Measurement Considerations for Automotive Radar

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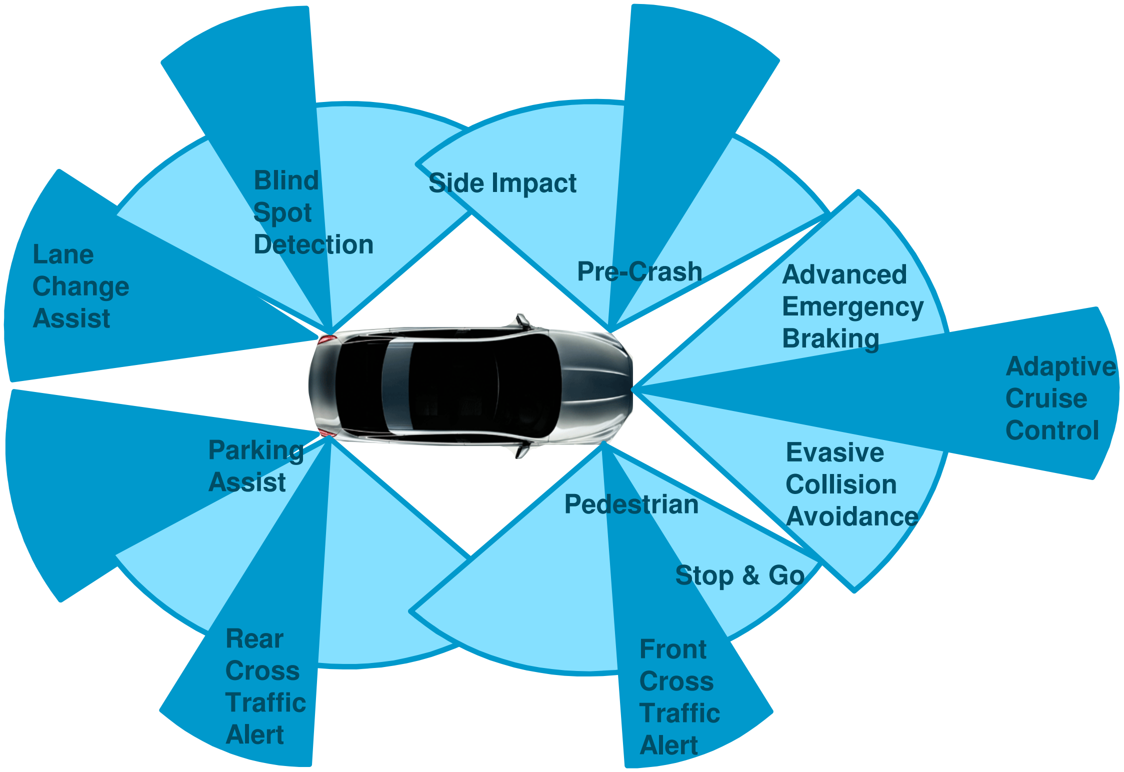
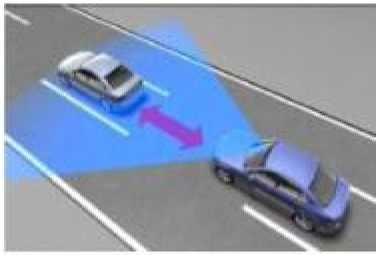
Agilent Technologies

Automotive Radar – What is it ?

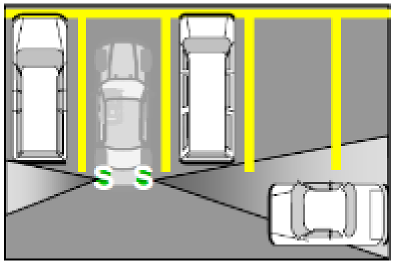




Adaptive Cruise Control (ACC)

Blind Spot Monitoring

Lane Change Assist



Rear traffic crossing alert

A Quick Comparison to “Traditional” Radar Development and Test

Traditional Systems:

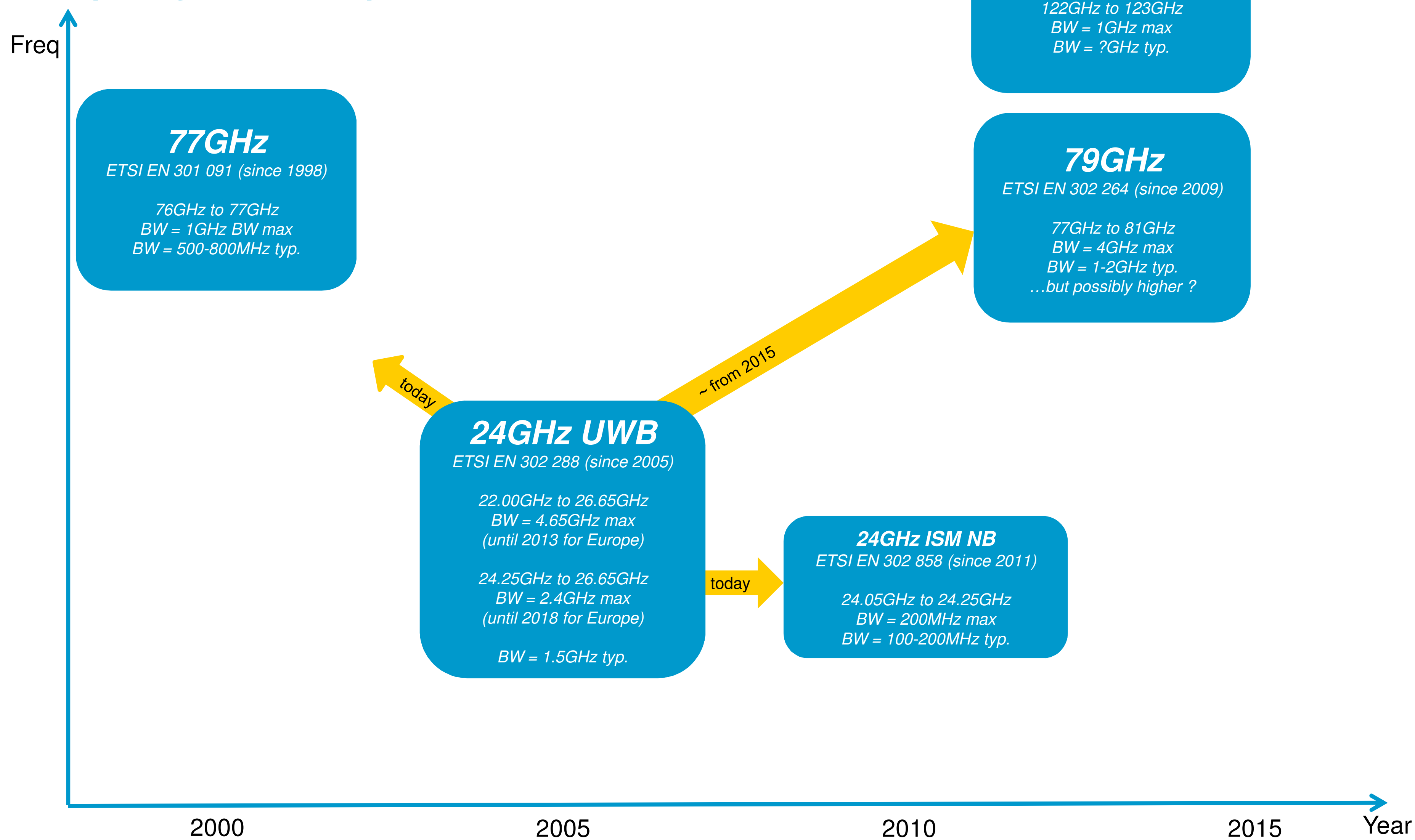
- Long range
- Electronic warfare
- Lots of signal processing
- Large budget programs
- Low volume production

Automotive:

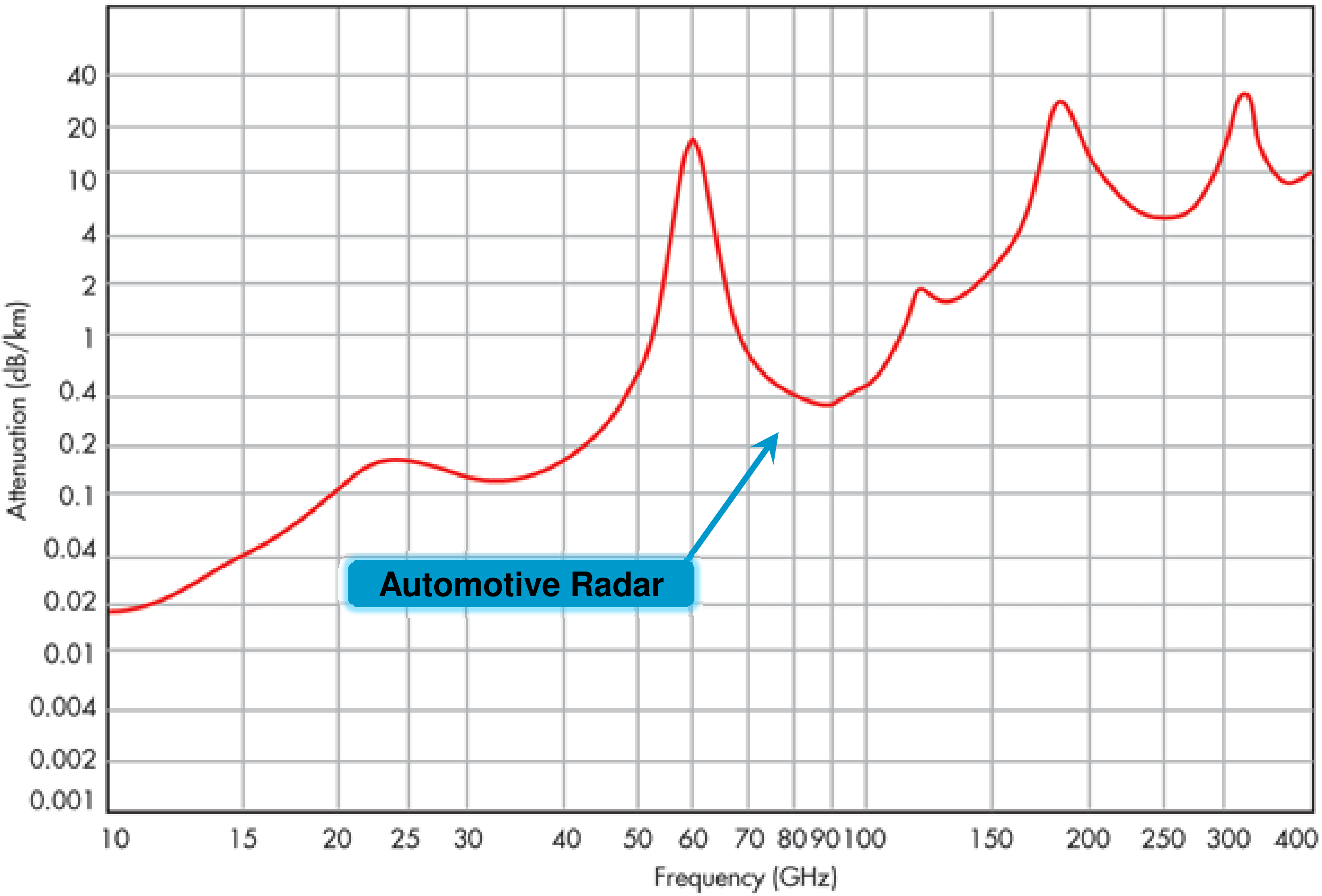
- Long range not a primary design challenge
- Interference is typically unintentional
- Low cost
- High Volume
- Regulation

Regulatory

Frequency Band Compare



Atmospheric Properties



Source: "Millimeter waves will expand the wireless future" by Lou Frenzel, Electronic Design Mar 2013

Millimeter Frequencies

Traditionally the 30 to 300 GHz spectrum (i.e., wavelength 10 ~ 1 mm)

Research now extending to 500 GHz, 1 THz, and beyond

Benefits:

- Small antenna size
- High resolution
- Uncluttered spectrum
- Wide bandwidths
- Advantageous use of atmospheric properties

Measurement Issues:

- Small and more fragile cables, adapters and accessories
- Costs increases
- Lack of power standards

Millimeter Signal Generation

Methods of generating signals

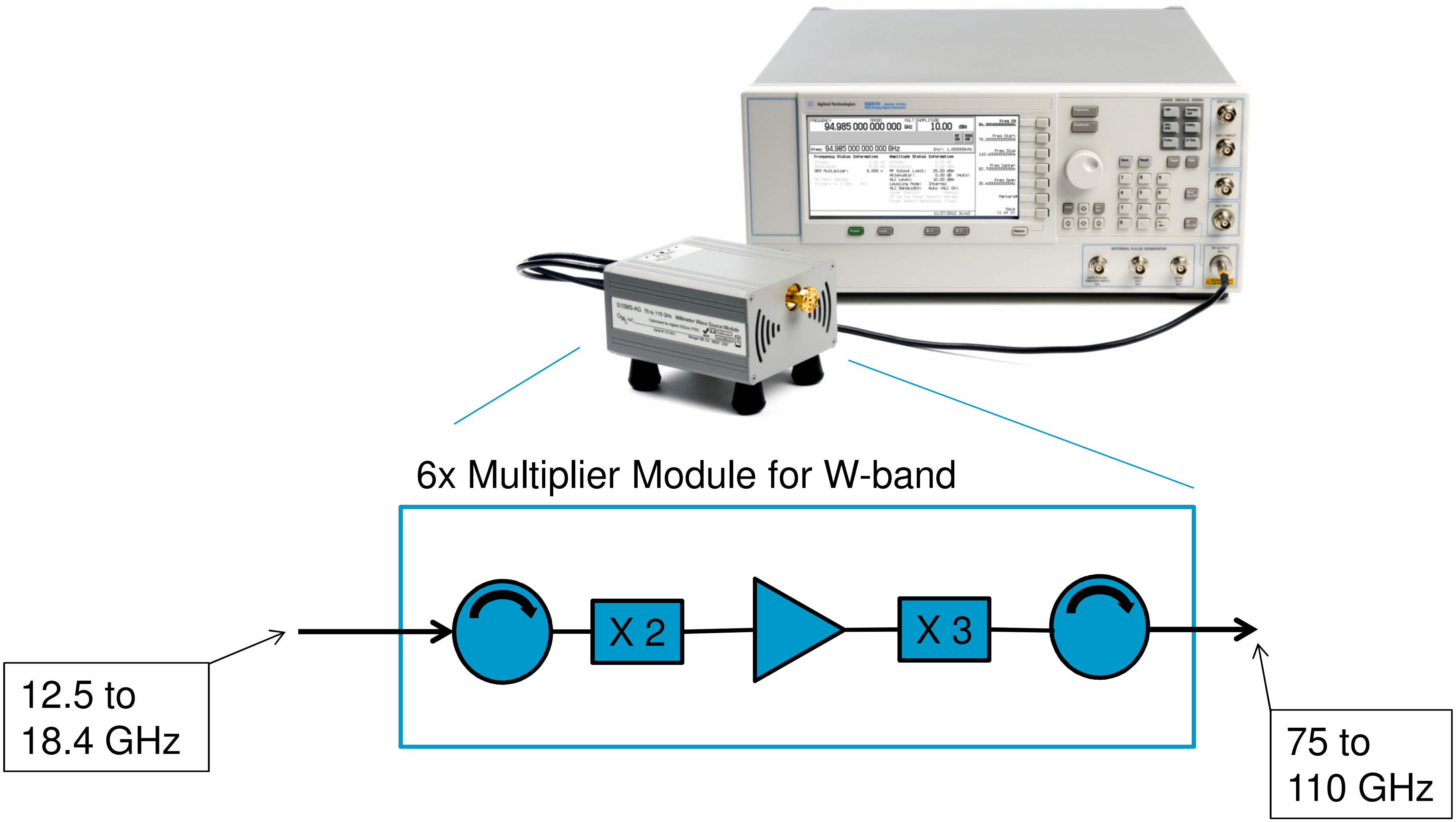
- Multiplication
- Upconversion

Considerations

- Frequency range requirements
- Output power requirements
- Modulation and bandwidth requirements
- Minimizing spurious signals

Signal Generation

Multiply a Microwave Signal to Achieve Millimeter Frequencies



Signal Multiplication
Pros and Cons

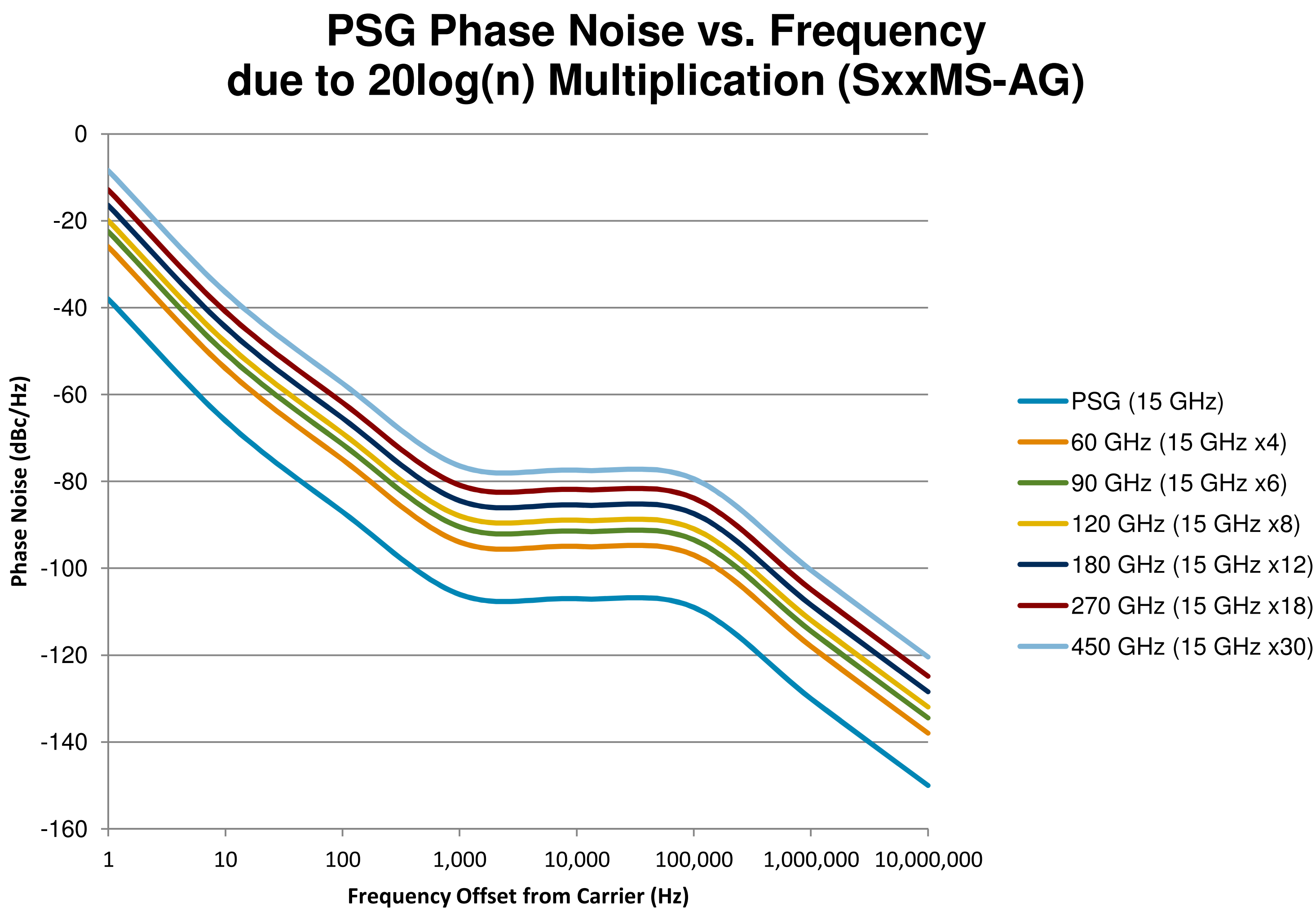
Pros

- A good choice for CW and pulse modulated signals
- Test setup simplicity
- Fixed or variable output power
- Commercially available modules from several manufacturers covering waveguide bands up to 1 THz and above

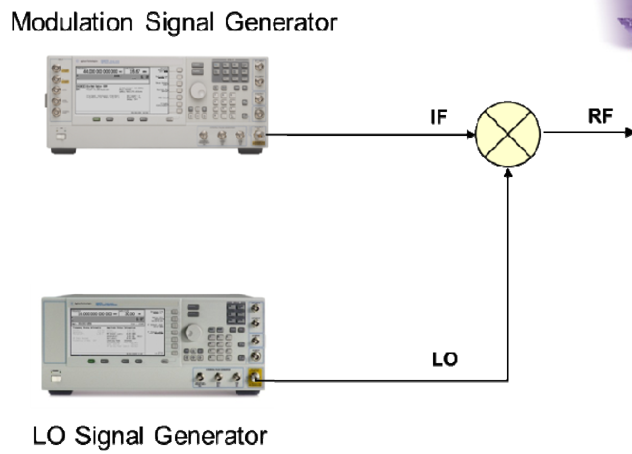
Cons

- Saturated output power
- Pulse modulation rise/fall times may be altered
- FM and ΦM deviation is multiplied by the multiplication factor
- AM modulation is severely distorted
- Not suitable for most digitally-modulated signals
- Creates harmonic, sub-harmonic and non-harmonic spurious signals, -20 dBc typical

Multiplication of Phase Noise



Signal Upconversion
Pros and Cons



$$F_{RF} = F_{LO} \pm F_{IF}$$

Pros

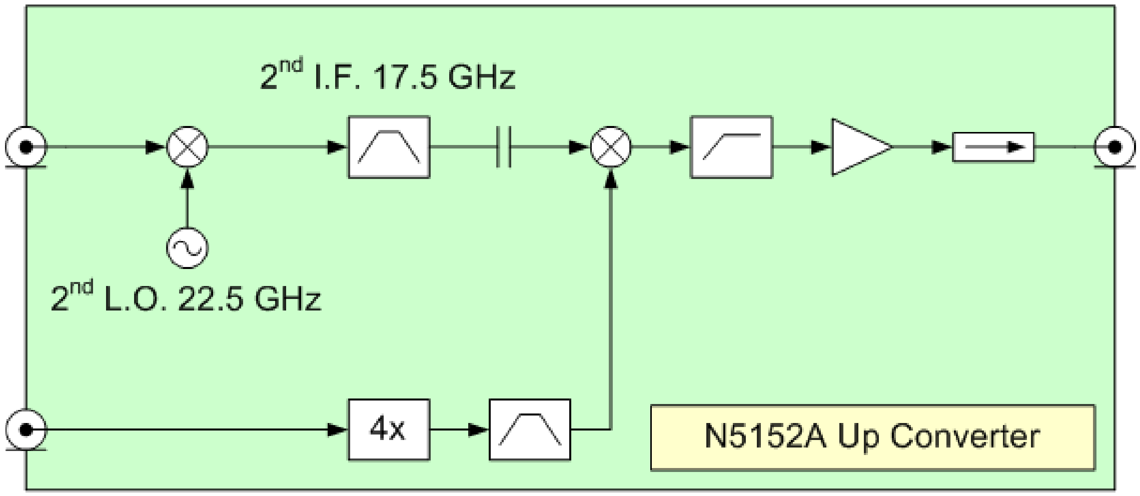
- Much better choice for modulated signals
- Can support wide bandwidth signals
- Reasonable output power

Cons

- Higher-complexity test setup – two sources required
- Limited choices among off-the-shelf upconverters
- Very limited amplitude control
- Creates images, harmonic, sub-harmonic and non-harmonic spurious signals

Signal Generation
Upconverting a Microwave Signal to Achieve Millimeter Frequencies

AWG input: 5 GHz IF



Transmitter Output:
+5 dBm
57 … 66 GHz

LO input: 10-12 GHz

Millimeter Signal Analysis

Methods of analyzing signals

- External harmonic mixers
- Smart mixers
- Downconversion

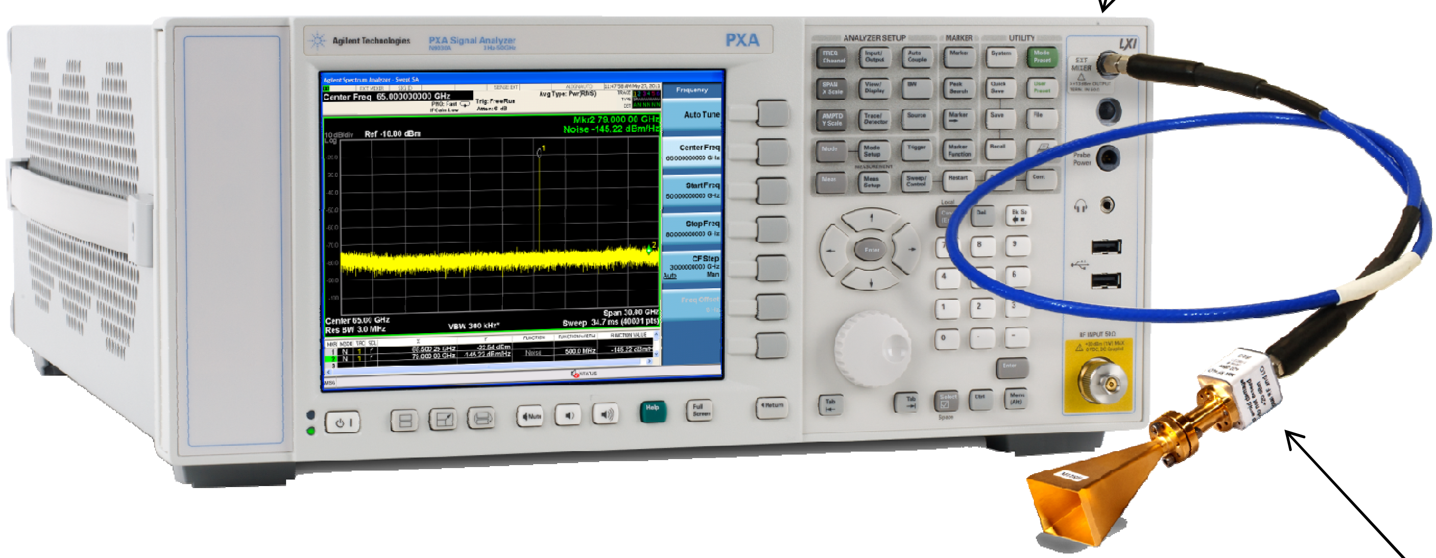
Considerations

- Frequency range requirements
- Conversion loss and sensitivity requirements
- Modulation and bandwidth requirements
- Minimizing spurious signals

Signal Analysis

Using a Harmonic Mixer to Extend the Spectrum Analyzer Frequency Range

Diplexer built-in to PXA/EXA allows LO and IF signals to share the same RF cable



Some harmonic mixers require DC bias

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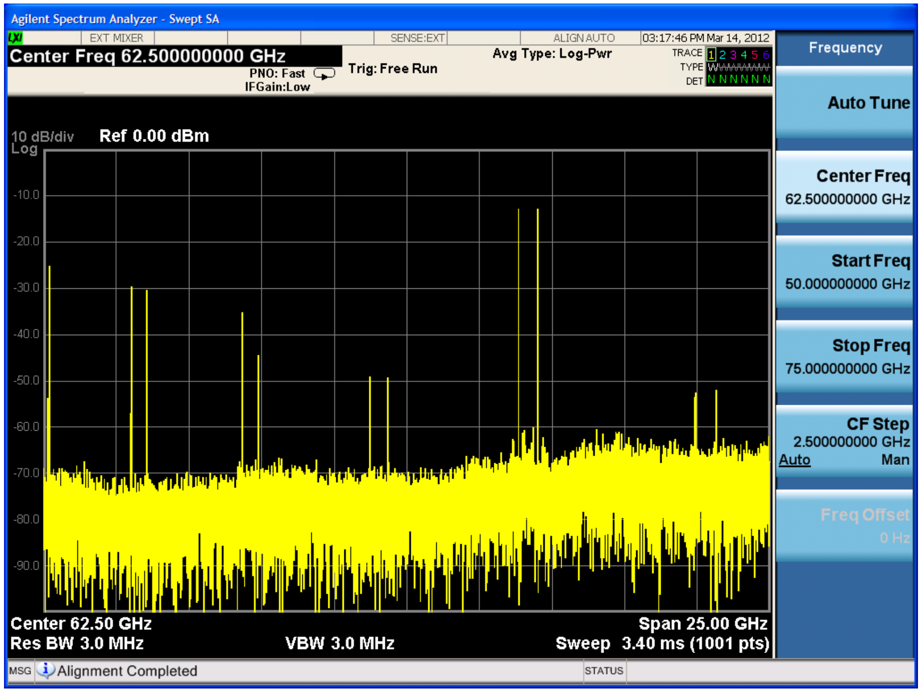
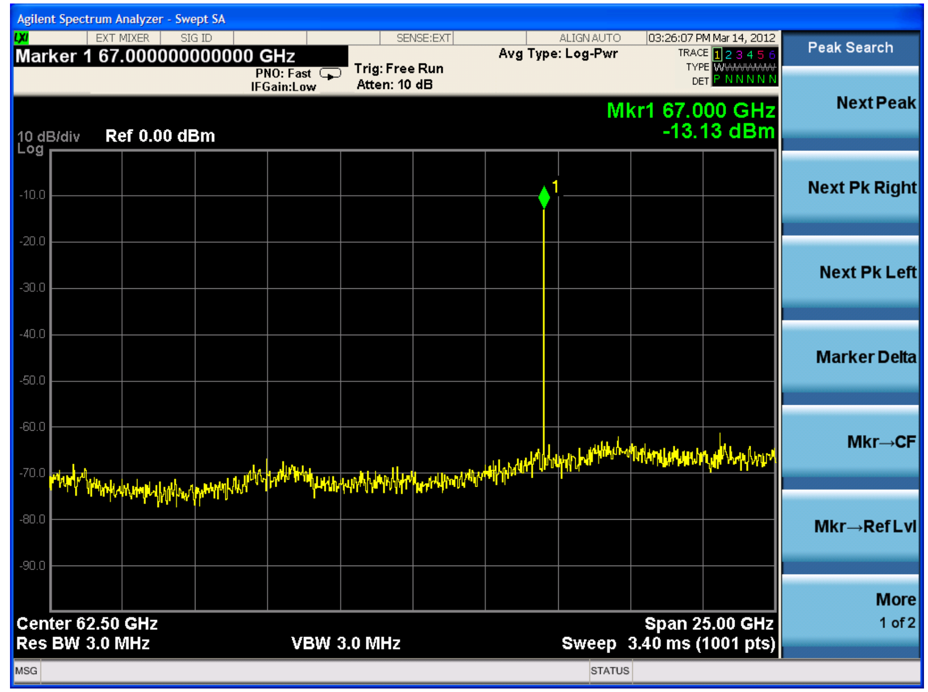
Signal Identification





Signal Identification OFF

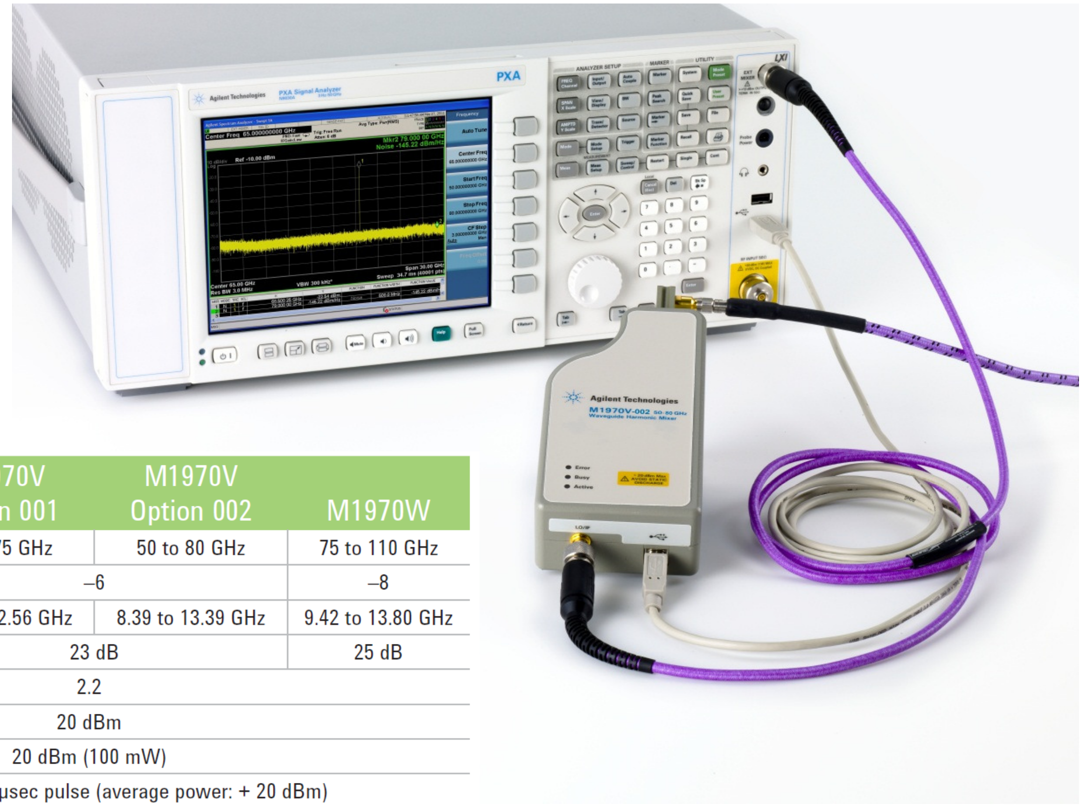
Signal Identification ON
using ***Image Suppress*** function

Signal Analysis

"Smart" Mixers Offer Improved Performance and Functionality

USB connection provides:

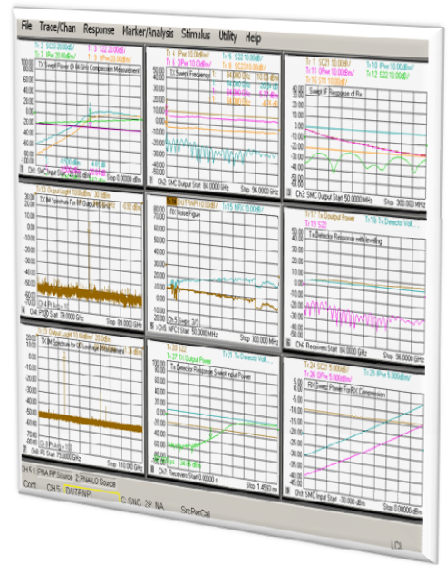
- Automatic ID
- Harmonic number
- Conversion loss data
- LO path loss



Specification	M1970E	M1970V Option 001	M1970V Option 002	M1970W
Frequency range	60 to 90 GHz	50 to 75 GHz	50 to 80 GHz	75 to 110 GHz
LO harmonic number[1]	–6/–8	–6		–8
LO input frequency range[2]	9.42 to 12.56 GHz	8.39 to 12.56 GHz	8.39 to 13.39 GHz	9.42 to 13.80 GHz
Maximum conversion loss[3]	27 dB	23 dB		25 dB
Calibration accuracy (*nominal*)[4]	2.2			
Maximum LO power	20 dBm			
Maximum CW RF input level	20 dBm (100 mW)			
Maximum RF peak pulse power	24 dBm with < 1 µsec pulse (average power: + 20 dBm)			
Odd order mixing product suppression (*nominal*)	15 dB			
Gain compression level (< 1dB) (*nominal*)	–1 dBm			
Input SWR (*nominal*)	2.6			
Noise figure (*nominal*)[5]	40 dB	36 dB		38 dB
System displayed average noise level (DANL) at 1 Hz resolution bandwidth (*nominal*)[6]	–136 dBm	–140 dBm		–138 dBm

Signal Network Analysis

High Frequency up to THz region



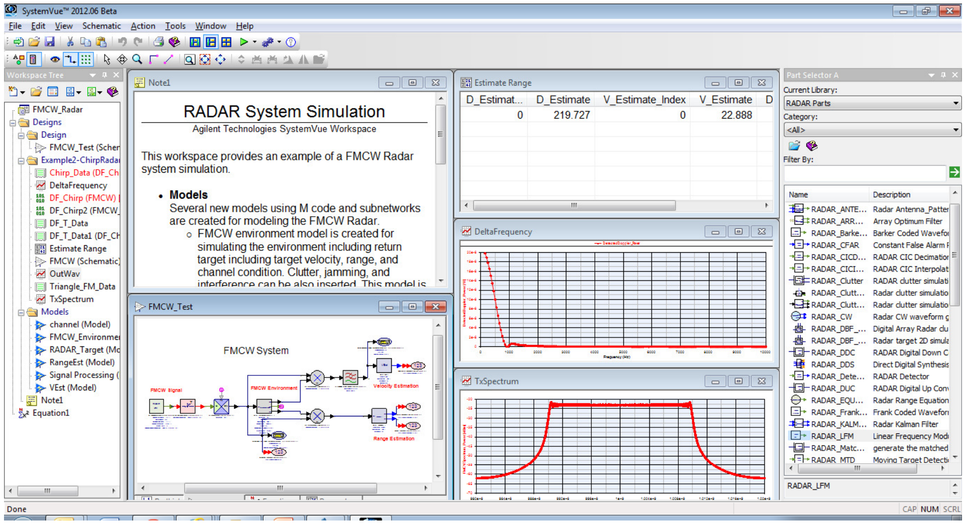
No longer just traditional scalar measurements:

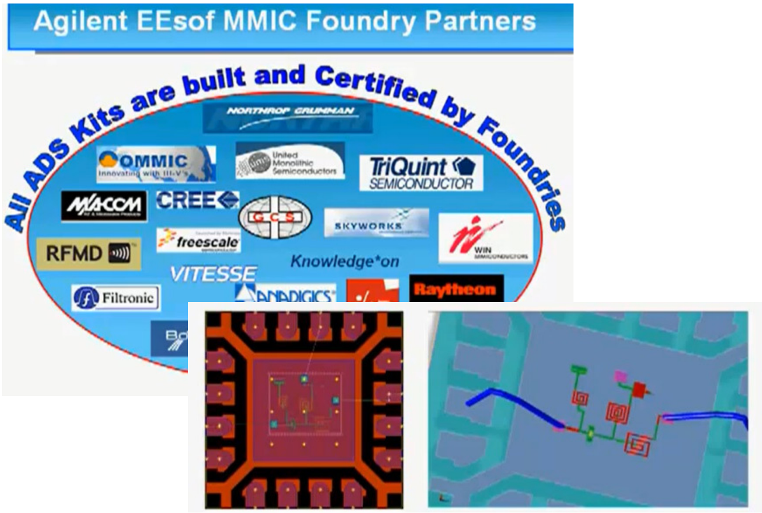
- Non-linear analysis
- Materials measurements
- Frequency range to THz
- Integration with design software

Design and Simulation

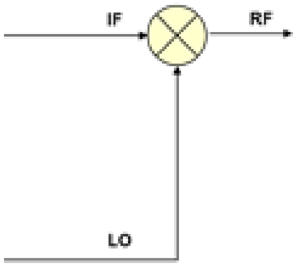
MMIC's & Baseband Design Tools

Design tools should provide:
- Accuracy
- Standardized design capability
- Integrated test
- Path from design to FAB





AWG - input



Radar

Analog Source - LO

Conclusions

In the future the automotive radar market is expanding into higher frequencies

High frequency measurement challenges can be addressed with technologies discussed:

- Banded up/down converters or multipliers dividers
- “Smart” external mixers
- Improved Phase Noise
- Wider bandwidth analyzers