Streamline EMC Testing with Prescan Analysis Tools

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Efficient EMC Testing Improves Revenue

Benefits both Compliance Test Houses and Manufacturers

Compliance testing
– Chamber time is limited resource
– Reducing test time improves efficiency and profitability

Precompliance testing
– Rapid diagnosis of early designs speeds time-to-market, facilitating product sales
Factors Affecting EMC Test Times

Many factors affect both Compliance and Precompliance Test times:

- Device Under Test (DUT) setup time
- Receiver/ Spectrum Analyzer Scan times
- Turntable and Antenna movement times
- Suspect frequency analysis
- Final Measurement
- Report Generation
Presentation Will Discuss Tools Used to Speed up Suspect Frequency Analysis

IF Spectrum Monitoring

Spectrum Analysis
Agenda

• Suspect List Analysis
  – What are suspect emissions and why do we have to analyze them?

• Emissions Prescan Measurements
  – Benefits - why we make them
  – Challenges – errors associated with prescan

• Solutions to Speed Up Suspect List Analysis
  – Spectrum Analysis
  – IF Spectrum Monitoring
But First….What are Suspect Frequencies?

- Frequencies measured during fast prescan that may fail final measurements to CISPR limits.
Why do I Need to Analyze Suspect Frequencies?

- CISPR requirements
  - Must maximize the signal and record azimuth and antenna orientation
  - Must ensure that you are measuring at the frequency of maximum emission
  - Must monitor emission Quasi-Peak (QP) amplitude to capture maximum value
    - If not constant, users must monitor QP value for 15 seconds or more (as per CISPR 16-2-3, section 6.5).

- Amplitude and frequency errors associated with prescan methods.
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Prescanning Reduces Overall EMC Test Time

• What is Prescanning?
  – Methodology used to reduce overall EMC test time
  – Scan target frequency range with Peak detector to identify frequencies where emissions exist
  – Peak detector significantly faster than weighted detectors

• Recommended by CISPR
  – Specifically to reduce test time
Prescan Saves Time for Both Compliance and Precompliance Testing
How Does Prescan Save Test Time?

- Focus final measurement efforts only on frequencies with emissions above or near the limit line.
How Does Prescan Save Test Time?

- Identify suspect frequencies more quickly by scanning with a **peak detector**.
  - Scanning with CISPR weighted detectors (Quasi-Peak, EMI Avg and RMS-Avg) slow due to defined charge and discharge times

Specified minimum scan times, as stated in CISPR 16-2-3

<table>
<thead>
<tr>
<th>Frequency band</th>
<th>Scan time $T_s$ for peak detection</th>
<th>Scan time $T_s$ for quasi-peak detection</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 9 kHz to 150 kHz</td>
<td>14,1 s</td>
<td>2 820 s = 47 min</td>
</tr>
<tr>
<td>B 0,15 MHz to 30 MHz</td>
<td>2,985 s</td>
<td>5 970 s = 99,5 min = 1 h 39 min</td>
</tr>
<tr>
<td>C and D 30 MHz to 1 000 MHz</td>
<td>0,97 s</td>
<td>19 400 s = 323,3 min = 5 h 23 min</td>
</tr>
</tbody>
</table>
Why is Scanning with Peak Detector Allowed?

- Peak values will always be equal to or larger than the Quasi-Peak (QP), EMI-Average or RMS-Avg detected values.
- If a peak value is over the limit (or margin), further measurement should be done with CISPR detector.

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**Example:**
- Peak value above QP limit
- QP value below QP limit

**Diagram:**
- QP Limit & Margin
- 500MHz pulsed RF
- 5us pulse width
- 100ms pulse period

**Table:**
- **Frequency 500 MHz**
  - Peak: 64.95 dBμV
  - QP: 39.22 dBμV
  - EMI Avg: 3.170 dBμV

**Graph:**
- Trace 1 Fail
- Ref 77.00 dBμV
- Mkr1 500.01 MHz
- 64.849 dBμV

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Challenges with Prescan

• Amplitude and Frequency Errors due to:
  – Amplitude or frequency modulation on detected signals
  – Receiver / Spectrum Analyzer sweeping/stepping
Signal Modulation Affects Measured Prescan Level

Assume a 500MHz emission with AM and FM modulation

FM deviation = 5 MHz

75% AM

Range of measured amplitudes displayed depending on intersection of receiver scan and emission modulation

Receiver display buckets

Start 495 MHz
Res BW 120 kHz
Stop 505 MHz
VBW 1.2 MHz
#Dwell Time 100 ms (30 kHz)
Prescan Errors due to Modulation on Emission

Modulation on emissions signal can indicate false peak frequency in signal list.

Detail analysis indicates emission measurement really needs to be made here.

Prescan indicated peak occurs here.

Max emission envelope due to AM and FM modulation.

Frequency List Entry
- w/o addition analysis, measurement would be made at this frequency.

Input: 500 MHz with FM and AM modulation.
Challenges with Prescan

• Amplitude and Frequency Errors due to:
  – Amplitude or frequency modulation of detected signals
  – Receiver / Spectrum Analyzer sweeping/stepping
How Modern Receivers Display Amplitude Levels per Frequency Step…

Receivers display amplitudes and frequencies in display “buckets”

Receiver Display

Max detected values displayed in center of each bucket

Resolution Bandwidth

Emission Signal

Midpoint of each bucket

step size or “bucket”

Span

Number of measurement points

= (Span/ step size)+1

Ref 77.00 dBμV

64.849 dBμV

Mkr1 500.01 MHz

Stop 505 MHz

#Dwell Time 100 ms (30 kHz)
Prescan Amplitude and Frequency Errors When Using a Stepping Receiver

Receiver Resolution Bandwidth fixed at center of bucket

Amplitude and Frequency errors occur when Receiver Bandwidth not centered on emission

Max errors occur when emission is half-way between bucket centers
Max errors occur when emission is half-way between bucket centers.

Max Frequency Error = \( \frac{1}{2} \) step size

Receiver Display

Emission displayed in two buckets

Up to 6 dB amplitude error

Prescan Amplitude and Frequency Errors When Using a Stepping Receiver (cont.)
Prescan Amplitude and Frequency Errors When Using a Swept Receiver

- Sweeping captures emission value within the bucket
- Frequency error due to displaying amplitude in center of bucket

![Diagram showing amplitude displayed at center of bucket, frequency error, and emission located on boundary between two buckets.]

Swept RBW captures amplitude of emission at edge of bucket.

Emission located on boundary between two buckets.
Prescan Amplitude and Frequency Errors When Using a Swept Receiver
### Example: Amplitude and Frequency Errors using 120kHz CISPR RBW

<table>
<thead>
<tr>
<th># Meas. per RBW</th>
<th>Step Size</th>
<th>Max Frequency Error</th>
<th>Max Amplitude Error</th>
<th>Max Amplitude Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120 kHz</td>
<td>60kHz</td>
<td>6 dB</td>
<td>0 dB</td>
</tr>
<tr>
<td>2</td>
<td>60 kHz</td>
<td>30 kHz</td>
<td>1.2 dB</td>
<td>0 dB</td>
</tr>
<tr>
<td>3</td>
<td>40 kHz</td>
<td>20 kHz</td>
<td>0.5 dB</td>
<td>0 dB</td>
</tr>
<tr>
<td>4</td>
<td>30 kHz</td>
<td>15 kHz</td>
<td>0.3 dB</td>
<td>0 dB</td>
</tr>
</tbody>
</table>
Tradeoff Between Error Magnitude and Test Time

Decreasing Step Size:
- improves accuracy
- adds data points
- increases scan time
  \( \text{( # of points x dwell time)} \)

<table>
<thead>
<tr>
<th># Meas. per RBW</th>
<th>Step Size</th>
<th>Stepped and Swept</th>
<th>Stepped</th>
<th>Swept</th>
<th>30MHz – 1 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max Frequency Error</td>
<td>Max Amplitude Error</td>
<td>Max Amplitude Error</td>
<td>Scan Time using 10ms dwell</td>
</tr>
<tr>
<td>1</td>
<td>120 kHz</td>
<td>60kHz</td>
<td>6 dB</td>
<td>0 dB</td>
<td>80 sec</td>
</tr>
<tr>
<td>2</td>
<td>60 kHz</td>
<td>30 kHz</td>
<td>1.2 dB</td>
<td>0 dB</td>
<td>160 sec</td>
</tr>
<tr>
<td>3</td>
<td>40 kHz</td>
<td>20 kHz</td>
<td>0.5 dB</td>
<td>0 dB</td>
<td>242 sec</td>
</tr>
<tr>
<td>4</td>
<td>30 kHz</td>
<td>15 kHz</td>
<td>0.3 dB</td>
<td>0 dB</td>
<td>320 sec</td>
</tr>
</tbody>
</table>
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Swept Spectrum Analysis versus IF Spectrum Monitoring

Swept Spectrum Analysis:
- Local Oscillator (LO) swept to generate spectral display

IF Spectrum Monitoring:
- LO fixed at display center frequency
- spectrum generated using FFT

Modern receiver block diagram with Digital IF
Spectrum Analysis Offers Excellent Flexibility

- **Benefits**
  - Multiple Traces
  - Broad range of resolution bandwidths, including CISPR RBWs
  - Wide Spans available
  - Wide range of detectors
  - Markers
  - Analog Demodulation

- **Concerns:**
  - Sweeping Weighted detectors is slow
    - More difficult to identify max amplitude and frequency of weighted detector response (needed for limit testing)
IF Spectrum Monitors Offer Both Active Span and Weighted Detector Display

**Benefits:**
- Active span and weighted detector amplitudes simplifies maximization
- Multiple Traces
- Markers
- Analog Demodulation

**Concerns:**
- Narrower spans (10MHz typically)
- Narrow range of RBWs (no CISPR)
- Sample detector only

Frequency display generated with FFT

LO fixed at center frequency

Weighted Detectors actively update
Use Tools to Update Frequency List Prior to Final Measure

Prescan Emission Frequency “Estimate”

Frequency of Max Emission identified with IF Spectrum Monitor

List ready for final measurement!
Modern EMI Measurement Tools Contain Both

Prescan analysis tools widely available

• Compliance Receivers
  – spectrum analysis built-in
  – IF analysis tool available standard or as option

• Precompliance Spectrum Analyzers
  – IF analysis tool available as option
Prescan Analysis Tools
Improve EMC Lab Efficiency

Prescan Analysis Tools:

• Facilitate suspect list analysis
• Enhance measurement accuracy
  – Identify frequency of maximum emission
• Improve testing quality
• Reduce overall test time
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November 16, 2016
www.emclive2016.com

Thanks for attending!