

Usage of Data Reduction in R&S®EMC32-K10 EMI Auto Test Templates Application Note

Products:

| R&S®EMC32 | EMC32-K10

The 'Data Reduction' sequence step is an essential part of an EMI Auto Test since it evaluates the relevant frequencies at which the final measurements are to be done.

The intention of this application note is to make the data reduction data flow more transparent (contents of input and output tables) and how the parameters (location and relations) influence the evaluation algorithm.

Table of Contents

1	Overview EMI Auto Test	3
1.1	Data Flow in an EMI Auto Test.....	4
2	Overview Data Reduction	7
2.1	Evaluation Paths, Overview	8
2.2	Data Reduction Sub dialog Settings	9
2.3	Data Reduction Algorithms (Filters).....	11
2.4	Options for Controlling the Test Flow.....	12
3	A Straight Forward Example	13
3.1	Settings Hardware Setup.....	14
3.2	EMI Scan Template Settings Preview Measurement	14
3.3	Settings EMI Auto Test Template	16
3.3.1	General Settings	17
3.3.2	Test Specific Parameters.....	18
3.3.3	Preview Measurements.....	19
3.3.4	Data Reduction	20
3.4	Preview Measurements, Data Reduction and Final Results	21
4	Data Reduction Step by Step	24
4.1	Data Reduction Using Evaluation Path 1 Only.....	24
4.2	Data Reduction Using Evaluation Path 2 Only.....	27
4.3	Reducing Merged Results from Evaluation Path 1 & 2	31
4.3.1	Acceptance Analysis on Path 1 & 2	33
4.4	Evaluation Path 3 – General Acceptance Analysis.....	35
4.5	All Data Reduction Paths as Overview	36
5	Control Auto Test Flow.....	37
5.1	Hardware Setup Ranges (HW SR)	37
5.2	Data Flow Variations	40
5.3	Interactive Data Reduction	42
6	Additional Information.....	43
6.1	Result Tables in EMI Auto Test.....	43

1 Overview EMI Auto Test

Automated EMI Tests are used for compliance testing and therefore shall lead to reliable, repeatable and traceable results based on one test set-up. Contrary to a simple EMI test (e.g. a single scan / sweep) an automated test is a collection of test sequences, each performing a dedicated task. Radiated and conducted automated tests may contain the following sequence steps:

Preview Measurements

Quick, complete test over the whole frequency range repeated for all necessary combinations of accessories (field strength measurement: turn table position, antenna height and antenna polarization; conducted measurement: lines of a LISN). At each combination an EMI scan or sweep according to the test template is performed and the output of all scans/sweeps is merged into result tables (output tables of this sequence step) with the information on relevant accessory settings for the larger of the measured values at all frequencies. The number of temporary generated tables for internal use and the resulting output tables is depending on the settings in the hardware setup (number of sub-ranges) and in the scan/sweep test template (number of detectors).

Data Reduction

Up to three evaluation paths are available to identify the critical frequencies from all frequencies measured in the preview. The output tables of the preview sequence step are the input tables of the data reduction sequence step. The internal data flow as well as the number of resulting critical frequencies are related to settings in the data reduction sub dialog but also on other settings in the Auto Test sub dialogs, hardware setup and scan/sweep templates. Showing these relations is the task of this application note.

Frequency Zoom Measurements 1

No influence on the number of critical frequencies, but the accuracy of the frequencies which remain after the data reduction can be increased through partial scans or sweeps.

If the preview measurements are defined with a sweep template and also the maximization measurements are to be done, then you should select a template here, because the frequency resolution of the preview might not be sufficient. When doing preview measurements with scans, then this feature is optional but may be useful if you expect the interference frequencies to be drifting over time.

Maximization Measurements

No influence on the number of critical frequencies. The critical frequencies will be analyzed for all device settings (accessories) defined in the corresponding dialog, and the maximum level will be stored along with the corresponding accessory setting (for example turn table, antenna height and polarization).

Frequency Zoom Measurements 2

No influence on the number of critical frequencies. This additional test sequence step for increasing of the accuracy of the frequencies is optional, but may be helpful for interference frequencies drifting over time.

If the preview measurements are based on a sweep template and the Zoom Measurements 1" as well as the Maximization measurements are skipped, then this step should be used for increasing the frequency accuracy.

Adjustment Measurements

No influence on the number of critical frequencies. At each critical frequency the test specific parameters - e.g. with field strength measurements first the turntable angle and then the antenna height - will be varied within a certain range. This way the location of the maximum emission is determined precisely for the final measurement.

Final Measurements

No influence on the number of critical frequencies. The final measurements are performed as single measurements based on the selected scan template. The scan template should fulfill all requirements of the EMC standard (detectors, IF bandwidth, measurement time).

The results will be evaluated against the corresponding limit line (selected in the Data Reduction sub dialog).

Note:

Zoom Measurements 2 + Adjustment Measurements + Final Measurements are performed in a closed sequence at a certain critical frequency, before switching to the next interferer. This helps to complete the measurement for the current frequency before the frequency may drift again too much.

1.1 Data Flow in an EMI Auto Test

In this application note radiated field strength EMI measurement with scans is taken as an example to demonstrate backgrounds and features of the data reduction sequence step.

EMI Measurements according to the EMI standards should deliver a total overview of EUT emission characteristics. Therefore Radiated EMI tests measure the field strength from all directions (Figure 1). Turn table positions and antenna height build up a cylindrical grid around the EUT. At each crossing of vertical and horizontal lines, two scans/sweeps shall be performed, one with horizontal and another with vertical antenna polarization, each using up to two detectors in parallel.

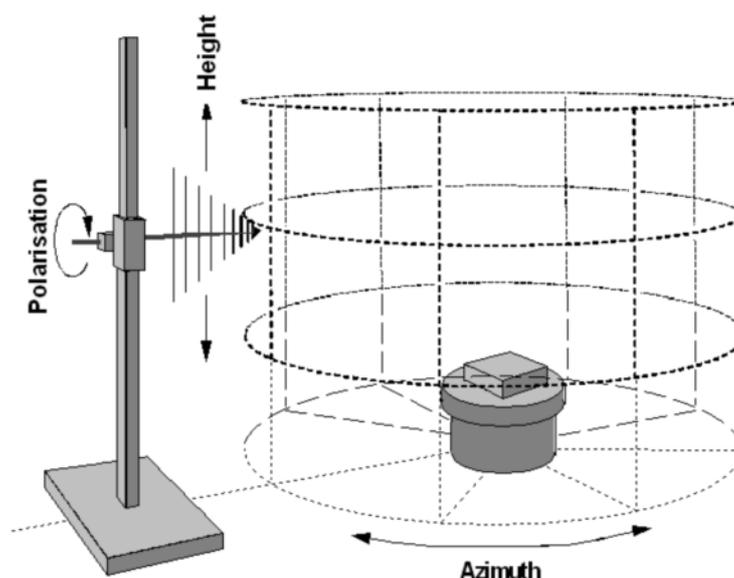


Figure 1: Automated Testing: EMI Field Strength testing principles

The total number of single measurement points depends on the characteristics of the Equipment under Test (EUT). A typical example is given in Table 1. It is obvious that more than 1 million single measurement points cannot be done with 1 s measurement time as it is mandatory for quasi-peak detector. For that reason the preview measurement sequence step structures the data into tables allocating the number of frequencies points for one scan as data rows. The number of test frequencies N is related to the frequency range and the step size Δf , which in turn is related to the IF bandwidth:

$$N = \text{int}\left(\frac{(f_{stop} - f_{start})}{\Delta f}\right) + 1; \text{ with } f_{start} + (N - 1) \cdot \Delta f = f_{stop}$$

or

$$N = \text{int}\left(\frac{(f_{stop} - f_{start})}{\Delta f}\right) + 2; \text{ with } f_{start} + (N - 1) \cdot \Delta f < f_{stop}$$

Thus one table per detector with N data rows is created containing at least the columns: frequency points, measured field strength levels and the accessory settings. Results of the current preview scan/sweep overwrite stored values from previous scans at frequency points where the currently measured level is higher than the stored level. To keep all information consistent levels are stored together with their associated accessory information. At the end of the Preview Measurement the output data is reduced to one table per detector with maximum level at each critical frequency point together with all information of accessory positions (“worst-case positions”).

Number of single measurement points per detector				
Estimation				
Parameter	Start	Stop	Step size	Number of
Frequency	30 MHz	1 GHz	60 kHz	Frequency points per scan: (range divided by step size) 16.168
Angle of turn table	0°	315°	45°	Measurement positions: 8
Antenna height	1 m	4 m	0,5 m	Measurement positions: 7
Antenna polarization	H	V		Measurements: 2
				Total number of single measurements: 1.810.816

Table 1: Estimation of total number of measurements per detector (example with 60 kHz step size)

Following the example in Table 1 the results of 112 scans are consolidated into one table per detector. If the preview scan template uses two detectors two tables in parallel will be generated: “Preview Result 1” (Detector 1) and “Preview Result 2” (Detector 2). According to the standard there are no detailed guidelines on the number of turntable and height positions but at least 2 turntable positions (front and back) and 2 heights to cover the interference by ground reflections are mandatory. These tables are the output of the preview measurement sequence step and consequently the input to the data reduction sequence step.

Data Flow					
Result Tables					
Preview Measurement		Data Reduction		...	
Input	Output	Input	Output	Input	Output
-	Preview Result Table Detector 1		DataReduction Detector1		...
-	Preview Result Table Detector 2		DataReduction Detector2		...

Table 2: *Input and output tables of the sequences: Preview Measurement and Data Reduction*

Preview Measurements depending on settings in other sub dialogs of the Auto Test Template Editor or Scan Template Editor may result in additional tables remaining as output but they are not used as input tables for other sequences (e.g. additional traces to show the measurement results for both polarizations).

2 Overview Data Reduction

Although the preview measurement sequence step merges the results to one table per detector, the amount of frequency points is too large for final measurements with quasi-peak detector. The data reduction sequence step is needed to avoid spending unnecessary measurement time for frequencies not of interest during Zoom, Maximization, Adjustment and Final Measurement. The number of measured frequencies (output of Preview Measurement) is reduced to a list of critical frequencies (output of Data Reduction) used as input at least for the Final Measurement (Figure 2).

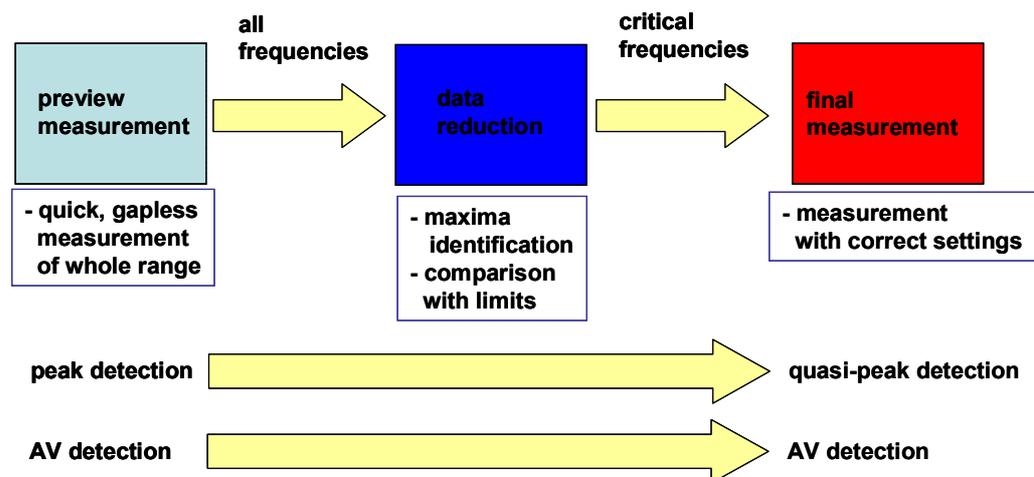


Figure 2: Data Reduction selects a list of critical frequencies from the preview measurement (typical detector assignment shown)

2.1 Evaluation Paths, Overview

A mouse click on the Data Reduction icon in the Auto Test Template Editor opens the Data Reduction sub dialog which is divided into three sections.

- Data Reduction



 - Evaluation Paths
 - Auto Test Flow Control
 - References to Limit Lines

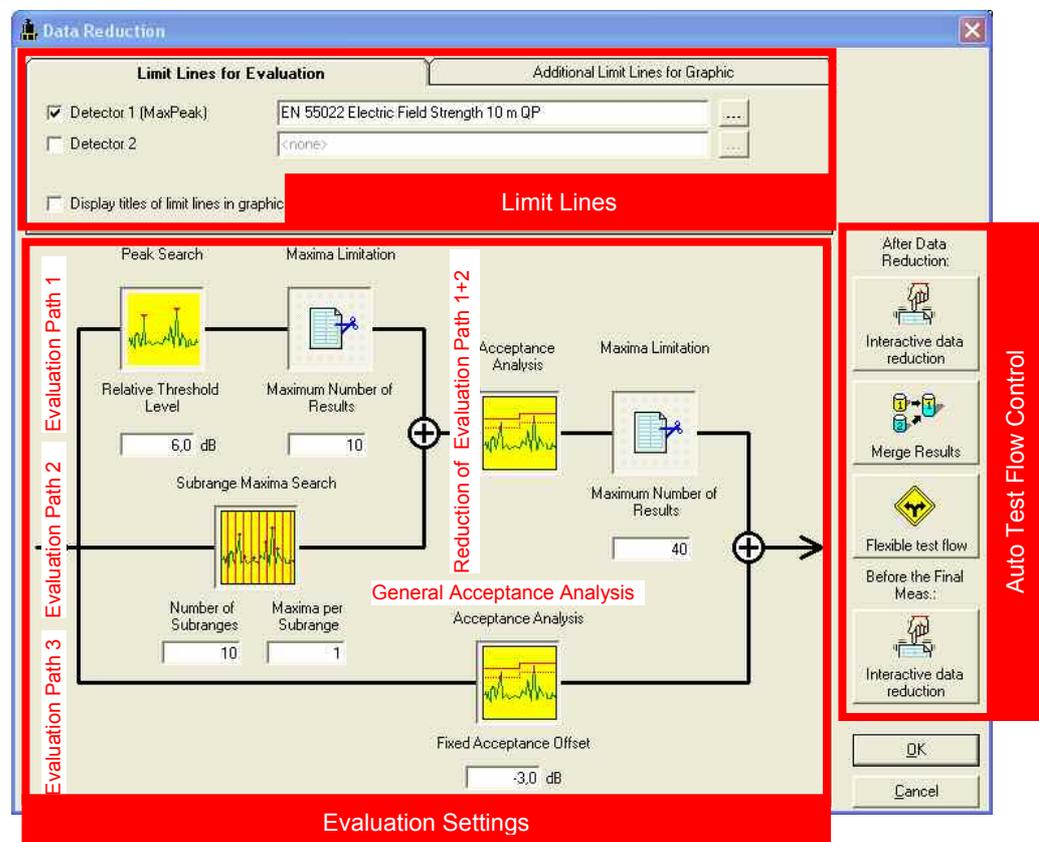
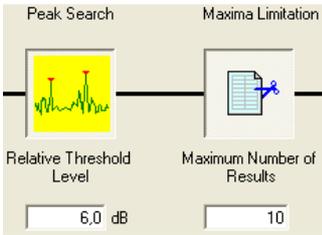
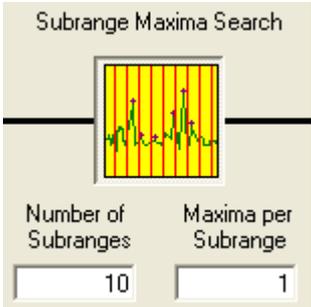
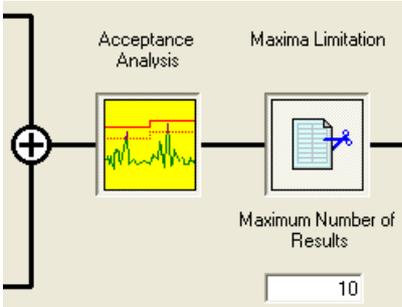


Figure 3 Data Reduction sub dialog and parameter sections

2.2 Data Reduction Sub dialog Settings

The Evaluation Settings (Figure 3) offer two parallel main paths:

- Evaluation Path 1 (Peak Search with Maxima Limitation) and Evaluation Path 2 (Sub range Maxima Search) merged as input to Reduction of Evaluation Path 1+2 (Acceptance Analysis with Maxima Limitation)
- General Acceptance Analysis

Elements of Data Reduction	
Evaluation Paths	
Sub dialog element	Description
<p>Evaluation Path 1</p> 	<p>In the first evaluation path a combination of a peak search with relative threshold level and a maxima limitation (Maxima Limitation 1) will be performed. This path helps to find the highest narrowband signals in the measured frequency range and limit them to a reasonable number for further evaluation.</p>
<p>Evaluation Path 2</p> 	<p>In the second path the sub range maxima function is applied. You can optionally define to determine 'n' points per sub range (normally you would use n = 1). The n highest local maxima will be collected from each sub range.</p> <p>When the parameter 'Execute Hardware Setup subranges separately' is activated the Number of Subranges refers to the total frequency range and not to the currently executed frequency subrange!</p>
<p>Reducing the number of Maxima from Path 1 and Path 2 Evaluation</p> 	<p>The results from the peak search algorithms in path 1 and path 2 will be combined and the number of maxima may be reduced by the following functions:</p> <p>For the acceptance analysis you can (optionally) select for each detector a limit line which will also be used later for the level evaluation in the final measurements.</p> <div data-bbox="590 1608 1417 1787"> <p>Limit Lines for Evaluation Additional Limit Lines for Graphic</p> <p><input checked="" type="checkbox"/> Detector 1 (MaxPeak) <input type="text" value="EN 55025 Automotive Components BB QP"/> </p> <p><input checked="" type="checkbox"/> Detector 2 <input type="text" value="EN 55025 Automotive Components NB PK"/> </p> <p><input checked="" type="checkbox"/> Display titles of limit lines in graphic</p> </div> <p><i>Note:</i></p>

Elements of Data Reduction	
Evaluation Paths	
Sub dialog element	Description
	<div style="text-align: center;">  <p>Limit Lines for Evaluation</p> </div> <p><i>If the Data Reduction dialog is disabled due to starting directly with a final result table or frequency list the limit lines can be set in the Limit Lines for Evaluation dialog. The icon for this dialog is shown beside the Actions icon when the Data Reduction icon is disabled.</i></p> <p>Besides, the acceptance offset has to be defined (an offset of e.g. -10 dB means that all level points which are higher than 10 dB below the limit will be kept).</p> <p>A mouse click on the Acceptance Analysis button opens Acceptance Analysis. Alternatively to a fixed acceptance offset, you can directly let filter the data with an arbitrary acceptance line for each detector. The acceptance offset will then be ignored.</p> <div style="text-align: center;">  </div> <p>This acceptance line is a user defined limit line (frequency range and level unit have to match the actual limit line) and is normally defined such that it runs closely above the noise floor.</p> <p>This is helpful in situations where the noise floor comes relatively close to the limit.</p> <p>The parameter 'Display titles of limit lines in graphic' allows to enable or disable the display of the limit line name label. Optionally two 'additional limit lines' can be defined which will be shown in the measurement graphics.</p> <p>The number of measurement points that will remain after the data reduction is determined through a further maxima limitation.</p>

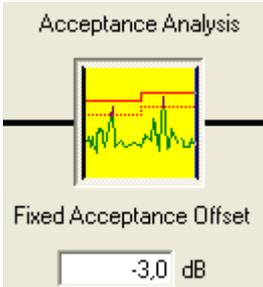
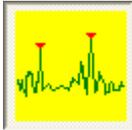
Elements of Data Reduction	
Evaluation Paths	
Sub dialog element	Description
Evaluation Path 3 	Optionally you can use a third evaluation path (general acceptance analysis) to make sure that any limit exceeding point will be kept. In rare cases a spike may dominate over a true interferer which therefore may not be kept (although exceeding the limit), depending on the parameters described above. An offset can be applied (e.g. -3 dB means that all points which are higher than 3 dB below the limit will be added).

Table 3: Data Reduction sub dialog, Evaluation Settings

2.3 Data Reduction Algorithms (Filters)

The Data Reduction sequence step uses four filter algorithms.

Data Reduction filters	
Dependences and function	
Filter	Description
Peak Search 	<p>This function is used to determine all "Peaks" (preferably narrowband interference) depending on a user-defined decision level. For this purpose, the trace is analyzed by means of a special algorithm. The decision level determines how far a local maximum must exceed the adjacent lower test points to be considered as a "Peak" and to appear in the output file.</p> <p>If a limit line is also specified, not the absolute level characteristic of the trace is examined, but the distance between the test point and the respective limit value.</p> <p>With a decision level of 0 dB, all local maxima are detected as "Peaks", whereas, with a value of e.g. 20 dB, only distinctive narrowband signals are detected.</p> <p>This function should be used only on non-intermittent curves, i.e., if combined with other data reduction functions, it should be the first one.</p>
Maxima Limitation 	<p>This function is used to transfer a given number (max. 1000) of maximum levels of the input file into the output file. If a limit line is also specified, not the absolute level characteristic of the trace is examined, but the distance between the test points and the respective limit value. Thus it is possible to focus e.g. on the 10 most critical points of a measurement result.</p>

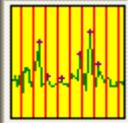
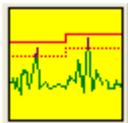
Data Reduction filters	
Dependences and function	
Filter	Description
<p>Sub range Maxima</p> 	<p>This function is used to split the trace of the input file into a given number (max. 1000) of sub ranges. The maximum is determined for each sub range and transferred to the output file. If a limit line is also specified, not the absolute level characteristic of the trace is examined, but the distance between the test points and the respective limit value. The limits of the sub range are equidistant for linear or logarithmic scales.</p> <p>The function is suitable for detecting broadband signals over the complete measured spectrum in addition to narrowband signals. When the parameter 'Execute Hardware Setup subranges separately' is activated the Number of Subranges refers to the total frequency range and not to the currently executed frequency subrange!</p>
<p>Acceptance Analysis</p> 	<p>The acceptance analysis is used to filter off signals which are further off a specified limit line. This includes in particular the background noise of the receiver. The acceptance analysis is implemented by means of an imaginary acceptance line which cuts off all measured values falling below it. The acceptance line runs parallel to a limit line with a specified offset (e.g. an offset of -10 dB means 10 dB below the limit line).</p> <p>If the offset is very large (e.g. 200 dB), all signals are cut off, if it is very small (e.g. -200 dB), they are all maintained.</p>

Table 4: Data Reduction Filter Algorithms

2.4 Options for Controlling the Test Flow

The Test Flow Control shows four buttons on the right side providing additional user interaction during the test flow. The button **Interactive data reduction** is given for two different points in the test flow:

- after the data reduction sequence
- before final measurement.

Test Flow Control	
After Data Reduction	
 <p>Interactive data reduction</p>	<p>When enabled the results from the data reduction can optionally be revised (interactive data reduction). For this purpose the test will be interrupted after the data reduction has been completed so that the list of suspect points can be edited or expanded (this will be indicated by the PAUSE sign in the test control toolbar).</p>
 <p>Merge Results</p>	<p>When enabled the following additional evaluation after the data reduction is done:</p> <ul style="list-style-type: none"> - If results for two detectors are being generated, then you can optionally merge both result lists into one single list which in the consecutive test phases will be used with the 1st detector only. Especially with DC motors involved, it may be interesting to extract maxima from a preview MaxPeak curve (broadband interferers) as well as maxima from a preview AV curve (NB interferers) and re-measure all these points with the same (Quasipeak) detector.
<p>Implicit behavior</p>	<ul style="list-style-type: none"> - If the preview results for only the 1st detector are being generated and the final measurements are defined with two detectors, then the preview result list will be copied for the 2nd detector.

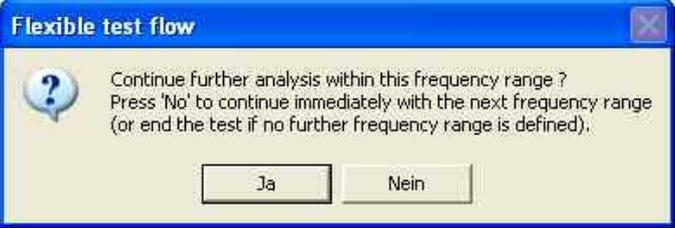
 <p>Flexible test flow</p>	<p>If the function flexible test flow is activated, then whenever the data reduction has been finished a dialog will show up. That dialog enables to skip any further analysis on the suspect points, so that the test continues either with the next frequency range or directly with the report if it is the last frequency range.</p>  <table border="1" data-bbox="707 651 1302 833"> <tr> <td>Yes</td> <td>Continue the test either with the next hardware setup range or if this was the last one with , maximisation, or final measurement</td> </tr> <tr> <td>No</td> <td>Continue the test either with the next hardware setup range or skip the rest of the test</td> </tr> </table>	Yes	Continue the test either with the next hardware setup range or if this was the last one with , maximisation, or final measurement	No	Continue the test either with the next hardware setup range or skip the rest of the test
Yes	Continue the test either with the next hardware setup range or if this was the last one with , maximisation, or final measurement				
No	Continue the test either with the next hardware setup range or skip the rest of the test				
<p>Before the final Measurement</p>					
 <p>Interactive data reduction</p>	<p>When enabled the results from the latest test phase (typically from the maximization) can optionally be revised in another interactive data reduction before the final measurements. For this purpose the test will be interrupted so that the list of suspect points can be edited (normally for removal of irrelevant points).</p>				

Table 5: Data Reduction sub dialog for Test Flow Control

3 A Straight Forward Example

A first approach uses the whole functionality and shows differences in usability of the filters.

Electric Field Strength with Scans

This example shows the basic algorithm of the Data Reduction sequence step with a minimum of parameters and settings. We will go through the evaluation paths step by step. First the preconditions given by hardware setup and scan test template will be shown. Since we concentrate on the Data Reduction sequence step we deactivate all sequence steps except the Preview Measurement and the Data Reduction (Figure 6). Thus the Auto Test Template references only the Hardware Setup and the Scan Template for the Preview Measurements.

3.1 Settings Hardware Setup

The Hardware Setup Editor (Figure 4) describes the test setup. Table 6 shows settings used for this test.

Hardware Setup with relevant settings	
Parameter	Description
Number of sub ranges	1
Start Frequency	30 MHz
Stop Frequency	500 MHz
Accessories	Turntable, Antenna, Tower

Table 6: Hardware Setup Settings influencing Data Reduction

None of the parameters influences the Data Reduction filters directly.

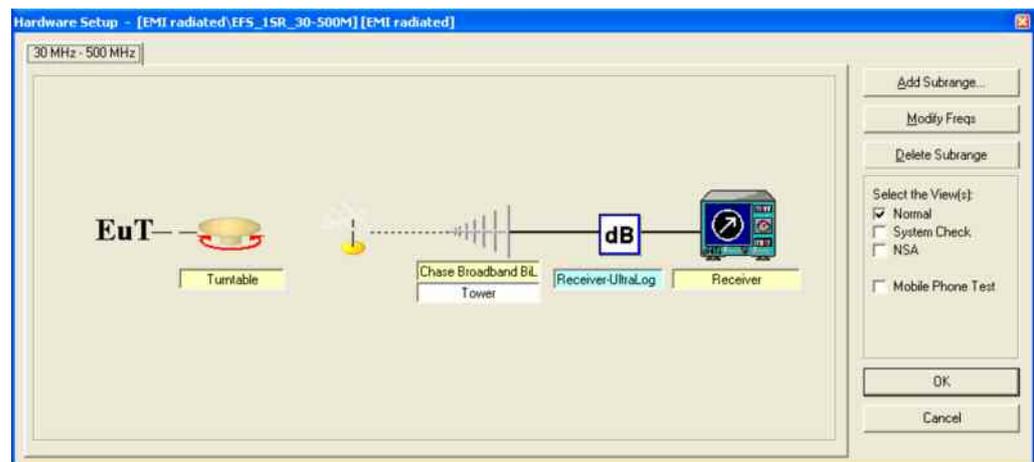


Figure 4: Hardware Setup Editor with only one Sub range defined

3.2 EMI Scan Template Settings Preview Measurement

The settings in the EMI Scan template for the Preview Measurement influence the number of generated tables and the number of columns in these tables. The tables can be divided into three groups:

- output table of preview measurement sequence step, used as input table for data reduction sequence step (Preview Result 1 and Preview Result 2)
- internal table, e.g. used for transient storage or table merging, deleted within preview measurement sequence step
- output table for subsequent evaluation, not used as input table for further sequence steps (e.g. Preview Result 1H, Preview Result 1V).

Scan Template for Preview Measurements	
Parameter	Description
General Setting	Hardware Setup as described above
Detector	1 st Detector = MaxPeak, 2 nd Detector = none; ClearWrite: unchecked, MaxHold: checked
Graphics	Limits = none (not used in Auto Test)
Start Frequency	30 MHz (may differ from Hardware Setup)
Stop Frequency	500 MHz (may differ from Hardware Setup)
Receiver	ScanLin, IF Bandwidth: 120 kHz, Step Size: 60 kHz, Measurement Time: 10 ms

Table 7: Scan Template Settings

Table 8 describes how the parameters of the example work on the generated tables and Data Reduction sequence step:

Scan Template for Preview Measurement		
Effect of relevant Parameter Settings in the Example		
Parameter	Settings	Interaction with Data Reduction sequence step
Detector	First detector: MaxPeak Second Detector: <none> ClearWrite mode	Only one input table is generated: Preview Result 1 For 2 nd Detector is <none>: no table "Preview Result 2" Only one measurement per frequency
Receiver	(Stop Frequency – Start Frequency) / Step Size gives the number of measured frequencies which is also the number of data rows in the output table.	Size of input table (number of rows: 7.835)

Table 8: How Scan Template Settings for Preview Measurement work on Data Reduction sequence step

To make the test as simple as possible we choose one detector only: MaxPeak
Additional we use the ClearWrite mode since the MaxHold is not applicable here (we run only one scan per accessory position so each frequency is only measured once).

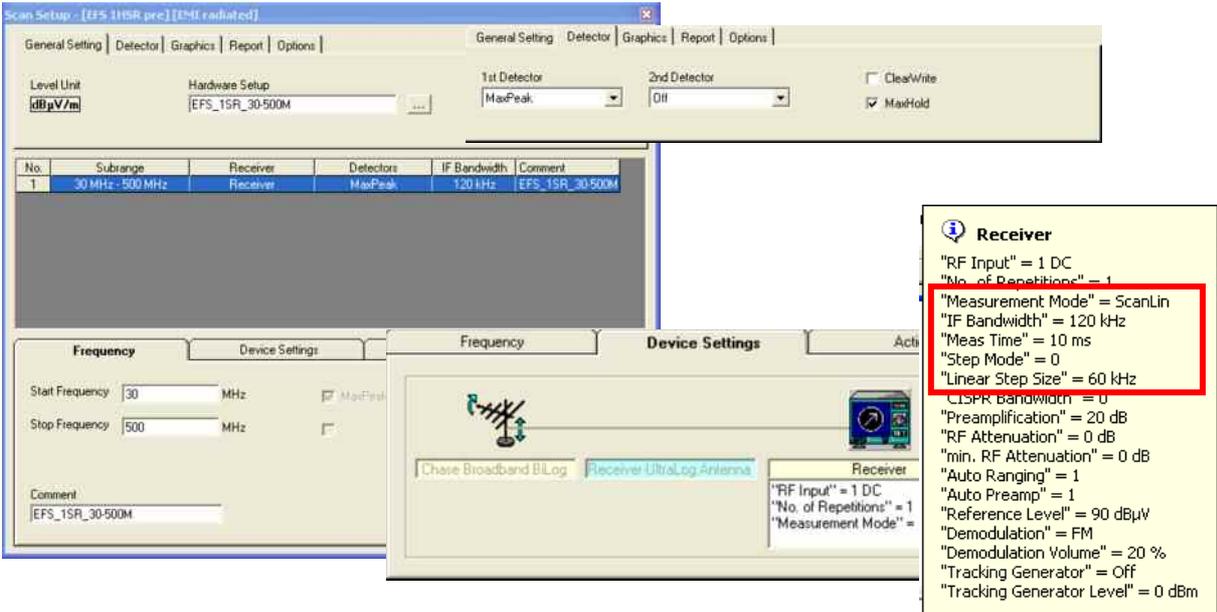


Figure 5: EMI Scan Test Template with relevant Settings

3.3 Settings EMI Auto Test Template

Using the created Hardware Setup and EMI Scan Test Template the settings of "General Settings" and "Test Specific Parameters" in the Auto Test Template Editor (Figure 6) do not influence the Data Reduction sequence step.

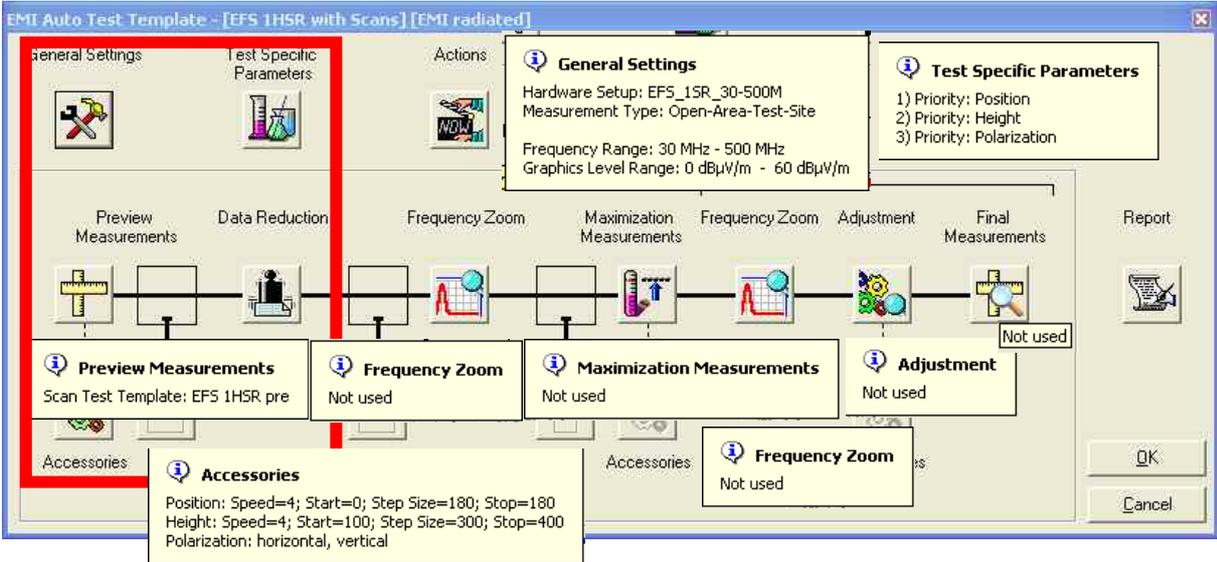


Figure 6: EMI Auto Test Template Editor with sequence steps used marked with red box, tool tips show all settings (overview) and unused sequence steps

3.3.1 General Settings

Here we define the general test settings like the test frequency range and the used hardware.

Auto Test Template – General Settings	
Setting	Description
Hardware Setup	as described above
Measurement Type	Open-Area-Test-Site
Execute HW SR separately	Checked (no influence, because only one Hardware Setup Range is defined)
Start Frequency	30 MHz (may differ from Hardware Setup and Scan Template)
Stop Frequency	500 MHz (may differ from Hardware Setup and Scan Template)

Table 9: General Settings of Auto Test Template

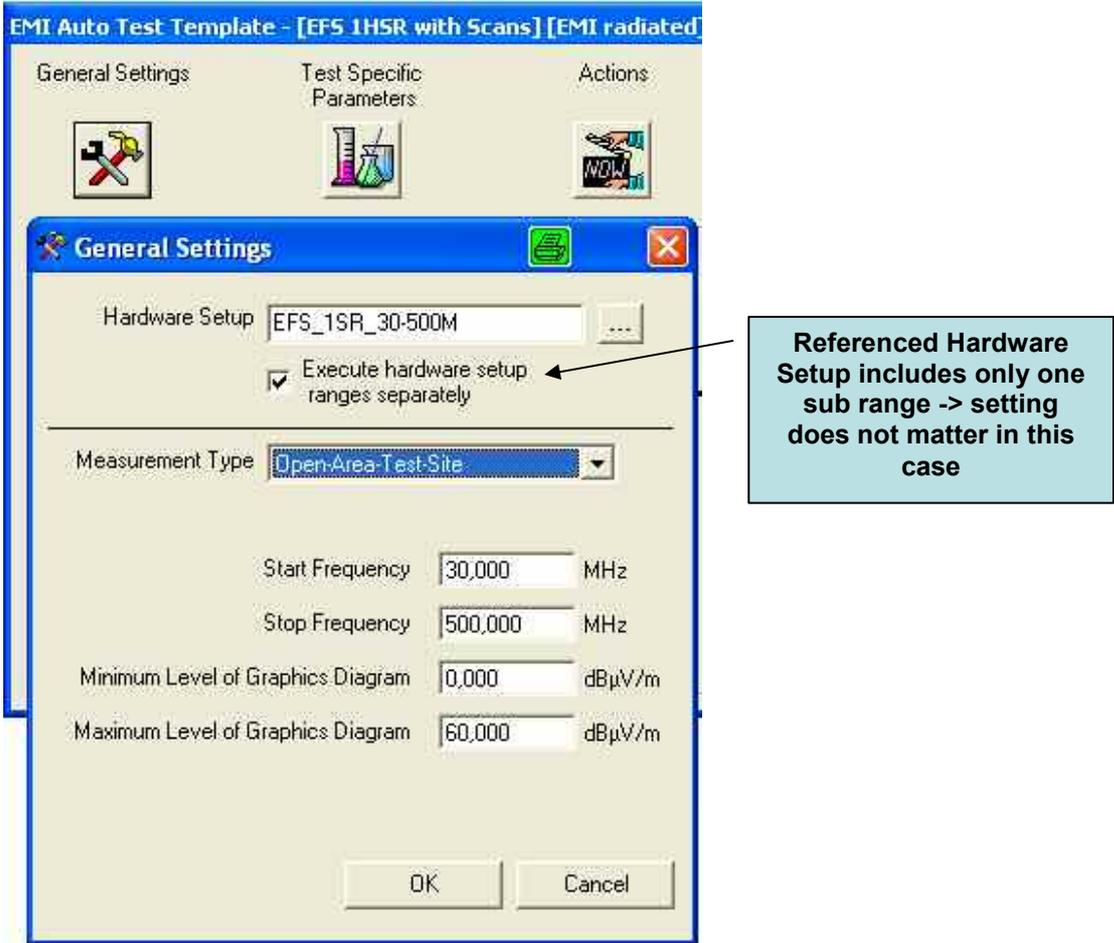


Figure 7: General Setting with reference to Hardware Setup

3.3.2 Test Specific Parameters

The Test Specific Parameters have no direct effect on Data Reduction results, but “Show separate traces for horizontal and vertical polarization” checked or unchecked determines the number of output files of the preview measurement.

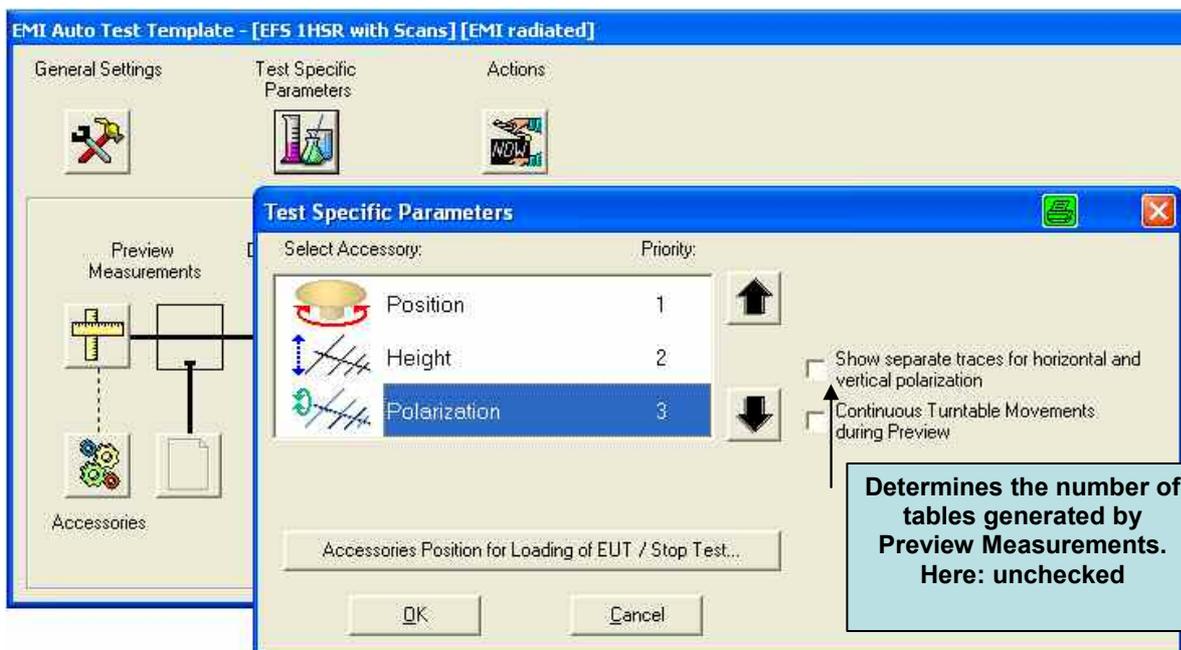


Figure 8: Test Specific Parameters with Accessories

3.3.3 Preview Measurements

With the button “Preview Measurements” we choose the Scan Test Template and with the button “Accessory” we select the step size for changing the positions of the turntable (two positions: front and back side of EUT) and the antenna height (two positions: 100 cm and 400 cm) and one polarization (horizontal).

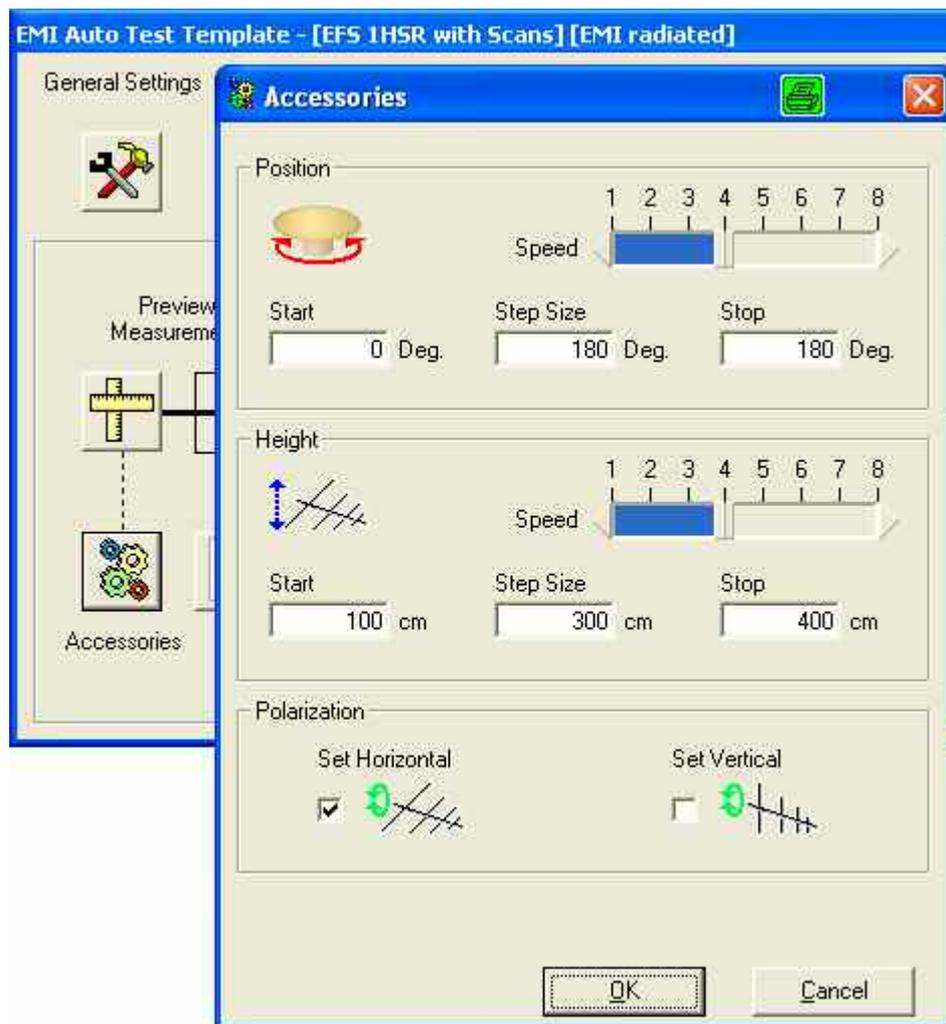


Figure 9: Preview Measurements, Settings of Accessories

The next step is to configure the Data Reduction sequence step itself.

3.3.4 Data Reduction

In order to reduce the number of frequency points from the preview measurement for performing the final measurement the data reduction dialog provides the following data reduction algorithms (filters), as shown in Figure 10.

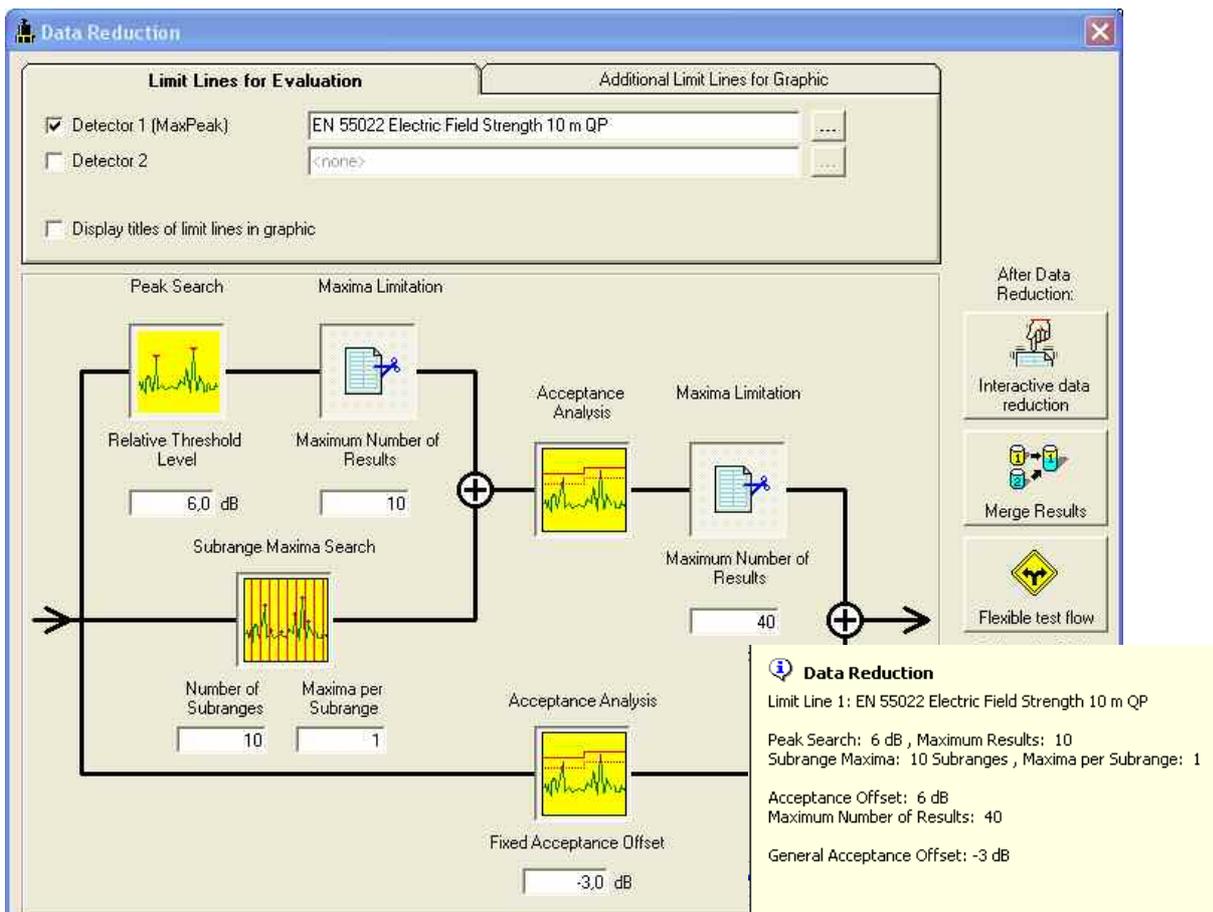


Figure 10: Overview Data Reduction Algorithm

3.4 Preview Measurements, Data Reduction and Final Results

In this application note we are mainly interested in the mode of operation of the data reduction sequence step. Therefore we deactivate all sequence steps of the Auto Test (Figure 11) following the Data Reduction.

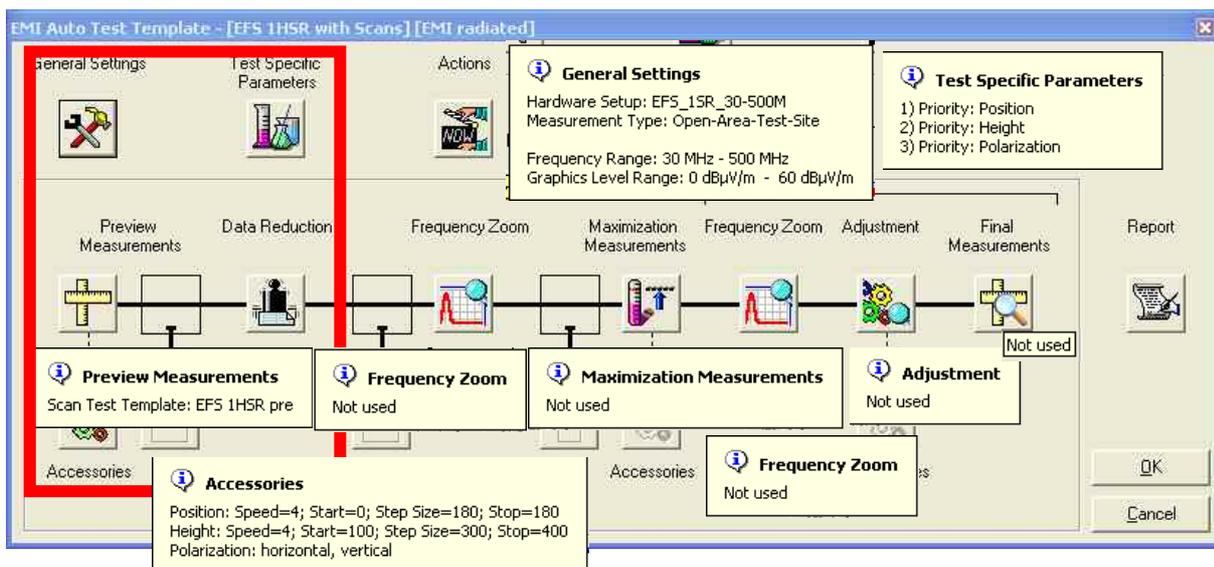


Figure 11: Overview EMI Auto Test Template Editor settings

The result (Figure 12) of the EMI Auto Test contains:

- four tables,
- the graphics, showing:
 - the trace of the preview measurement (Detector 1 with 7835 frequency points),
 - the remaining frequency points from merged results of data reduction evaluation paths 1 & 2 filtered by acceptance analysis
 - the frequency points as output of acceptance path 3, and
- the test protocol.

More detailed and step by step we find:

- The Evaluation Path 1 'Peak Search' gives 156 points. reduced by 'Maxima Limitation' to 10 points.
- The Evaluation Path 2 'Sub range Maxima Search' with 10 sub ranges and one peak per sub range gives 10 points.
- The results of Evaluation Path 2 merged with the results of Evaluation Path 1 results in 18 points.
- The following Acceptance Analysis with Maxima Limitation reduces 18 points to 17 critical frequencies (Evaluation paths 1 and 2 with Acceptance Analysis).
- The result of Evaluation paths 1 & 2 with Acceptance Analysis is completely covered by 7329 points of acceptance path 3 (General Acceptance Analysis with - 3 dB) as reported by the test protocol.

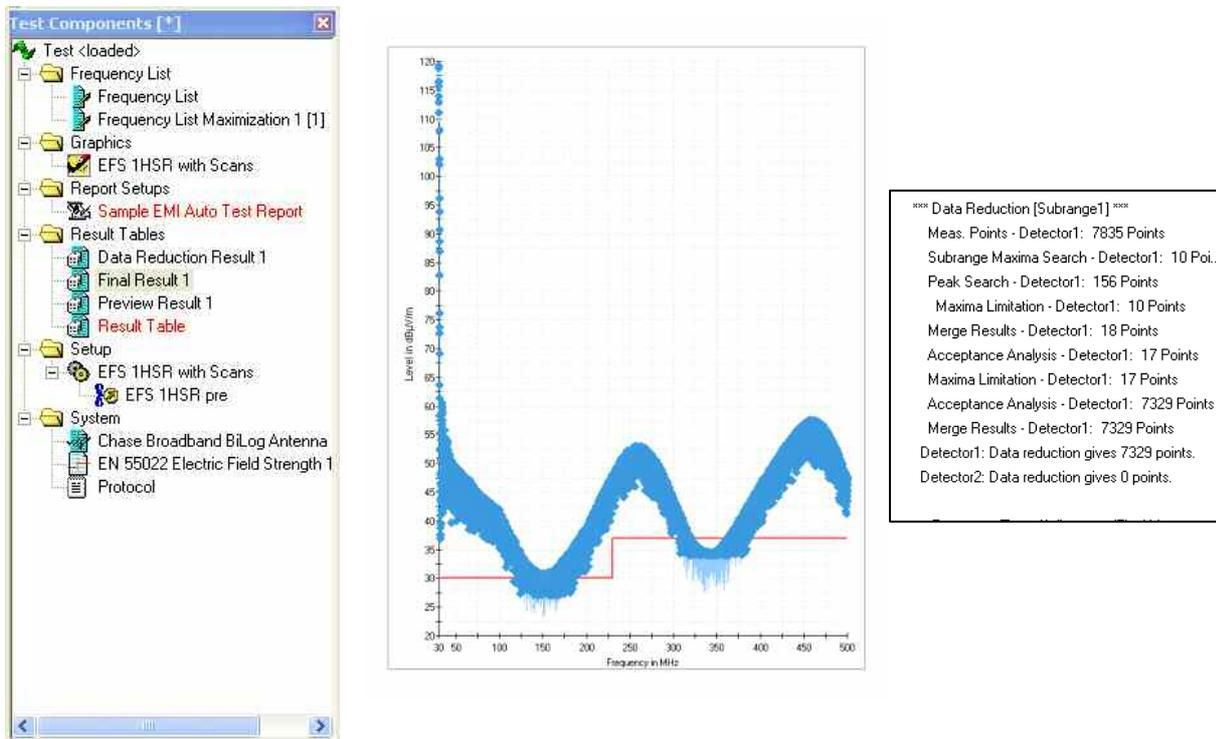
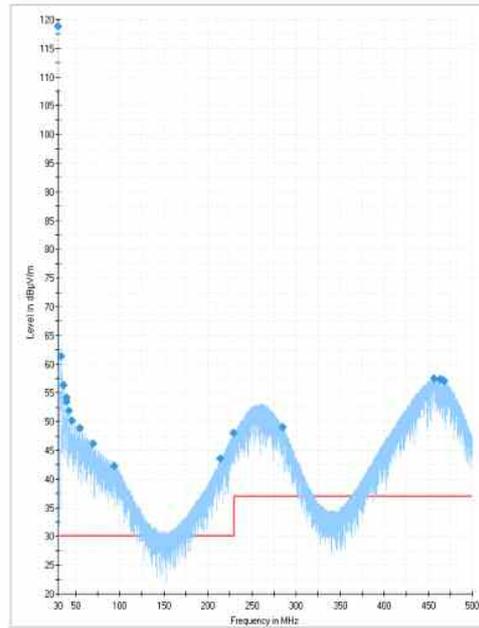
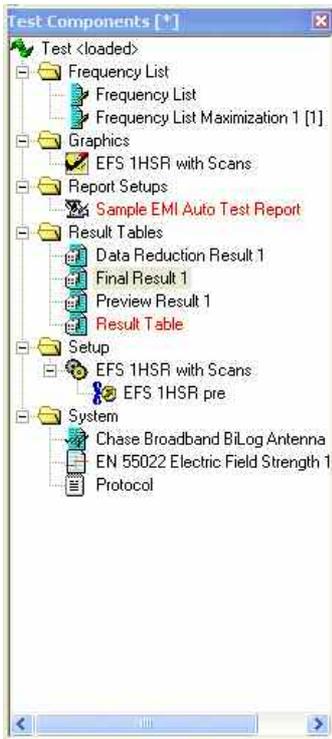


Figure 12: Results of the test with Test Components and Graphics

After the test end we cannot trace back which data reduction filter has added the individual frequency points to the final result table. For understanding the influence of the relevant settings in all hierarchy layers of the EMI Auto Test and Data Reduction evaluation paths we need to go through the Preview Measurements and Data Reduction step by step.

It is obvious that application of Evaluation Path 3 (General Acceptance Analysis) is different from Partial Acceptance Analysis following Evaluation Path 1 and 2. With Evaluation Path 3 disabled the residual number of measurement points selected as critical frequencies by Evaluation Paths 1 and 2 together with Partial Acceptance Analysis is 17 (Figure 13).



**** Data Reduction [Subrange1] ****
 Meas. Points - Detector1: 7835 Points
 Subrange Maxima Search - Detector1: 10 P...
 Peak Search - Detector1: 161 Points
 Maxima Limitation - Detector1: 10 Points
 Merge Results - Detector1: 18 Points
 Acceptance Analysis - Detector1: 17 Points
 Maxima Limitation - Detector1: 17 Points
 Detector1: Data reduction gives 17 points.
 Detector2: Data reduction gives 0 points.

Figure 13: Results of the test, Evaluation Path 3 (General Acceptance Analysis) deactivated

4 Data Reduction Step by Step

The Data Reduction sequence step provides three Evaluation Paths with individual algorithms (see section 2.1 above).

4.1 Data Reduction Using Evaluation Path 1 Only

This evaluation path is used to determine all "Peaks" (preferably narrowband interference) depending on a user-defined decision level (Relative Threshold Level). For this purpose, the trace is analyzed by means of a special algorithm. The decision level determines how far a local maximum must exceed the adjacent lower test points to be considered as a "Peak" and written into the output file. Figure 14 shows the working principles of this algorithm in an example (detection of three peaks which are with a decision level of 6 dB above the ambient noise).

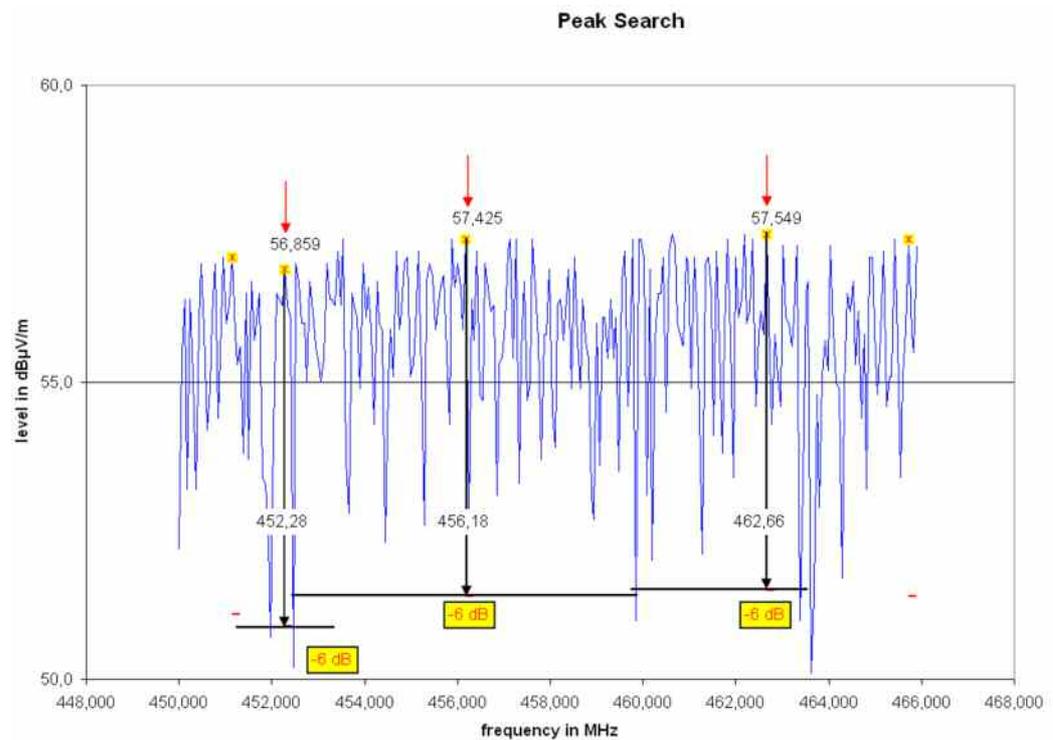


Figure 14: Example for Peak Search

The following Peak Search example selects 152 points from the Preview Result (Figure 15).

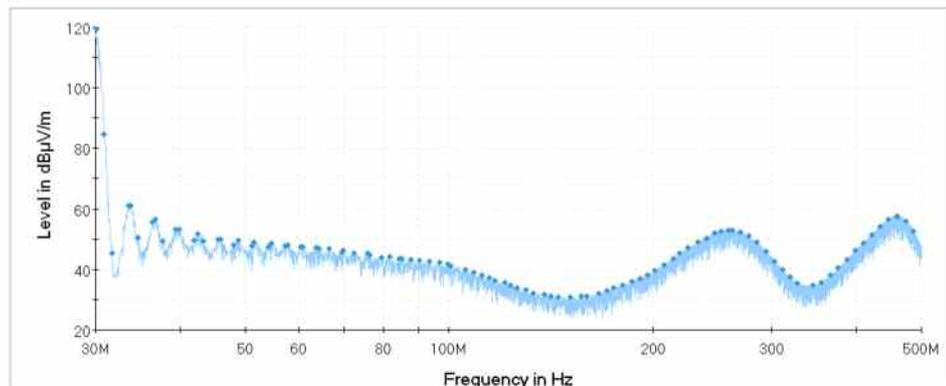


Figure 15: Output values of Data Reduction with Peak Search and without Maxima Limitation (= Maximum Number of Results = 1.000)

If additionally a limit line is specified (limit line and level must be given with the same unit), not the absolute level characteristic of the trace is examined, but the distance between the test point and the respective limit value (distance = limit - level). In this case only measurement values at frequencies covered also by the limit line are sent to the evaluation process, all others are completely ignored (Figure 16). If the limit line contains steps the lower - more critical - value of the limit is used.

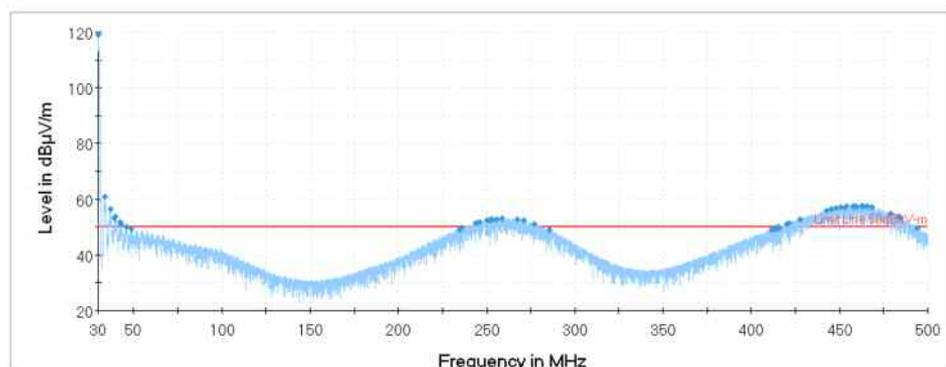


Figure 16: Using continuously defined Limit Lines (without gaps) gives no changes

Reducing the Maximum Number of Results to less points than found by peak search concentrates remaining points more and more to maximum levels. Examples given in

- Figure 17: Maxima Limitation: Maximum Number of Results = 100,
- Figure 18: Maxima Limitation: Maximum Number of Results = 50,
- Figure 19: Maxima Limitation: Maximum Number of Results = 10

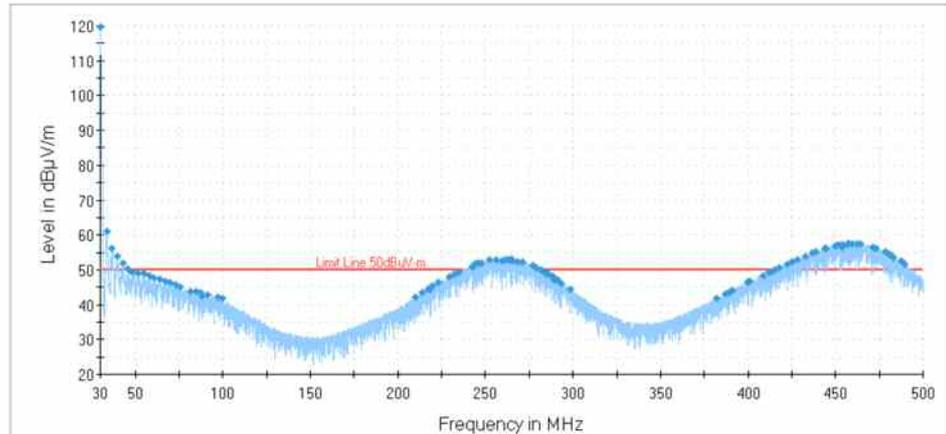


Figure 17: Peak Search with Maxima Limitation, Maximum Number of Results = 100

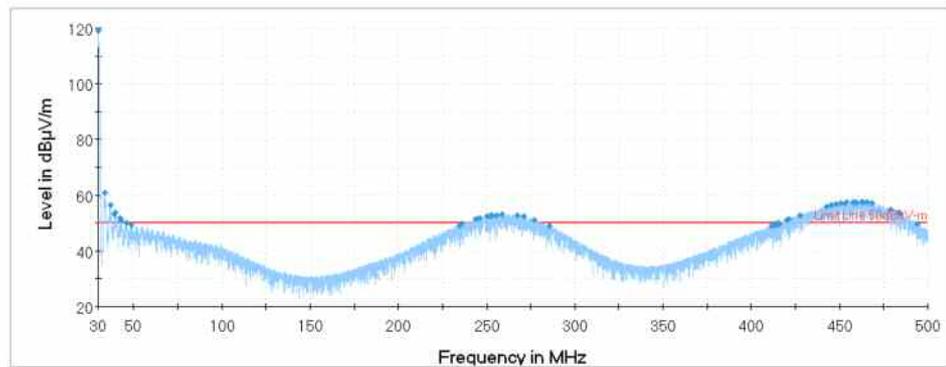


Figure 18: Peak Search with Maxima Limitation, Maximum Number of Results = 50

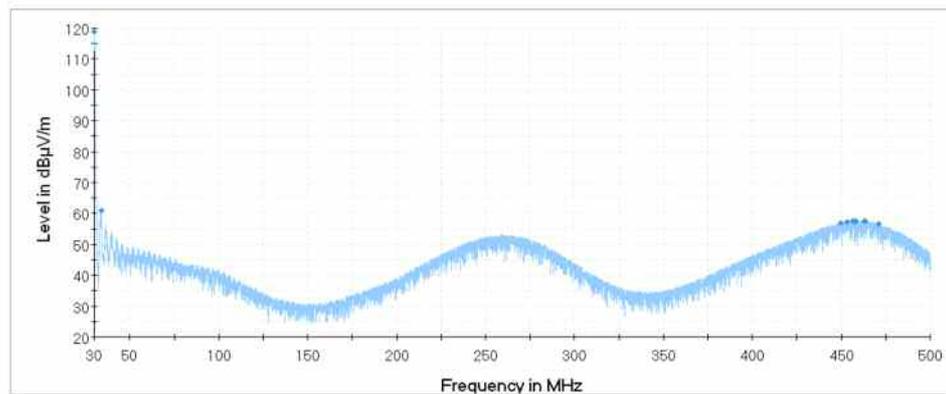


Figure 19: Peak Search with Maxima Limitation, Maximum Number of Results = 10

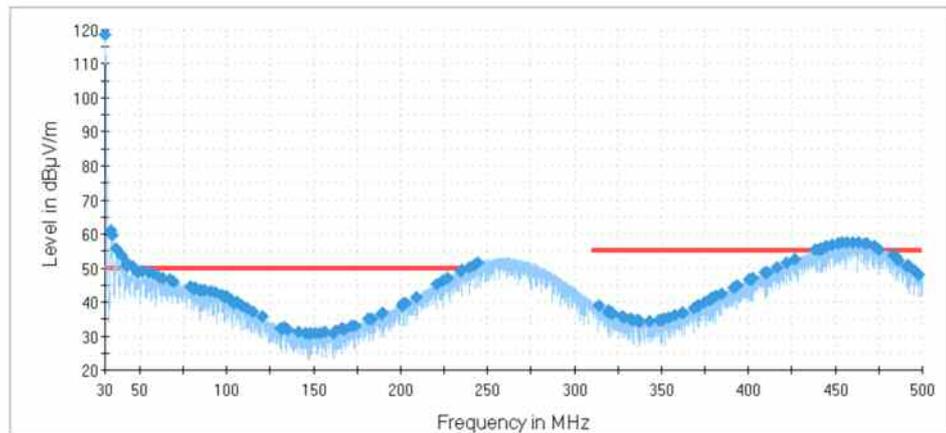


Figure 20: Discontinuous Limit Lines have no points in gaps

When a limit line is specified the Data Reduction and Final Result Table (Figure 21) will contain two additional columns: Limit (unit: dBµV/m) and Margin (Unit: dB).

Name	Frequency	MaxPeak-MaxHold	Height	Polarization	Azimuth	Corr.	Margin	Limit	Comment
Unit	MHz	dBµV/m	cm		deg	dB	dB	dBµV/m	
1	30.000000		119,4	100,0 H		180,0	17,5	-69,4	50,0
2	33,720000		61,5	400,0 H		180,0	15,2	-11,5	50,0
3	36,540000		56,1	100,0 H		0,0	13,7	-6,1	50,0
4	39,660000		54,2	400,0 H		180,0	12,2	-4,2	50,0
5	40,680000		48,4	100,0 H		180,0	11,6	1,6	50,0
6	42,960000		51,6	400,0 H		0,0	10,2	-1,6	50,0
7	45,600000		50,1	100,0 H		0,0	8,9	-0,1	50,0

Figure 21: Data Reduction Result Table with Limit Line and Margin

With a decision level of 0 dB, all local maxima are detected as "Peaks", whereas, with a value of e.g. 20 dB, only distinctive narrowband signals are detected.
(Remark: if this filter is used from *menu* → *EMI Analysis ...* → *Peak Search* it should be the first filter in the chain.)

4.2 Data Reduction Using Evaluation Path 2 Only

The filter Sub range Maxima is suitable for detecting broadband signals in addition to narrowband signals over the complete measured spectrum.
This function is used to split the trace of the input file into a given number (max. 1000) of sub ranges. The distribution of the sub range borders is equidistant for logarithmic scales, compare Figure 22 and Figure 23. The maximum is determined for each sub range and transferred to the output file.

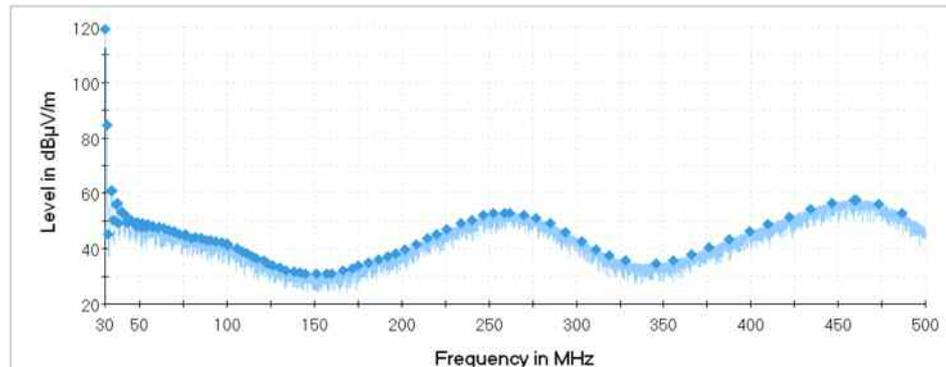


Figure 22: Sub range Maxima Search, 100 sub ranges and 1 Maximum per Sub range, Frequency axis is given in linear scaling

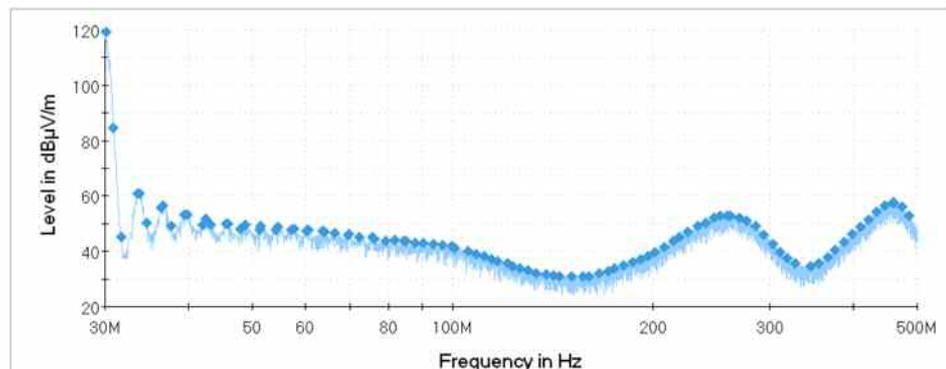


Figure 23: Sub range Maxima Search, 100 sub ranges and 1 Maximum per Sub range, Frequency axis is given in logarithmic scaling

Sub range Maxima Search allows to search for more than one maximum per sub range. Therefore 50 sub ranges with 1 maximum (Figure 24) will result in the same number of resulting points as 10 sub ranges with 5 maxima each (Figure 25) but with a different distribution over the frequency range, which is more similar to 10 sub ranges with one maximum (Figure 26).

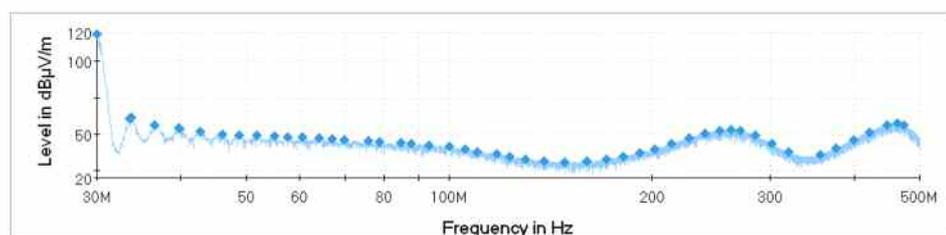


Figure 24: Sub range Maxima Search, 50 sub ranges and 1 Maximum per Sub range, Frequency axis is given in logarithmic scaling

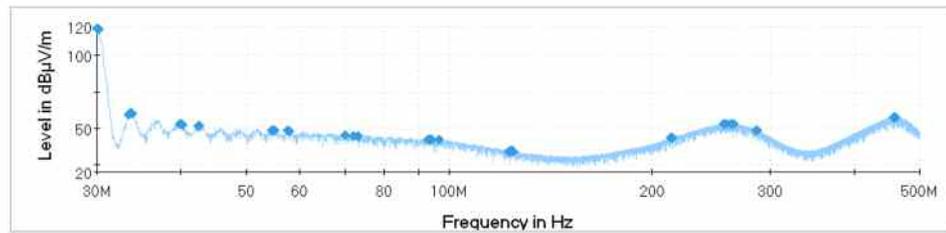


Figure 25: Sub range Maxima Search, 10 sub ranges and 5 Maxima per Sub range, Frequency axis is given in logarithmic scaling

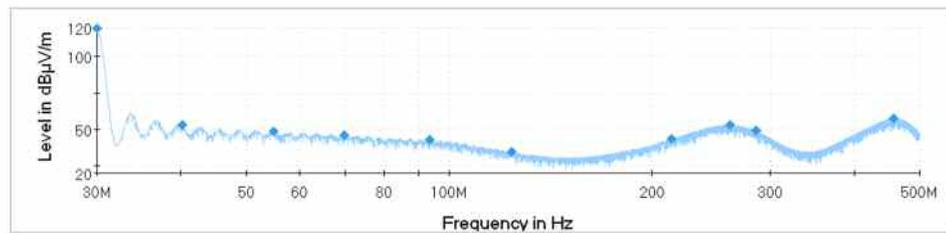


Figure 26: Sub range Maxima Search, 10 sub ranges and 1 Maximum per Sub range, Frequency axis is given in logarithmic scaling

If also a limit line is specified, not the absolute level characteristic of the trace is examined, but the distance between the test points and the respective limit value.

In this case only measurement values at frequencies covered also by the limit line are sent to the evaluation process, all others are completely ignored.

If the limit line covers the entire frequency range the result will only differ in the number of columns in the Data Reduction and Final Result Table. There are two new columns: Limit (unit: dBµV/m) and Margin (Unit: dB). The total number of resulting frequency points is independent from the presence of the limit line.

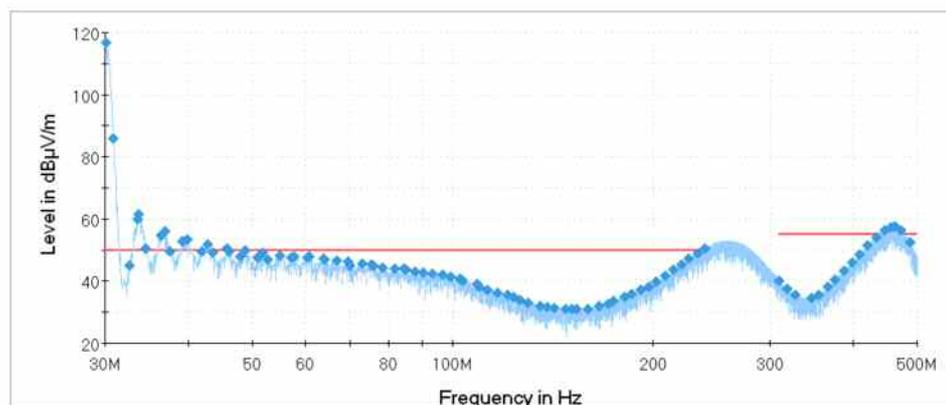


Figure 27: Sub range Maxima Search, Limit Line given is not defined between 245 MHz and 310 MHz

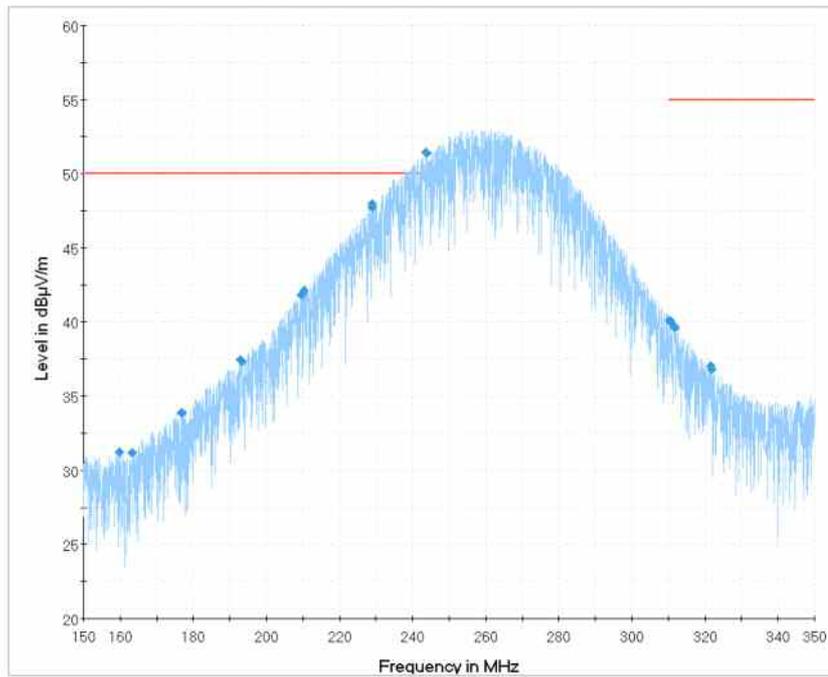


Figure 28: Sub range Maxima Search only delivers points at frequencies where the limit line is defined

If a sub range contains a part of the limit line, the resulting points are taken from this part.

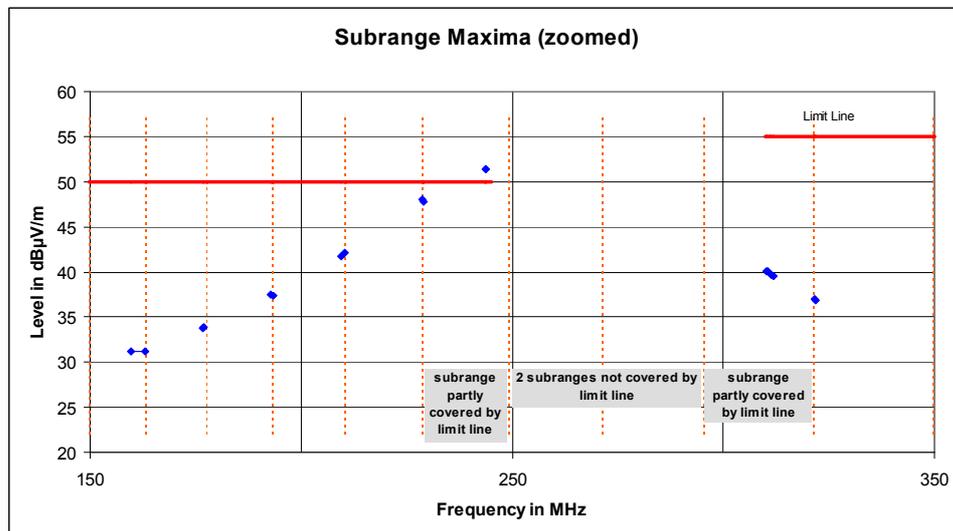


Figure 29: Details on results of non-continuous limit lines, frequency axis linear but borders of sub ranges equidistant in logarithmic scaling

4.3 Reducing Merged Results from Evaluation Path 1 & 2

The result table of Evaluation Path1 is merged (merge method: union) with the results of Evaluation Path 2.

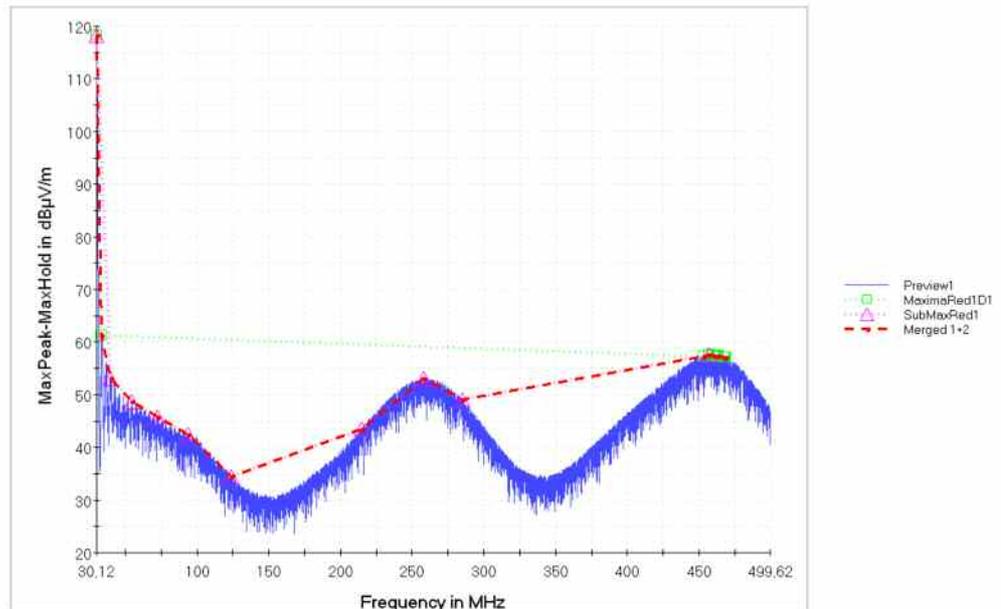


Figure 30: Merged results of Peak Search and Sub range Maxima, dashed and dotted lines highlight the differences

Peak Search with Maxima Limitation (maximum number of results: 10) gives 10 critical frequencies and Sub range Maxima Search (Number of Sub ranges: 10 and Maxima per Sub range: 1) gives also 10 critical frequencies. After merging the Data Reduction Result 1 table contains 18 rows (Table 10 and Figure 31).

Method: union		
Peak Search / Maxima Limitation	Sub range Maxima	Column header
30,12	30,12	30,12
33,66		33,66
	40,08	40,08
	54,6	54,6
	72,54	72,54
	93,66	93,66
	124,14	124,14
	214,74	214,74
	258,36	258,36
	285,36	285,36
456,9	456,9	456,9
460,2		460,2
463,5		463,5
463,08		463,08
453,48		453,48
467,76		467,76
468,42		468,42
467,58		467,58
10 rows	10 rows	18 rows

Table 10: *Merging the rows of the result tables MaximaReduction1 and SubMaxRed1 to Data Reduction Result 1*

The image shows three overlapping 'Table Editor' windows. The leftmost window shows a table with 10 rows of frequency data. The middle window shows a similar table with 10 rows. The rightmost window shows a merged table with 18 rows, combining the data from the first two windows. The frequency values are in MHz, and the units are dBμV/m.

Name	Frequency	Max
Unit	MHz	dBμV/m
1	30,120000	
2	33,660000	
3	456,900000	
4	460,200000	
5	463,500000	
6	463,080000	
7	453,480000	
8	467,760000	
9	468,420000	
10	467,580000	

Name	Frequency	Ma
Unit	MHz	dBμV/m
1	30,120000	
2	40,080000	
3	54,600000	
4	72,540000	
5	93,660000	
6	124,140000	
7	214,740000	
8	258,360000	
9	285,360000	
10	456,900000	

Name	Frequency	MaxPeak-Max
Unit	MHz	dBμV/m
1	30,120000	1
2	33,660000	
3	40,080000	
4	54,600000	
5	72,540000	
6	93,660000	
7	124,140000	
8	214,740000	
9	258,360000	
10	285,360000	
11	453,480000	
12	456,900000	
13	460,200000	
14	463,080000	
15	463,500000	
16	467,580000	
17	467,760000	
18	468,420000	

Figure 31: Result tables Evaluation Path 1 and 2 and the resulting table from merging process

4.3.1 Acceptance Analysis on Path 1 & 2

For the acceptance analysis the operator can (optionally) select for each detector a limit line which will also be used later for the level evaluation in the final measurements. When a limit line is selected the Acceptance Analysis button is activated and a mouse click on the Acceptance Analysis icon opens the Acceptance Analysis sub dialog (section 2.2). Two alternative functions are available:

- A fixed Acceptance Offset (e.g. -10 dB, Figure 32 or -6 dB, Figure 33). An offset means that all level points which are higher than the limit line value reduced by the offset value will be accepted.
- an **arbitrary acceptance line** (Figure 34) for each detector (the acceptance offset will then be ignored). This acceptance line is a user-defined limit line and all level points which are higher than the arbitrary acceptance line will be accepted.

The Partial Acceptance Analysis filters the merged output of Evaluation Path 1 & 2 and not directly the output of the Preview Measurement.

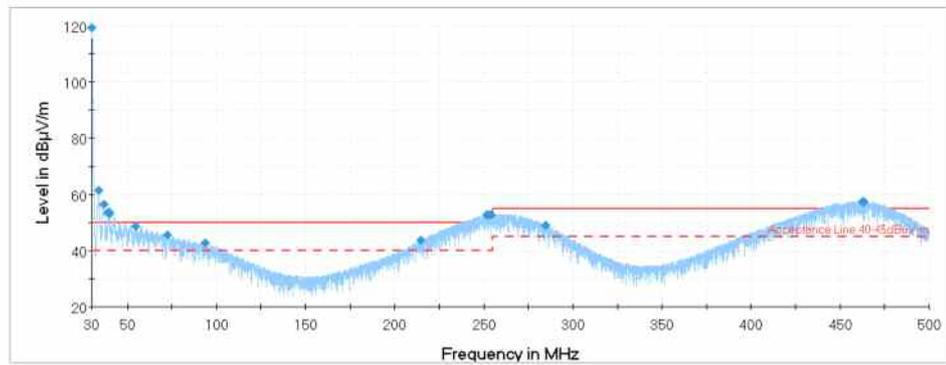


Figure 32: Partial Acceptance Analysis with -10 dB Threshold, blue points are merged results of the previous peak analysis (Path 1 & 2)

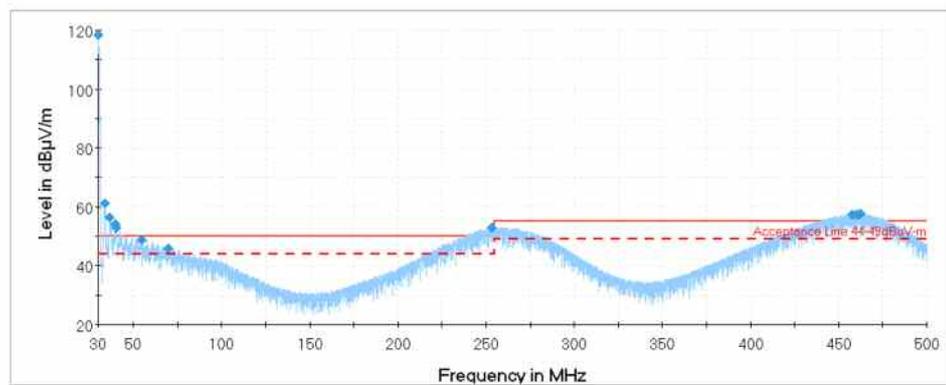


Figure 33: Partial Acceptance Analysis with -6 dB Threshold

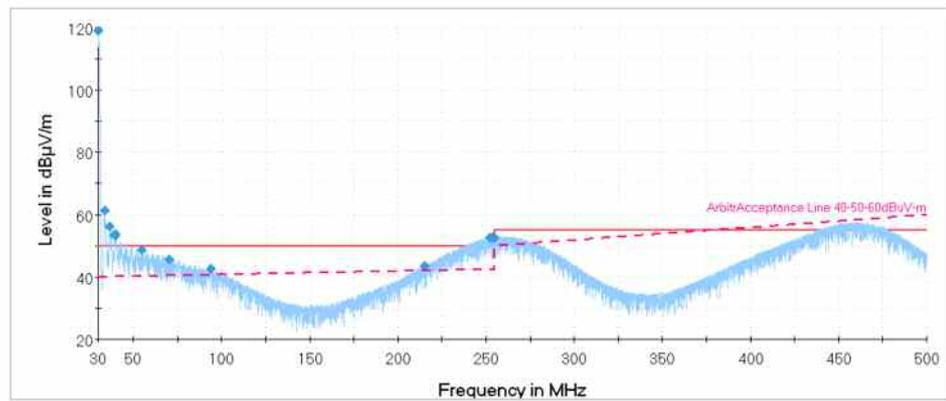


Figure 34: Partial Acceptance Analysis with arbitrary Acceptance Line

4.4 Evaluation Path 3 – General Acceptance Analysis

This optional filter has the same functionality as the Acceptance Analysis on Path 1 & 2 with a fixed acceptance offset but offers no arbitrary acceptance line. Since the Evaluation Paths 1 and 2 are bypassed the filter directly gets all Preview Measurements results.

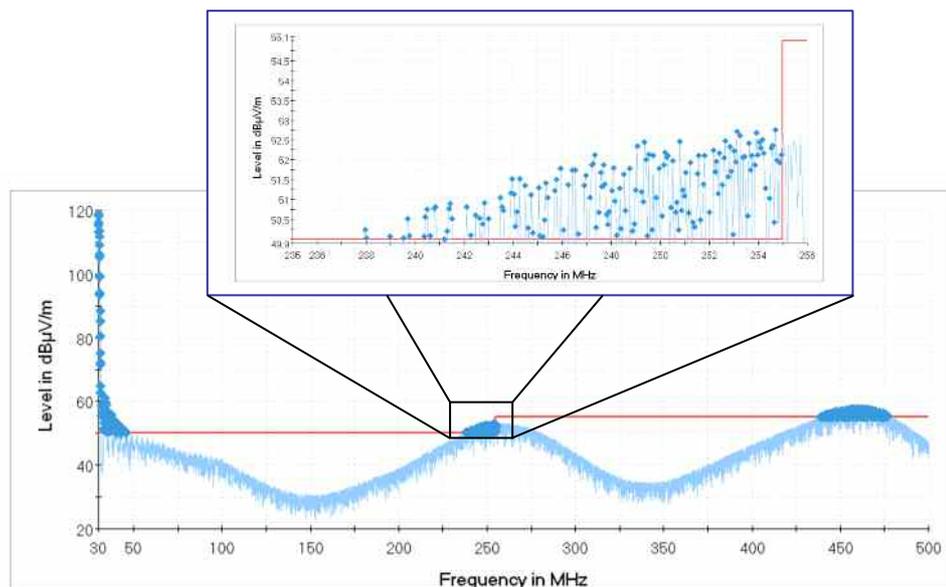


Figure 35: General Acceptance Analysis with 0 dB Threshold

Zooming into the accepted points shows not only maxima but also all other points with a level higher than the limit line (offset = 0 dB, Figure 35) including minima. This combination of Preview Measurements and General Acceptance Analysis is useful to make sure that e.g. a spike cannot dominate over a true interferer which therefore may not be kept (although exceeding the limit), depending on the parameters for Path 1 & 2.

4.5 All Data Reduction Paths as Overview

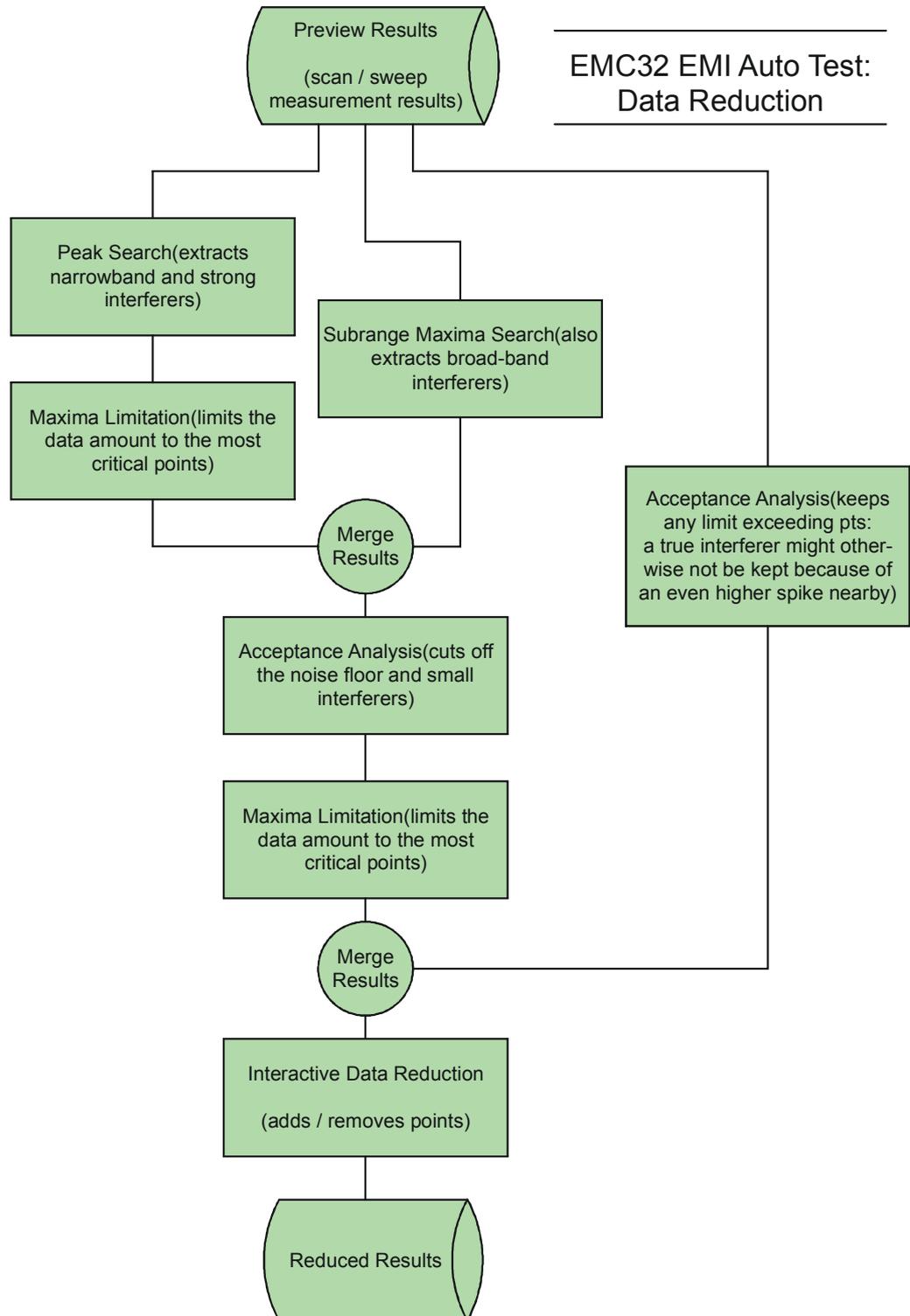


Figure 36: Data Reduction Overview

5 Control Auto Test Flow

There are options to control the auto test flow itself as well as the data reduction sequence step.

5.1 Hardware Setup Ranges (HW SR)

All test sequence steps will be executed in a chain over the entire frequency range of the auto test. Internally this frequency range may be split into sub ranges, both:

- in the hardware setup and
- in the scan/sweep test template.

Using two or more antennas in a radiated test requires to define in the hardware setup different sub ranges at least one for each antenna.

If the measured frequency range of the EMI Auto Test covers now several Hardware Setup sub ranges in every Scan/Sweep the antenna has to be changed when entering the next sub-range. By splitting the test into hardware sub-ranges executed separately, the antenna only has to be changed once for every hardware sub-range since the whole measurement sequence will be executed for each Hardware Setup sub range from the preview to the final measurement.

Further reasons for additional sub ranges in the scan/sweep test template are different test receiver settings in the frequency sub ranges of the test, e.g. IF Bandwidths. These sub ranges do not influence the test flow.

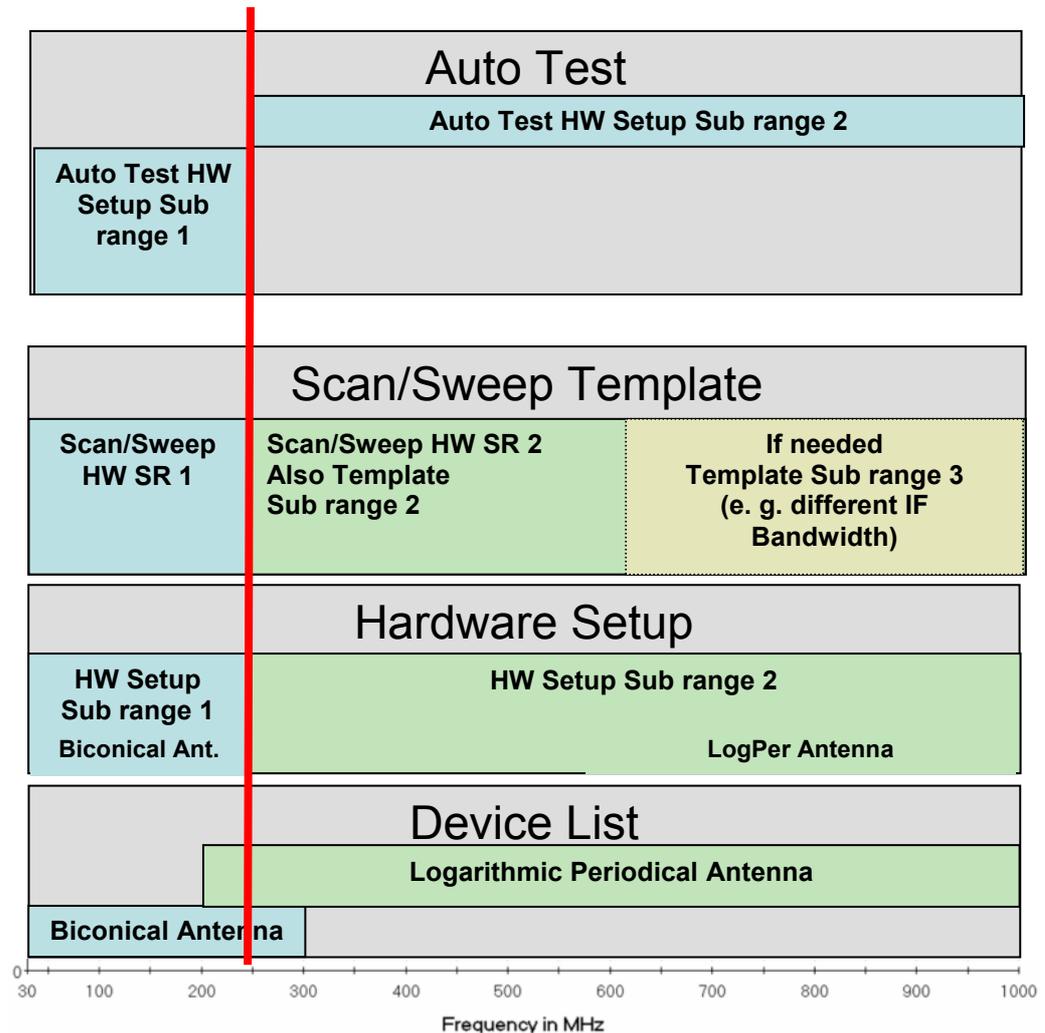


Figure 37: Relation of Frequency sub ranges over the layer hierarchy of EMC32

The Auto Test Template Editor allows to choose whether the entire frequency range of the auto test is executed by the test sequences from start to stop frequency regardless of different antennas used (hardware setup ranges) or not. If more than one hardware setup range is defined and if in the Auto Test Template Editor 'General Settings' the check box "Execute hardware setup ranges separately" is ticked, the complete chain of sequences is carried out for the first hardware setup range before continuing with the second range.

When the parameter 'Execute Hardware Setup subranges separately' is activated the Number of subranges refers to the total frequency range and not to the currently executed frequency subrange!



Figure 38: Selection of the Hardware Setup and the usage of sub-ranges

After the final measurement of the first range is completed the Preview Measurement of the next hardware setup range starts and so on until all ranges are processed (Figure 39).

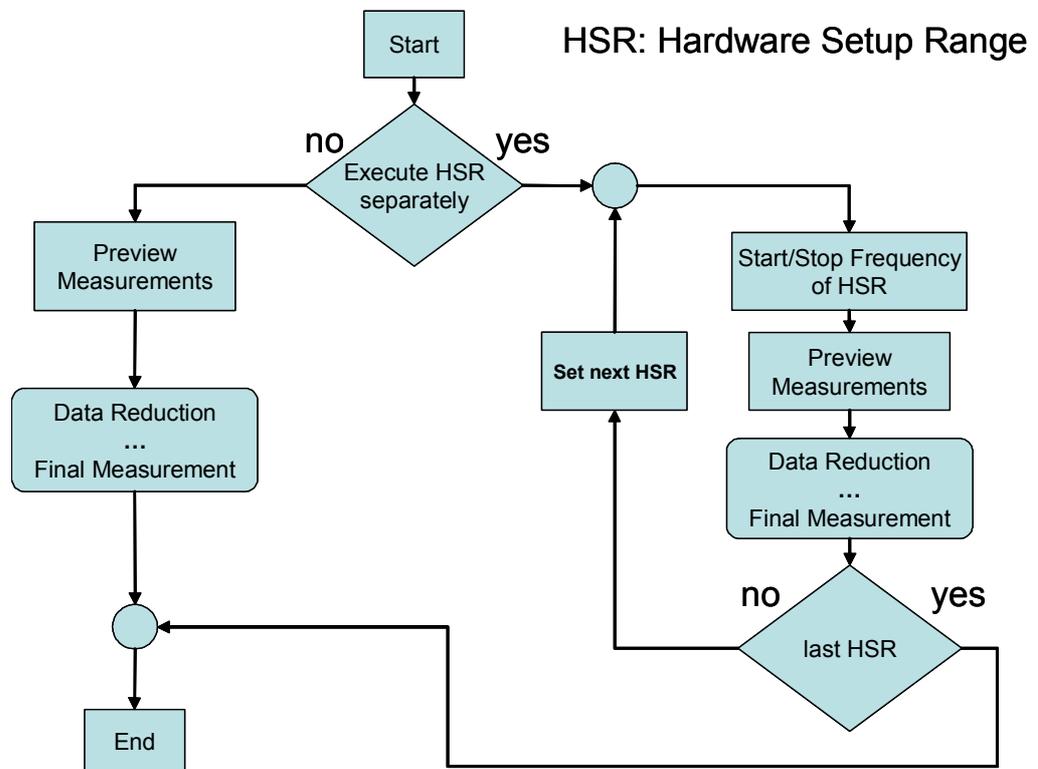


Figure 39: Handling of Hardware Setup Ranges in Auto Test

The number of tables in the Preview Measurement sequence step is directly related to the number of sub ranges defined in the Hardware Setup. The Test flow according to the setting “Execute hardware setup ranges separately” in the Auto Test Template contains all ranges as one block or executes in the first step HSR 1 and then the next. The results are merged at the end of the auto test.

5.2 Data Flow Variations

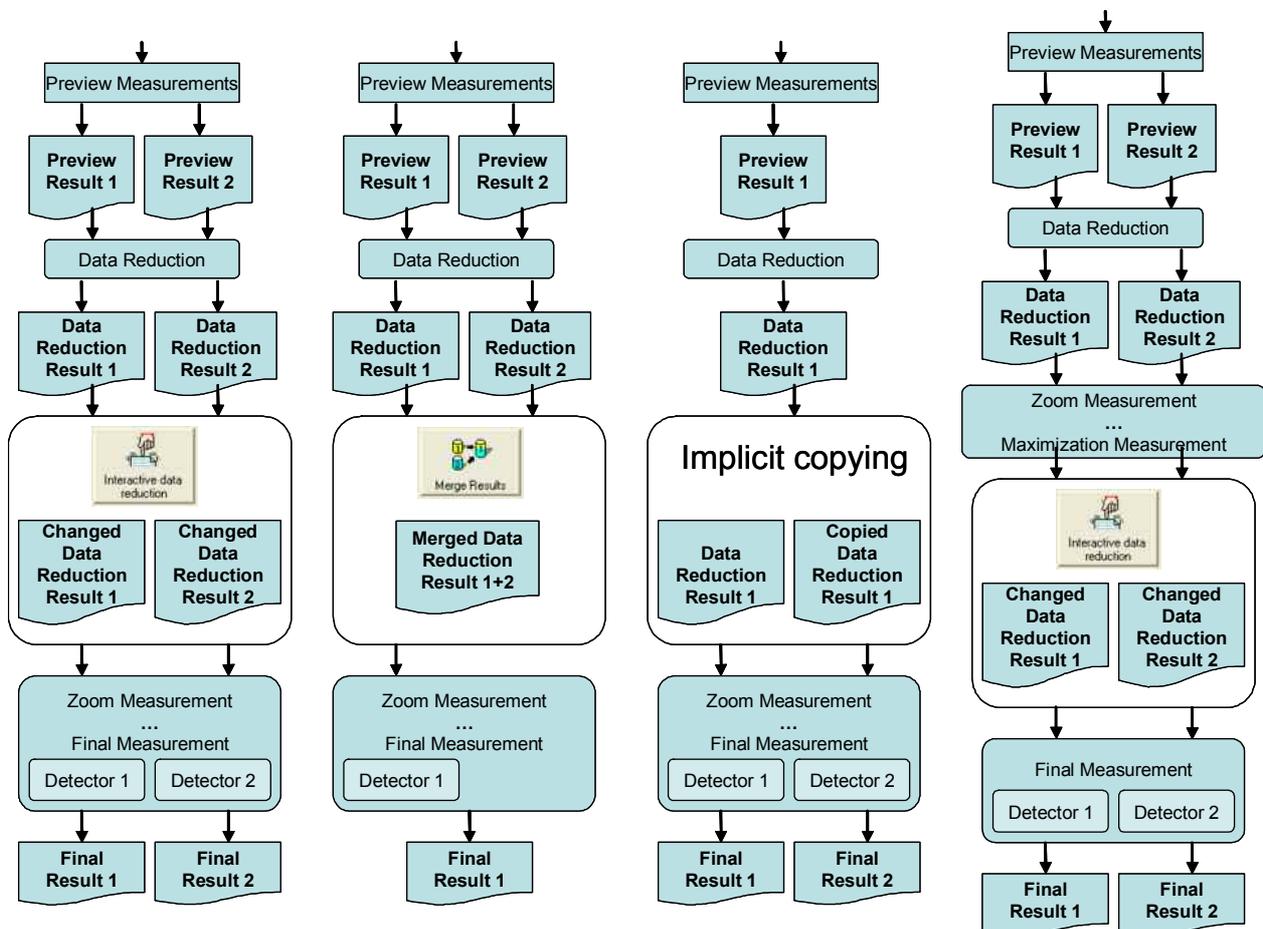


Figure 40: Interactive data reduction and Merge Results

The figure above shows the data flow of the detector 1 and detector 2 results from the preview to the final measurement. Different options of the Data Reduction parameters allow to influence the data flow as follows:

- 1st flow chart: the interactive data reduction table allow to modify the result table of the data reduction interactively before the final measurement sequence is performed.
- 2nd flow chart: the merge results function will merge all frequencies found in the detector 2 table to detector 1 table for the final measurement.
- 3rd flow chart: the preview is only done with one detector. After the data reduction the result table for detector 1 is copied and the final measurement is done for both detectors.
- 4th flow char: in comparison to the 1st flow chart the interactive data reduction is here performed before the final measurement is done.

EMC32 - EMI Auto Test: Standard Data Flow

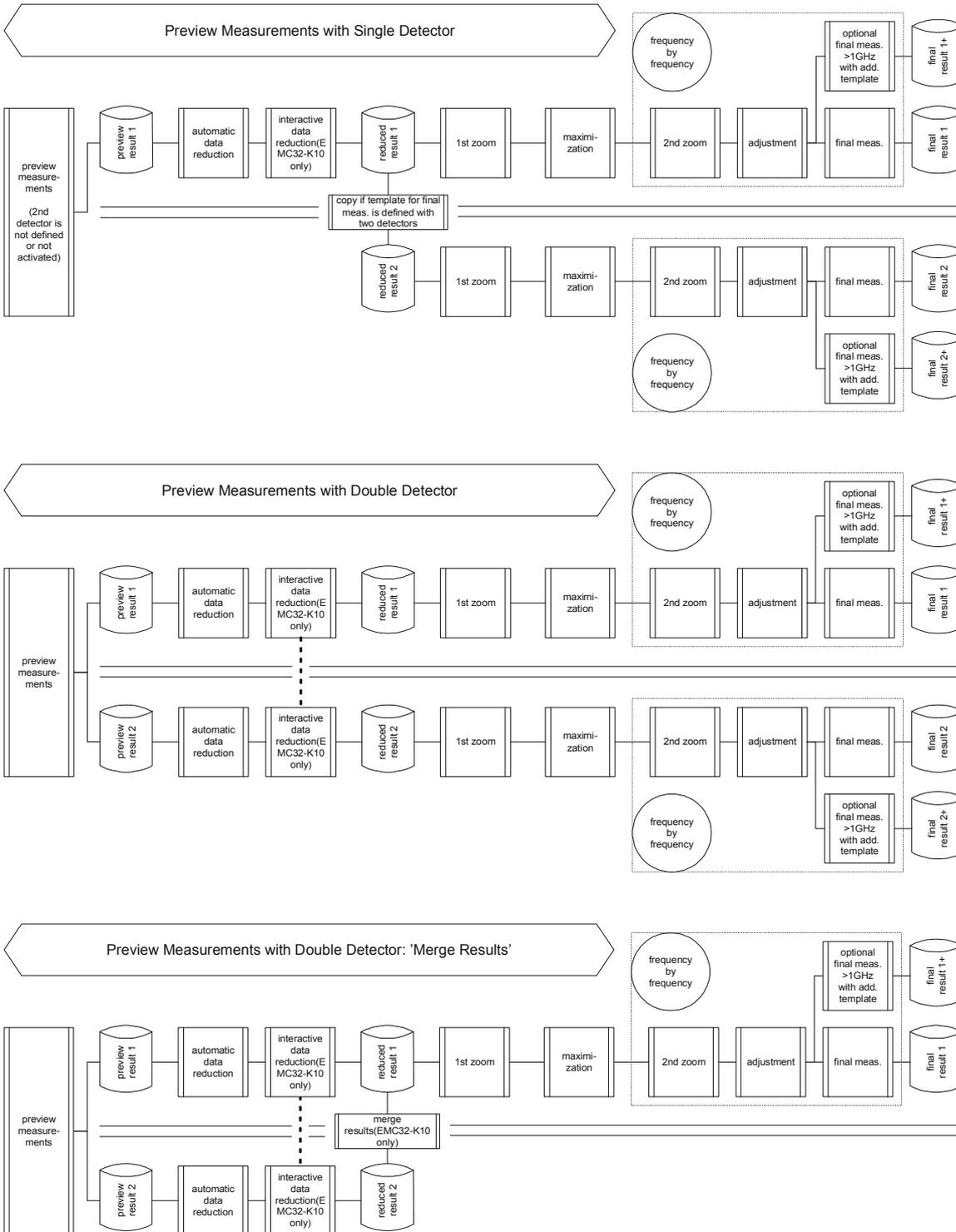


Figure 41: EMC32 - EMI Auto Test Data Flow

5.3 Interactive Data Reduction

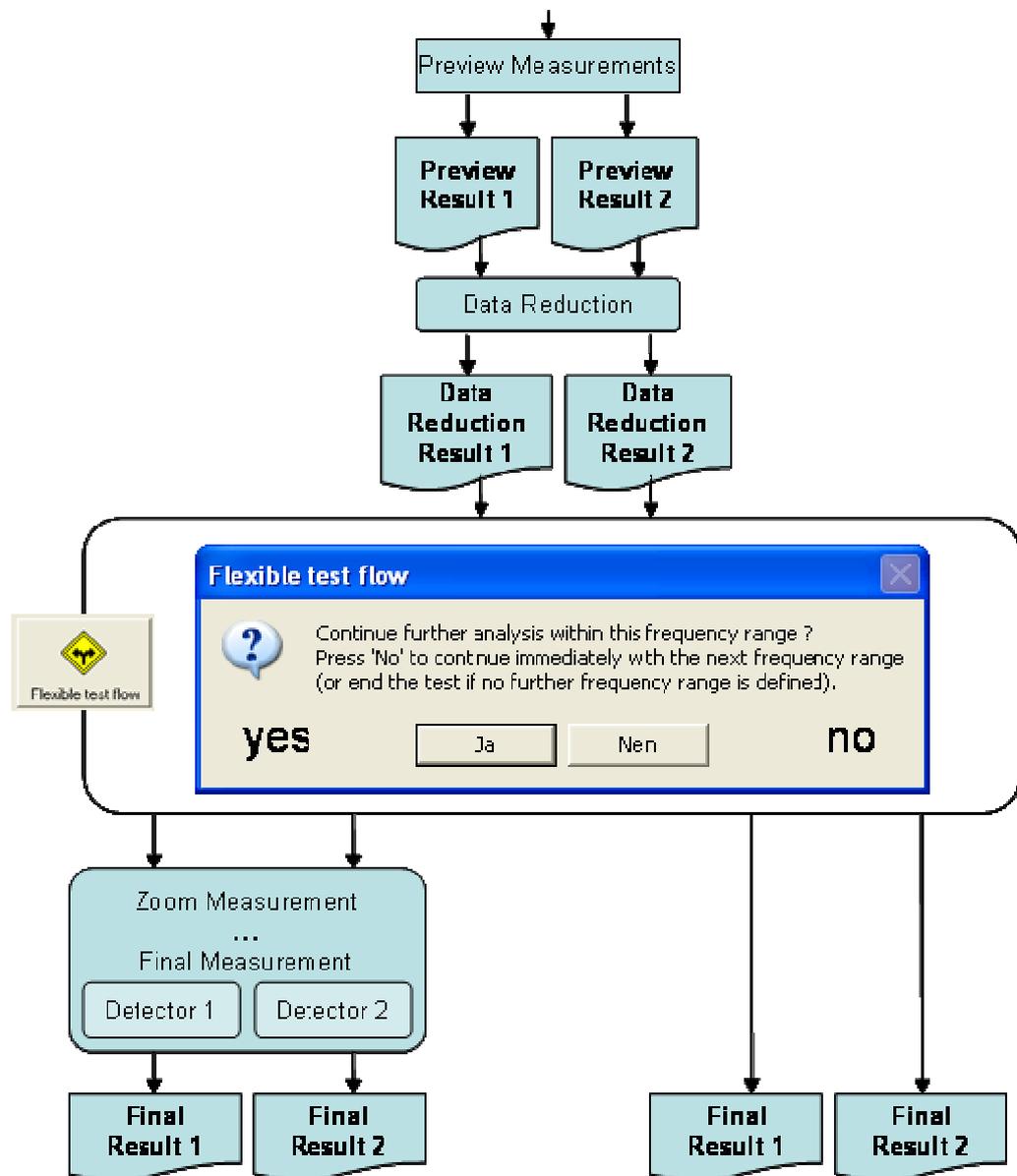


Figure 42: Flexible test flow

This data flow example shows the scenario when using the measurement mode 'Execute hardware setup ranges separately' and the Flexible Test Flow option in the data reduction parameter settings. This options allows to either run the final measurement sequence with Zoom to Final Measurement or to skip this sequence where the data reduction result tables will copied directly to the final result tables.

6 Additional Information

6.1 Result Tables in EMI Auto Test

In the previous example we examined the Data Reduction Evaluation Paths step by step starting with Evaluation Path 1. We have had a look to the results presented in the graphics. Now we will have a closer look to the tables generated during Preview Measurements sequence step and subsequently used in the following sequence steps. We cannot deactivate Maxima Limitation without deactivating the whole Evaluation Path 1 therefore we choose a value of 1000 points which is the maximum value and greater than the number of frequency points found by Peak Search. The Preview Measurement starts with an empty Result Table (no Limit Line defined) and moves the accessories to turntable 0° and Antenna height 100 cm with horizontal polarization.

Name	Frequency	MaxPeak-MaxHold	Height	Polarization	Azimuth	Corr.	Comment
Unit	MHz	dB μ V/m	cm		deg	dB	
1	30,000000	...	...		...	...
2	30,060000	...	...		...	...
3	30,120000	...	...		...	...
4	30,180000	...	...		...	...
5	30,240000	...	...		...	...
6	30,300000	...	...		...	...
7	30,360000	...	...		...	...

Figure 43: Columns of Result Table at start of the test

Then the first scan is performed. The measurement values and accessory information are stored in the Result Table. Before the turntable is moved to 180°, the Result Table is being copied (merged) to Preview Result 1 (contains preview values for detector 1: MaxPeak) and Preview Result 1 [1] (contains preview values for detector 1 in the first Hardware Setup Range [1]). According to the Accessory settings the Preview Measurement sequence step will execute four scans. After each scan a merging process of the tables is performed.

- ▶ Accessories: 100 cm / 0 deg. / H → scan → merge of tables
- ▶ Accessories: 100 cm / 180 deg. / H → scan → merge of tables
- ▶ Accessories: 400 cm / 180 deg. / H → scan → merge of tables
- ▶ Accessories: 400 cm / 0 deg. / H → scan → merge of tables

At the end of the Preview Measurement the table Preview Result 1 [1] with 7.835 points is forwarded as input to the Data Reduction sequence step. The algorithm Peak Search reduces 7.835 points to 154 critical frequencies and writes this to the temporary table PeakRedMaxRedD1 which is then copied (merged) to the tables Data Reduction Result 1 and Data Reduction Result 1 [1] as output tables of the Data Reduction sequence step. At the start of Zoom Measurement 1 the table Data Reduction Result 1 [1] is copied (merged) to table Final Measurement Result 1 and then deleted. Preview Result 1 holds the results of the Preview Measurement and the Result Table will be empty. Next steps are: copying "Final Measurement Result 1" to "Final Result 1" and deleting "Final Measurement Result 1".

Tables shown in Test Window	
Changes during test run	
<p>Start of Test</p>	<p>After the first scan until start of data reduction</p>

<p>Test Components [*]</p> <ul style="list-style-type: none"> Test <loaded> <ul style="list-style-type: none"> Frequency List <ul style="list-style-type: none"> Frequency List Frequency List Maximization 1 [1] Graphics <ul style="list-style-type: none"> Current measurement EFS 1HSR with Scans Report Setups <ul style="list-style-type: none"> Sample EMI Auto Test Report Result Tables <ul style="list-style-type: none"> Data Reduction Result 1 Data Reduction Result 1 [1] Final Measurement Result 1 Preview Result 1 Result Table Setup <ul style="list-style-type: none"> EFS 1HSR with Scans EFS 1HSR pre System <ul style="list-style-type: none"> Chase Broadband BiLog Antenna CBL 6112 Protocol 	<p>Test Components [*]</p> <ul style="list-style-type: none"> Test <loaded> <ul style="list-style-type: none"> Frequency List <ul style="list-style-type: none"> Frequency List Frequency List Maximization 1 [1] Graphics <ul style="list-style-type: none"> EFS 1HSR with Scans Report Setups <ul style="list-style-type: none"> Sample EMI Auto Test Report Result Tables <ul style="list-style-type: none"> Data Reduction Result 1 Final Result 1 Preview Result 1 Result Table Setup <ul style="list-style-type: none"> EFS 1HSR with Scans EFS 1HSR pre System <ul style="list-style-type: none"> Chase Broadband BiLog Antenna CBL 6112 Protocol
<p>Test components and tables after data reduction</p>	<p>Test components and tables after end of Auto Test</p>

Table 11: Tables used during test run and stored after test

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment

- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system



Regional contact

USA & Canada

USA: 1-888-TEST-RSA (1-888-837-8772)

from outside USA: +1 410 910 7800

CustomerSupport@rohde-schwarz.com

East Asia

+65 65 13 04 88

CustomerSupport@rohde-schwarz.com

Rest of the World

+49 89 4129 137 74

CustomerSupport@rohde-schwarz.com

This application note and the supplied programs may only be used subject to the conditions of use set forth in the download area of the Rohde & Schwarz website.

R&S® is a registered trademark of Rohde & Schwarz GmbH & Co. KG. Trade names are trademarks of the owners.

Rohde & Schwarz GmbH & Co. KG

Mühlendorfstraße 15 | D - 81671 München

Phone + 49 89 4129 - 0 | Fax + 49 89 4129 - 13777

www.rohde-schwarz.com