



EMI Testing Using Spectrum Analyzers vs. Test Receivers

**Vic Hudson
Rohde&Schwarz**

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 ?

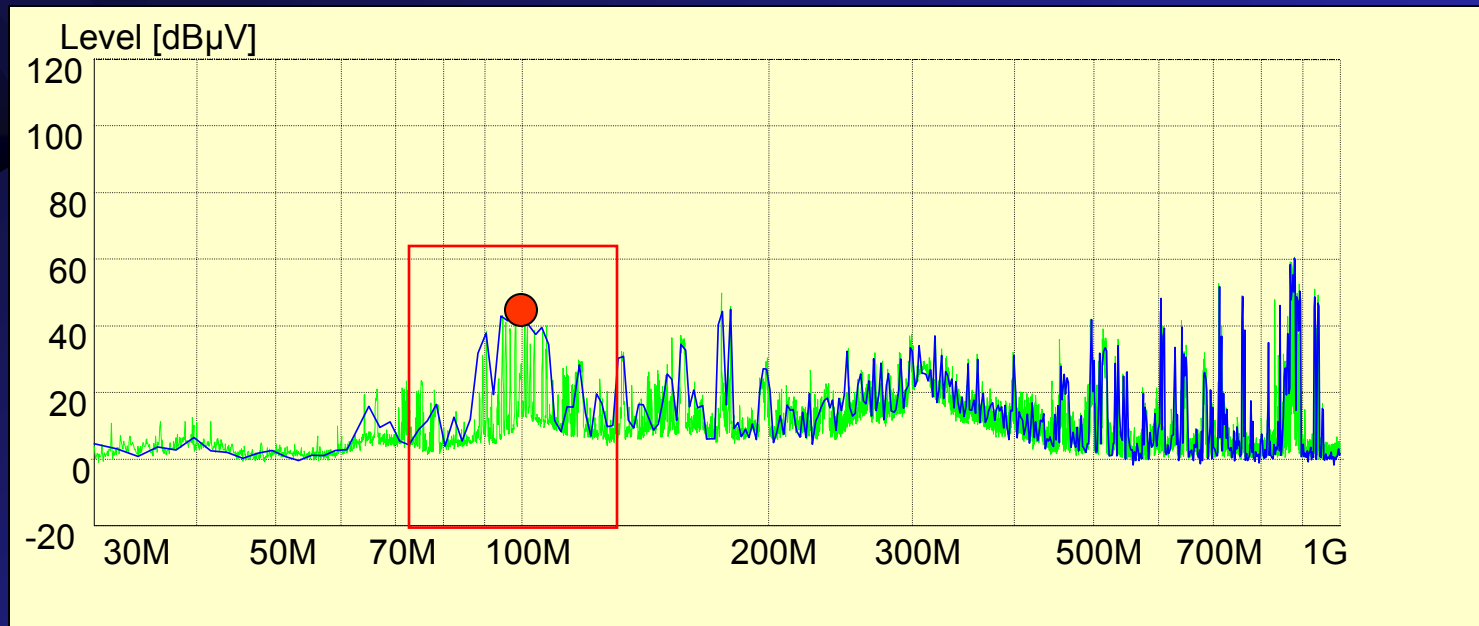
Overview

- ❖ 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

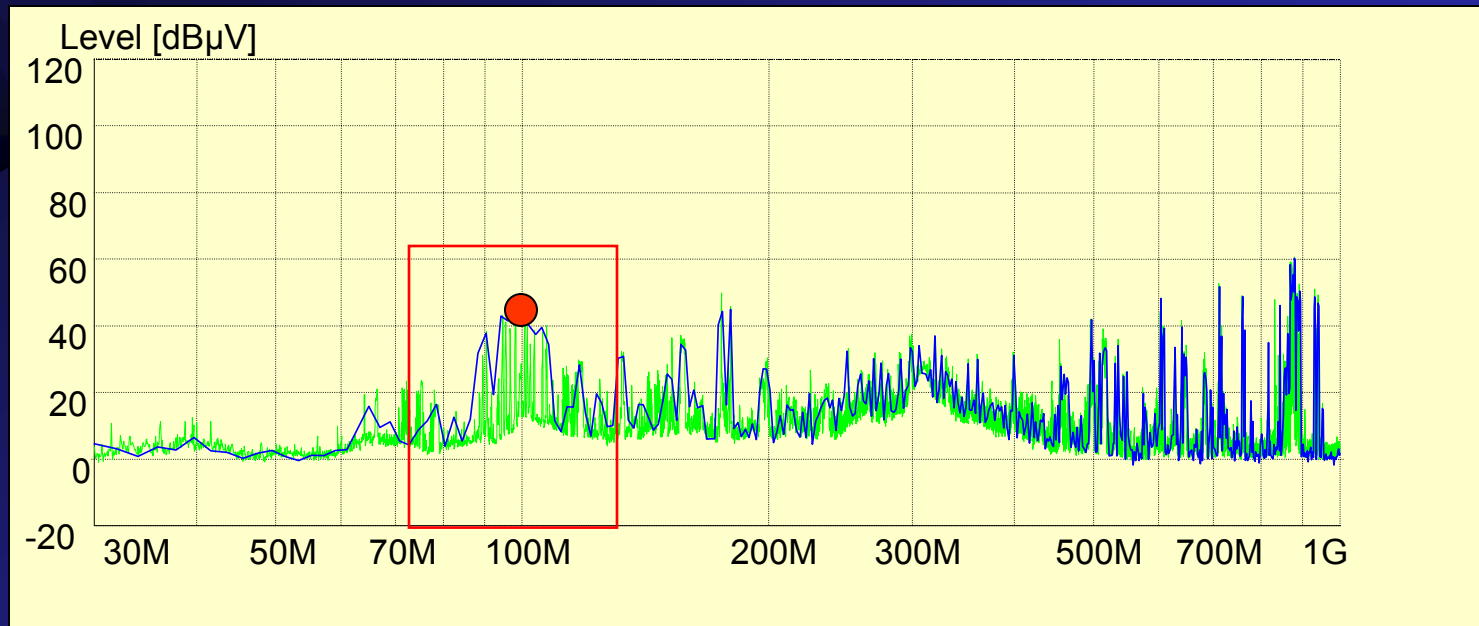
⇒ **Versatility: Wide range of uses**

⇒ **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

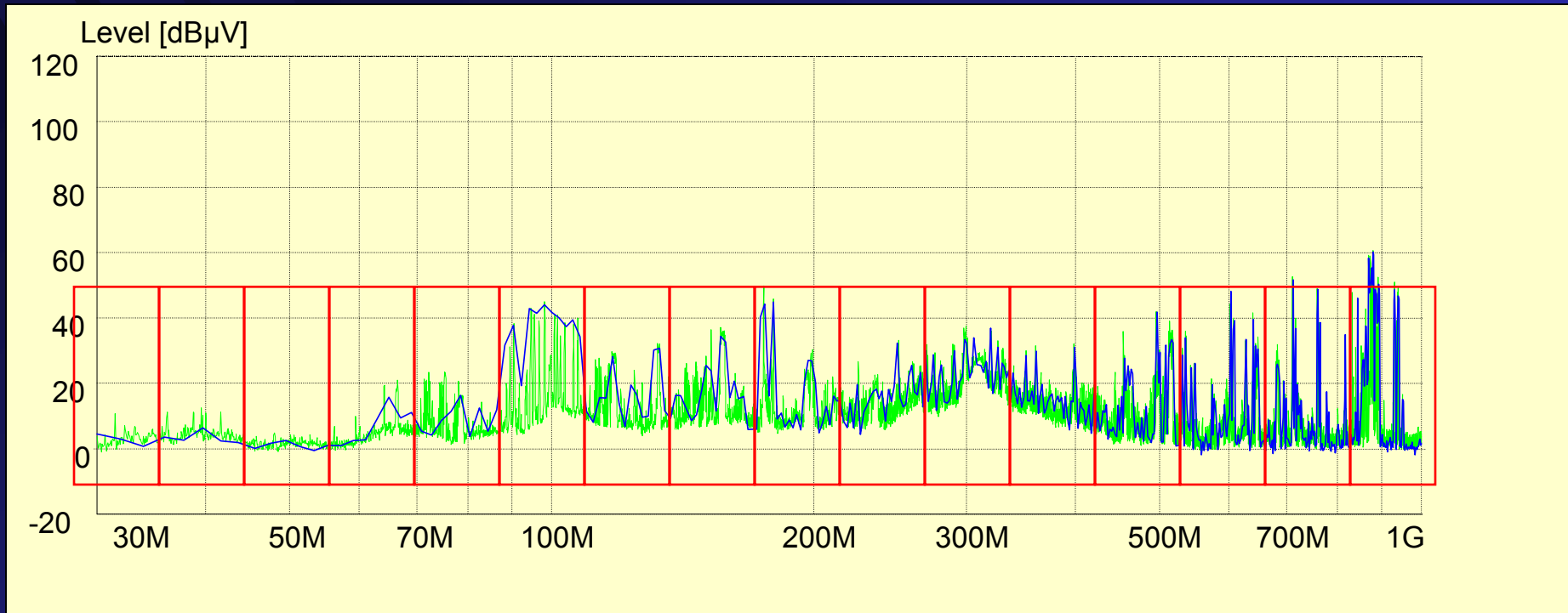
❖ Question

- 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

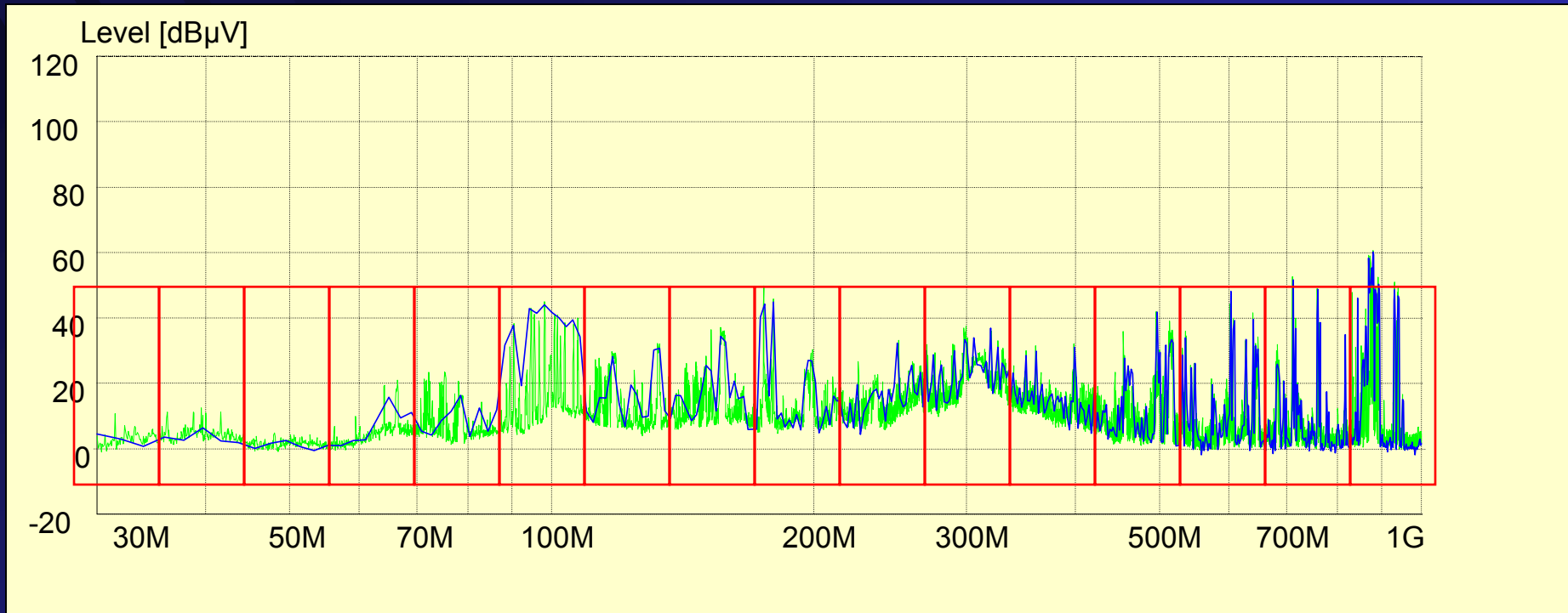
Spectrum Analyzers for EMI



❖ 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 $\frac{1}{2}$ 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 coarse for EMI without sub-ranging 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

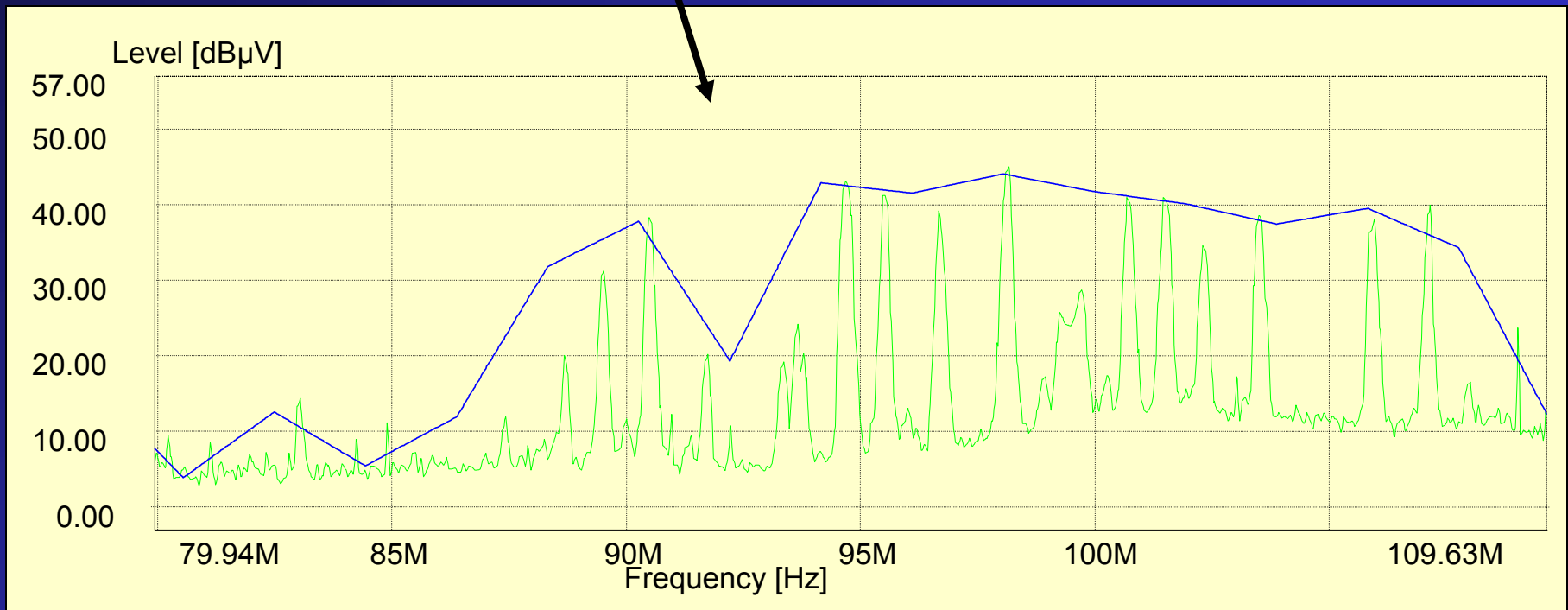
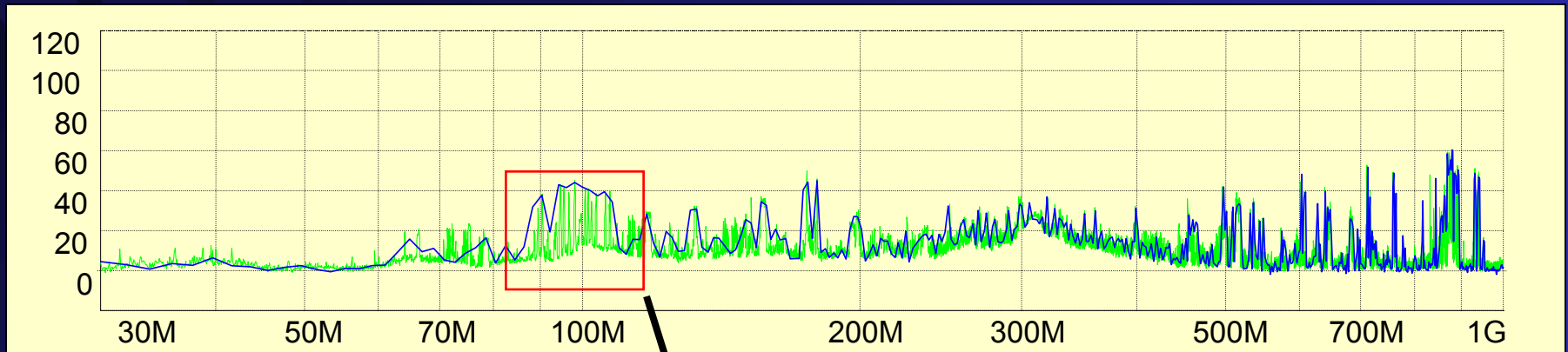
- ❖ What exactly is a EMI Test Receiver?
 - Fixed Tuned receiver versus Swept Tuned
 - Built-in Firmware for doing only EMI

Test Receivers for EMI

❖ Controls for Receivers

- 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+
- $\text{Span} / x = \text{frequency resolution}$

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?

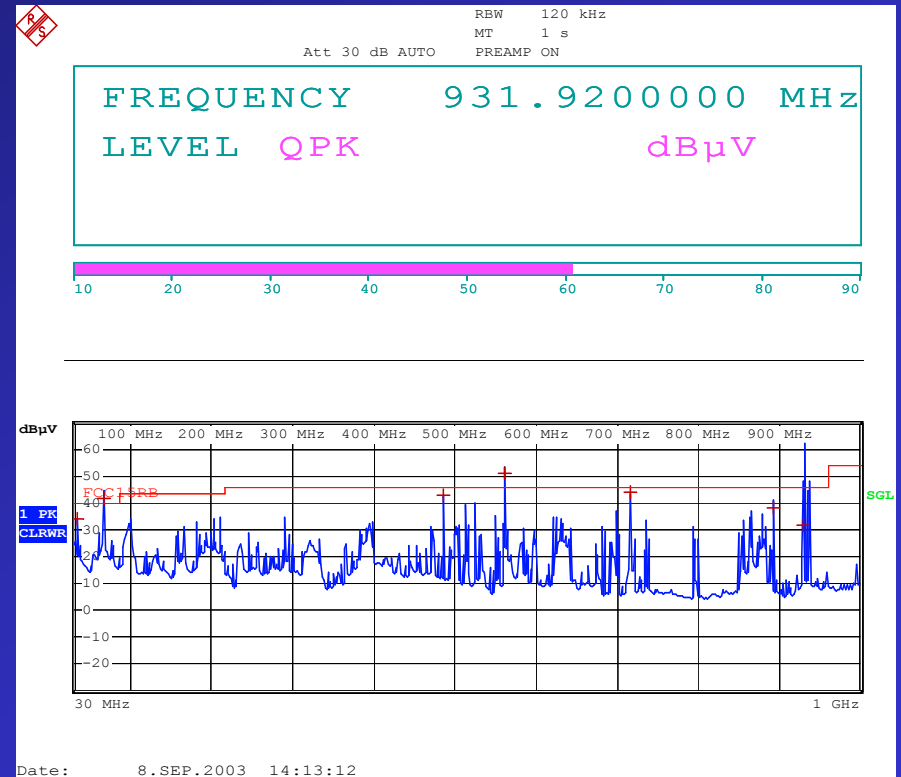
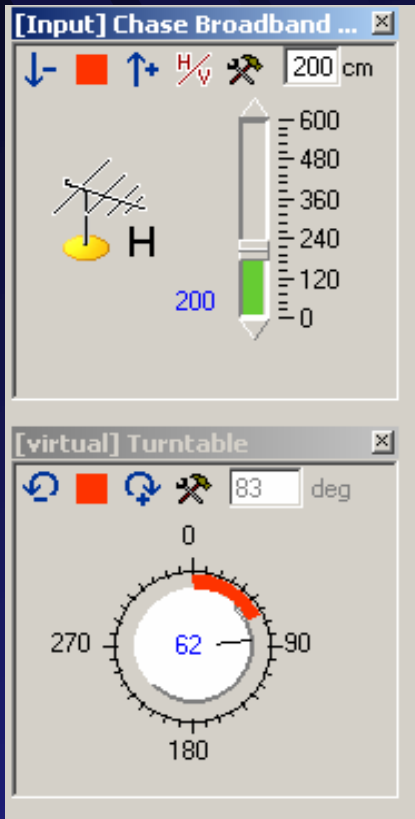
❖ Pros and Cons of Each

- 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

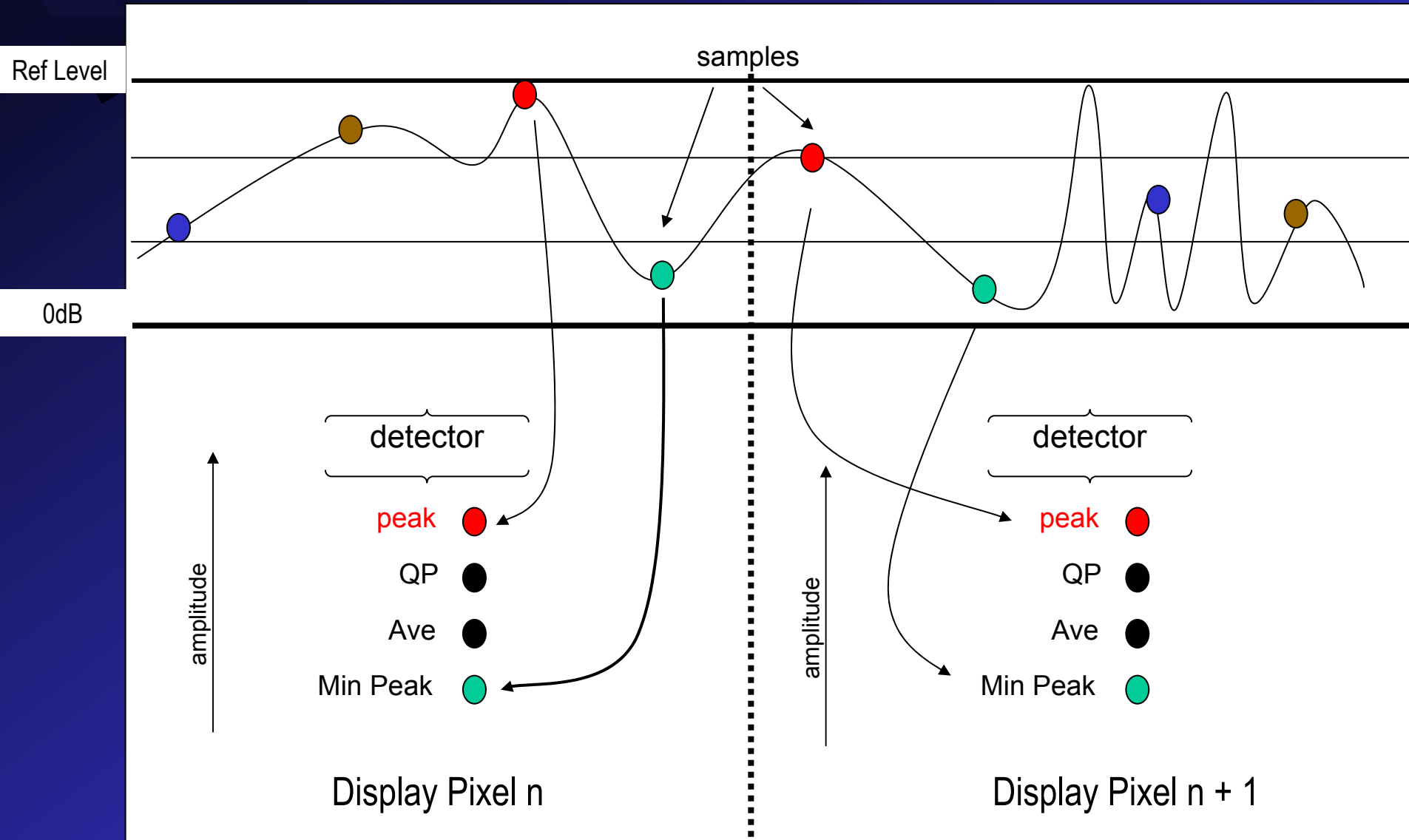
RBW Filters for EMI

Preamps

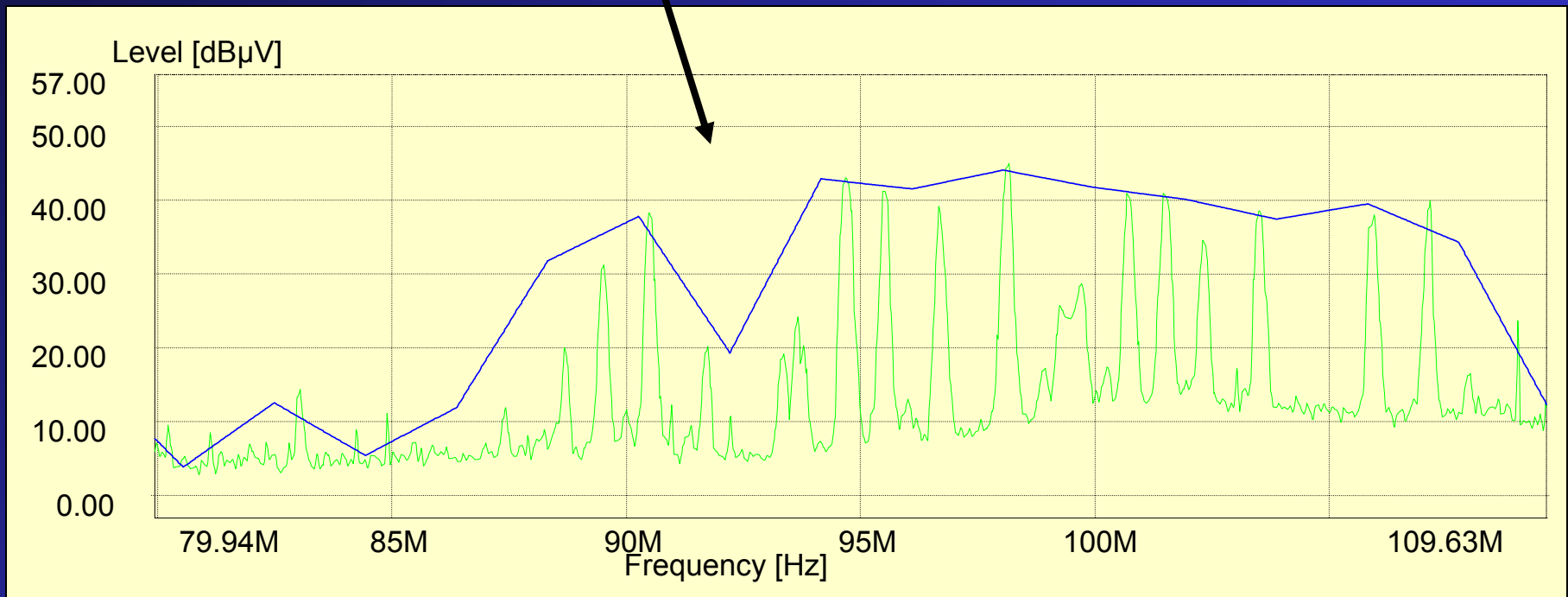
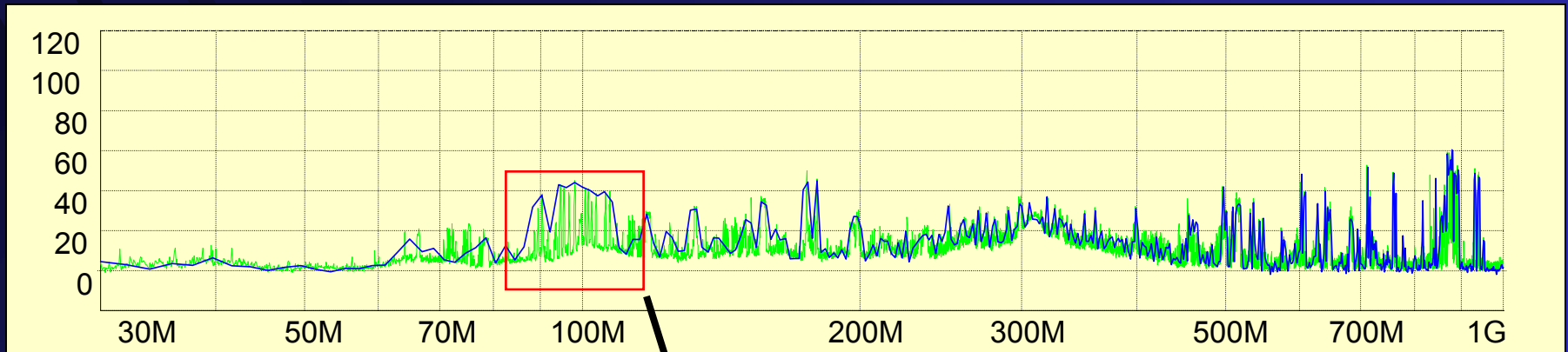
Accurate Measurement

- ❖ 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

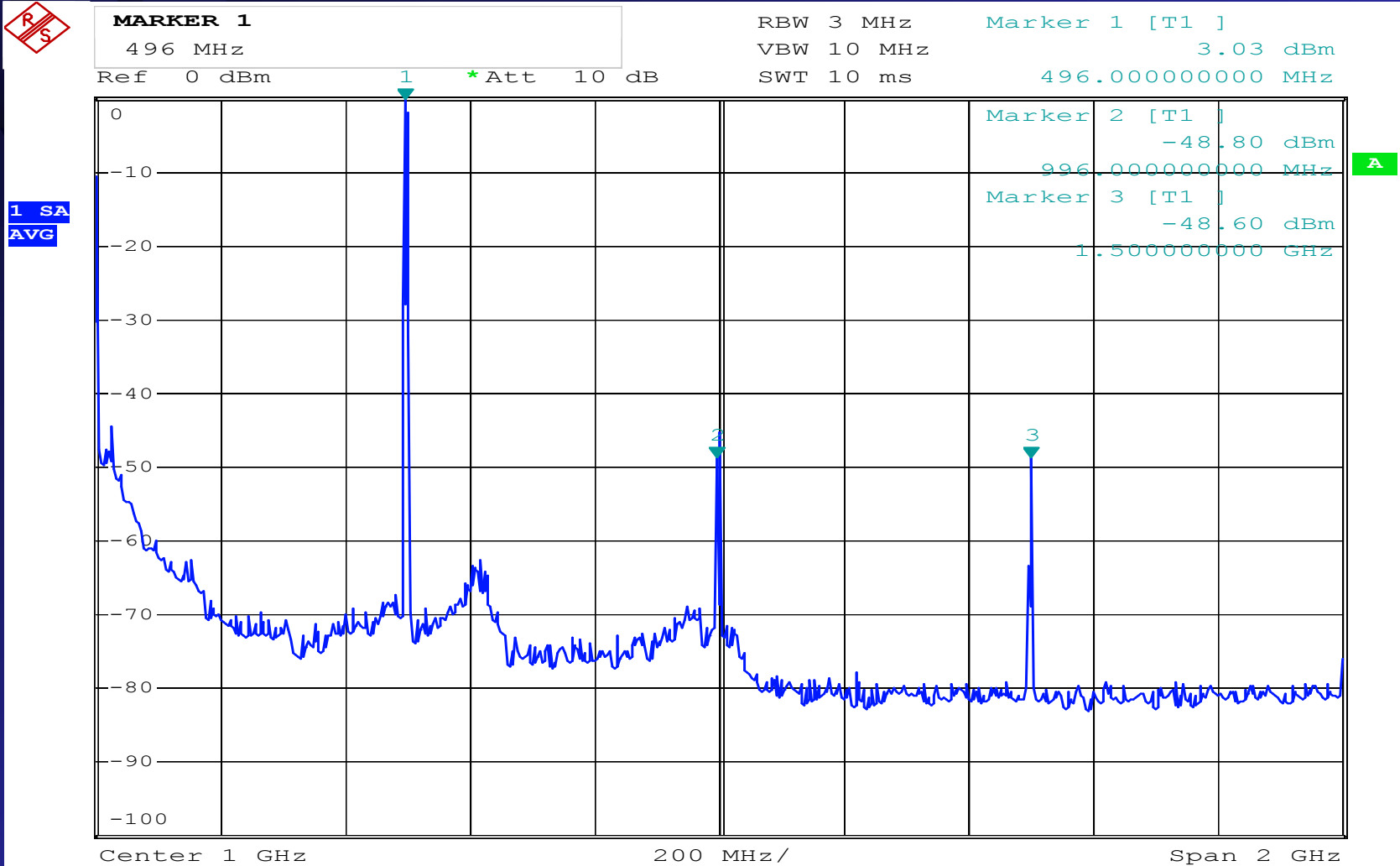


Sample Points Example



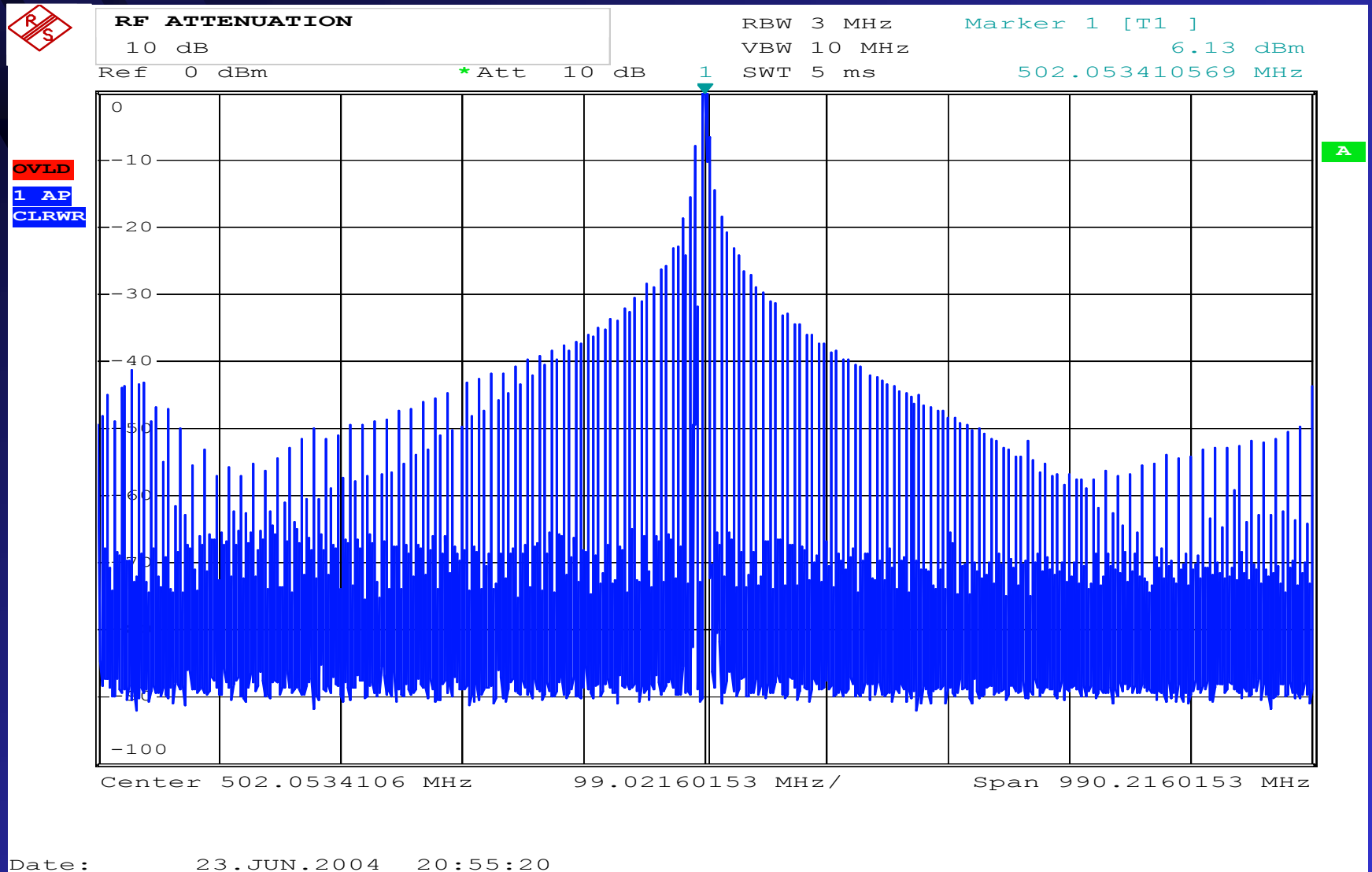
❖ Example: TR vs. SA sample points

RF Overload Example



❖ Example: amplified signal at 500 MHz

IF Overload Example

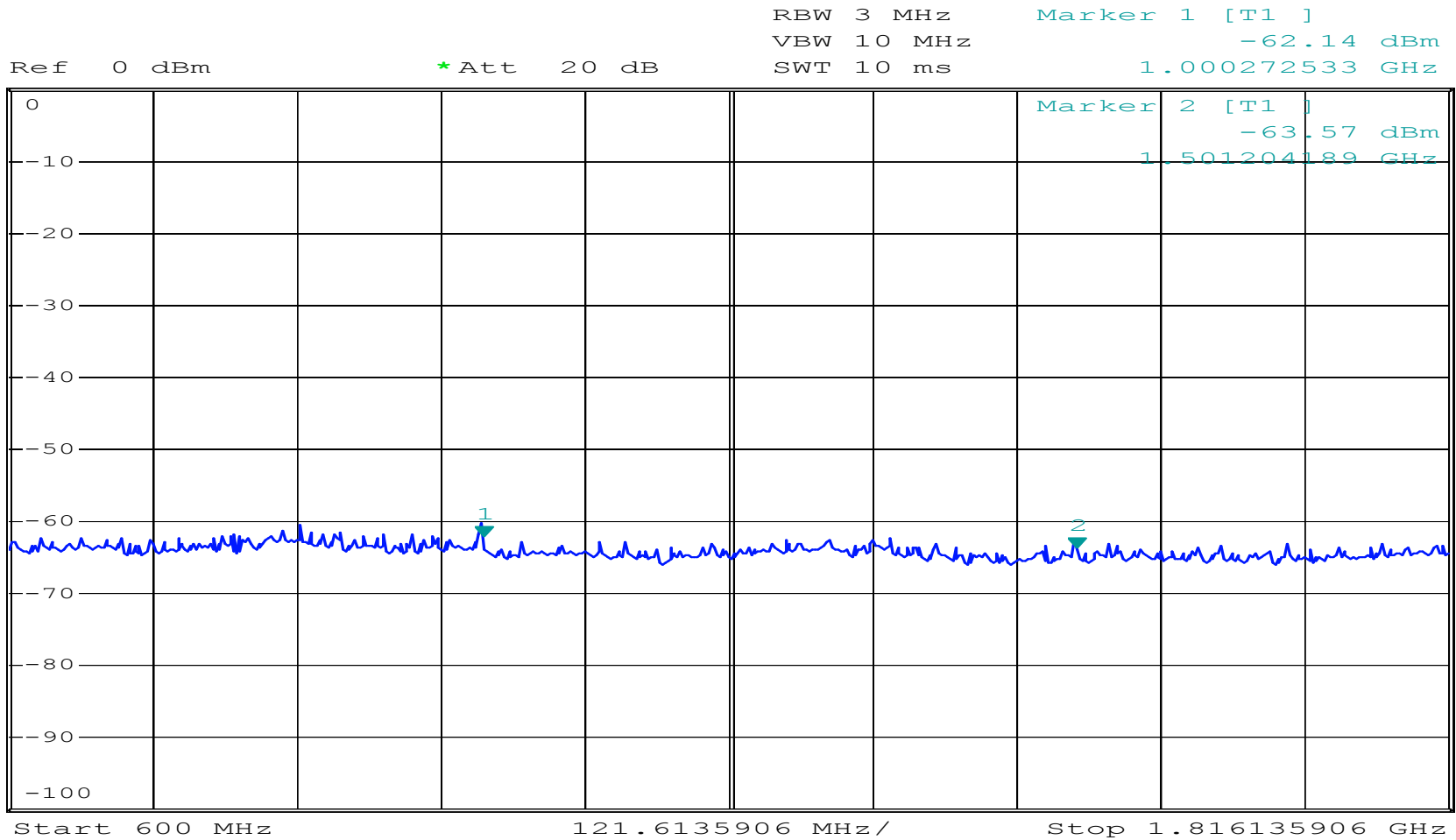


❖ Example: +6 dBm Pulse

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



Date: 8.SEP.2003 13:04:47

❖ 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)

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!

Vic Hudson

Rohde&Schwarz

EMC Systems

Ph 847 612-0618

Vic.Hudson@rohde-schwarz.com