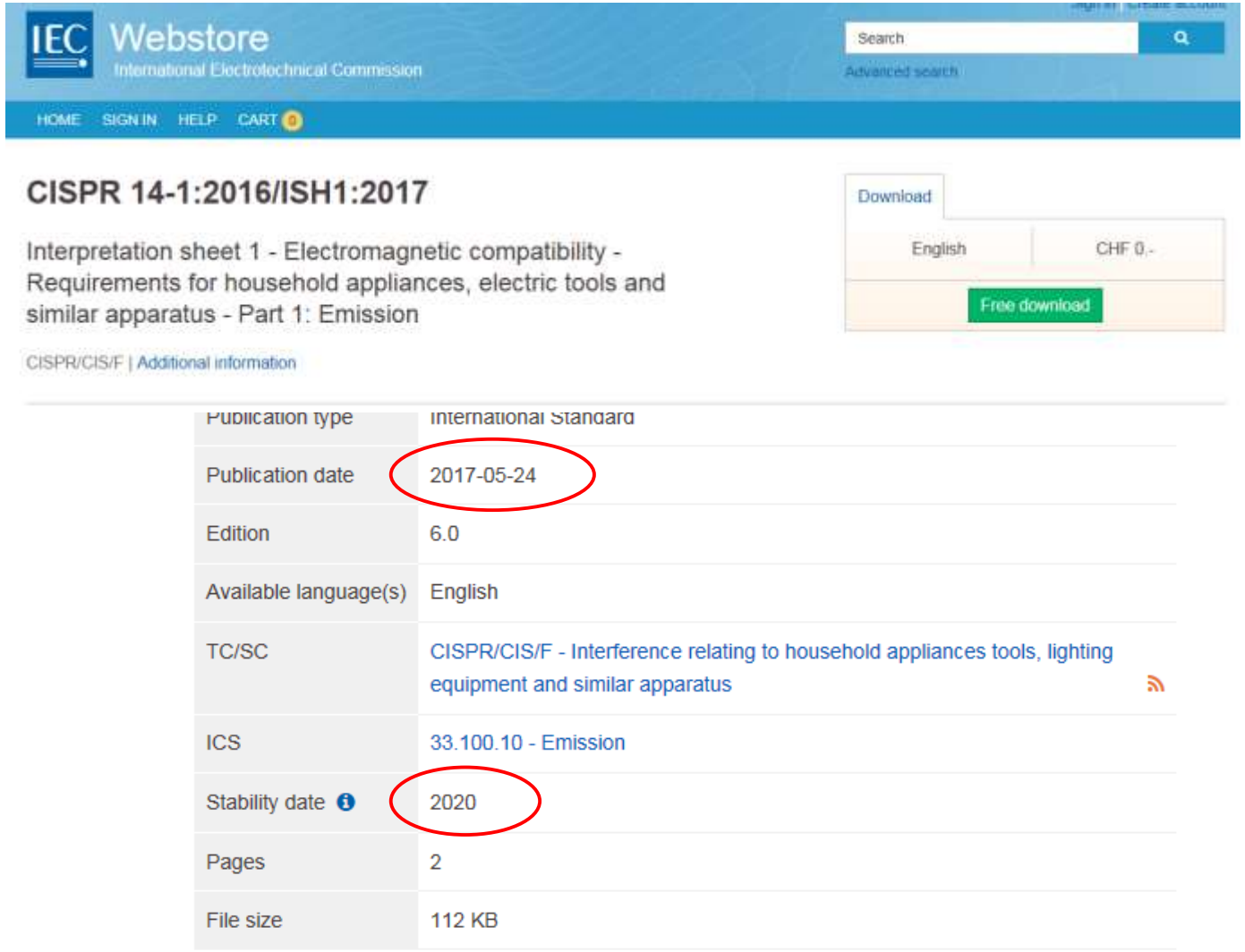
The same number of clicks counted while assessing the click rate at 500 kHz are used to define the number of clicks allowed to exceed the click limit at 1.4 and 30 MHz

- **2 Rates – 4 Quartiles**

Even though the relaxation offset is based on the number of clicks counted at 500 kHz, the number of clicks are measured at 1.4 and 30MHz during the same observation time. The number of clicks allowed to exceed the click limit are ¼ of click counted at 1.4 and 30 MHz respectively.

Different methods provide different results!

CISPR Interpretation Sheet



Related publications

CISPR 14-1:2016
CISPR 14-2:2015

Share this page

Both methods are valid:

In any situation where it is necessary to verify the original measurement, the assessment method (interpretation 1 or 2) originally chosen shall be used to ensure consistency of the results.

1st evolution: Click meter integrated in EMI receiver

PMM first in the world
'90s

PMM 9010 w/Click Option

PMM 9010 w/ 4-Channel Click Option

2nd evolution: Click meter in FFT EMI receivers

Concept:

- FFT measures all frequencies at the same time
- Powerful computing on board
- Hence, the 4-channel Click Meter function is just firmware… **Isn't it??**

Not to be forgotten: FFT does not reduce Click test time at all! Test time is only determined by the product standard, say by the EUT operation cycles.

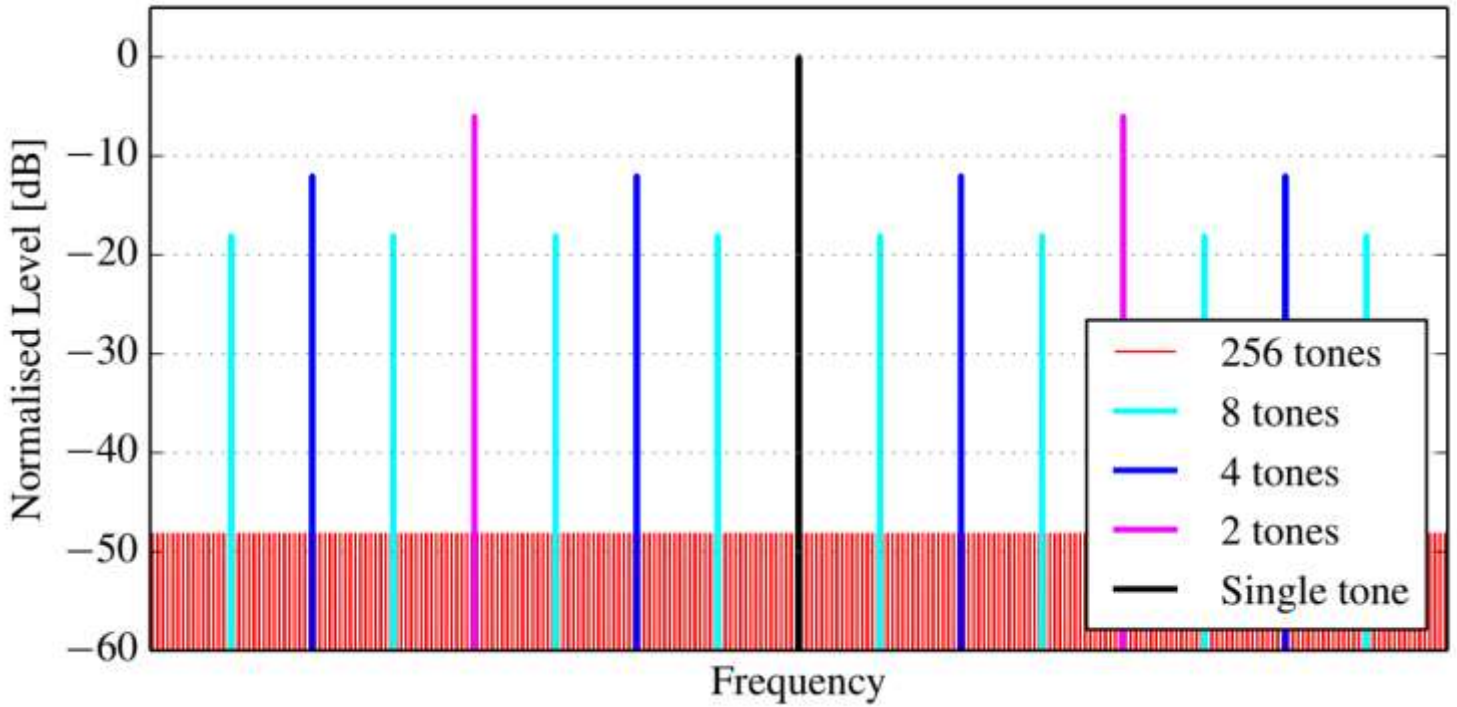
FFT EMI receiver & 4-channel Clicks : not possible by sw/fw only!

- FFT EMI receivers aim to measure the widest possible frequency band at once
- However, each one of the 4 Click frequencies must deal with very different amplitudes = channel-individual input autoranging is indispensable
- It is described (*) that FFTing a ≈ 30 MHz band means an unbearable loss of receiver's dynamic range
- Sw emulations, filtering etc. cannot compensate or go against physics
- Narrowband frequency preselection at the RF input guarantees full CISPR compliance of the 4-channel Click Meter, whatever the receiver's technology

(*) M. Monti, E. Puri and M. Monti, "Pitfalls in measuring discontinuous disturbances with latest click analysers" 2016 IEEE International Symposium on Electromagnetic Compatibility (EMC), Ottawa

More about dynamic range

- Dynamic range is the difference, in dB, between lowest and highest level that can be measured at the same time without compression or saturation.



Non-compressing level of multiple-tone signals normalised to a single-tone signal (full scale)

Pulsed disturbances are broad band signals.
Their energy is spread over a wide frequency band.

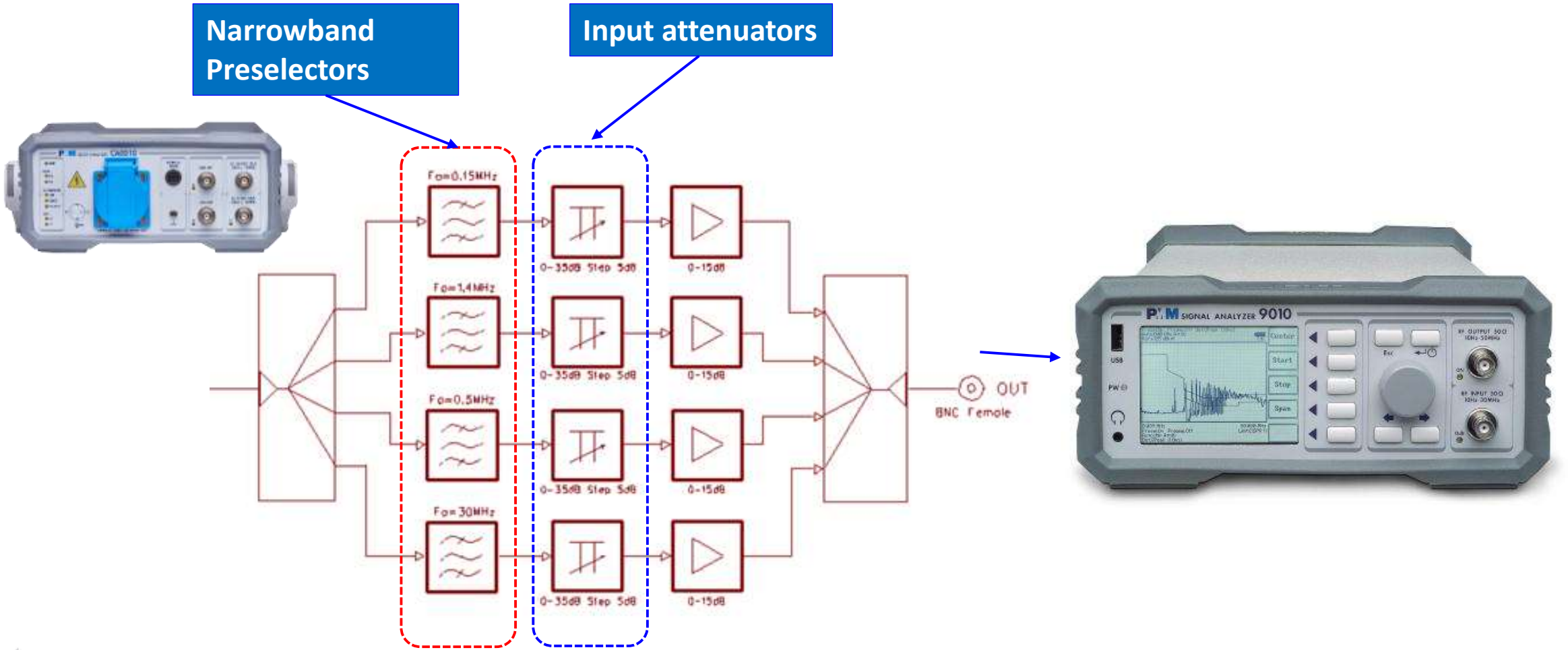
How to… reducing testing time

- 4 channel click analyzer instead of 1 ch
- No time difference between 4 channel systems based on 4 receivers or a single TD FFT receiver able to measure the 4 frequencies at the same time.
  - A dedicated front end for click analysis is required if using broad band time domain receiver.
- If confident that no saturation occured during the first run and all amplitude and duration parameters related to every discontinuous disturbance have been stored, the second run can be avoided:
  - Use already available information for the upper quartile method and for the test report.

CA-0010: 4 ch. Click extension for 9010F Time Domain EMI receiver

- ✓ It makes the FFT EMI Receiver PMM 9010F a complete 4-channel Click Analyzer
- ✓ Full CISPR 14-1 & 16-1-1 compliance
- ✓ Internal 16 A LISN
- ✓ Internal threshold for Switching Operations counting
- ✓ Internal Click & CISPR pulse generator

From the block diagram of PMM CA-0010



CA-0010: main connections

Internal 16 A/230 V LISN
And Switching Operations Box

LISN output to
EMI Receiver for Continuous
conducted emission test

RF output to
EMI Receiver 9010F
for Discontinuous
(Clicks) Disturbances
Tests

RF intput
From external LISN

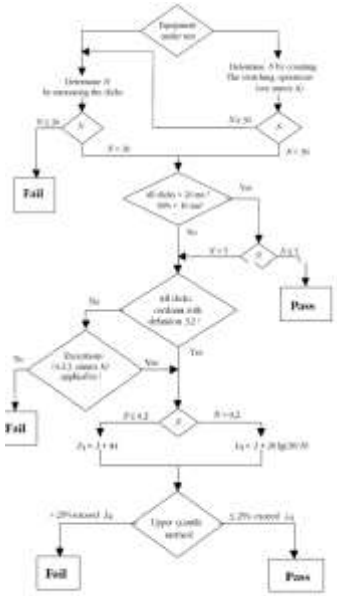
Internal Click Calibrator output

CDD-4: The All-in-one for all Conducted Disturbances

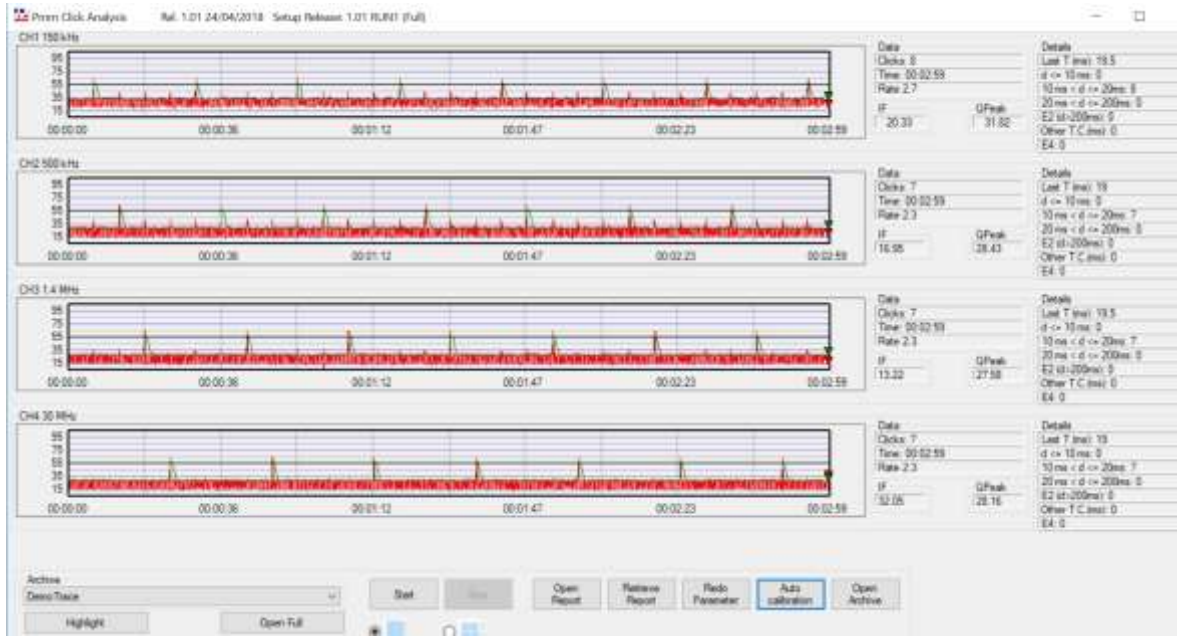
- ✓ All functions for full compliance conducted emission tests
- ✓ Full CISPR 14-1 & 16-1-1 compliance
- ✓ Internal 16 A LISN
- ✓ Internal Click & CISPR pulse generator

PMM Click Analysis Software

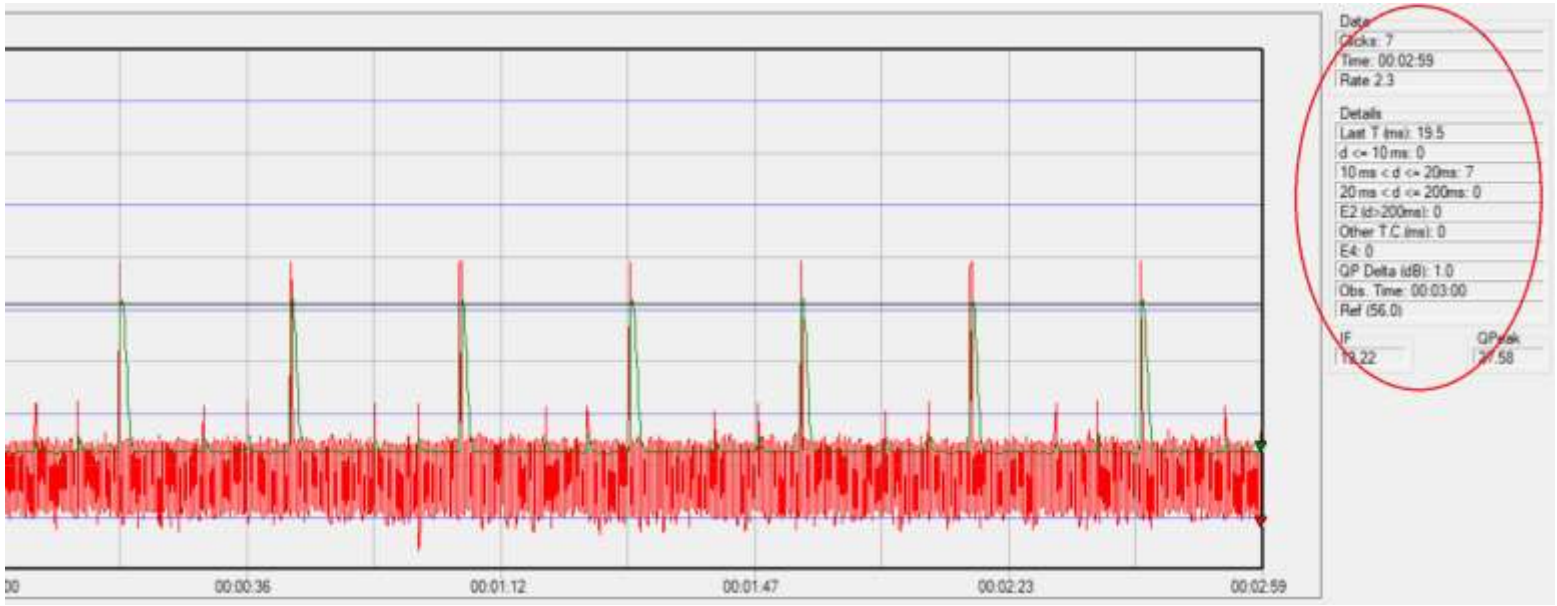
- The click measurement is an automated procedure that takes all the steps and decisions required by the Standard.



- Nevertheless, detailed analysis of single disturbances, within the entire history, is very beneficial for debugging and achieving the E.U.T. compliance.



PMM Click Analysis software



Data
Clicks: 7
Time: 00:02:59
Rate 2.3

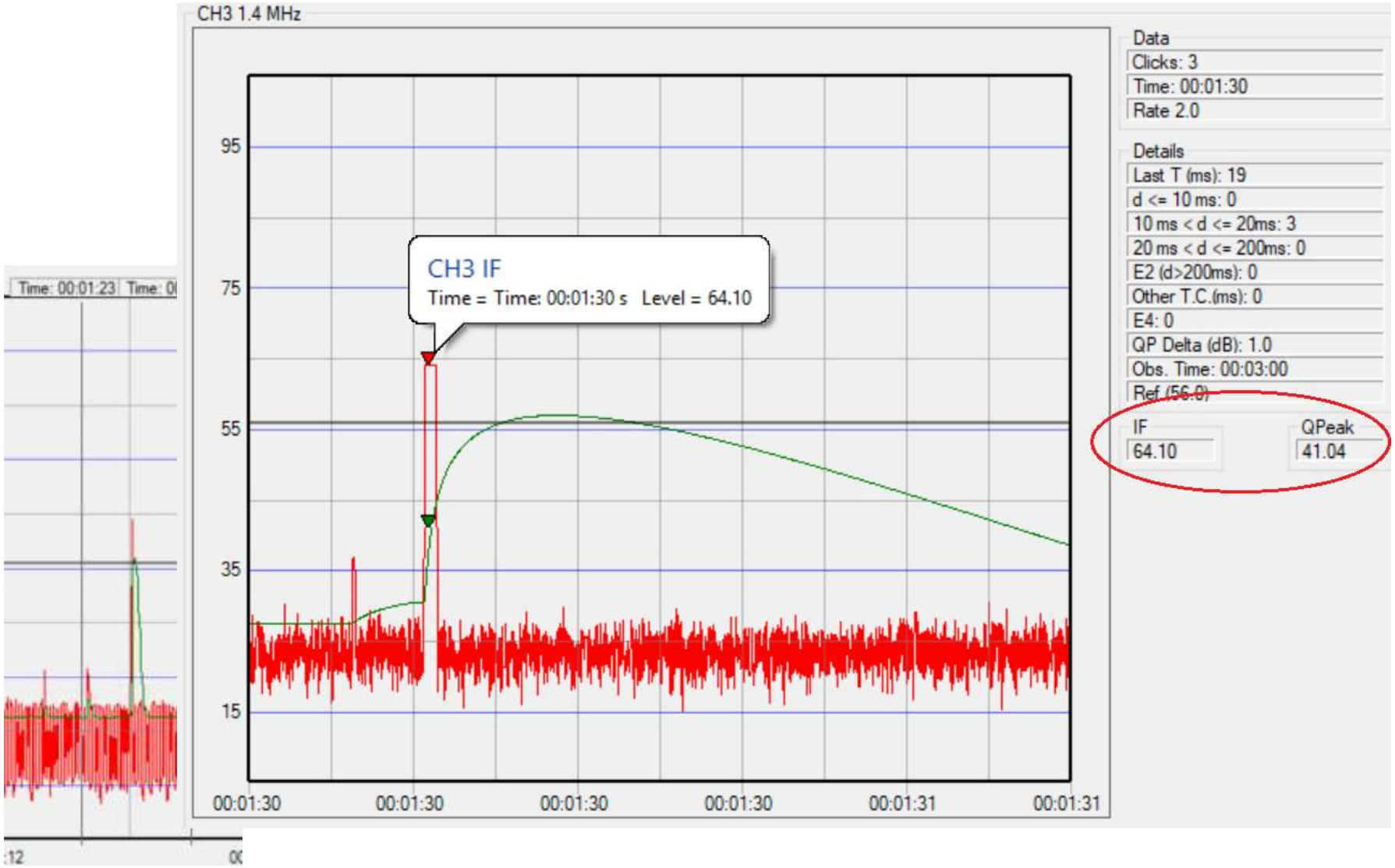
Details
Last T (ms): 19.5
d <= 10 ms: 0
10 ms < d <= 20ms: 7
20 ms < d <= 200ms: 0
E2 (d>200ms): 0
Other T.C.(ms): 0
E4: 0
QP Delta (dB): 1.0
Obs. Time: 00:03:00
Ref (56.0)

IF
13.22

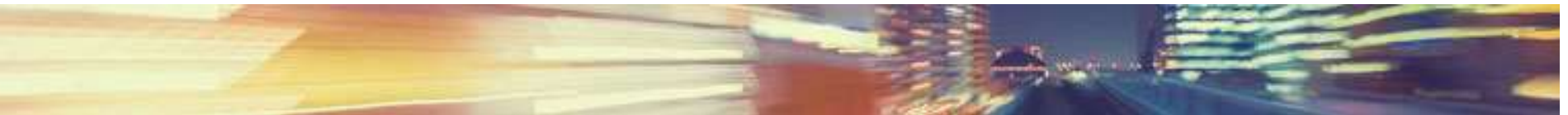
QPeak
27.58

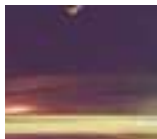
The entire measurement relevant parameters are shown on the right

PMM Click Analysis software

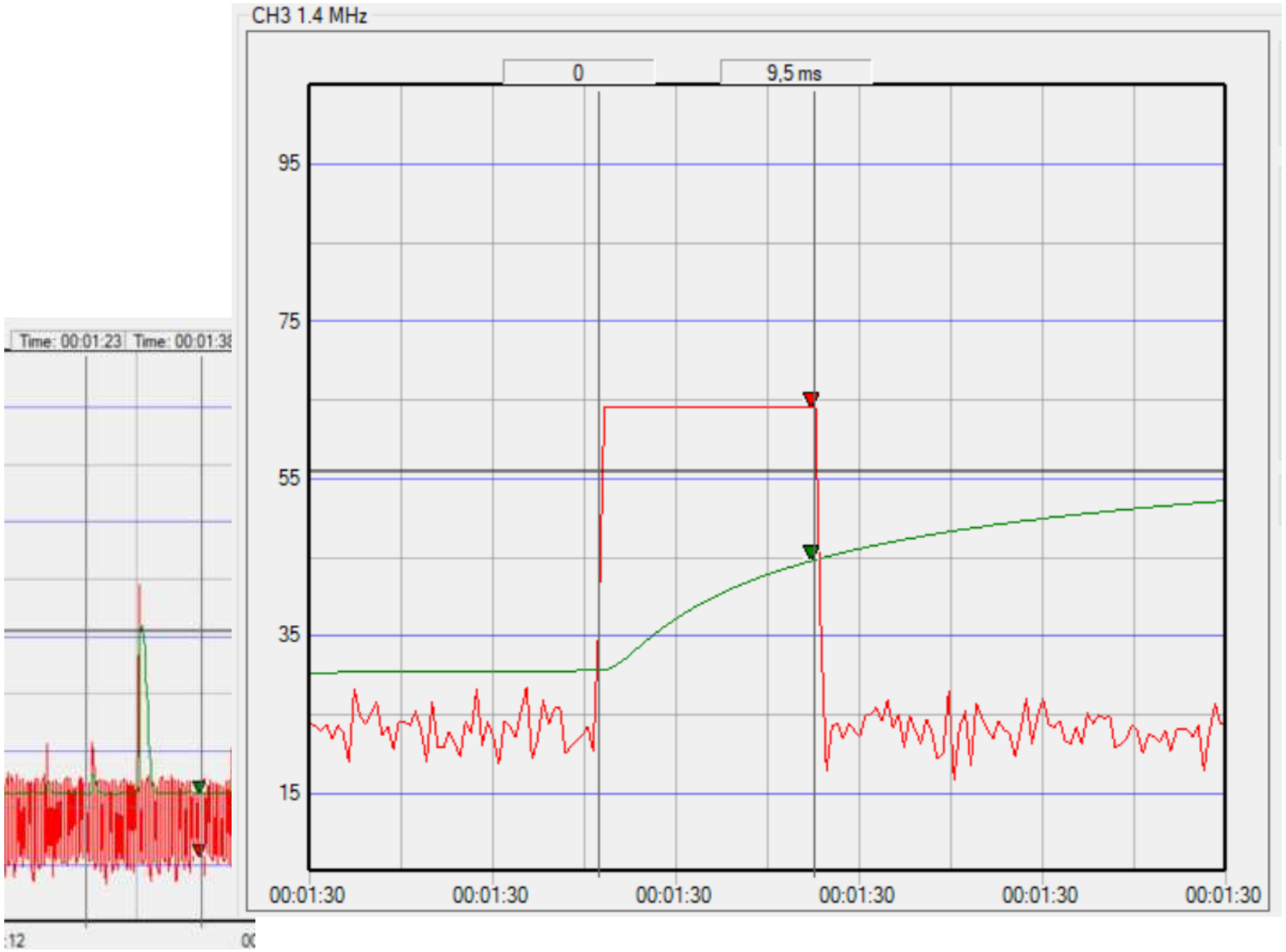


Zoom function: instantaneous IF and QP levels at marker position



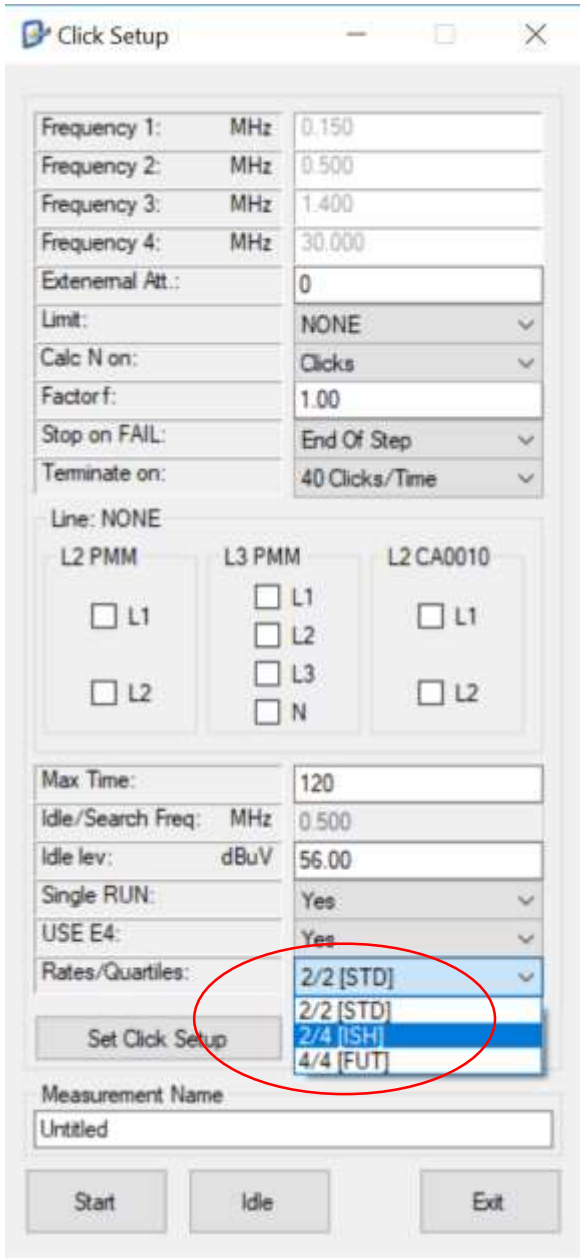


PMM Click Analysis software



Zoom function: manual measurement of event duration

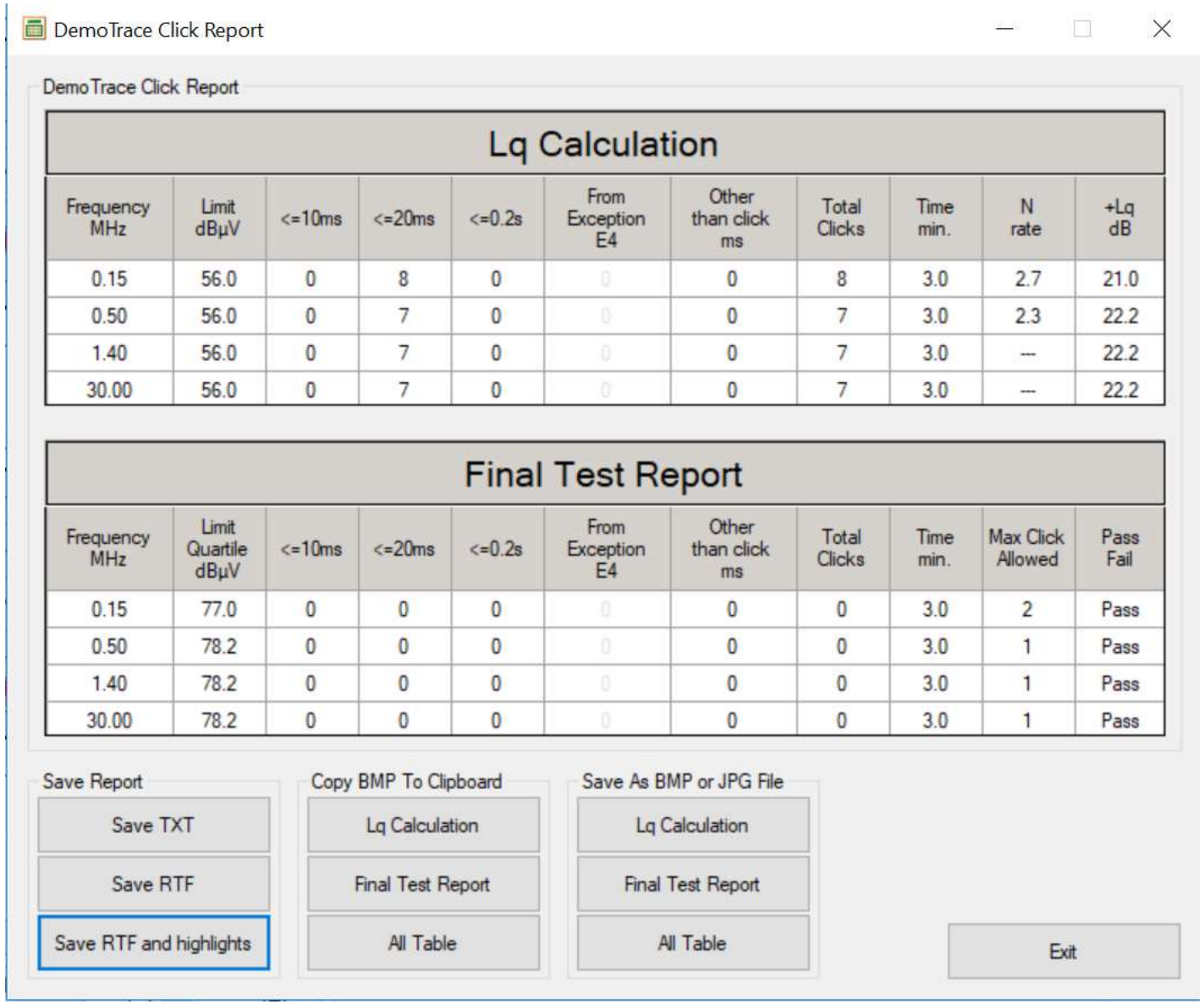
PMM Click Analysis software



Setting up a new measurement and selecting the evaluation method:

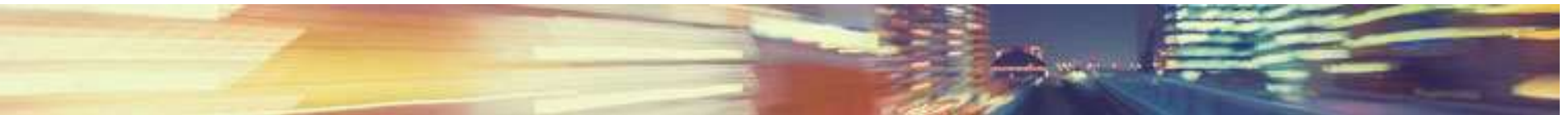
- 2 rates, 2 quartiles
- 2 rates, 4 quartiles
- Possible evolution: 4 rates, 4 quartiles already available

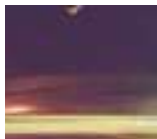
PMM Click Analysis software



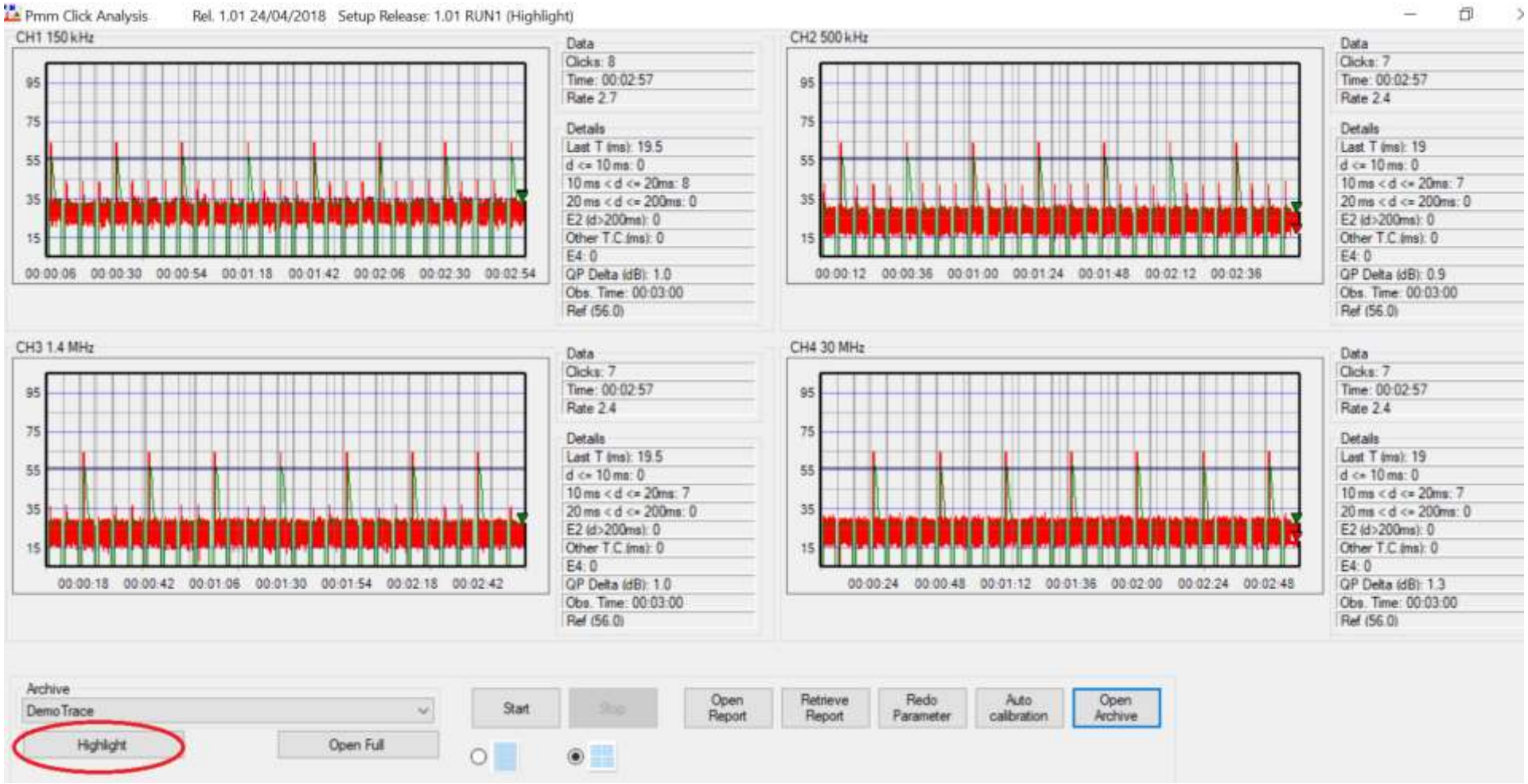
Test report:

- It can be saved in different formats and may include graphs of relevant events

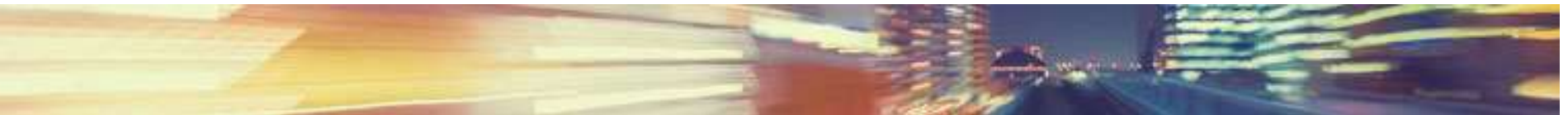


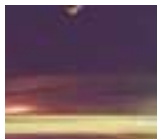


PMM Click Analysis software

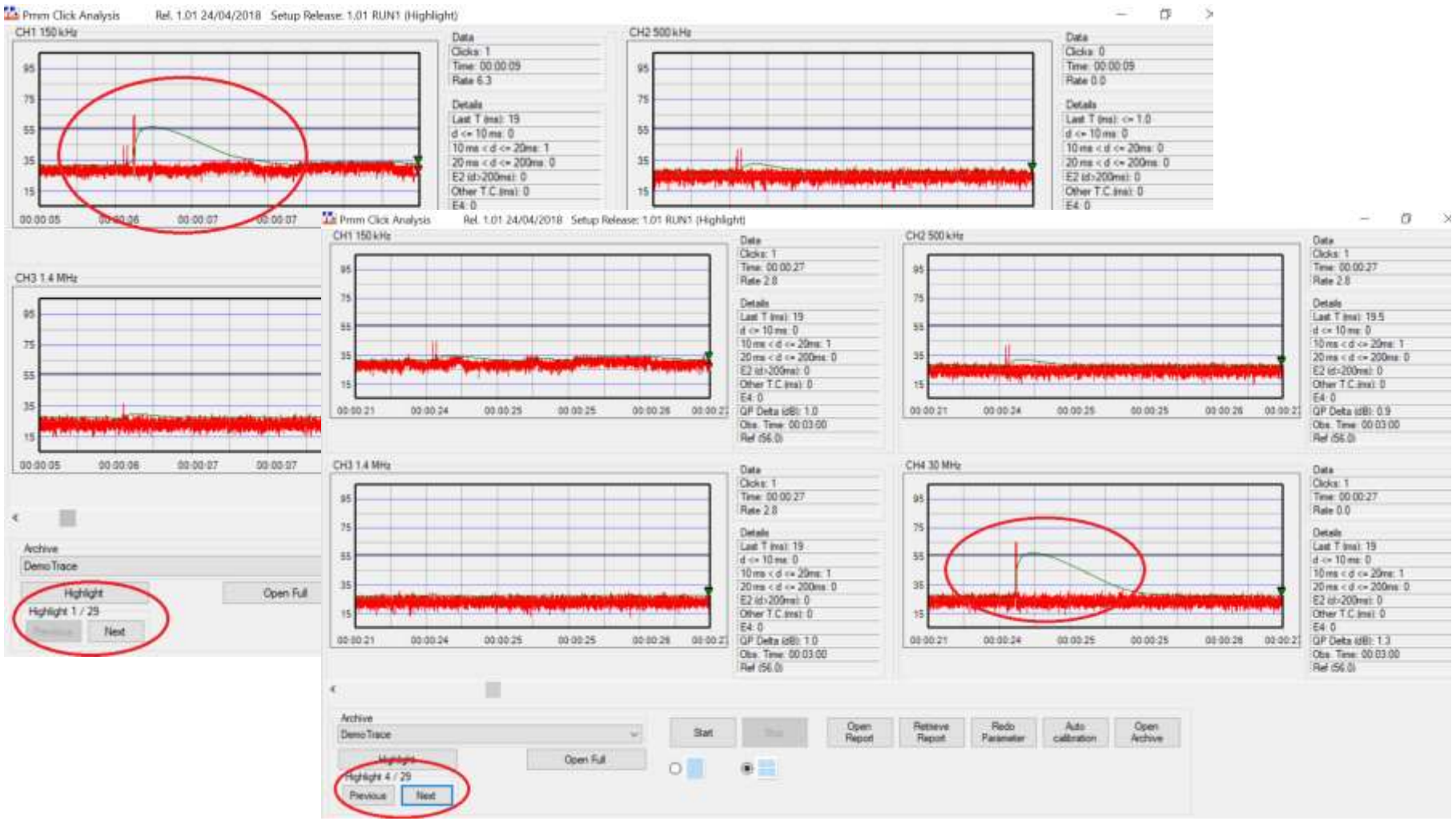


Opening a measurement by means of the Highlight method.

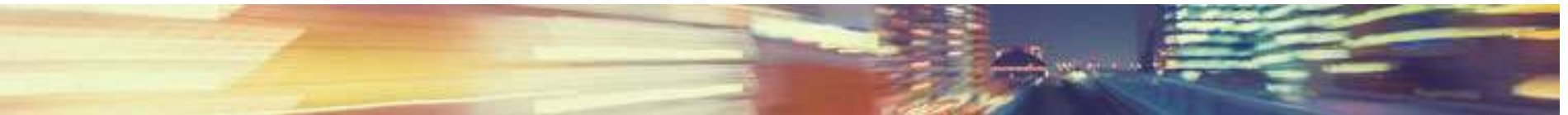


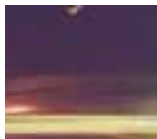


PMM Click Analysis software

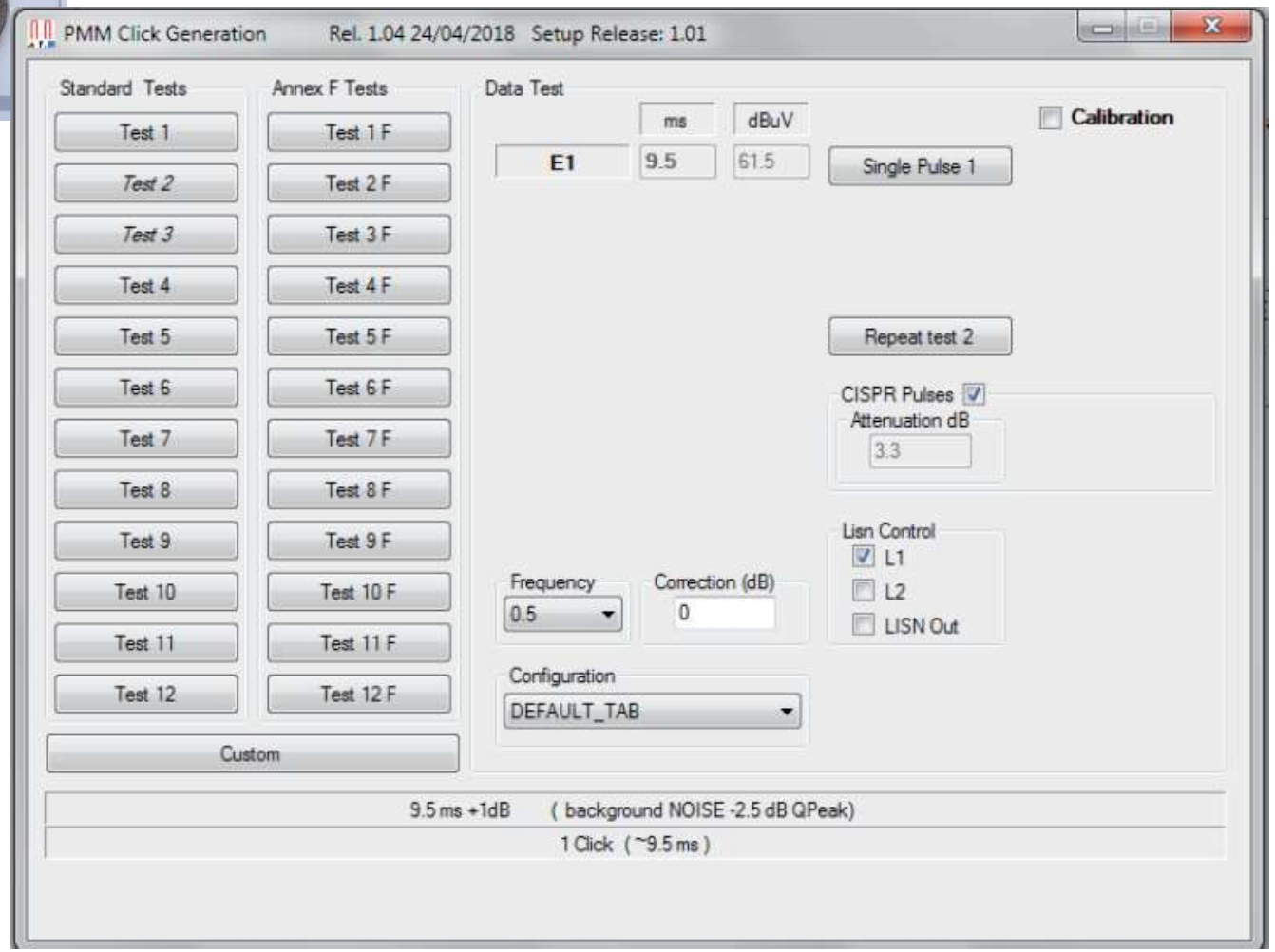


Displaying relevant events only by means of the “Next/Previous” buttons



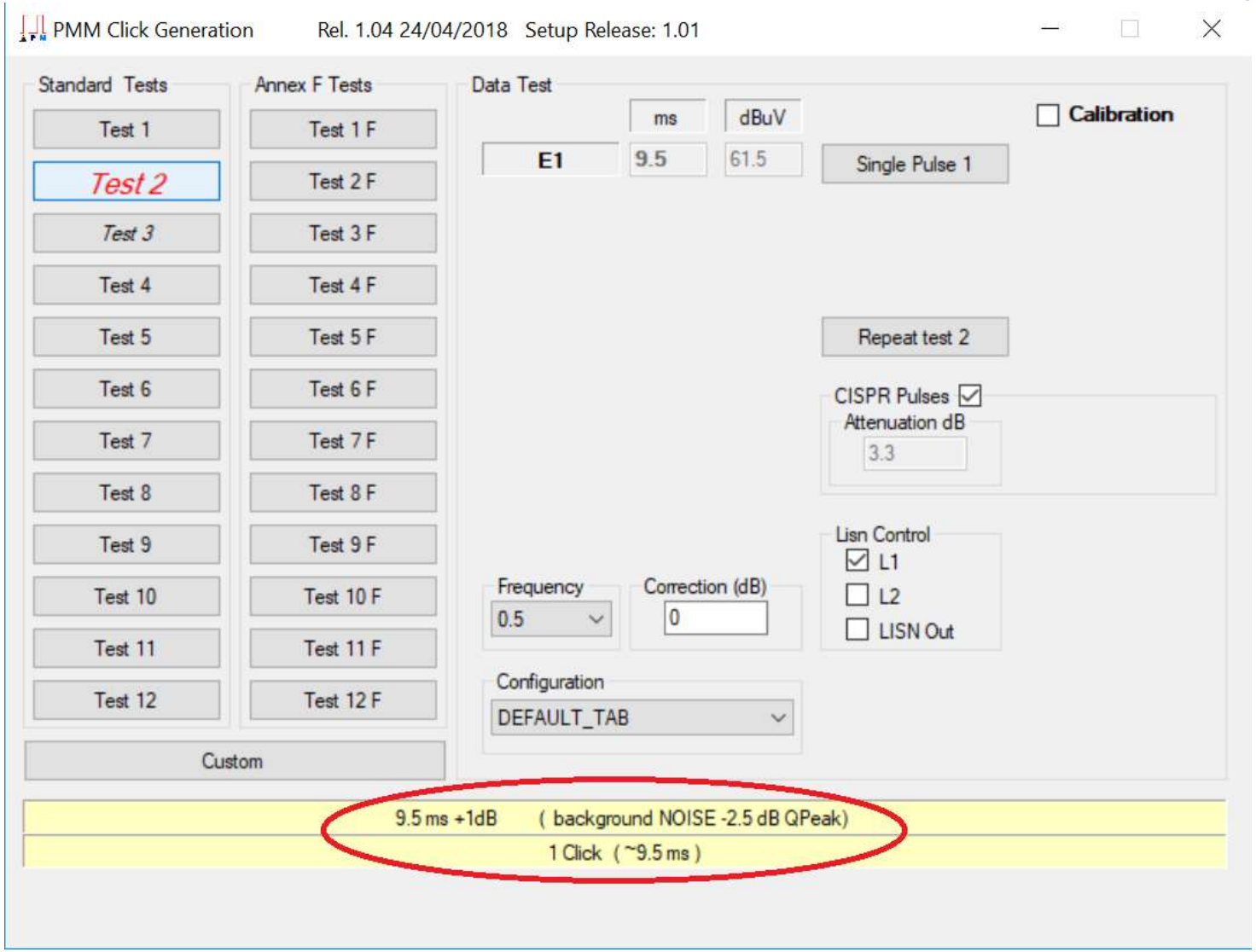


PMM Click Generation software



- Autocal performed by internal CISPR and Click pulse generator.
- Output for CISPR performance test of any click analyzer.

PMM Click Generation software



- Test values and expected results description.
- Same test ID as CISPR Standard.

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Thank you for attending!

See you next year for

EMC Live 2019 - April 23 – 25!