EMI Testing Using Spectrum Analyzers vs. Test Receivers

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IEEE-LI Presentation

- Topic of the Meeting Description
  - ⇒ Spectrum Analyzers (SA)
  - ⇒ Test Receivers (TR)
  - Uses and descriptions of each
- Reasons for using either or both units
- Advantages and disadvantages
- Making accurate measurements

Q&A

- Who uses what ?
  - ⇒ Spectrum Analyzers (SA)
  - ⇒ Test Receivers (TR)
- Commercial, MIL-STD or Automotive?
- Software or front panel ?
- Novice, Capable, Fluent or Expert ?

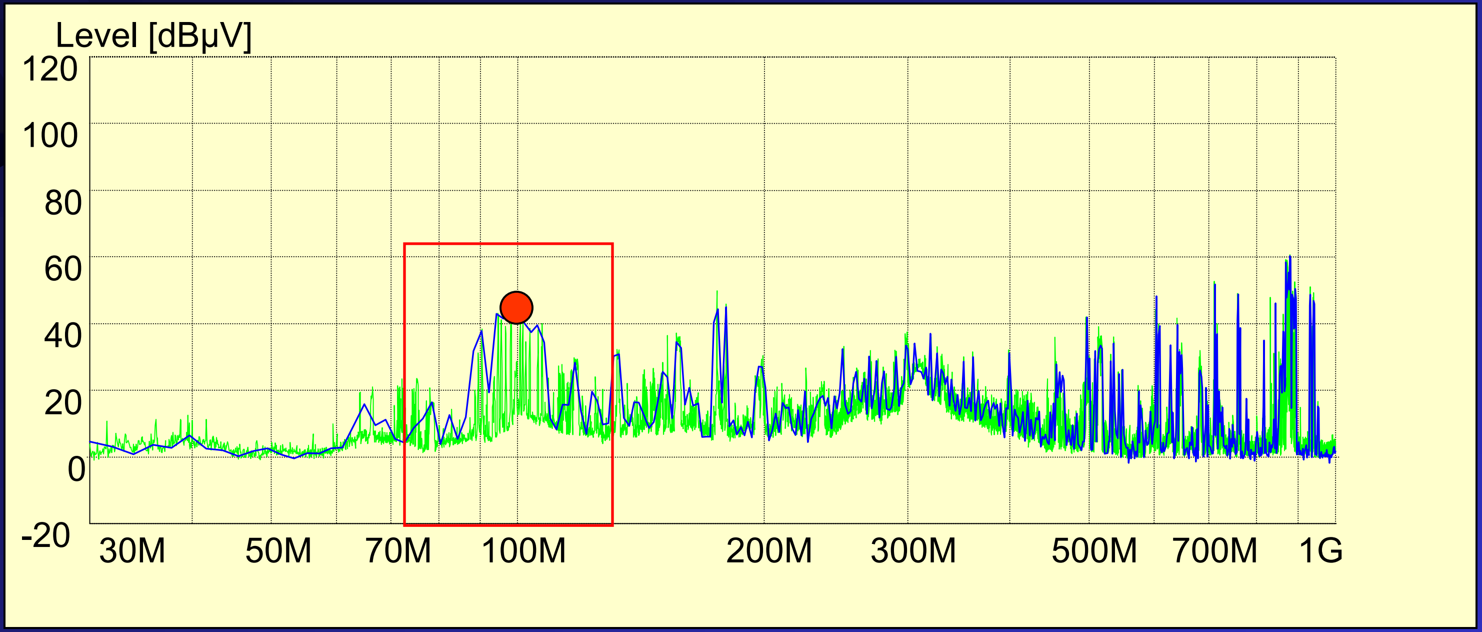
Overview

- EMI Equipment in general
  - ⇒ Spectrum Analyzers (SA)
  - ⇒ Test Receivers (TR)

- Two Most common tools are SA / TR

Spectrum Analyzers for EMI

Spectrum Analyzers for EMI



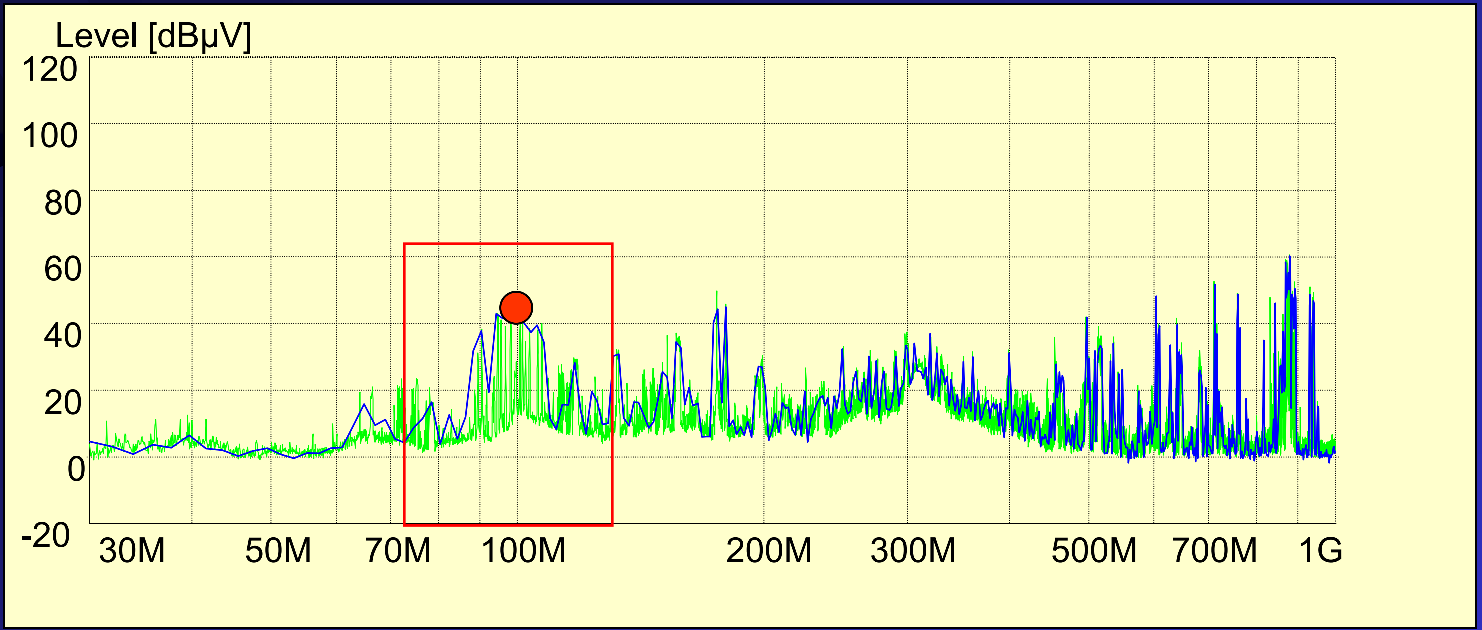
- SA Settings for EMI measurements
  - Span, Reference Level, RBW, VBW and detector
  - Span is the Stop – Start Frequency
  - Ref Level is typically the Highest point SA can measure
  - Coupling with VBW usually some multiple of the RBW
  - RBW usually selected per required standard

Spectrum Analyzers for EMI

- ❖ Reasons for Using SA for EMI Measurements

  - ⇒ Versatility: Wide range of uses
  - ⇒ Familiarity
  - ⇒ Speed … real or imagined
  - ⇒ Price … real or imagined

Spectrum Analyzers for EMI

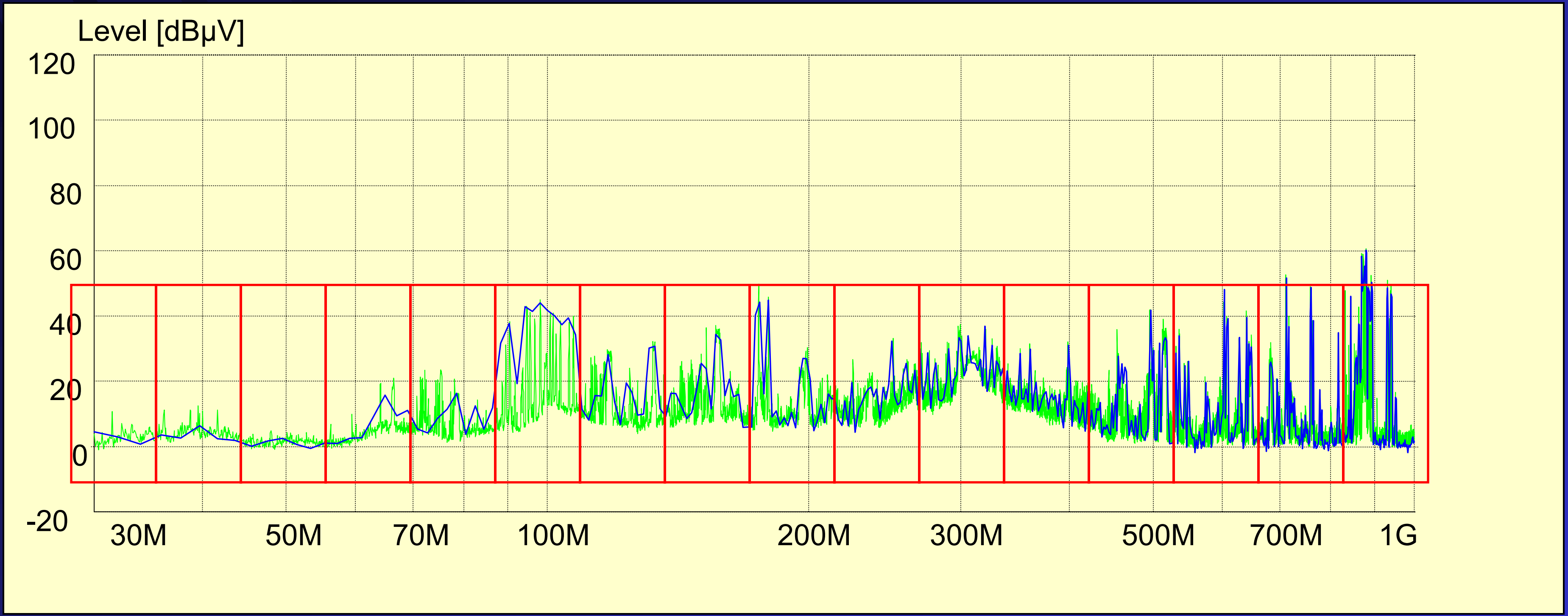


- SA setup for EMI Example
  - Set Span, RBW and detector
  - Span of 970 MHz / 500 points = 2 MHz resolution !
  - x samples within RBW are stored
  - samples are weighted by some detector
  - Common EMI detectors are QP, Ave, Pk, RMS

Spectrum Analyzers for EMI

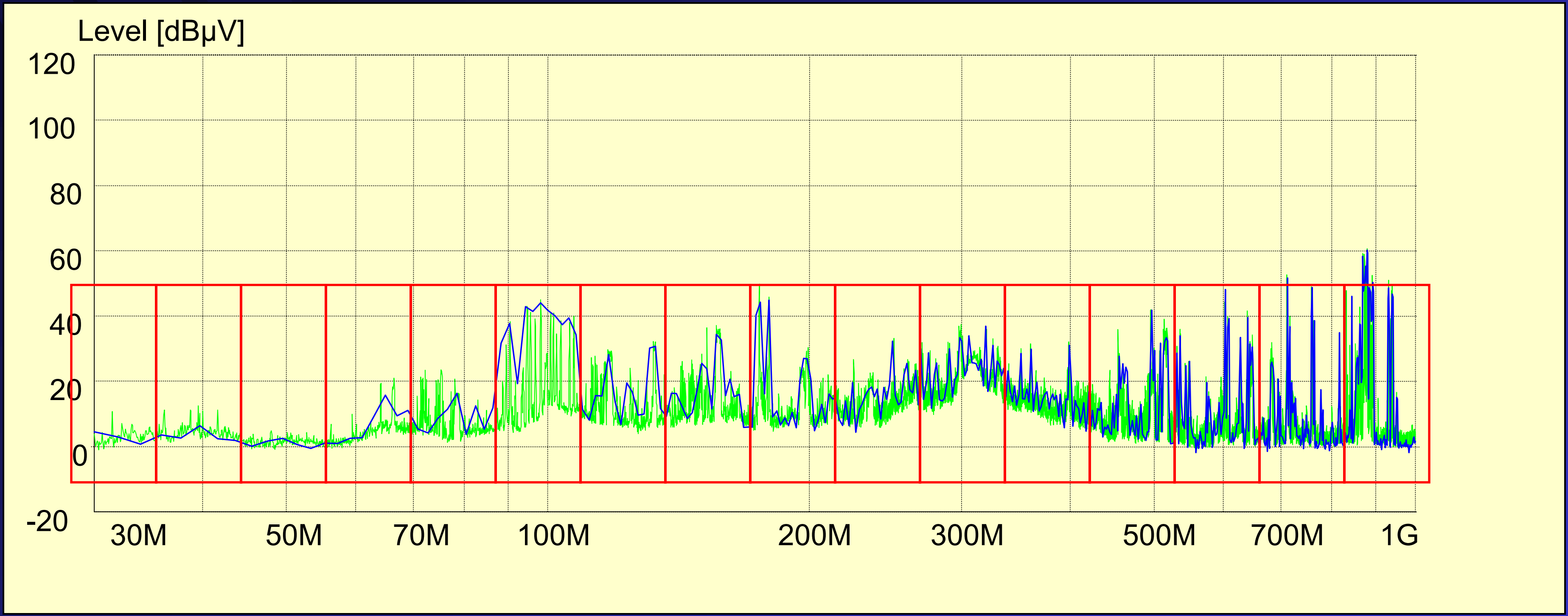
- Question
  - What was wrong with the previous setup?
- Answer
  - Frequency and amplitude accuracy depend on many samples falling within each RBW filter width.
  - set this parameter with frequency span

Spectrum Analyzers for EMI



- Issue # 1 Subranging Required
  - Span of 970 MHz / 500 = 2 MHz resolution
  - If using 120 KHz RBW, CISPR recommends 60 KHz sample points (17 x finer than 1 MHz)
  - Solution: subrange in the span

Spectrum Analyzers for EMI



- Subrange Issue Revisited
  - Per CISPR ½ RBW recommendation
  - For unit with 500 point unit = 30 MHz Spans
  - Solution: 970 MHz Span = 32 Spans required!

Spectrum Analyzers for EMI

- Frequency Accuracy of SA
  - SA resolution is far too course for EMI without subranging the CISPR span
  - SA frequency accuracy when exploring peaks influenced by Span, RBW, VBW, marker accuracy
- Amplitude Accuracy of SA
  - 6 dB (EMI) filters vs. 3 dB
  - QP and AVE detector times are observed
  - Data correction for system transducers
  - EUT specific timing issues are considered
  - Subranges set properly for sample #
  - RF and IF stages are not overloaded

Spectrum Analyzers for EMI

- ❖ Issue # 2 Proper QP and Average Detectors

⇒ Is QP / AVE Detector CISPR-16-1 Compliant?

- ❖ Issue # 3 Correct CISPR RBW Filters

- Typical SA have 1-3-5 Steps RBW
- EMI Filters ..200 Hz, 9 kHz, 120 kHz

Spectrum Analyzers for EMI

- Issue # 4 Dwell Time
  - Sweep Time vs. Span
  - Max Hold
- Issue # 5 Lack of Preselection/ Overload Protection

  -EMI Can be very high – wide
  -Real Signal or not?
  -How to protect your measurement/ SA
  -Verify RF and IF stages are not overloaded

Spectrum Analyzers for EMI

- Has to be a better way!

Test Receivers for EMI

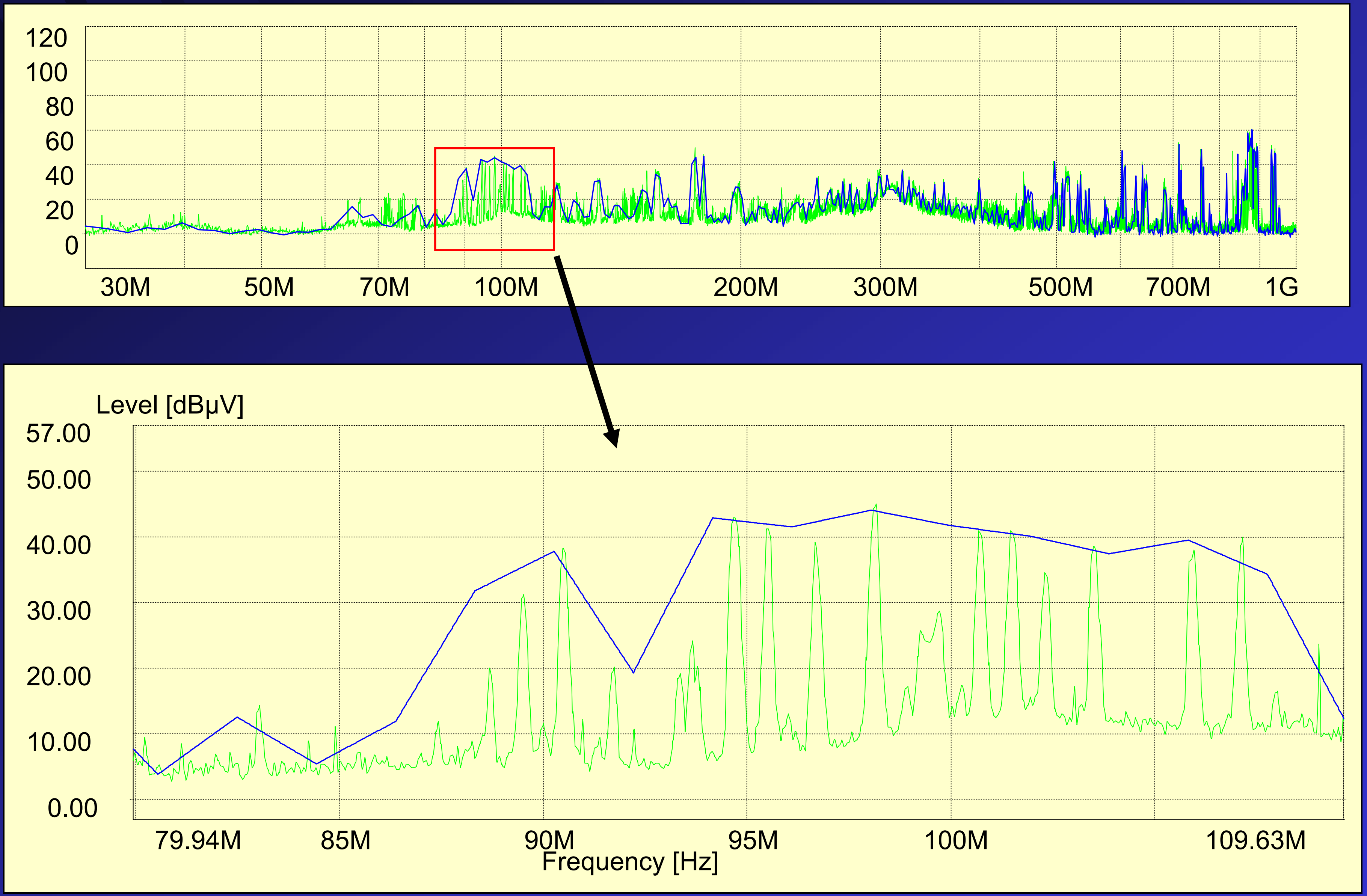
Test Receivers for EMI

- What exactly is a EMI Test Receiver?
  - Fixed Tuned receiver versus Swept Tuned
  - Built-in Firmware for doing only EMI

Test Receivers for EMI

- Controls for Recievers
  - Frequency Span (start / stop)
  - RBW Filter and detector
  - DWELL TIME at each measurement point
  - FREQUENCY INCRIMENT (step size)
  - TR adjusts sample x depending on span
  - x is often 16,000 – 100,000+
  - Span / x = frequency resolution

Test Receivers for EMI



Test Receivers for EMI

- EMI TR Advantages
  - Measurement Points
  - Tune and Dwell Time method
  - DWELL TIME at each measurement point
  - FREQUENCY INCRIMENT (step size)
  - TR adjusts sample x depending on span
  - EMI Specificity
  - Automatic Control – ATT, Preselection, Filters

Test Receivers for EMI

- Conclusion

⇒ TR incorporates EMI control parameters

- STEP SIZE between measurement points
- DWELL TIME at each measurement point
- # of sample points as necessary for accuracy

- Time Penalty ?

- Time dependant on detector and EUT, not measurement speed of instruments

Best Instrument for EMI?

- Pros and Cons of Each

  - SA is faster for initial preview

  - SA can also be used for RX and TX measurements

  - TR has little use outside EMI, expensive unit for one use

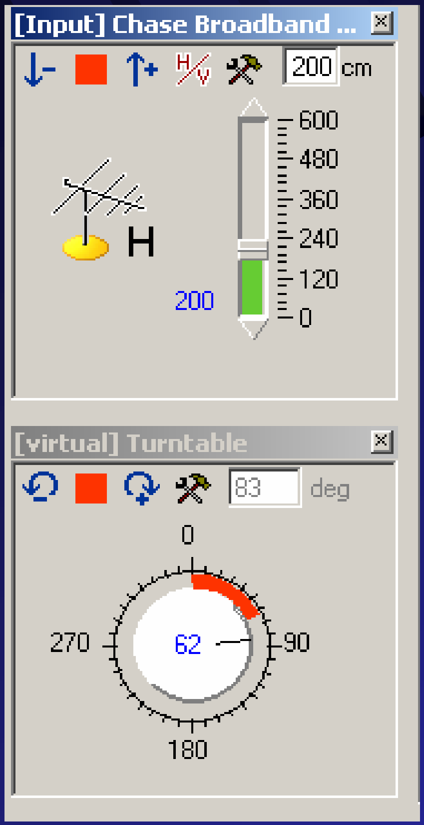
  - SA subranging negates any speed advantage over TR for EMI

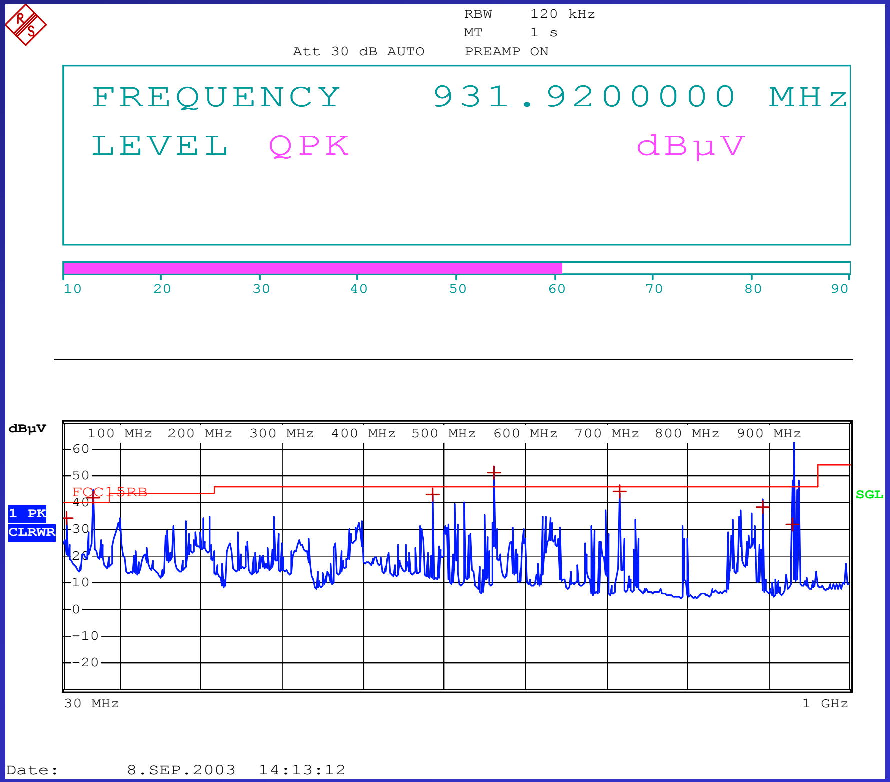
  - SA amplitude accuracy easily skewed by improper settings and interpretation

Which one to use?

- Use SA or TR for hit list

Use SA or TR for maximization





- TR is optimum for final (dwell time & auto attenuator)

Making accurate measurements

Overload protection

Detectors for EMI

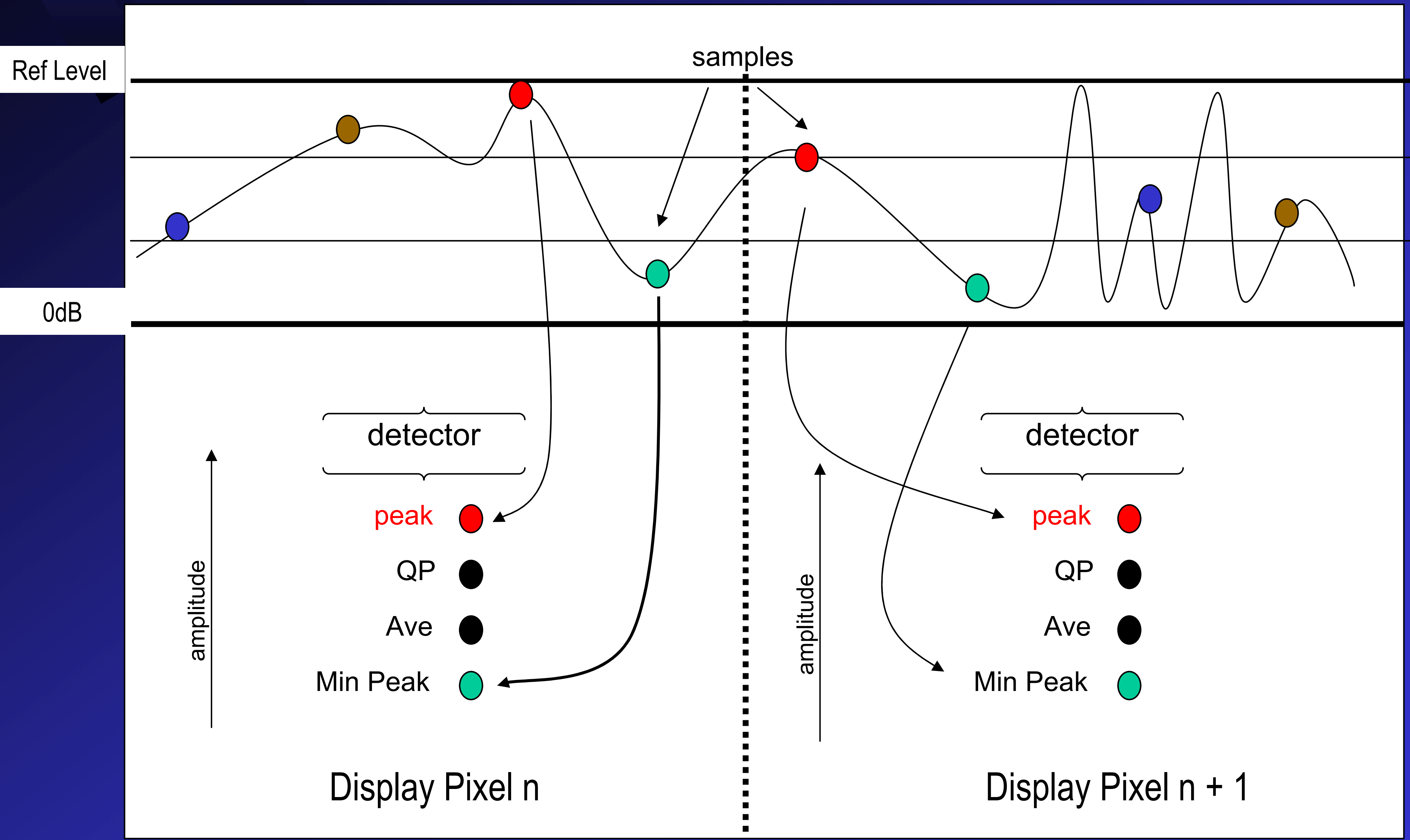
RBW Filters for EMI

Preamps

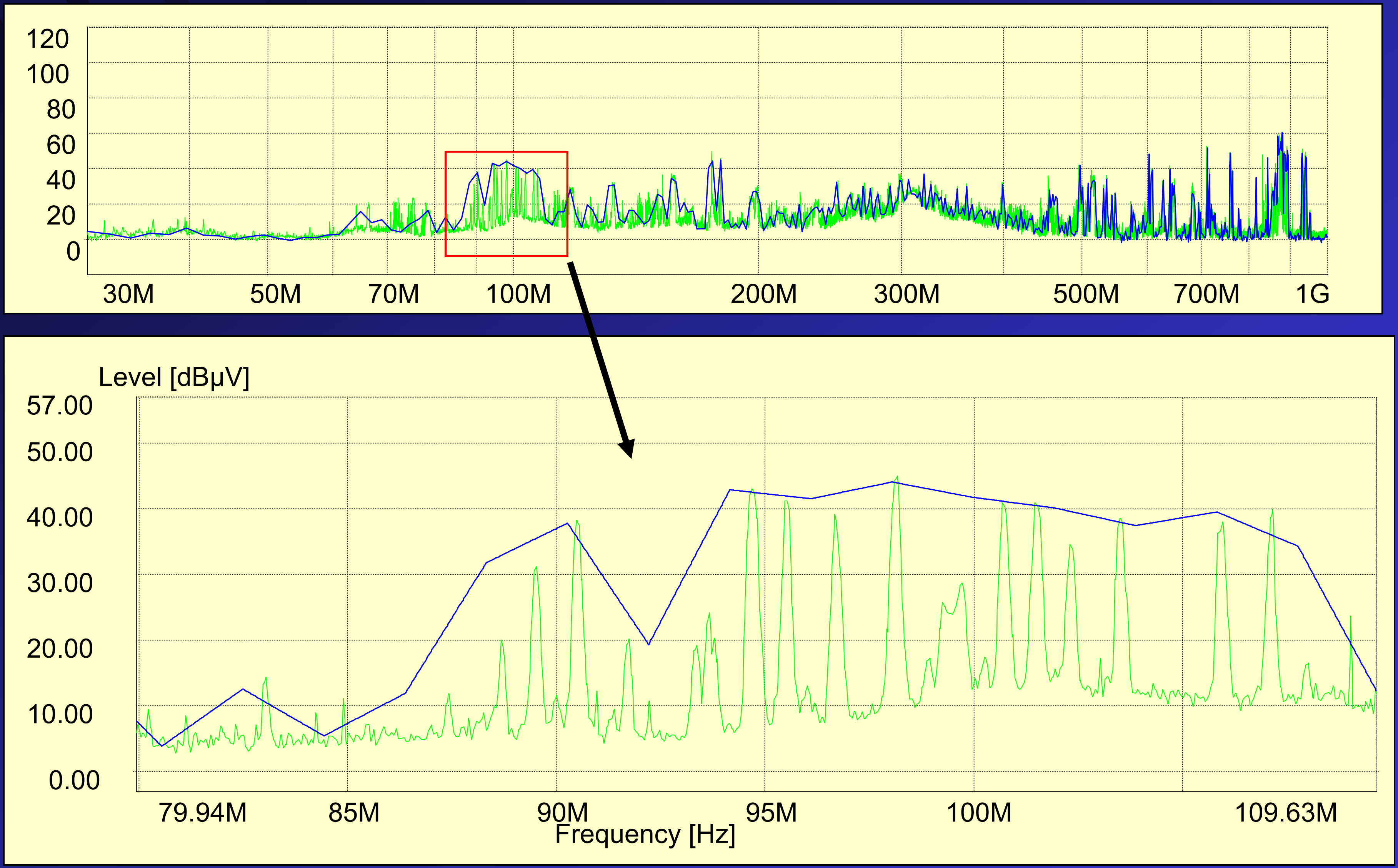
Accurate Measurement

- Background
- Dynamic Range of SA / TR is ~ 160 dB
- EMC engineers don't know what signals they are looking for initially
- Accuracy killers
  - Overloads
  - Incorrect detector settings
  - PRF & directivity of EUT emissions
  - Transducer correction factors

Samples and pixels

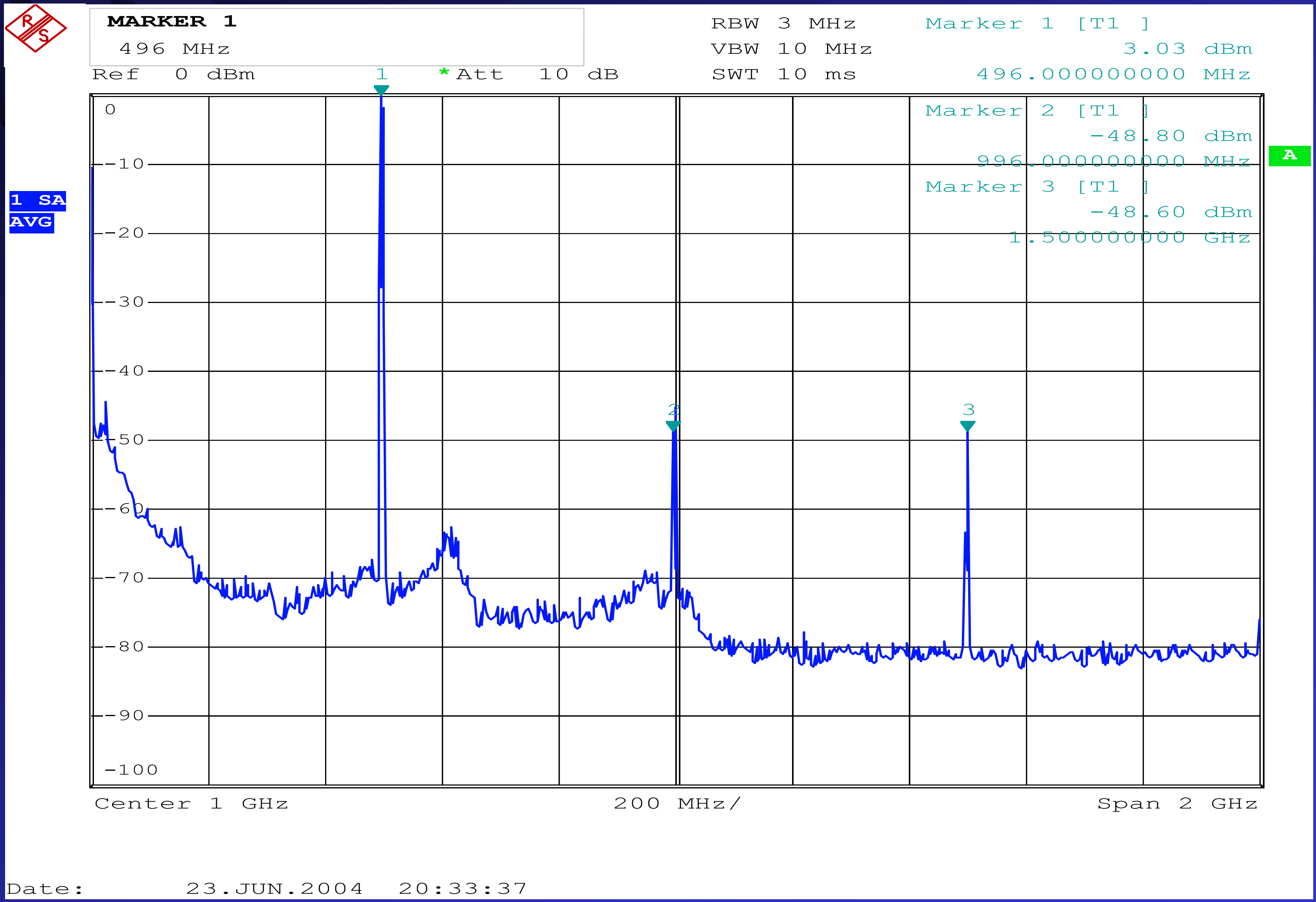


Sample Points Example



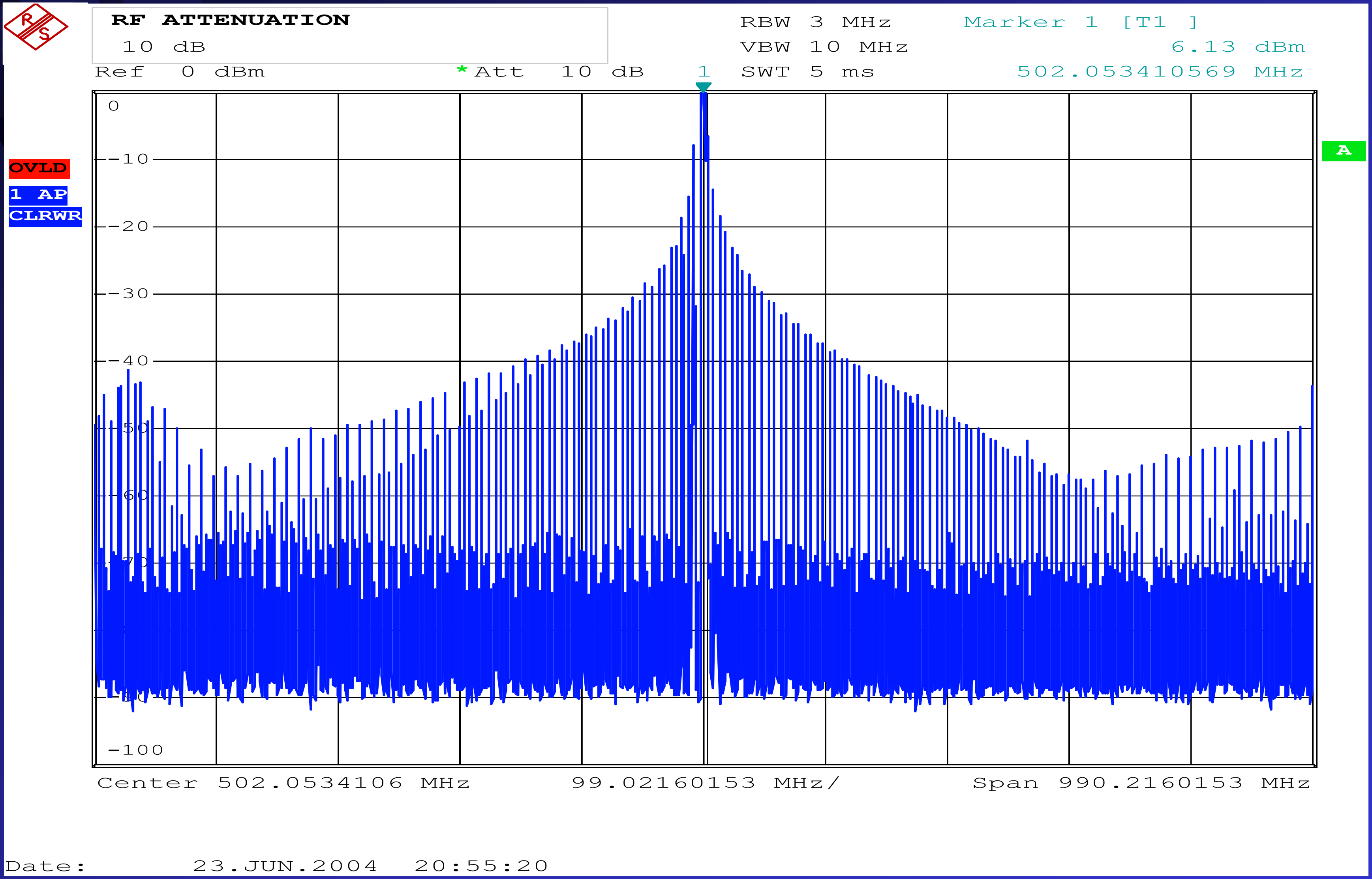
- Example: TR vs. SA sample points

RF Overload Example



- Example: amplified signal at 500 MHz

IF Overload Example

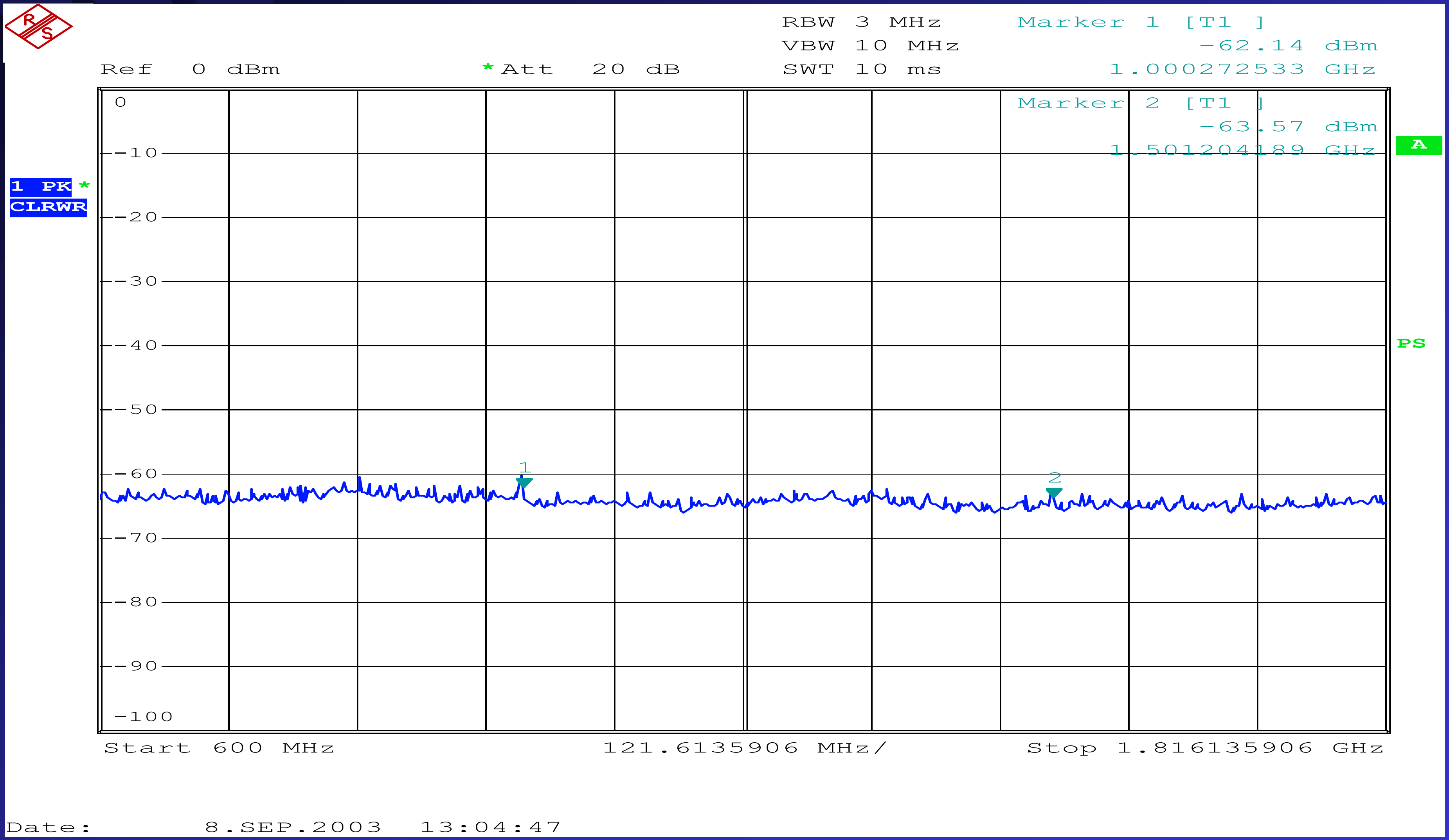


- Example: +6 dBm Pulse

Preselection Filtering

- Preselector is a "tracking" RF filter
  - ALL RF power (noise & signals) go into mixer
  - high amplitude signals outside span can influence amplitude and may be aliased
- Cure: Suppress signals before RF or IF
  - SA may not warn of RF or IF overdrive
  - IF overload won't show on display
  - Signals outside display ruin amplitude reading

Overdrive and Preselection



❖ Example: +10 dBm signal at 500 MHz

PRF and Detectors

- EUT / Detector dwell time requirements
  - Must capture "worst case" emissions of EUT
  - Cycle time and pulse repetition frequency may require extended dwell in each subrange
  - Some detectors require extended dwell settings (ave, QP)

Detector Settings

- QuasiPeak ????

  ⇒ QP is an attempt to quantify a signals Impact on a radio receiver (annoyance)

  - Factors: amplitude, frequency, width, PRF

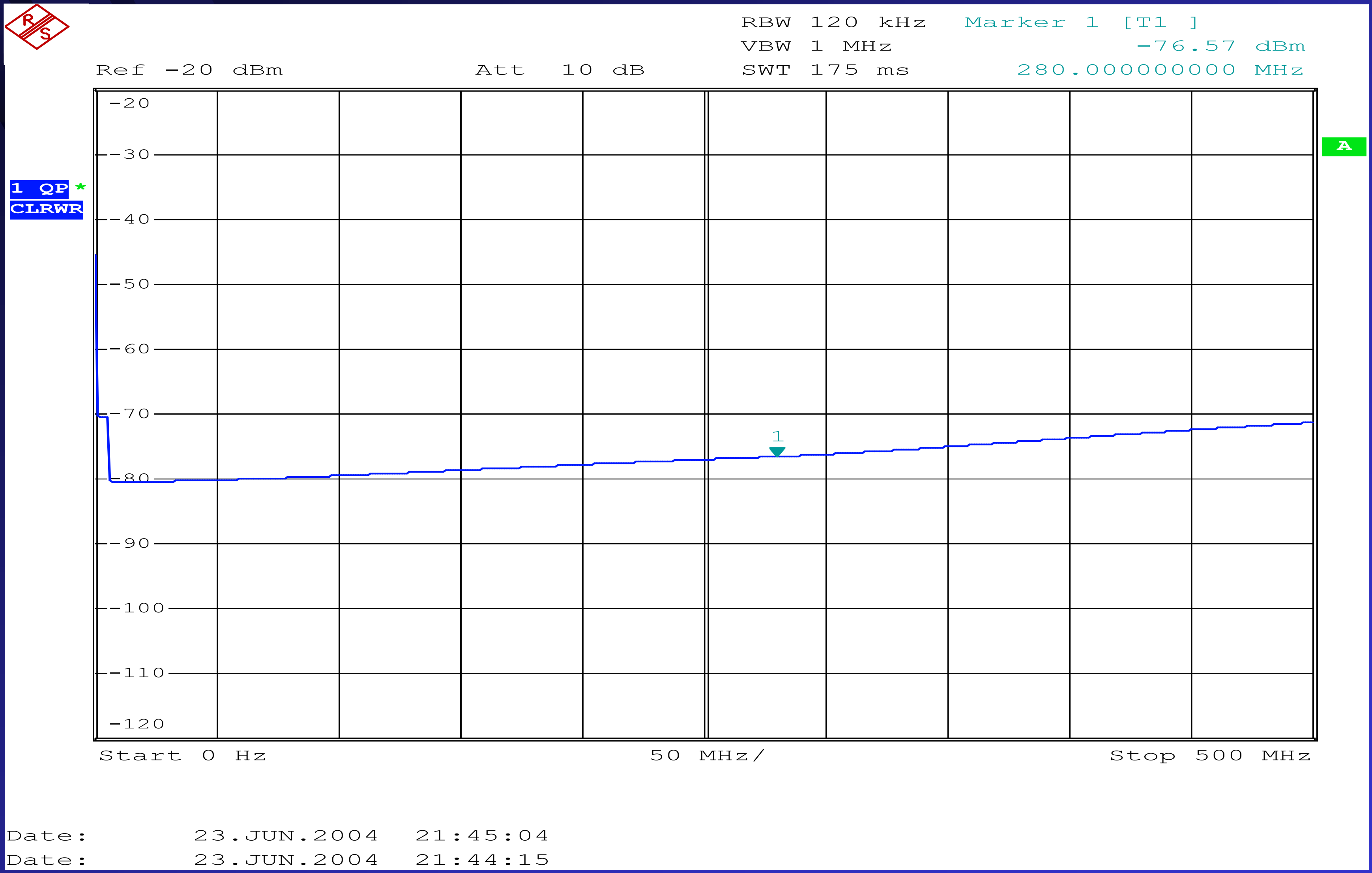
- Quasipeak restrictions

  - Dwell time (per step or subrange) > 600 mS
  - PRF issues increase dwell time requirements

Detector Settings

- Peak Detector
  - Peak gives “worst case”
  - Safest detector; Fast enough to see signals even with incorrect RBW or dwell settings
- Average Detector
  - Above 1 GHz for FCC
  - dwell for ~ 100 mS
  - Watch RBW (1MHz or 120 KHz)

Detector Settings Example



- Example: -40 dBm signal at 280 MHz

Transducers and PRF

- Transducer correction
  - CISPR needed a way to eliminate effects of chambers, antennas and cable losses
  - Standards require normalization of these effects to compare results to limit line
- EUT dwell time requirements
  - Must capture “worst case” emissions of EUT
  - Cycle time and pulse repetition frequency may require extended dwell in each subrange

Conclusion

- TR vs. SA

Span Subranges step size resolution dwell time overloading preselection

- RF & IF Overloads

RF -> Harmonics IF -> If overload flag Attenuator Ref Level

- Preamps

amplify at antenna know linear region below 1gz system check (attenuator) static

Conclusion

- Go Yankees… Enjoy the Game!

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