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1 Relevant CISPR standards

QUESTION

Which CISPR standards are relevant to set up projects in EMCview?

ANSWER:

EMCview already contains many pre-defined project. In most cases it is as simple as connecting your DUT to a LISN and the spectrum analyzer, start EMCview, select the applicable standard / project file and click the start button to run a measurement.

The spectrum analyzer parameters have been chosen in order to cover many different analyzer brands and models.

With respect to spectrum analyzer settings, you have to look primarily at CISPR 16-1-1, CISPR 16-2-1, CISPR 16-2-2, CISPR 16-2-3 and CISPR 25.

With respect to emission limits, you need to figure out which of the standards CISPR 11, 13, 14, 15, 22, 25, 32 are applicable for your DUT. Most limit lines for conducted and radiated noise are already predefined in EMCview. EMCview segment files are specified to be on the safe side, rather than to achieve the fastest measurement speed. However, with good knowledge of CISPR 16 and depending on the properties of your DUT and on the capabilities of your analyzer model, you can optimize segment files to speed measurement time.

Below a few screenshots of relevant CISPR 16 and CISPR 25 details. CISPR xx and EN 550xx standards are equivalent. The full standards need to be purchased.

Standards can be obtained in the web shops of national standardization institutes and various other sellers in the internet.

There are also free sources as some countries provide free access to national standards which often are adopted CISPR standards. They may however not always match the latest edition of the relevant base standards. For example:

<https://law.resource.org/pub/in/bis/manifest.litd.9.html>

CISPR 25 / 4.4.1 Parameters when using spectrum analyzers:

Table 1 – Spectrum analyser parameters

| Service / Frequency range MHz | Peak detection | | Quasi-peak detection | | Average detection | |
|---|----------------|----------------|----------------------|----------------|-------------------|--------------|
| | RBW at -3 dB | Scan time | RBW at -6 dB | Scan time | RBW at -3 dB | Scan time |
| AM broadcast and mobile services 0,15 - 30 | 9/10 kHz | 10 s / MHz | 9 kHz | 200 s / MHz | 9/10 kHz | 10 s / MHz |
| FM broadcast 76 - 108 | 100/120 kHz | 100 ms / MHz | 120 kHz | 20 s / MHz | 100/120 kHz | 100 ms / MHz |
| Mobile services 30 - 1 000 | | | | | | |
| TV Band I 41- 88 | | | | | | |
| TV Band III 174 - 230 | | | | | | |
| TV Band IV/V 470- 890 | | | | | | |
| DAB 171- 245 | | | | | | |
| DTTV 470 - 770 | 100/120 kHz | 100 ms / MHz | Does not apply | Does not apply | 100/120 kHz | 100 ms / MHz |
| Mobile service 1 000 - 2 500 | 100/120 kHz | 100 ms / MHz | Does not apply | Does not apply | 100/120 kHz | 100 ms / MHz |
| GPS L1 civil 1 567 – 1 583 | Does not apply | Does not apply | Does not apply | Does not apply | 9/10 kHz | 1 s / MHz |

When a spectrum analyser is used for measurements, the **video** bandwidth shall be at least three times the resolution bandwidth (RBW).

CISPR 16-2-1 / 6.6.2 Measurement times / scan rates for CW signals:

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CISPR 16-2-1:2014 © IEC 2014

Table 1 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors

| Frequency band | | Scan time T_s for peak detection | Scan time T_s for quasi-peak detection |
|----------------|---------------------|------------------------------------|--|
| A | 9 kHz to 150 kHz | 14,1 s | 2 820 s = 47 min |
| B | 0,15 MHz to 30 MHz | 2,985 s | 5 970 s = 99,5 min = 1 h 39 min |
| C and D | 30 MHz to 1 000 MHz | 0,97 s | 19 400 s = 323,3 min = 5 h 23 min |

Table 2 – Minimum measurement times for the four CISPR bands

| Frequency band | | Minimum measurement time T_m |
|----------------|---------------------|--------------------------------|
| A | 9 kHz to 150 kHz | 10,00 ms |
| B | 0,15 MHz to 30 MHz | 0,50 ms |
| C and D | 30 MHz to 1 000 MHz | 0,06 ms |
| E | 1 GHz to 18 GHz | 0,01 ms |

Depending on the type of disturbance, the scan time may have to be increased, especially for swept quasi-peak measurements. In extreme cases, the measurement time T_m at a certain frequency may have to be increased to 15 s, if the level of the observed disturbance is not steady (see 6.5.1).

CISPR 16-2-1 Minimum sweep time

CISPR 16-2-1:2014 © IEC 2014

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B.7 Frequency scan rate

The scan rate of a spectrum analyzer or a scanning measuring receiver should be adjusted for the CISPR frequency band and the detection mode used. The minimum sweep time/frequency, or the fastest scan rate, is listed in Table B.1:

Table B.1 – Sweep time/frequency or fastest scan rate

| Band | Peak-detection | Quasi-peak detection |
|---------|----------------|----------------------|
| A | 100 ms/kHz | 20 s/kHz |
| B | 100 ms/MHz | 200 s/MHz |
| C and D | 1 ms/MHz | 20 s/MHz |

For a spectrum analyzer or scanning measuring receiver used in a fixed tuned non-scanning mode, the display sweep time may be adjusted independently of the detection mode, and according to the needs for observing the behaviour of the disturbance. If the level of disturbance is not steady, the reading on the measuring receiver should be observed for at least 15 s to determine the maximum (see 6.5.1).

CISPR 16-2-1 / D.2.1 Scan rates and measurement times for AVG detector

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CISPR 16-2-1:2014 © IEC 2014

Table D.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth

| | Band A | Band B | Bands C and D |
|-----------------------------|------------------|-------------------|---------------------|
| Frequency range | 9 kHz to 150 kHz | 150 kHz to 30 MHz | 30 MHz to 1 000 MHz |
| IF bandwidth B_{res} | 200 Hz | 9 kHz | 120 kHz |
| Video bandwidth B_{video} | 100 Hz | 100 Hz | 100 Hz |
| Max. scan rate | 17,4 kHz/s | 0,9 MHz/s | 12 MHz/s |
| Max. suppression factor | 6 dB | 39 dB | 61,5 dB |

CISPR 16-2-1 / D.4 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances

CISPR 16-2-1:2014 © IEC 2014

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Table D.2 – Meter time constants and the corresponding video bandwidths and maximum scan rates

| | Band A | Band B | Bands C and D |
|-----------------------------|------------------|-------------------|---------------------|
| Frequency range | 9 kHz to 150 kHz | 150 kHz to 30 MHz | 30 MHz to 1 000 MHz |
| IF bandwidth B_{res} | 200 Hz | 9 kHz | 120 kHz |
| Meter time constant | 160 ms | 160 ms | 100 ms |
| Video bandwidth B_{video} | 0,64 Hz | 0,64 Hz | 1 Hz |
| Maximum scan rate | 8,9 s/kHz | 172 s/MHz | 8,3 s/MHz |

2 Measurement time

QUESTION

Measurements take very long. Can't it be accelerated?

ANSWER:

In short: Yes, measurement times can be accelerated. However it requires good knowledge of the CISPR standards and of the technical specifications of your spectrum analyzer. If the sweep time is too short, the measurement result may not be correct. You can change the sweep time easily by modifying the segment files of your project.

The implementation of sweep times of EMCview is conservative to put you on the safe side and to find a common denominator for all the supported spectrum analyzer models.

Things you need to consider:

CISPR 16 standards

DUT properties – are its emissions mainly CW or are there also slowly fluctuating or short sporadic emissions?

Spectrum analyzer properties such as the number of display points / frequency steps per sweep, sweep settings for its Quasi-Peak detector

The measurement time is dominated by sweep time settings. Next, the number of segments could be reduced by matching it with the number of display points of your analyzer. Less segments means less sweeps and consequently less time for initializing sweeps and read out measurement data via SCPI. However the gain in speed is relatively small, compared to what you can achieve with faster sweep times.

Detailed answer:

We were considering following points when choosing the sweep time settings in the segment files:

- 1) CISPR 16 which specifies measurement equipment, measurement equipment settings and test set ups is done for measurement receivers mainly. There are also some specifications for spectrum analyzers, but for really compliant measurements you must use a measurement receiver. FFT based measurement / real time spectrum analysis can considerably speed up measurement times. Optimizing measurement speed for FFT based analyzers is not considered, as the documented technical properties of various analyzers may not be detailed enough.
- 2) Measurement equipment settings also depend on the properties of the DUT. A DUT which predominantly produces CW emissions can be measured with faster sweep times than a DUT which produces random disturbances. E.g. a device with a microcontroller that carries out various tasks and turns peripherals on/off depending on firmware tasks; a fast measurement could miss noisy events. In practice, the engineer in the test house would observe the DUT emissions for fluctuations first and then determine measurement time.
- 3) It must be clear, it is not a target of EMCview to carry out 100% CISPR compliant measurements. First of all, we use a low cost spectrum analyzer and not an expensive measurement receiver. We are carrying out pre-compliance measurements to get an idea, if our DUT behaves well and most likely would pass type approval in the test house. Else, we would improve and re-test the design of the DUT, until we are confident to carry it to the test house.
- 4) We want to make pre-compliance measurements as simple as possible for.
- 5) EMCview has to cover many different models of low cost spectrum analyzers.
- 6) We want to find a "common denominator" for the settings in order to cover analyzer models with different specifications
- 7) We want to make the settings to cover as many possible noise scenarios

In order to accomplish the points above, we tried to make a general table for measurement settings based on CISPR 16 specs. These meant, that we had to find the most applicable settings and consequently the sweep time is not optimized for every single case. You can measure too fast to be compliant, but you can't measure too slow.

QP detector measurement times are rather influenced by SA model performance than by CISPR specs. Typically, according to CISPR 16 we could measure faster, but we were looking at the sweep time auto settings of the analyzers, based on RBW and sweep frequency range. Using CISPR 16 parameters, would make the UNCAL message pop up at many spectrum analyzers.

Our considerations for sweep segment size:

- 1) The frequency step size must be equal to half of the resolution bandwidth (band A: 200 Hz, band B: 9 kHz, band C/D: 120 kHz) or less.
- 2) The number of frequency steps is determined by the number of pixels on the frequency axis of the display
- 3) Taking a Rigol DSA815 with its relatively small display with 601 measurement points per sweep as a common denominator.

As an example for the 150 kHz – 30 MHz band, we have RBW = 9kHz, -> frequency step size = 4.5 kHz, maximum sweep bandwidth = 600 * 4.5 kHz = 2.7 MHz

To simplify the creation of segment files, we use a sweep bandwidth of 2.5 MHz

This results in following sweep segments: 150 kHz – 2.5 MHz, 2.5 MHz – 5 MHz, 5 MHz -7.5 MHz, 7.5 MHz – 10 MHz,27.5 MHz – 30 MHz

(easier to write down, copy and paste, etc. than 150 kHz – 2.7 MHz, 2.7 MHz – 5.4 MHz, 5.4 MHz – 8.1 MHz, 8.1 MHz – 10.8 MHz)

Optimizing sweep range to every analyzer would not significantly increase measurement time. The time reduction would come from less segments requiring less time to set up the sweep and read out the measurement results via SCPI.

Our sweep time selection is based on the following table:

| Frequency range | CISPR Band | CISPR RBW | VBW | spacing between adjacent measurement points (=RBW/2) | min. Peak detection sweep time | min. QP detection sweep time | min. AVG detection sweep time |
|------------------|------------|-----------|-----------|--|--------------------------------|------------------------------|-------------------------------|
| 9 kHz - 150 kHz | Band A | 200 Hz | >= 3* RBW | 100 Hz | 100 ms/kHz | 20 s/kHz | 100 ms/kHz |
| 150 kHz - 30 MHz | Band B | 9 kHz | >= 3* RBW | 4.5 kHz | 10 s/MHz | 200 s / MHz | 10 s/MHz |
| 30 MHz - 300 MHz | Band C | 120 kHz | >= 3* RBW | 60 kHz | 100 ms/MHz | 20 s/MHz | 100 ms/MHz |
| 300 MHz - 1 GHz | Band D | 120 kHz | >= 3* RBW | 60 kHz | 100 ms/MHz | 20 s/MHz | 100 ms/MHz |
| 1 GHz - 18 GHz | Band E | 1 MHz | >= 3* RBW | 500 kHz | 100 ms/MHz | n.a. | 100 ms/MHz |

It is conservatively taking values from various CISPR tables and selecting the slowest sweep times as common denominator. Anyhow, every user can easily modify it upon his own considerations.

3 Segment files

QUESTION

In the software, if I want to select a different STEP frequency, e.g. 5 KHz (inside the CN RBW) to get more information or 20 KHz (more than CN RBW) to speed up the measuring, how can I do?

I think that I must change the low and high limit for each SEG1 band that compose the test configuration file right? But how many points for each band to increase or decrease the frequency step? Can you explain better with a little example?

ANSWER:

Inside EMCview segment files you specify a series of single sweeps.

Example:

```
.....
FRQa__1=150.000
FRQb__1=2.500.000
BW___1=9000
Sweep_1=25000
Att__1=0
PreAmp1=off
Detector1=VAV
FRQa__2=2.500.000
FRQb__2=5.000.000
BW___2=9000
Sweep_2=25000
Att__2=0
PreAmp2=off
Detector2=VAV
.....
```

In the above example, each segment has a start and stop frequency. With exception of the very first sweep, we always use 2.5 MHz sweep bandwidth between 150kHz and 30 MHz. Reason is that CISPR16

specifies two adjacent frequency points shall not be separated more than half of the RBW. Now CISPR 16 specifies in parallel the RBW for the frequency ranges 9kHz to 150kHz (RBW 200Hz), 150kHz to 30MHz (RBW 9kHz), 30 MHz to 1GHz (RBW 120kHz) and above 1 GHz (RBW 1 MHz).

Coming back to the above example, the step size shall be $9 \text{ kHz} / 2 = 4.5 \text{ kHz}$. Given the default number of measurement points of Rigol analyzers per sweep, 601 points, you can make a single sweep not larger than $(601-1) * 4.5 \text{ kHz} = 2.7 \text{ MHz}$. For easier segment file creation, I use 2.5 MHz per sweep. Siglent has a larger display and hence 710 points per sweep. Means, in order to be compliant with CISPR 16, you can make sweeps of $(710-1) * 4.5 \text{ kHz} = 3.2 \text{ MHz}$. You could make segments of 150 kHz – 3.35 MHz, 3.35 MHz – 6.55 MHz, 6.55 MHz to 9.75 MHz and so on all the way up to 30 MHz. This would be perfectly compliant with CISPR 16.

In our segment files we use 2.5 MHz segments, because the segment file is easy to read and it is CISPR 16 compliant for all analyzers supported by EMCview plus some margin.

If you want any other step size, e.g. 1 kHz and you use a Siglent with 710 measurement points, simply change the segment file using a text editor to:

.....

```
FRQa__1=150.000
FRQb__1=860.000
BW___1=9000
Sweep_1=25000
Att__1=0
PreAmp1=off
Detector1=VAV
FRQa__2=860.000
FRQb__2=1.570.000
BW___2=9000
Sweep_2=25000
Att__2=0
PreAmp2=off
Detector2=VAV
```

.....

However, CISPR 16 specifies one more parameter – the sweep time. For the band 150 kHz to 30 MHz, CISPR 16 specifies a sweep time of 100 kHz/second. This is why for 2.5MHz sweep segments, the segment file sets the sweep time to 25000 (=25000ms = 25 sec). Means that you could change the above segment file to:

.....

```
FRQa__1=150.000
FRQb__1=860.000
BW___1=9000
Sweep_1=7100
Att__1=0
PreAmp1=off
Detector1=VAV
FRQa__2=860.000
FRQb__2=1.570.000
BW___2=9000
Sweep_2=7100
Att__2=0
PreAmp2=off
Detector2=VAV
```

.....

The sweep is faster now, but you have more segments. Neglecting the time needed to read out the results of a sweep and starting a new sweep, the total sweep time remains the same. It would be no different, if

you would increase the step size. Your sweep bandwidth becomes larger, but since you have to adjust the sweep time, the time would remain the same. At least unless you want to operate outside CISPR 16 specs, which you already would do by increasing the step size above RBW/2 anyway.

I have seen that it is possible into the SEG file to change the time sweep (expressed in ms) but they are very high value (500000ms for QP Detector or 200000ms for AVG Detector). I have tried some tests and checked that if more long is the value and more detailed are the result of final sweep. From you side what are the best value to use (compared to EMI Receiver) for Peak, Qpeak and Avg detectors?

ANSWER:

A part of this question is already covered by the answer to the previous question. Of course CISPR 16 sweep times differ depending on frequency range and detector type. Have a look at our CN application notes for more details.

When it comes to QP sweep times, we could use any sweep time equal or higher specified in CISPR 16. Now the sweep times specified for QP detectors specified by CISPR 16 would be too fast for the Rigol and Siglent analyzers. Using CISPR 16 QP sweep time would make an UNCALIBRATED message or icon pop up on the Siglent or Rigol analyzer. Uncalibrated means, that the sweep time is too fast for the chosen resolution bandwidth and sweep bandwidth. The filter would not have sufficient time to settle and the displayed amplitude would be lower than in reality. You would also see a frequency shift due to the delay of the filter response. Of course, you can change any settings in the segment file according to your will, however watch for the UNCALIBRATED message/icon on your analyzer.

4 Span / final scan

Question:

There is a term called "SPAN" which I do not understand. Normally span is regarded as the total frequency coverage from start to stop and is often used when a centre frequency is selected and the span then prescribes the frequency range which will operate about that centre. I do not see this as the case in the software so maybe, as is often the case with the EMC View software the terminology is not correct and it applies to something else.

Answer:

I assume your question refers to the entry box below

| | |
|-----------------|-------|
| Detector | POS |
| Sweep [ms] | 250 |
| RBW [Hz] | 9k |
| Span [Hz] | 50000 |
| PreAmp | on |
| Attenuator [dB] | 0 |

This is explained in chapter 10 of the manual. The "span" refers to the span of the final scan/peak re-measurement. It has no influence on standard measurement mode. When re-measuring peaks, it may happen that the frequency of the peak has drifted away in the meantime. This is what we observed with other EMC tools, which simply make a single frequency peak measurement. When we measured power supplies, we saw peaks disappearing due to the temperature related frequency drift of the switched mode regulators free-running oscillators. Consequently we developed EMCview and specified a "span" where EMCview sweeps around the frequency of the peak frequencies in order to find the maximum of potentially drifted peaks.

5 Manual setting of spectrum analyzer parameters / VBW

Question:

I want to manually set the video bandwidth upfront to a measurement, however it always jumps to VBW “auto”,

Answer:

We can't enable setting VBW manually upfront to the measurement. As we need to have a defined state for the initialisation of the measurement, we issue a preset command to the analyzer first. Consequently the VBW BW gets preset to auto and once in remote mode, there is no manual access anymore, except by pressing the escape button which would abort communication between EMCview and the analyzer.

With EMCview REV 5.xxx you will be able to choose between VBW = Auto and VBW = 3*RBW.

6 Modified settings don't seem to have any effect

Question:

I changed the detector type and the sweep time, but it did not have any effect on the settings of the analyser when running a measurement

Answer 1:

You most likely changed the settings for peak re-measurement and then ran a “Set 1” or “Set 2” measurement.

| | | |
|-----------------|-------|---------------------------------------|
| seg-berz | none | |
| Detector | QPEAK | settings for peak re-measurement only |
| Sweep [ms] | 250 | |
| RBW [Hz] | 9k | |
| Span [Hz] | 50000 | |
| PreAmp | on | |
| Attenuator [dB] | 0 | |
| Remnt | none | |

These settings are for re-measuring peaks (or doing a final scan as it is called sometimes). There is a chapter in the manual, explaining peak re-measurements.

In order to change the settings for “set 1” or “set 2” measurements, you need to change the settings in the segment files. This can either be done with any text editor or with the built in editor in the SETTINGS menu of EMCview.

Answer 2:

If you change a segment file, while EMCview is open, you have to press the “Reload Project Files” button in the right upper corner of the window, after saving the modified segment file.

Answer 3:

If you set a spectrum analyzer parameter manually, before starting EMCview, it will be reset to default when EMCview starts. Means, manual spectrum analyzer settings will not have any effect. EMCview needs to start from a known configuration of parameters to ensure consistent measurements.

7 Graph / Traces

Question:

If I want to compare some traces in the same windows, I need to save each sweep in CHART mode? And is it possible to load the previous sweep and make a traces compare?

Answer:

Go to the FILE/UTILITIES menu and click SAVE CHART. You then can load up to three charts as reference traces in FILE/UTILITIES/LOAD REFERENCE TRACE/TRACE1,2,3

You would then see your latest chart plus 3 loaded charts (reference traces) in the graph window. In total you could see up to 8 curves – 4 charts composed of two graphs (set1/set2). The selected traces will then be listed on top of the graph window. By clicking on either the chart name or trace name, you can move it into the foreground. You can also compare curves against each other using the math function. E.g. subtract two curves from each other to explicitly show the difference.

8 ADC overload / IF overload

Question 1:

When I make measurements, the analyzer beeps and displays the warning ADC overload or IF overload. What is the reason?

Answer 1:

ADC overload or IF overload warnings report that the input of the spectrum analyzer is overdriven. Overdriven does not necessarily mean that the maximum permitted RF input power is exceeded.

If the internal attenuator setting is 0 and/or the pre-amplifier is on, strong input signals can drive the IF or ADC section into saturation. Increase the internal attenuation and / or turn off the pre-amplifier in the EMCview segment file.

Question 2:

When making conducted noise measurements with a Tekbox RF-current probe I get ADC / IF overload warnings? However I do not see any noise with excessive amplitude.

Answer 2:

The useful frequency range of Tekbox RF-current probes starts in the very low kHz range. You may measure an automotive switched mode regulator, starting conductive noise testing at 150 kHz according to CISPR 25. Have a look at the frequency range below 150 kHz. Your switched mode regulator may produce sub – harmonics, which you are not aware of. Sub-harmonics typically have high amplitude. The RF current probe picks it up and the amplitudes are high enough to saturate the spectrum analyzer. Use a 150 kHz high pass filter to suppress the sub harmonics, without losing dynamic range in the main frequency range of your measurement.

9 Base noise at low frequencies

Question:

When I make measurements using a pre-configured project, even with the DUT not powered, I see that the base noise at very low frequencies is higher and then decreases towards higher frequencies. Is this normal?

Answer:

There are two reasons, why you see higher noise at very low frequencies. The architecture of spectrum analyzers causes “0” Hz falling into the pass-band of the IF filter. As the filter curve does not have a perfectly rectangular shape, sideband noise appears at low frequencies, decreasing with increasing frequency. This noise behavior can also be observed without using EMCview. Second, when applying frequency response correction for LISN or RF-current probes, there is increased transmission loss towards low frequencies. Means conducted emission levels need to be compensated for the frequency response of the LISN or RF-current probe. This compensation also shifts the base noise of the analyzer to higher levels, similar as you would see on your analyzer in manual mode, when increasing the internal attenuator value.

10 Manually adding frequency points to the peak list

Question 1:

I want to add some spurious which are close to the limits to the list of peaks?

Answer 1:

Set a margin line, so that these spurious cross the margin line. Next press display peaks and all peaks crossing the margin line will be listed for consecutive peak measurement.

Question 2:

I want to manually add frequencies to the peak list?

Answer 2:

Press the MARKER button in the upper right corner of the EMCview screen. Select the measurement graph to which you want to add a marker (Set1/M1 or Set2/M2). Place a marker at the frequency, which you want to get added to the peak list. Press the COPY MARKERS button and the frequency will be copied into the peak list for consecutive peak measurement.

11 How to merge two measurement graphs to a worst case graph

Question 1:

I carry out conducted noise measurements on Line and Neutral, or on the positive and negative supply line. How can I merge the two graphs to a worst case graph, showing the maximum spurious levels of both measurements in a single graph?

Answer 1:

Carry out the measurement runs and save the results as chart. Click the MATH button in the right upper corner of the EMCview screen. In the File menu, load both graphs as traces, e.g. the measurement result of the positive supply line as Trace 1 and the measurement result of the negative supply line as Trace 2. Select the two traces, using the mathematical operations box at the right side of the EMCview screen. Select MAX as mathematical operation. Press the CALC button and a graph with the merged result will be displayed.

12 History

| Version | Date | Author | Changes |
|---------|------------|------------|--------------------------|
| V 1.0 | 30.08.2019 | Mayerhofer | Creation of the document |
| V 1.1 | 31.08.2019 | Mayerhofer | corrections |
| V 1.2 | 30.08.2019 | Mayerhofer | Chapter 8, 9 added |
| V 1.3 | 27.02.2020 | Mayerhofer | Chapter 10, 11 added |