MIC-MRA Workshop

Challenges in the evaluation of
IEEE 802.11ad (60 GHz) signals

Discussion on dynamic, test procedures, etc.

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ROHDE&SCHWARZ

Signal Generation / Analysis

Modulated Signal

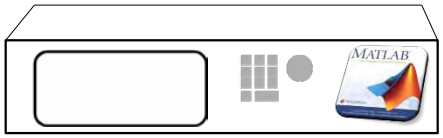
Oscilloscope used as ADC with large bandwidth

- **Signal Generation / Analysis up to 67 GHz and above**
- **2GHz Bandwidth**

Analysis above 67 GHz and 2GHz RF bandwidth

2GHz RF bandwidth

…any Wideband ARB generator

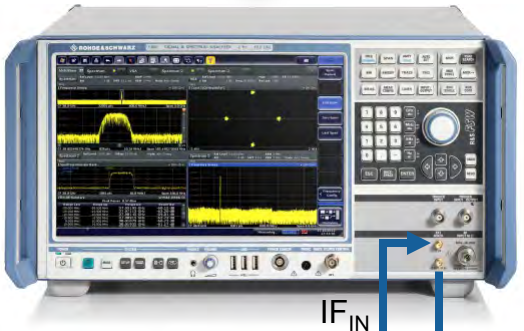


IQ

Wideband IF

IQ data

Signal and Spectrum Analyzer



mm-wave reference plane:
DUT is inserted here

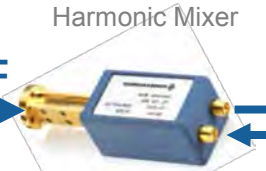
Vector Signal Generator

Special Upconverter Solution

IF

RF

Harmonic Mixer



i.e. 72 GHz

LO

IF_{IN}

LO_{out}

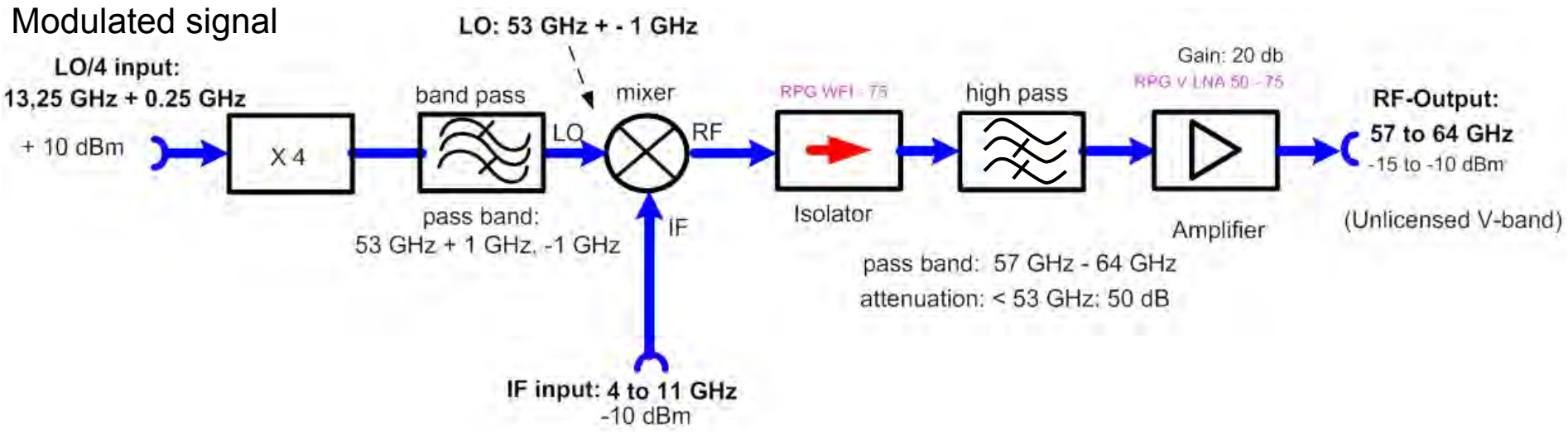
Two paths
up to 20 GHz each:
e.g. f_{LO}=17 GHz
and f_{IF}= 4 GHz

Up to 67GHz no external mixer for analyzer required

Signal Generation / Analysis

Modulated Signal

High effort to provide with a 2 GHz-BW signal on the transmitter side.



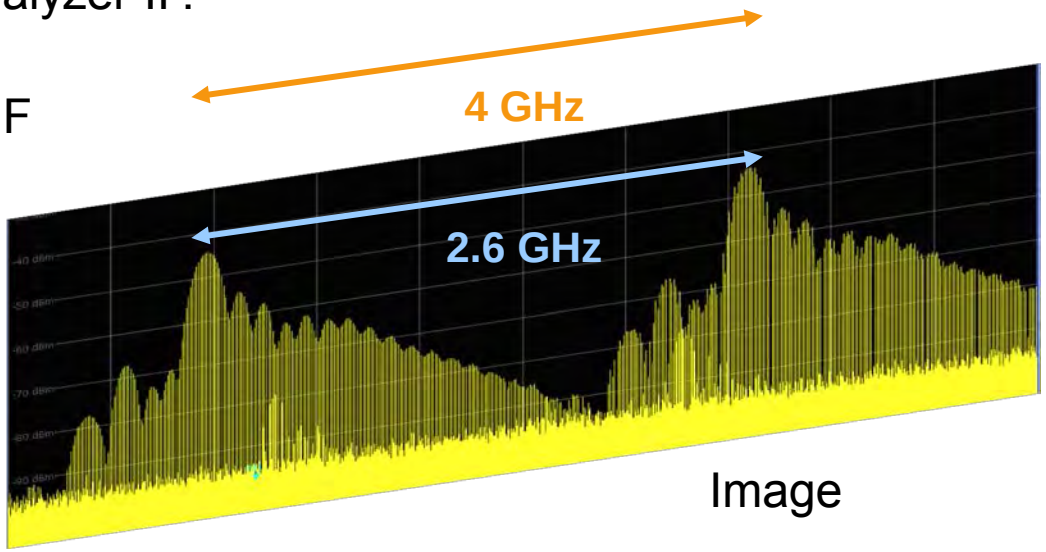
Upconverter example with discrete RF components.

Image-free Ranges

Modulated Signal

Distance between true signal and image signal depends on analyzer IF.

Distance = 2*IF



Example: evaluation of pulsed signal
pulse length 10 ns and PRF 10 MHz.

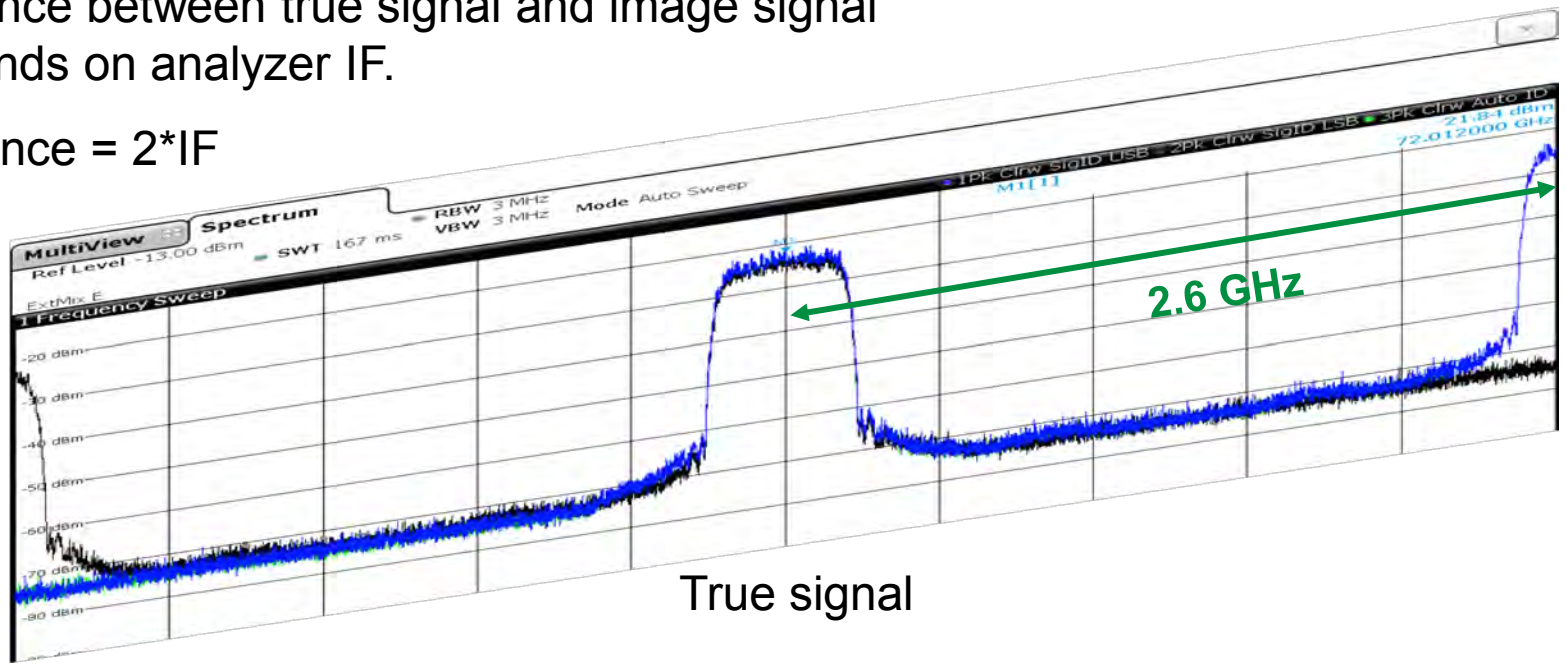
IF = 1.32 GHz for FSW built until Q2/2014.
IF = 2.0 GHz available for FSW built after Q2/2014

Image-free Ranges

Modulated Signal

Distance between true signal and image signal depends on analyzer IF.

Distance = 2*IF



True signal

Image

Example: evaluation of E-Band radio link signal

4 GHz distance possible depending on analyzer model version.

Image-free Ranges

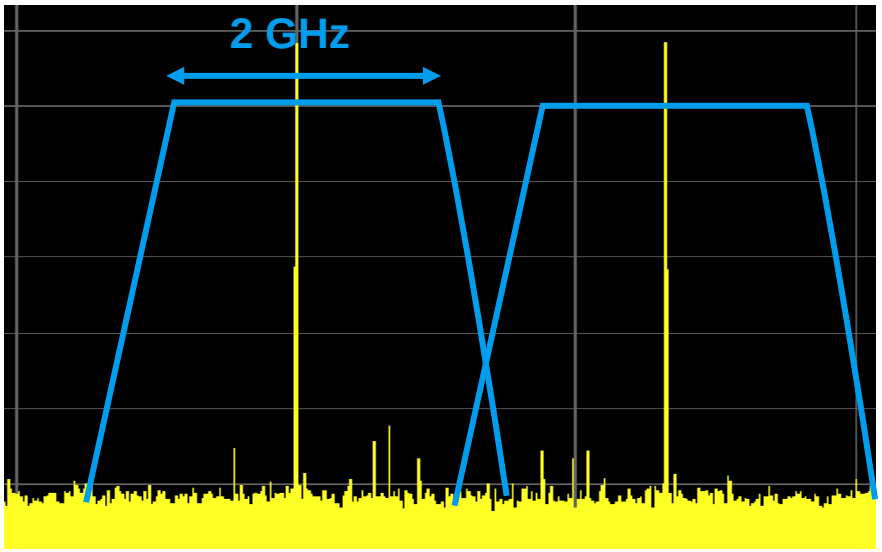
CW Signal / Modulated Signal

Distance between true signal and image signal depends on analyzer IF.

Distance = 2*IF

True signal

Image signal

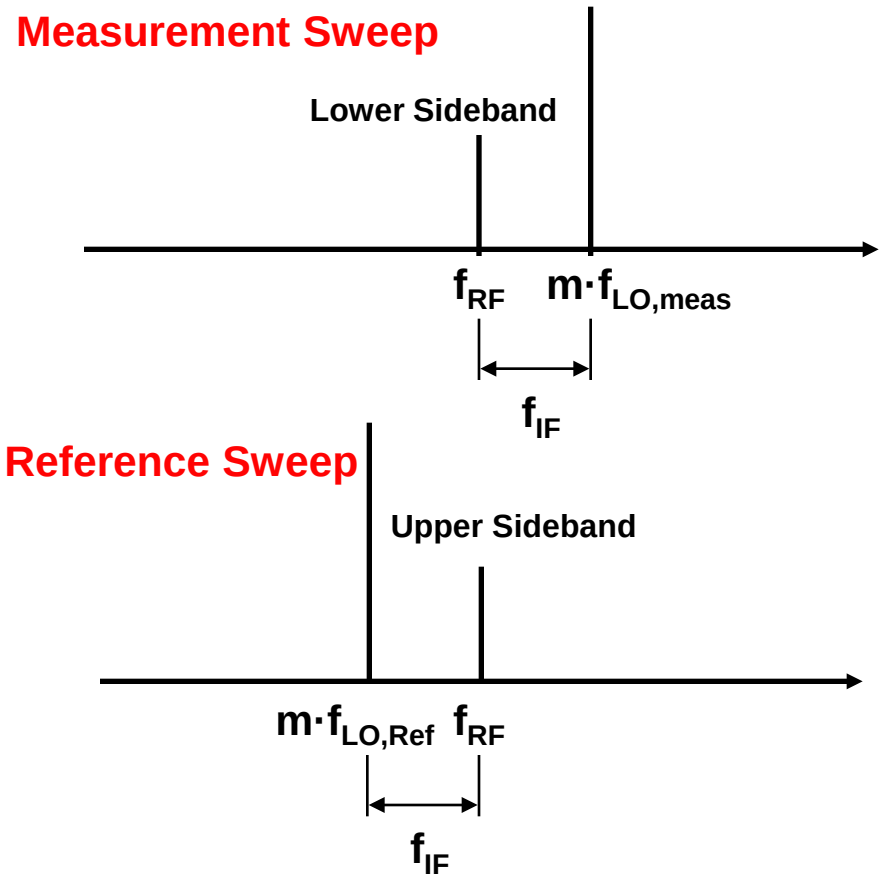


Example: evaluation of CW signal (without image exclusion).

Image removal possible for CW signals by Auto ID procedure

Image-Removal for CW Signals

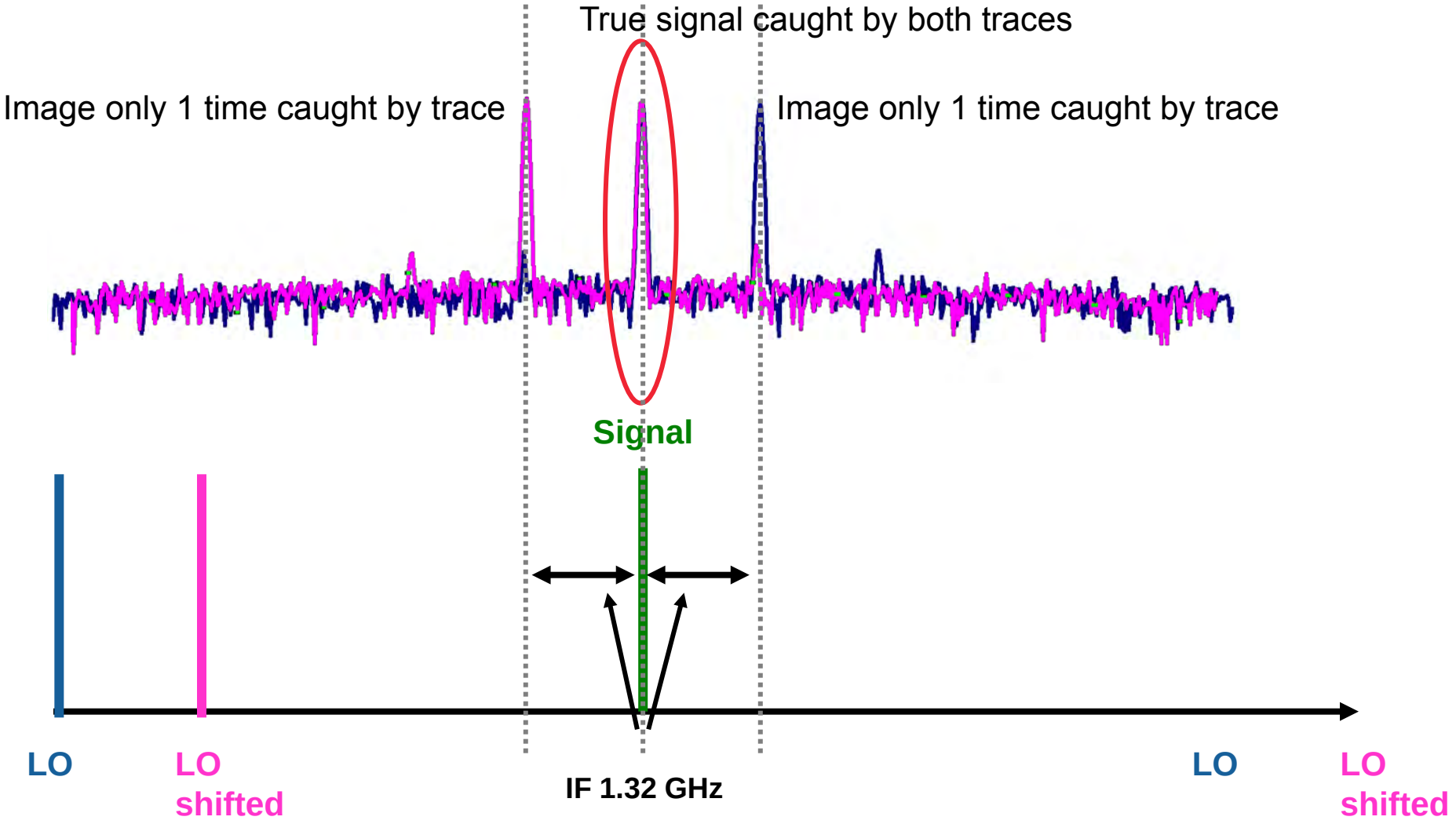
- **How to identify the real signal out of the mixture ?**



- Two different sweeps are necessary to identify the real signal
- Measurement sweep and reference sweep must have an LO frequency offset of $2*f_{IF}$
- For measurement sweep the lower sideband and for reference sweep the upper sideband is wanted
- Lower and upper sidebands of the real signal are displayed at the same position in measurement and reference sweep (only for m=m‘ !)

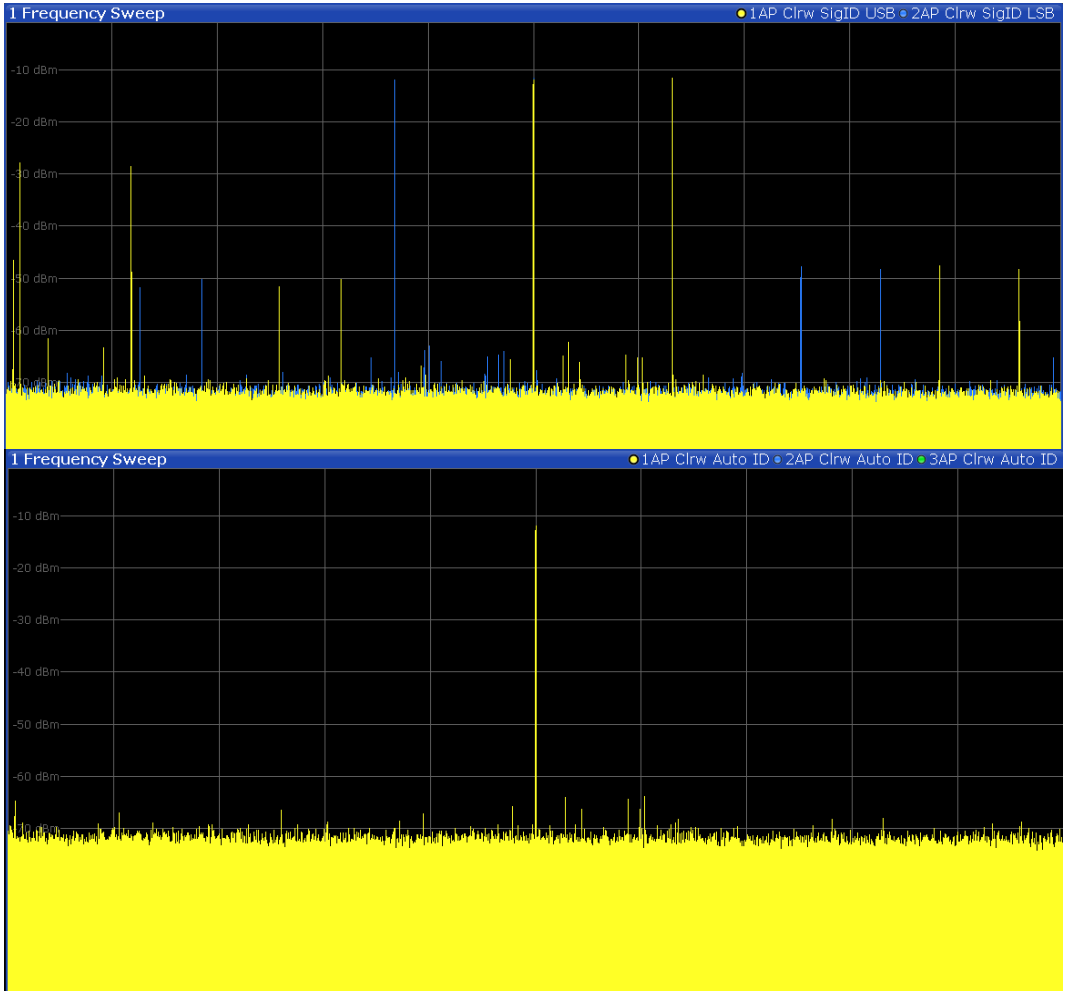
Applies to harmonic mixer with LO and IF controlled by analyzer

Image-Removal for CW Signals



Applies to harmonic mixer with LO and IF controlled by analyzer

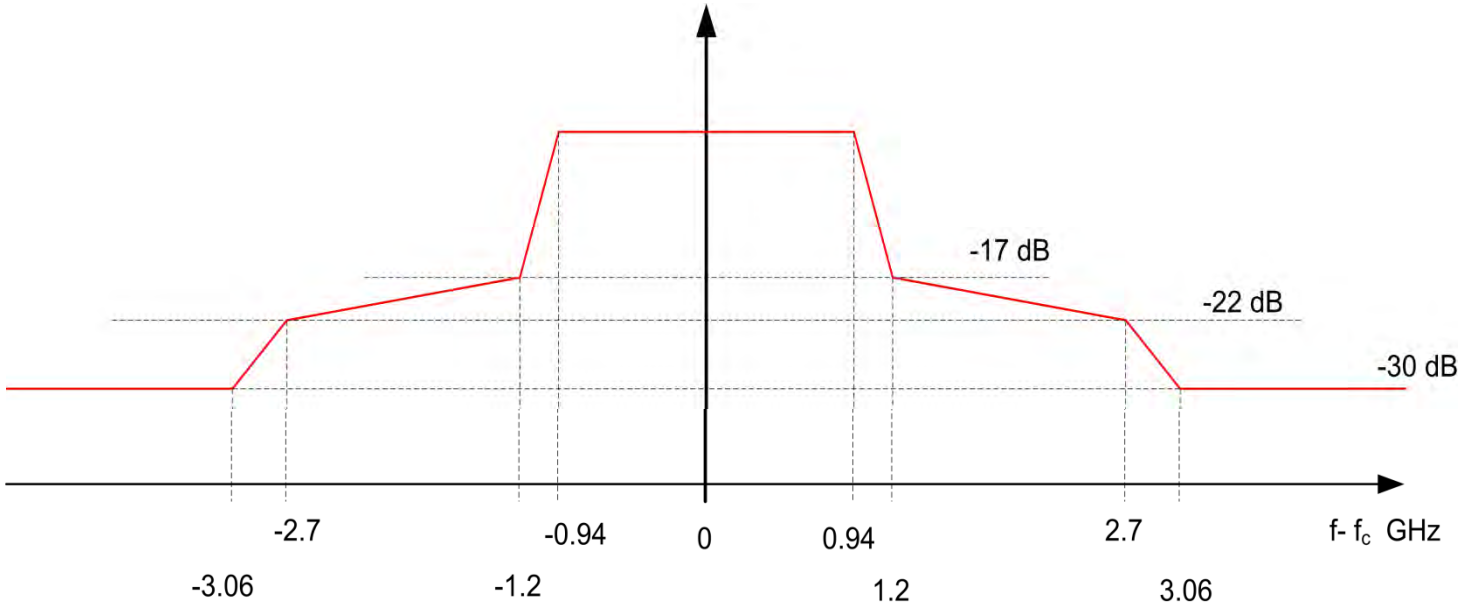
Image-Removal for CW Signals



Applies to harmonic mixer with LO and IF controlled by analyzer.
Function name: Auto ID

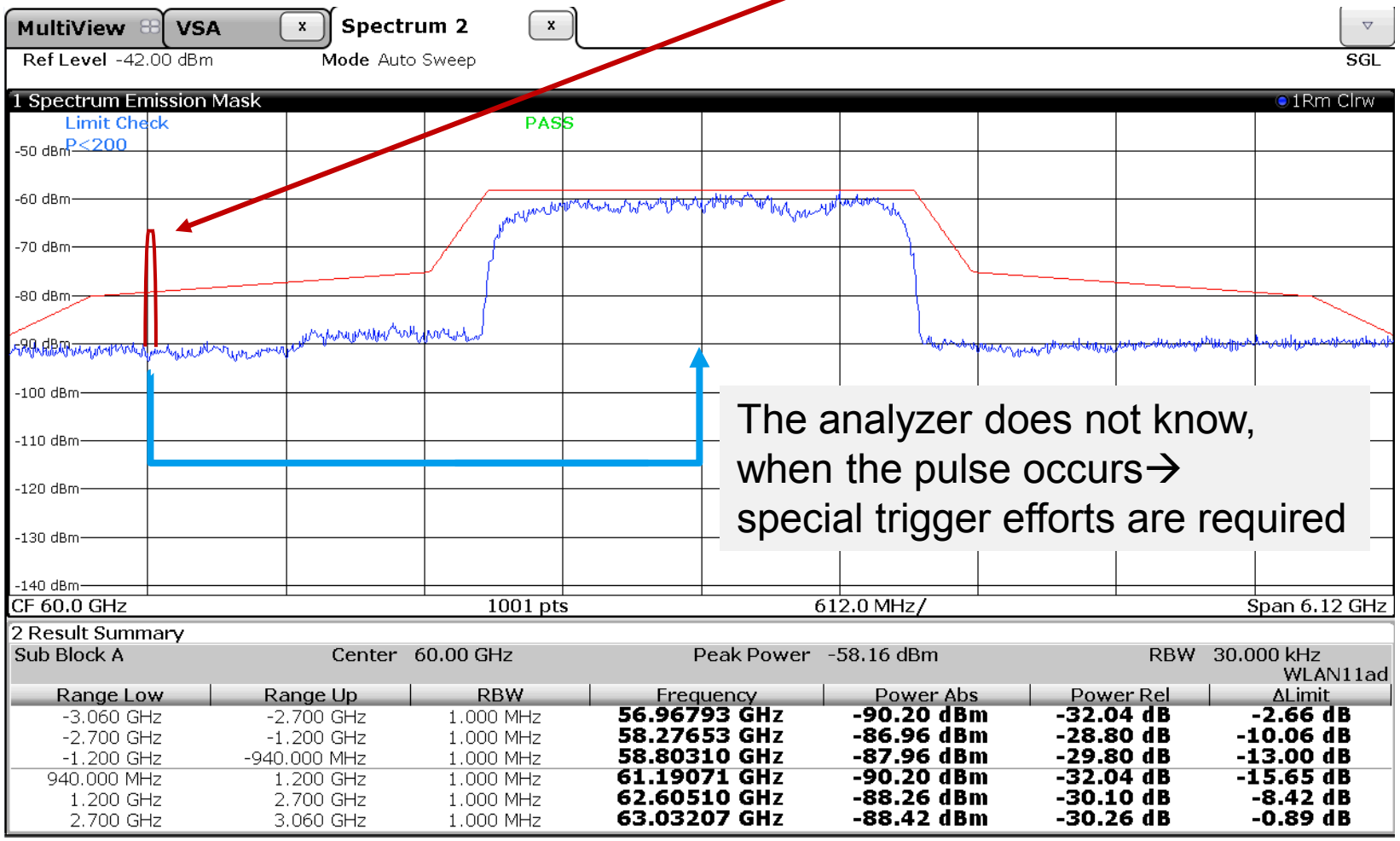
Transmit Mask

- Referenced to peak power
- Identical for all packet types
- RBW = 1MHz
- Packet Length ≤ 10µs



Transmit Mask

YIG Preselection Filter

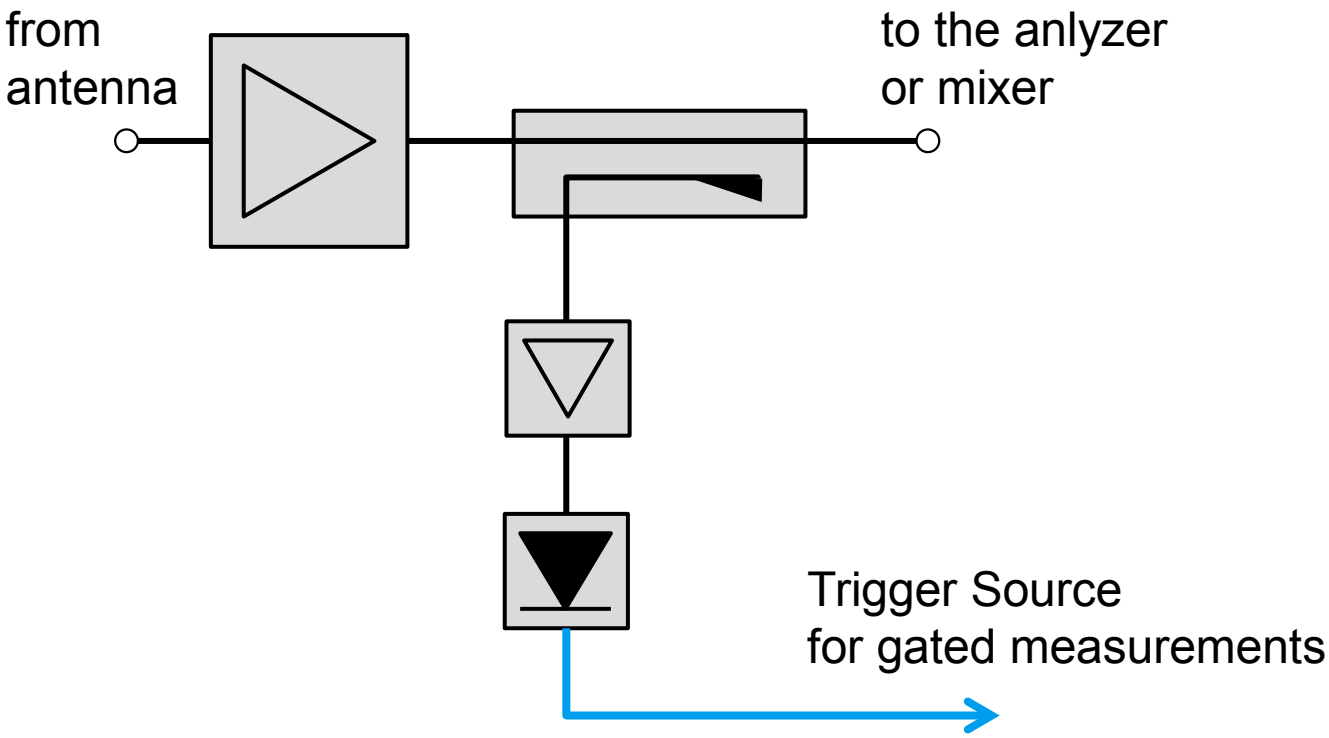


2 Result Summary

Sub Block A | Center 60.00 GHz | Peak Power -58.16 dBm | RBW 30.000 kHz | WLAN11ad

Range Low	Range Up	RBW	Frequency	Power Abs	Power Rel	ΔLimit
-3.060 GHz	-2.700 GHz	1.000 MHz	**56.96793 GHz**	**-90.20 dBm**	**-32.04 dB**	**-2.66 dB**
-2.700 GHz	-1.200 GHz	1.000 MHz	**58.27653 GHz**	**-86.96 dBm**	**-28.80 dB**	**-10.06 dB**
-1.200 GHz	-940.000 MHz	1.000 MHz	**58.80310 GHz**	**-87.96 dBm**	**-29.80 dB**	**-13.00 dB**
940.000 MHz	1.200 GHz	1.000 MHz	**61.19071 GHz**	**-90.20 dBm**	**-32.04 dB**	**-15.65 dB**
1.200 GHz	2.700 GHz	1.000 MHz	**62.60510 GHz**	**-88.26 dBm**	**-30.10 dB**	**-8.42 dB**
2.700 GHz	3.060 GHz	1.000 MHz	**63.03207 GHz**	**-88.42 dBm**	**-30.26 dB**	**-0.89 dB**

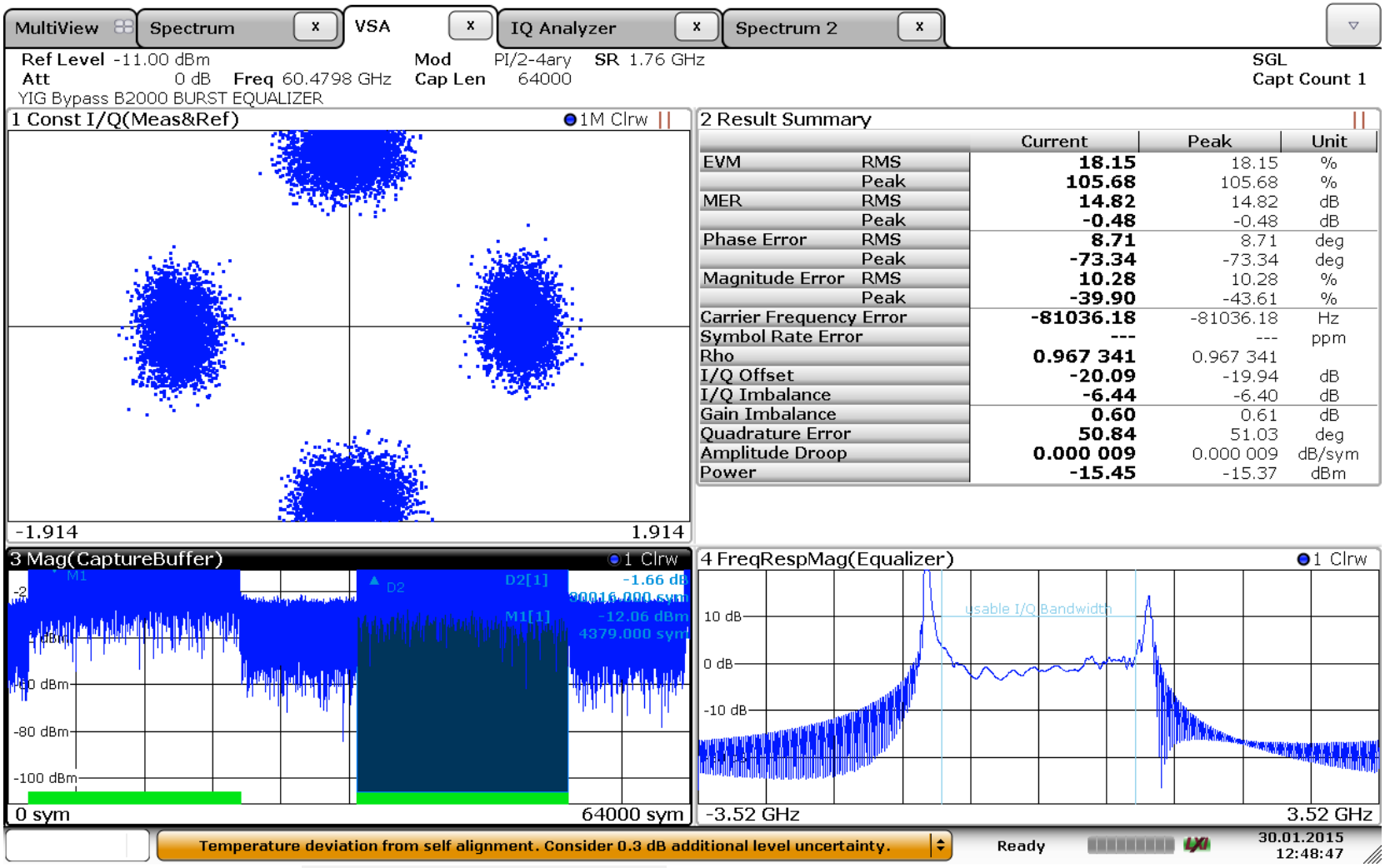
Efforts for Trigger



If the PRF is known for the transmit mask measurement procedures, then the sweep speed can be defined easily and no special trigger source is required.

Signal Characteristic

Radiated measurement. DUT: commercial PC

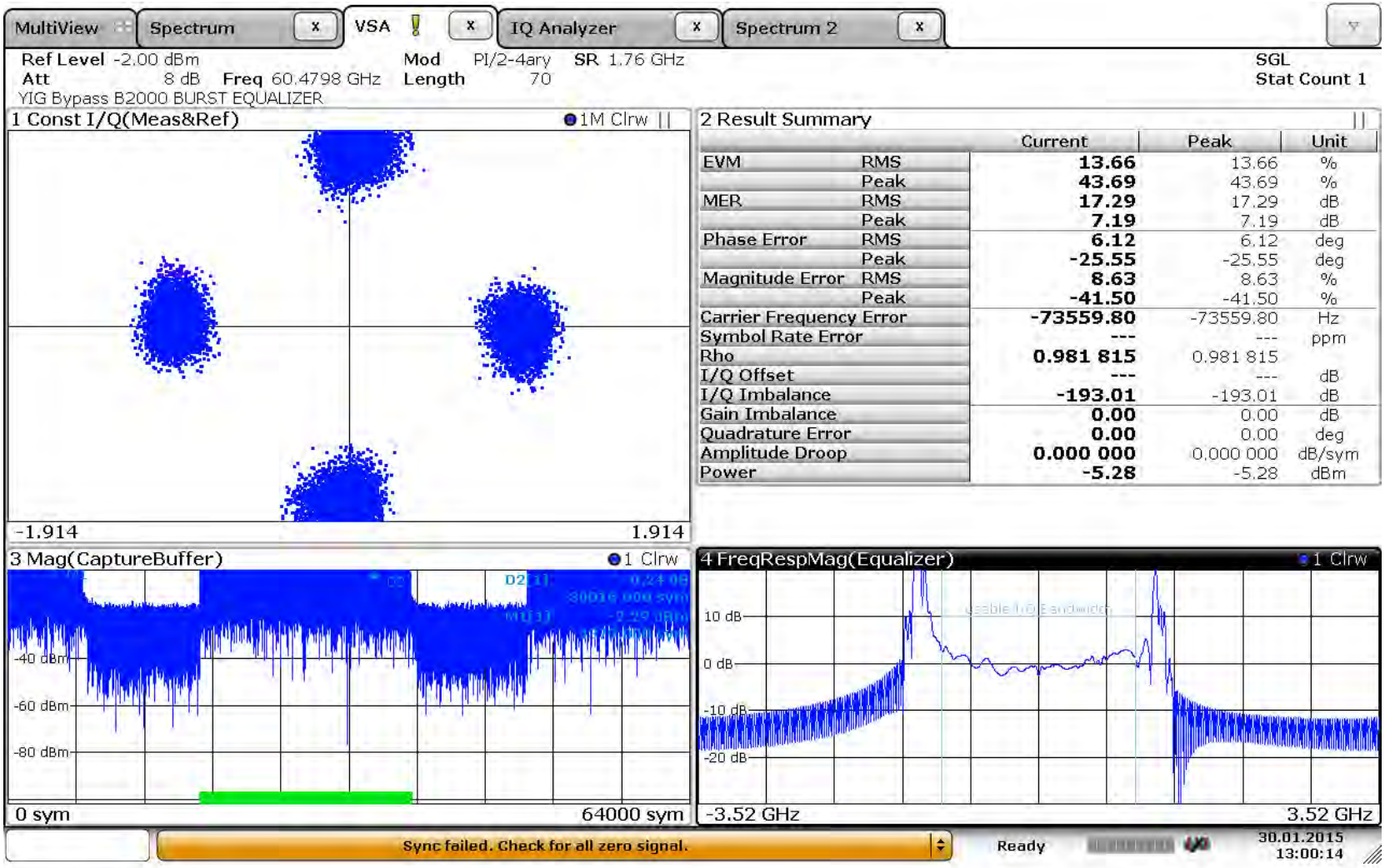


Date: 30.JAN.2015 12:48:47

Signals are pulsed

Signal Characteristic

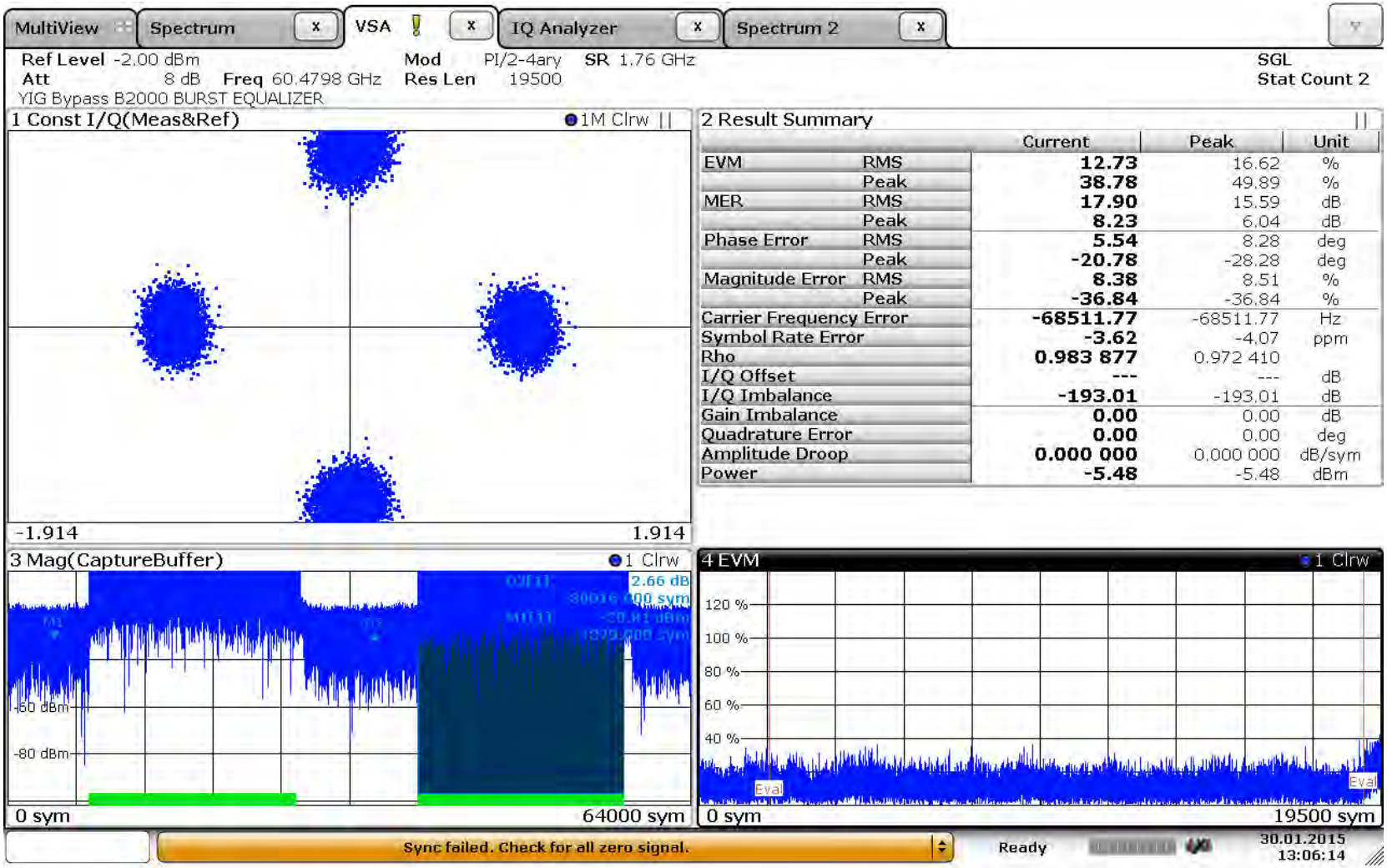
Radiated measurement. DUT: commercial PC



Date: 30.JAN.2015 13:00:14

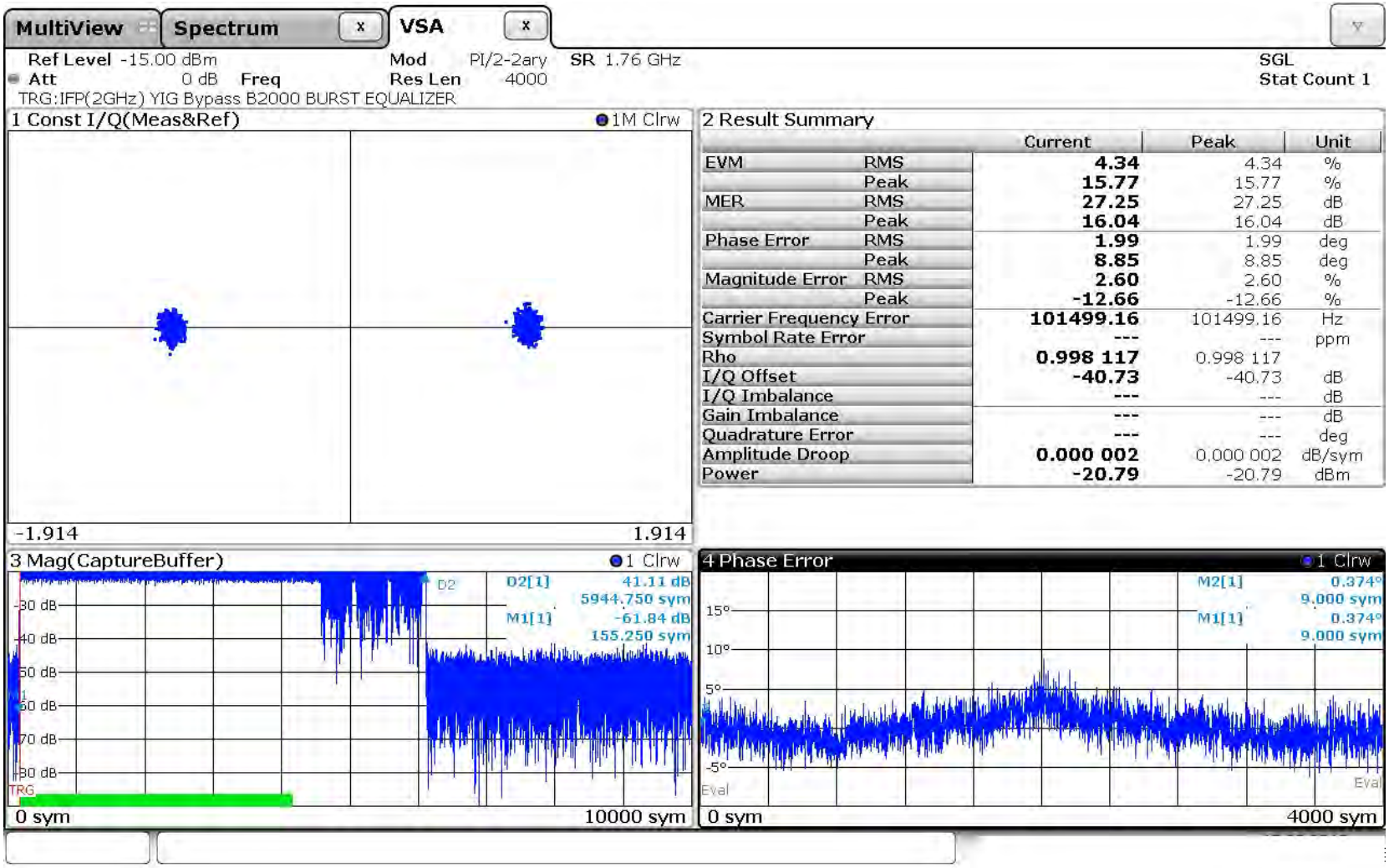
Signal Characteristic

Radiated measurement. DUT: commercial PC



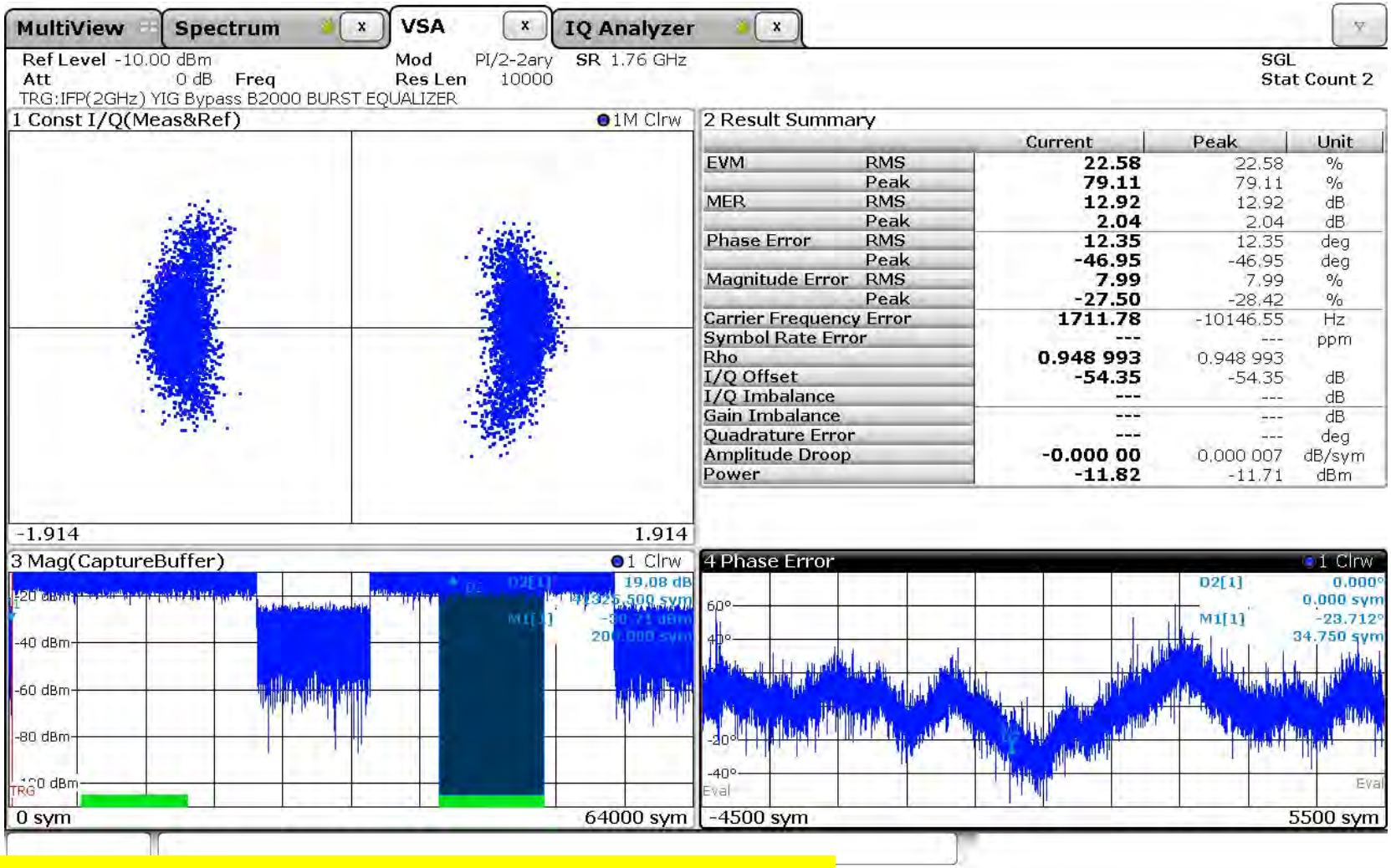
Date: 30.JAN.2015 13:06:14

Phase Shift Indication w/o Synch on GI



Signal before upconversion.

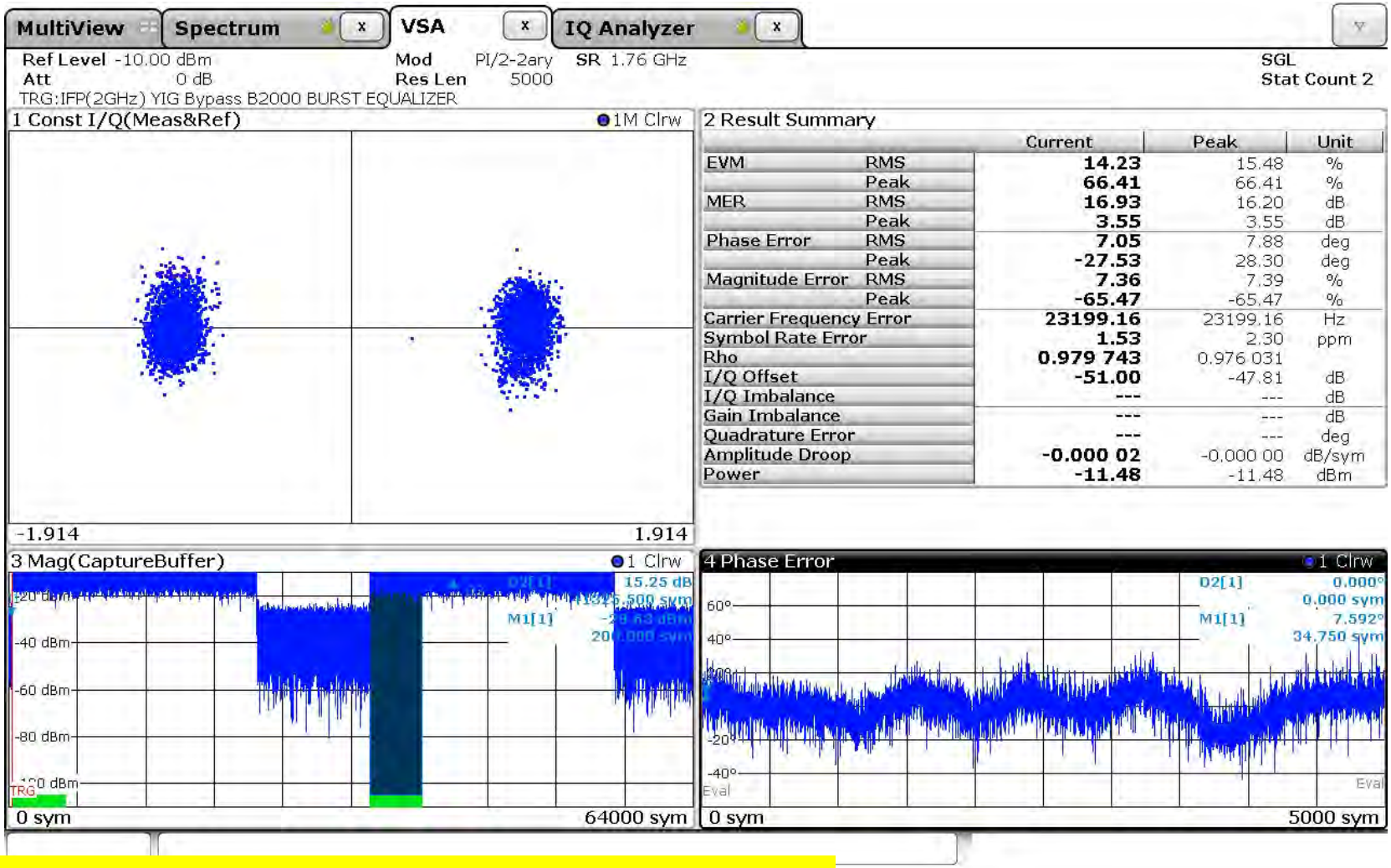
Phase Shift Indication w/o Synch on GI



Signal on desired channel. Longer capture buffer.

Vector signal analysis not tracked on GI

Phase Shift Indication w/o Synch on GI



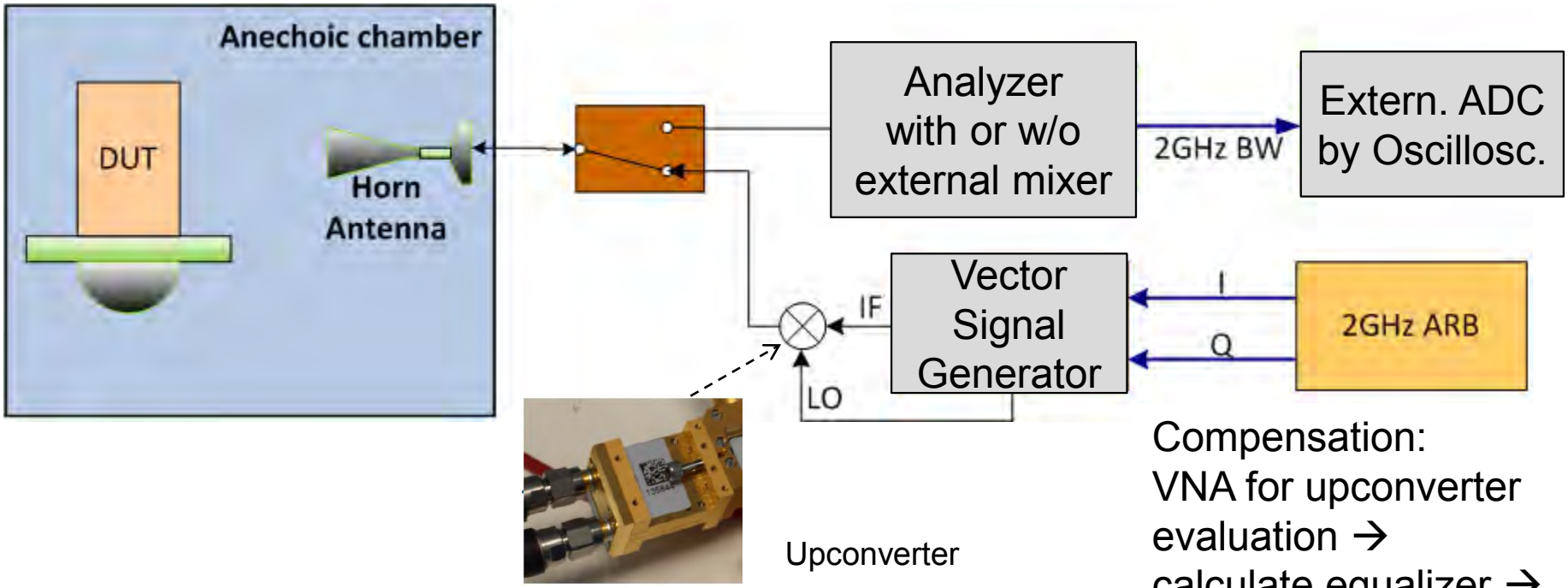
Signal on desired channel. Shorter capture buffer.

Vector signal analysis not tracked on GI

Measurement Setup

Golden Device?
Substitution method?
Reference antenna?
Efficient test methods?

- **Patch antennas require measurements over the air**
- **Anechoic chamber or compact antenna test range with**
  - **Horn antenna for Tx and Rx tests**
  - **Rotating Mount to test / verify beamforming**



Upconverter

Compensation:
VNA for upconverter evaluation →
calculate equalizer →
change waveform

Dynamic Considerations

Analyzer without inbuilt Preamplifier

Distance / m	0.3	0.5	1	2	3
EIRP (Tx) / dBm	30	30	30	30	30
Free Space Loss / dB	58	62	68	74	78
Arriving level / dBm	-28	-32	-38	-44	-48
Gain of Receiver Horn	25	25	25	25	25
Level at receive antenna output / dBm	-3	-7	-13	-19	-23
Loss by wave guide and other loss (budget) / dB	10	10	10	10	10
Level at analyzer input	-13	-17	-23	-29	-33
Attenuator of analyzer / dB	0	0	0	0	0
Level after attenuator / dBm	-13	-17	-23	-29	-33
Preamplifier Gain--> None	0	0	0	0	0
Level at mixer input	-13	-17	-23	-29	-33
BW Corr dB (2000 MHz --> 1 MHz)	33	33	33	33	33
Indicated Level (for RBW = 1 MHz) / dBm	-46	-50	-56	-62	-66
DANL (normalized to RBW = 1 Hz) / dBm	-129	-129	-129	-129	-129
DANL (at RBW = 1 MHz, preamp off) / dBm	-69	-69	-69	-69	-69
Distance to DANL / dB	23	19	13	7	3

Dynamic Considerations

Analyzer with inbuilt Preamplifier

Distance / m	0.3	0.5	1	2	3
EIRP (Tx) / dBm	30	30	30	30	30
Free Space Loss / dB	58	62	68	74	78
Arriving level / dBm	-28	-32	-38	-44	-48
Gain of Receiver Horn	25	25	25	25	25
Level at receive antenna output / dBm	-3	-7	-13	-19	-23
Loss by wave guide and other loss (budget) / dB	10	10	10	10	10
Level at analyzer input	-13	-17	-23	-29	-33
Attenuator of analyzer / dB	10	10	10	10	10
Level after attenuator / dBm	-23	-27	-33	-39	-43
Preamplifier Gain	30	30	30	30	30
Level after preamplifier (mixer input) / dBm	7	3	-3	-9	-13
BW Corr dB (2000 MHz --> 1 MHz)	33	33	33	33	33
Indicated Level (for RBW = 1 MHz) / dBm	-26	-30	-36	-42	-46
DANL (normalized to RBW = 1 Hz) / dBm	-152	-152	-152	-152	-152
DANL (at RBW = 1 MHz, preamp on) / dBm	-82	-82	-82	-82	-82
Distance to DANL / dB	56	52	46	40	36

Dynamic Considerations

Harmonic Mixer + Preamplifier

Distance / m	0.3	0.5	1	2	3
EIRP (Tx) / dBm	30	30	30	30	30
BW Corr dB (2000 MHz --> 1 MHz)	33	33	33	33	33
Free Space Loss / dB	58	62	68	74	78
Arriving level / dBm	-61	-65	-71	-77	-81
Gain of Receiver Horn	25	25	25	25	25
Level at receive antenna output / dBm	-36	-40	-46	-52	-56
Amplifier behind receive antenna: Gain /dB	20	20	20	20	20
Loss by wave guide and other loss (budget) / dB	10	10	10	10	10
Level at mixer input (max. -7 dBm for 1 dB comp.)	-26	-30	-36	-42	-46
Conversion loss / dB	23	23	23	23	23
Level at mixer output / dBm	-49	-53	-59	-65	-69
Indication Level / dBm (*)	-26	-30	-36	-42	-46
DANL (normalized to RBW = 1 Hz) / dBm	-138	-138	-138	-138	-138
DANL (at RBW = 1 MHz) / dBm	-78	-78	-78	-78	-78
Distance to DANL / dB	52	48	42	36	32

*) no TDF for amplifier or attenuation regarded.

Spurious Measurements

- Requirements
  - Distance for prequalification of spurious frequencies
    - “As close as possible“ → recommendation: 20 cm…25 cm
  - Calculation of expected spurious levels
    - Is the pre-qualified spurious still above instrumentation noise floor after attenuation over the air by e.g. 68 dB?

Upper Frequency Limits

Regulatory and RF measurements according to
ETSI TR 103 052 V1.1.1. (2011-03)
Measurement of RSE and EMI up to 100 GHz (Europe).
(FCC up to 200 GHz).
This standard gives information on:
test environment
test equipment
test methods
calibration and uncertainty