

Determining Amplifier Nonlinearities by using “Real-World“ Signals

European Microwave Week 2003



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Nonlinear Measurement Techniques
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Swept Power
Measurement

Two Tone
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Real Signal
Any Stimulus

Real Signal
Modulated

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 - Swept Power Measurement
 - Two-Tone Measurement
 - Measurement with a real signal – Any Stimulus
 - Measurement with a real signal – Modulated Stimulus
- ◆ Conclusion

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Techniques and Fundamentals

Problem

Fundamentals
Techniques

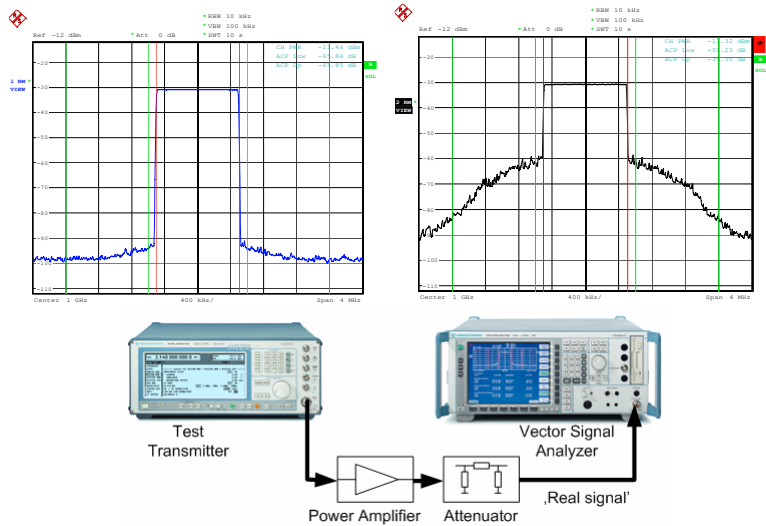
Swept Power
Measurement

Two Tone
Measurement

Real Signal
Any Stimulus

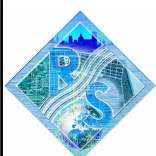
Real Signal
Modulated

Conclusion



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Techniques and Fundamentals

Goals

Fundamentals
Techniques

Swept Power
Measurement

Two Tone
Measurement

Real Signal
Any Stimulus

Real Signal
Modulated

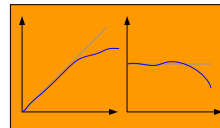
Conclusion

- ◆ Predistortion Method:

**Digital
Predistortion**



- ◆ Measure:
**AM/AM and AM/PM
compression curve**



- ◆ Model:
Polynomial approximation

- ◆ Goal:
Low ACP and EVM values

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Swept Power Measurement

Results with a Network Analyzer

Fundamentals
Techniques

Swept Power
Measurement

Two Tone
Measurement

Real Signal
Any Stimulus

Real Signal
Modulated

Conclusion

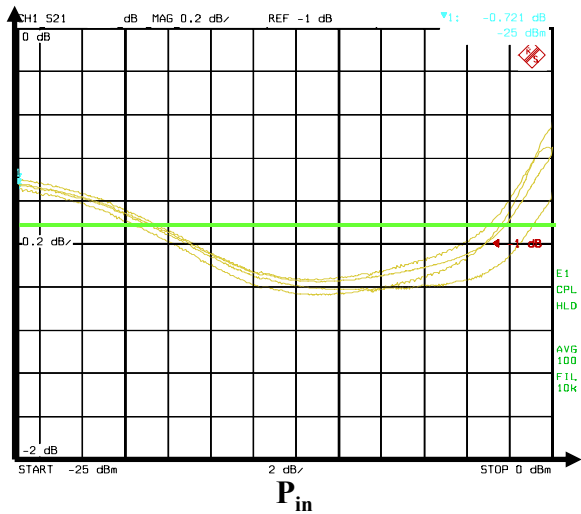
$P_{in} - P_{out}$

Increase power
FAST▶

Increase power
SLOW —▶

Decrease power
FAST ◀...

Decrease power
SLOW ◀—



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Two tone measurement

Princip of Measurement

Fundamentals
Techniques

Swept Power
Measurement

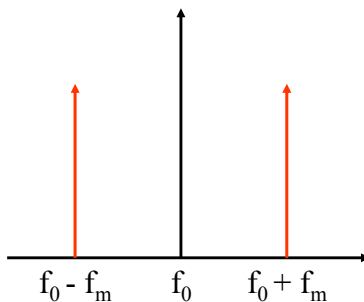
Two Tone
Measurement

Real Signal
Any Stimulus

Real Signal
Modulated

Conclusion

- ◆ Measurement with a two-tone signal
- ◆ Which modulation frequency f_m must be selected?



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Two tone measurement

Typical Result with different Modulation Frequencies

Fundamentals Techniques

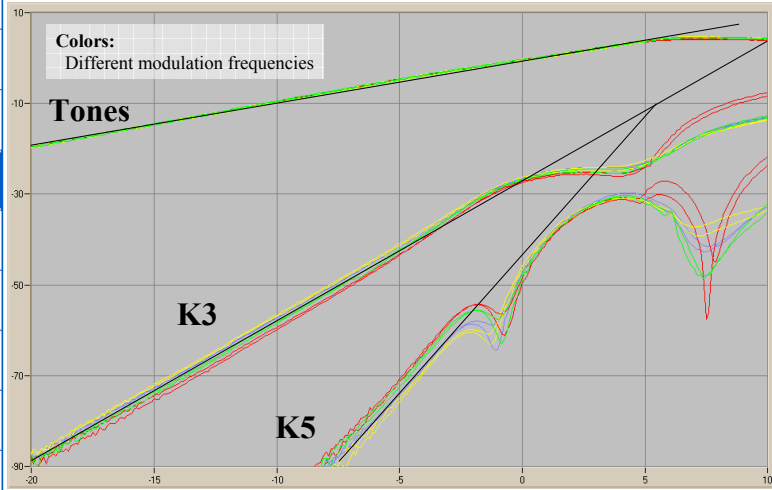
Swept Power Measurement

Two Tone Measurement

Real Signal Any Stimulus

Real Signal Modulated

Conclusion



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Two Tone Measurement

The new R&S Vector Signal Generator SMU

Fundamentals Techniques

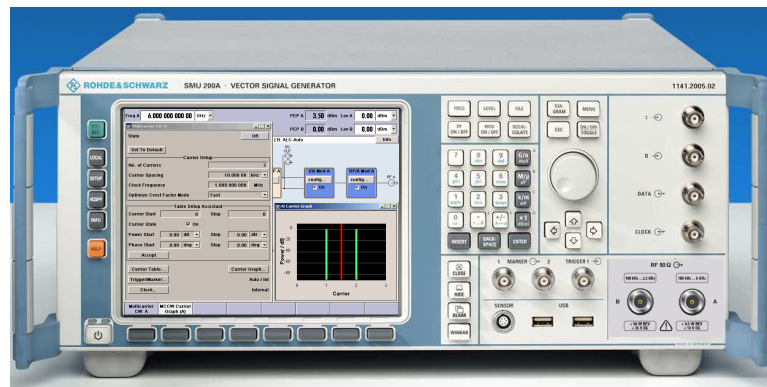
Swept Power Measurement

Two Tone Measurement

Real Signal Any Stimulus

Real Signal Modulated

Conclusion



For more information, visit our stand

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Results with different test signals

CW – Multi-Tone - Pulse

Fundamentals
Techniques

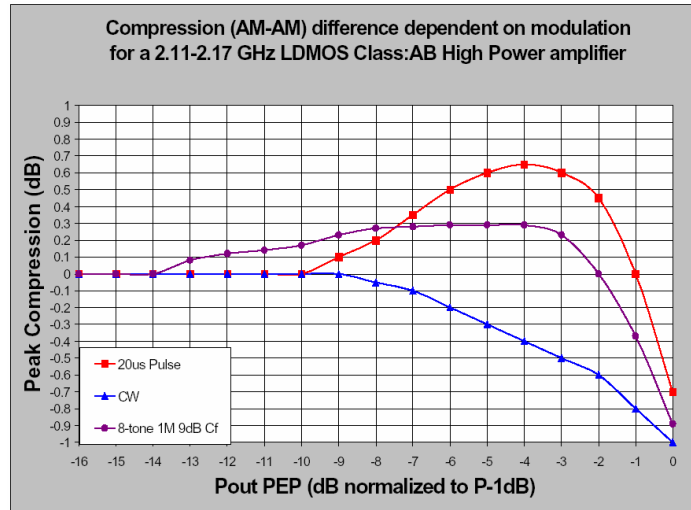
Swept Power
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Results with different test signals

Conclusion

Fundamentals
Techniques

Swept Power
Measurement

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Real Signal
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Real Signal
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Conclusion

- ◆ The crest factor of the stimulus signal has a significant influence on the measured AM/AM and AM/PM compression curve


CONSEQUENCE:

Measurements need to be performed on a signal with the same bandwidth and crest factor as in real operation conditions

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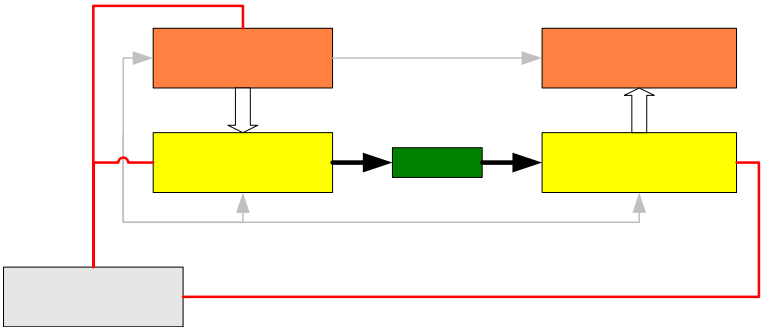
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Real Signal – Any Stimulus

Test Setup Overview – R&S Software *AmpTune*

Fundamentals Techniques	
Swept Power Measurement	
Two Tone Measurement	
Real Signal Any Stimulus	
Real Signal Modulated	
Conclusion	


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Real Signal – Any Stimulus

Measurement Steps

Fundamentals Techniques	<ul style="list-style-type: none"> ◆ Generate the test signal or load it via file ◆ Adjust the DUT input level for the desired RMS output level ◆ Downconvert the RF signal to IQ baseband and sample it ◆ Perform a synchronization ◆ Calculate the AM/AM and AM/PM model ◆ Predistore the test signal ◆ Verify the predistortion effect
Swept Power Measurement	
Two Tone Measurement	
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Real Signal Modulated	
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Real Signal – Any Stimulus

Available Test Signals

Fundamentals
Techniques

Swept Power
Measurement

Two Tone
Measurement

Real Signal
Any Stimulus

Real Signal
Modulated

Conclusion

- ◆ Bandlimited Noise (generated internally)
- ◆ Two Tone (generated internally)
- ◆ Signals from WinIQSIM (import via file)
- ◆ Signals from many simulation tool (import via IQWizard)
- ◆ NPR (Noise Power Ratio) signals (import via IQWizard, generation via NPR tool)

<http://www.rohde-schwarz.com> -> Application Notes

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Real Signal – Any Stimulus

Key Features

Fundamentals
Techniques

Swept Power
Measurement

Two Tone
Measurement

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Any Stimulus

Real Signal
Modulated

Conclusion

- ◆ Precise timing synchronisation and delay calculation
- ◆ Auto-leveling of the DUT output power
- ◆ Measurement of RF-to-RF devices (Amplifiers, ...)
- ◆ Measurement of IQ-to-RF devices (direct-upconverter, ...)
- ◆ Support of all R&S Signal Generators and IQ Sources (AMIQ, SMIQ-B60, SMIQ, SMU)
- ◆ Support of all R&S Signal and Spectrum Analyzers (FSIQ, FSP, FSU, FSQ)
- ◆ HTML Measurement Report including curve coefficients
- ◆ Free-of-charge software

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Real Signal – Any Stimulus

Signal Processing

Fundamentals
Techniques

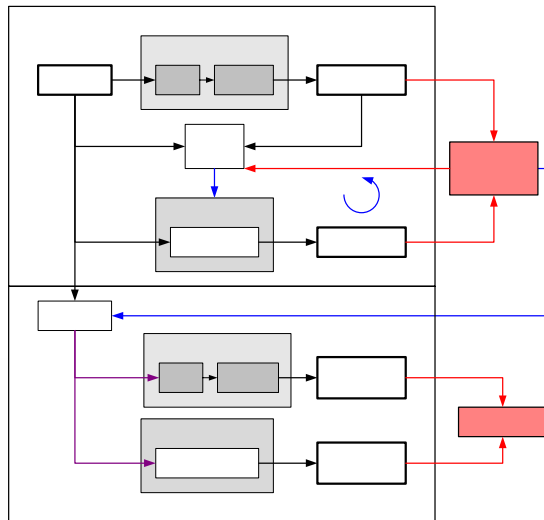
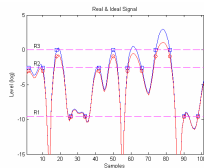
Swept Power
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Real Signal – Any Stimulus

AM/AM and AM/PM Measurement and Predistortion

Fundamentals
Techniques

Swept Power
Measurement

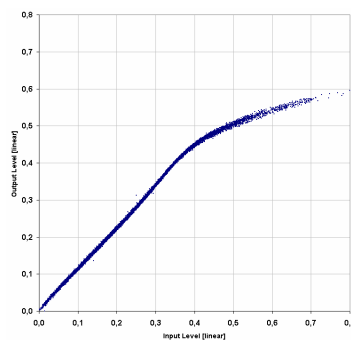
Two Tone
Measurement

Real Signal
Any Stimulus

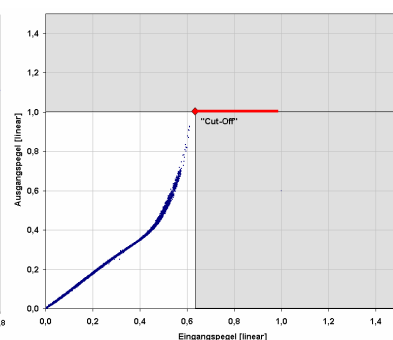
Real Signal
Modulated

Conclusion

AM/AM curve



AM/AM predistortion



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Real Signal – Any Stimulus

Predistortion Results with 8 MHz signal, 10 dB Crest

Fundamentals Techniques

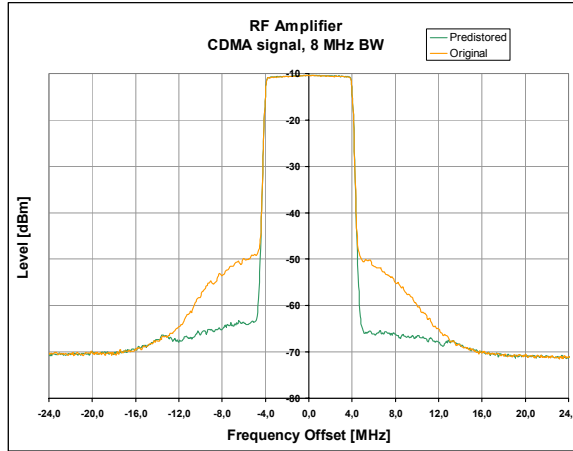
Swept Power Measurement

Two Tone Measurement

Real Signal Any Stimulus

Real Signal Modulated

Conclusion



Without predistortion	
CH Power	-11.26 dBm
ACP Low	-44.46 dB
ACP Up	-44.47 dB
ALT1 Low	-61.73 dB
ALT1 Up	-61.85 dB

With predistortion	
CH Power	-11.25 dBm
ACP Low	-58.09 dB
ACP Up	-58.28 dB
ALT1 Low	-61.12 dB
ALT1 Up	-61.23 dB

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Real Signal – Any Stimulus

Free software **AmpTune** from Rohde & Schwarz

Fundamentals Techniques

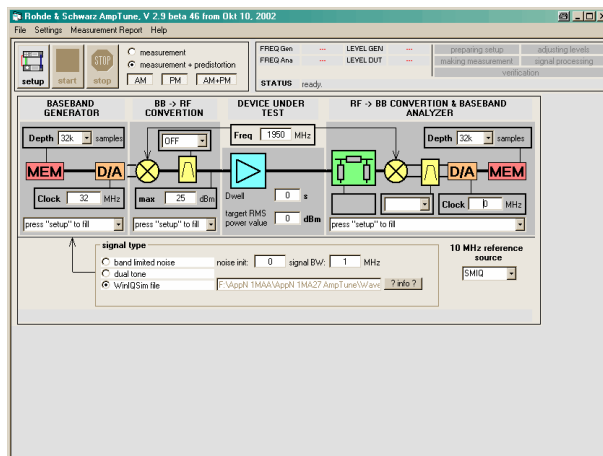
Swept Power Measurement

Two Tone Measurement

Real Signal Any Stimulus

Real Signal Modulated

Conclusion



<http://www.rohde-schwarz.com/AppNote/1MA27>

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Real Signal – Modulated

Measurement with Rohde & Schwarz FSQ & FSQ-K70

Fundamentals
Techniques

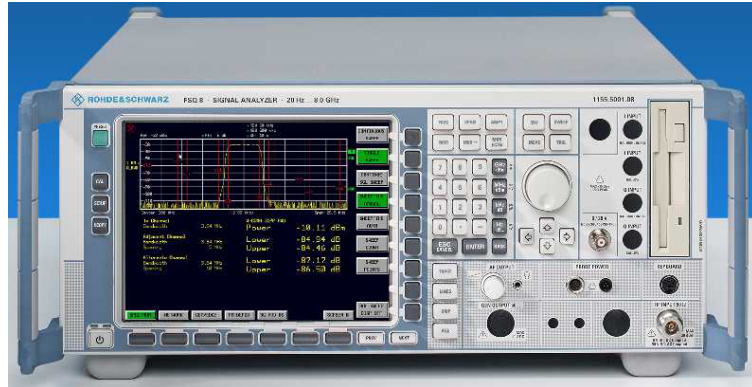
Swept Power
Measurement

Two Tone
Measurement

Real Signal
Any Stimulus

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Conclusion



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Real Signal – Modulated

Principals of Operation – Vector Signal Analysis

Fundamentals
Techniques

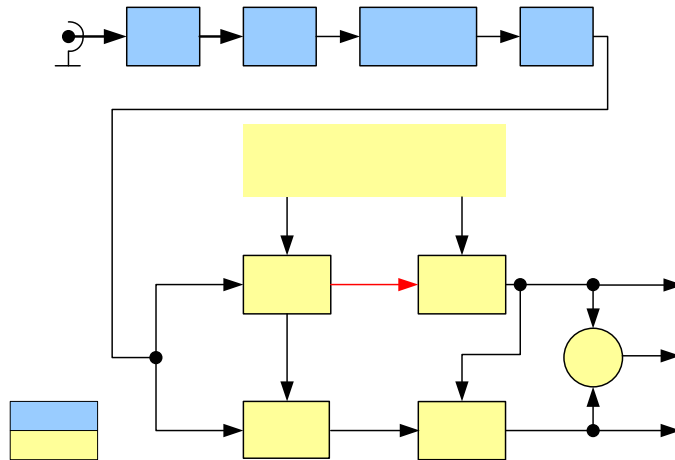
Swept Power
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Two Tone
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Real Signal
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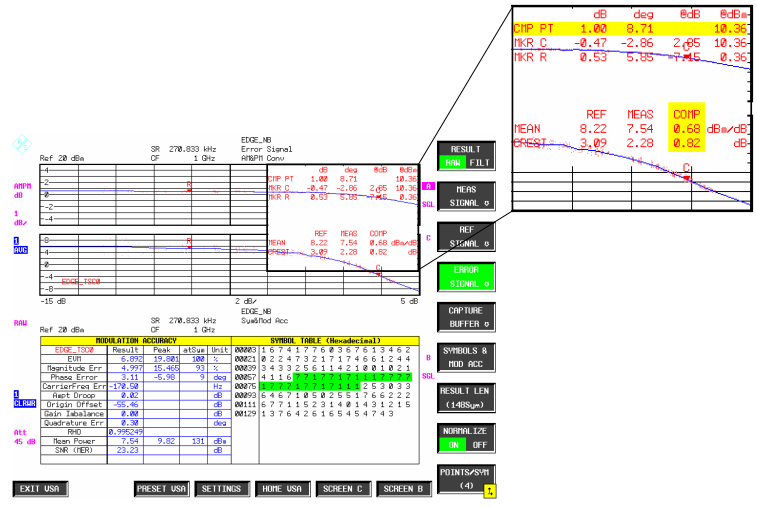




Real Signal – Modulated

Measurement with Rohde & Schwarz FSQ-K70

- Fundamentals Techniques
- Swept Power Measurement
- Two Tone Measurement
- Real Signal Any Stimulus
- Real Signal Modulated
- Conclusion



Conclusion

Overview over the Presented Methods

- Fundamentals Techniques
- Swept Power Measurement
- Two Tone Measurement
- Real Signal Any Stimulus
- Real Signal Modulated
- Conclusion

	Swept Power	Two Tone	Real Signal „AmpTune“	Real Signal FSQ-K70
Suitable for Amplifier Test	NO	PARTLY	YES	YES
Stimulus	Single Carrier	Two Tone	Any Signal	Vector Mod. Signal
Measurement Bandwidth	LOW	HIGH	HIGH	HIGH
Automatic Predistortion	NO	NO	YES	NO
Measurement Report	NO	NO	YES	NO
Generator	Network Analyzer ZVx	SMU	SMIQ / SMU	SMIQ / SMU
Analysator		FSP/U/Q	FSP/U/Q	FSQ
Software	---	---	AmpTune	---





Thank you for your attention!
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Fundamentals
Techniques

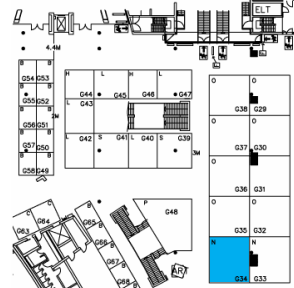
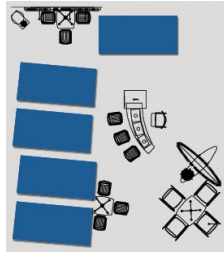
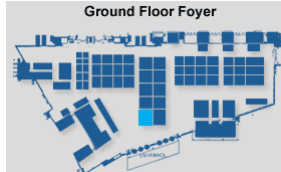
Swept Power
Measurement

Two Tone
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**Ground Floor Foyer
Stand G34**

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