Teseq / Milmega

New Medical EMC Standard
Effect on RF Immunity Testing

MILMEGA
a TESEQ Company

Accelonix
keeping you ahead.

TESEQ
Advanced Test Solutions for EMC

Relevant Standards

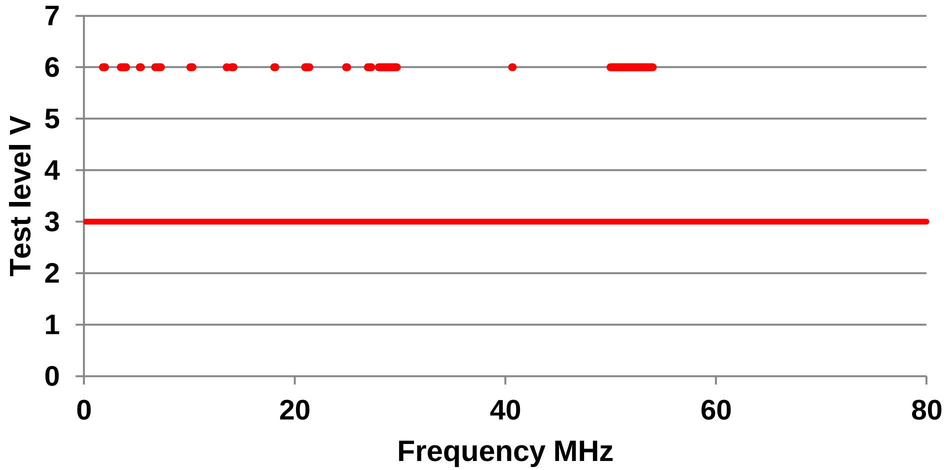
- IEC 60601-1-2
    - Product Specific Standard
    - Current version Ed 4.0 Feb 2014
- References
    - IEC 61000-4-6
        - Conducted RF
    - IEC 61000-4-3
        - Radiated RF

Frequencies and Levels

- Conducted RF (IEC 61000-4-6)
  - 150kHz to 80MHz
  - $3V_{emf}$ (Before modulation)
  - $6V_{emf}$ (Before modulation) in ISM and Amateur Radio Bands
  - Modulation 1kHz 80% Sinusoidal AM

The ISM (industrial, scientific and medical) bands between 150 kHz and 80 MHz are 6,765 MHz to 6,795 MHz; 13,553 MHz to 13,567 MHz; 26,957 MHz to 27,283 MHz; and 40,66 MHz to 40,70 MHz.
The amateur radio bands between 0,15 MHz and 80 MHz are 1,8 MHz to 2,0 MHz, 3,5 MHz to 4,0 MHz, 5,3 MHz to 5,4 MHz, 7 MHz to 7,3 MHz, 10,1 MHz to 10,15 MHz, 14 MHz to 14,2 MHz, 18,07 MHz to 18,17 MHz, 21,0 MHz to 21,4 MHz, 24,89 MHz to 24,99 MHz, 28,0 MHz to 29,7 MHz and 50,0 MHz to 54,0 MHz.

ISM and Amateur Radio Bands

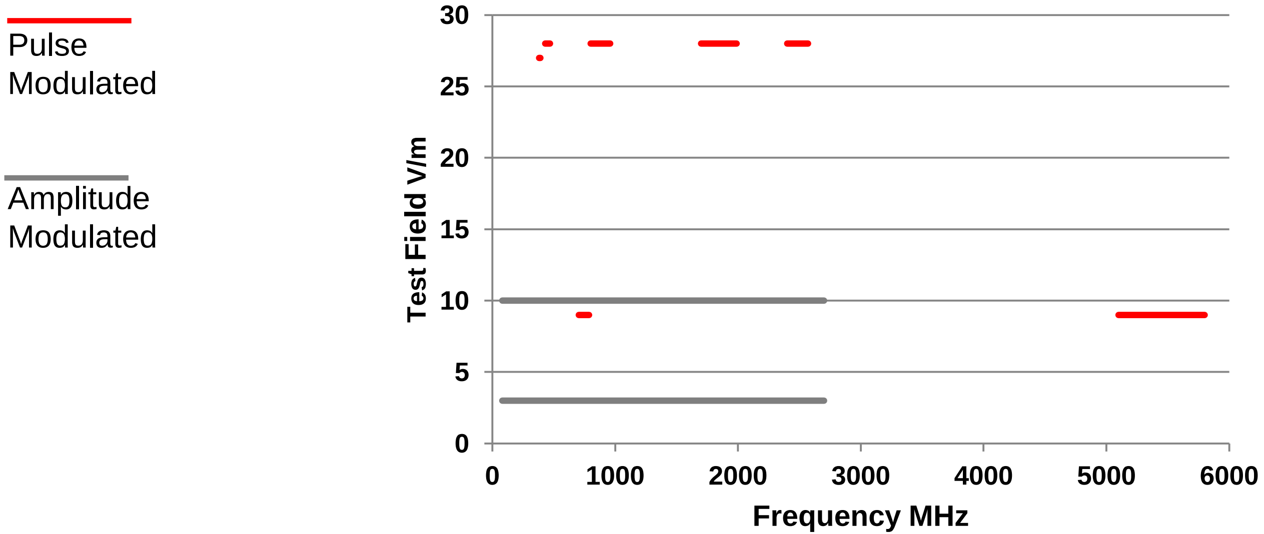


While it is possible to set up the test to produce different test levels in different bands, the test equipment needs to be selected to produce the higher level over the whole band

Frequencies and levels

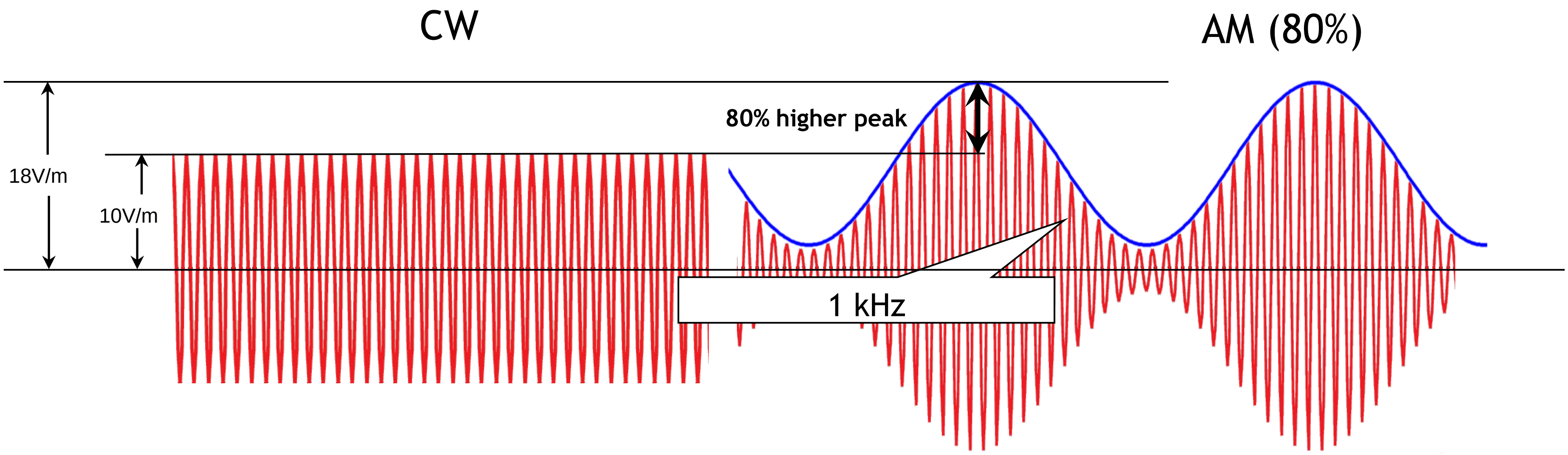
- Radiated RF (IEC61000-4-3)
  - 80MHz to 2.7GHz
    - 3V/m (Before modulation) Professional Healthcare Facility Environment
    - 10V/m (Before modulation) Home Healthcare Environment
    - Modulation 1kHz 80% Sinusoidal AM
  - 385MHz to 5.785GHz
    - Various levels in specified Communications Bands
    - Modulation pulsed at either 18Hz or 217Hz 50% Duty Cycle

Communications Bands



While it is possible to set up the test to produce different test levels and modulations in different bands, the test equipment needs to be selected to produce the higher level over the whole band
i.e. 28V/m 80MHz to 2.7GHz and 9V/m 5GHz to 6GHz

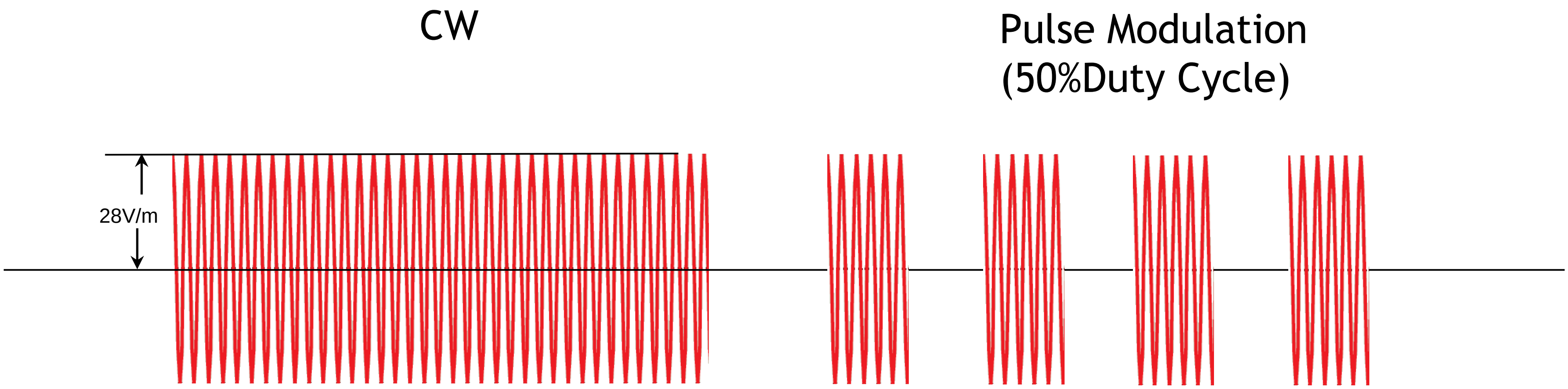
- Amplitude Modulation as used between:
  - 150kHz and 80MHz (Conducted RF)
  - 80MHz and 2.7GHz (Radiated RF)



Power α Voltage^2

$1.8^2 = 3.24$

- Pulse Modulation as used between:
  - 2.7GHz and 5.8GHz (Radiated RF)



Basic Field/Power Calculation

Power required to generate a field of E V/m
at a distance d metres from the antenna
(in free space)

$$\textbf{Power (watts)} = (E^2 * d^2) / (30 * g)$$

$g = 10^{(G/10)}$ {g = ratio gain, G = gain (dBi) }

$\text{Gain}_{(dBi)} = 20\log f_{(MHz)} - 29.79 - AF_{(dB/m)}$

Modulation

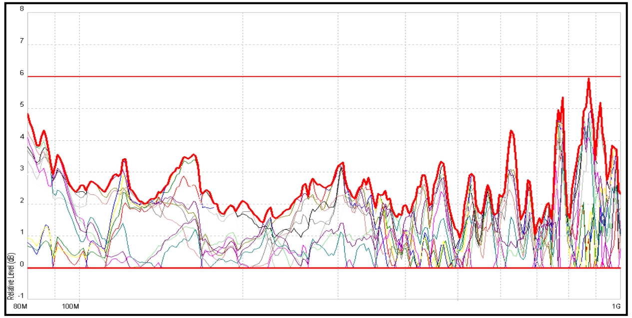
- Additional 5.1dB (or 3.24 x Calculated Power) required for Amplitude Modulation
- No addition required for Pulse Modulation
- 28V/m un-modulated requires more power than 10V/m 80% AM

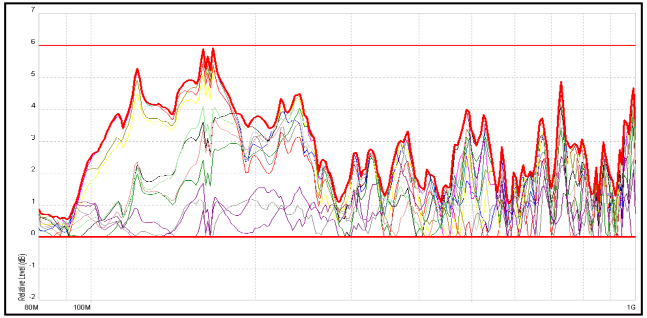
Additional Factors to be included

- Free space Vs chamber
  - Manufacturers test and calibrate antenna in Free Space
    - They actually calibrate in a chamber or Open Area Test Site (OATS) and calculate to free space
  - Test chambers are not free space
    - Presence of the ground plane and absorber changes the antenna performance
    - Changes are somewhat unpredictable

Additional Factors to be included

- Chamber variation
  - No chamber is perfectly uniform
  - The ‘so called’ uniform area can have variation up to dB
  - Potentially you could require 6dB more power = 4 times more





Additional Factors to be included

- Manufacturers data
  - There is always some uncertainty in the calibration data
  - Data shown in datasheets could be from just one antenna
    - There will be unit to unit variation

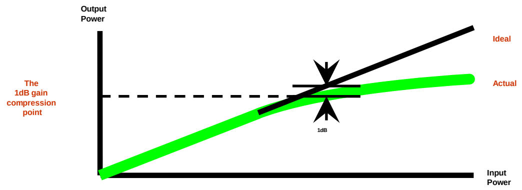
- Cable loss
  - There are losses between the amplifier output and the antenna

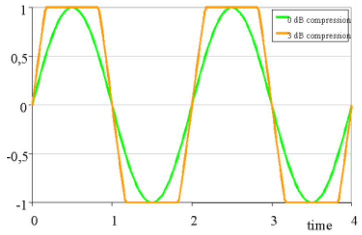
Test Rack to Antenna	
■ 1.5m rack to penetration	(Loss 0.25 dB @ 1GHz)
■ 5m penetration to floor panel (underfloor cable)	(Loss 0.8 dB @ 1GHz)
■ 3m floor panel to antenna	(Loss 0.5 dB @ 1GHz)
Internal to rack	
■ 0.4m RF switch output – rack bulkhead	(Loss 0.1 dB @ 1GHz)
■ 0.4m Directional Coupler output – RF switch input	(Loss 0.1 dB @ 1GHz)
■ Werlatone C5982 Directional Coupler	(Loss 0.1 dB @1GHz)
■ RF Switch – 2 Way N type	(Loss 0.1 dB @ 1 GHz)

- **TOTAL LOSS** **1.95 dB @ 1 GHz**

The Amplifier Output above P1dB

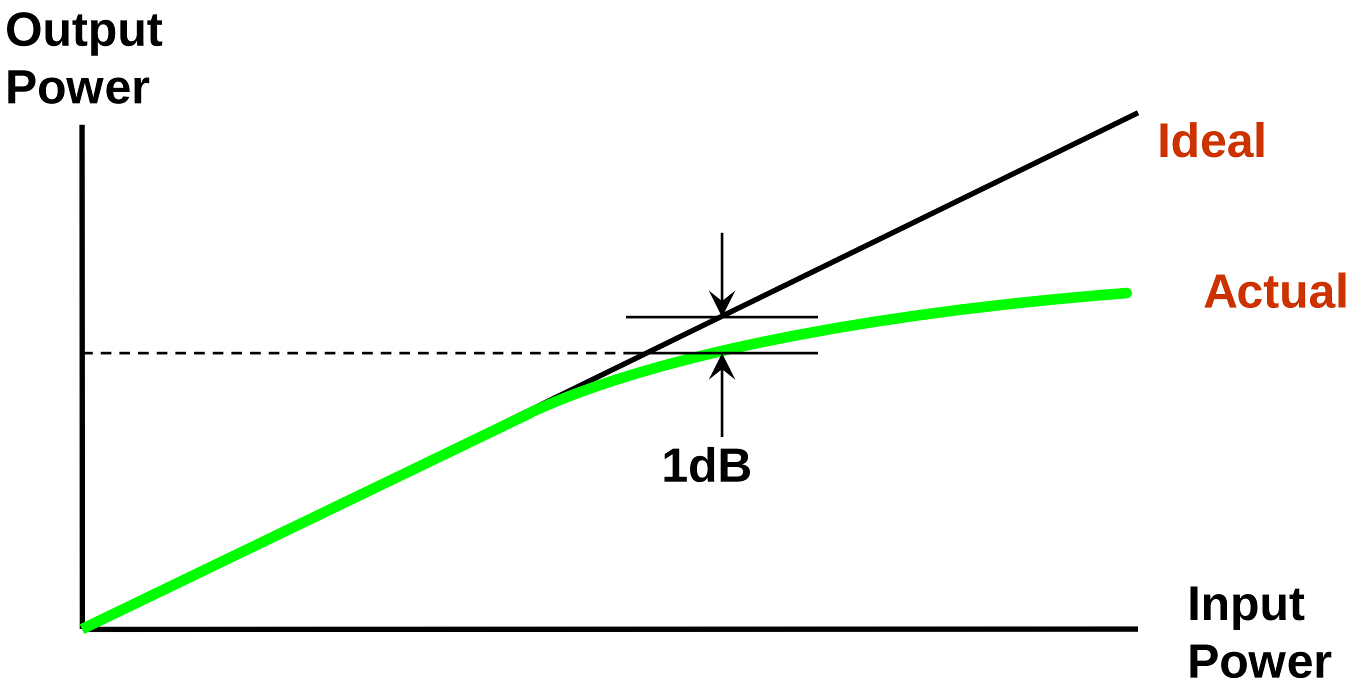
- As the output approaches the P1dB Point
- Output becomes Non Linear
  - Change in input power is not matched at the output
- Harmonics Increase
  - Clipping of the Sine wave creates higher harmonics



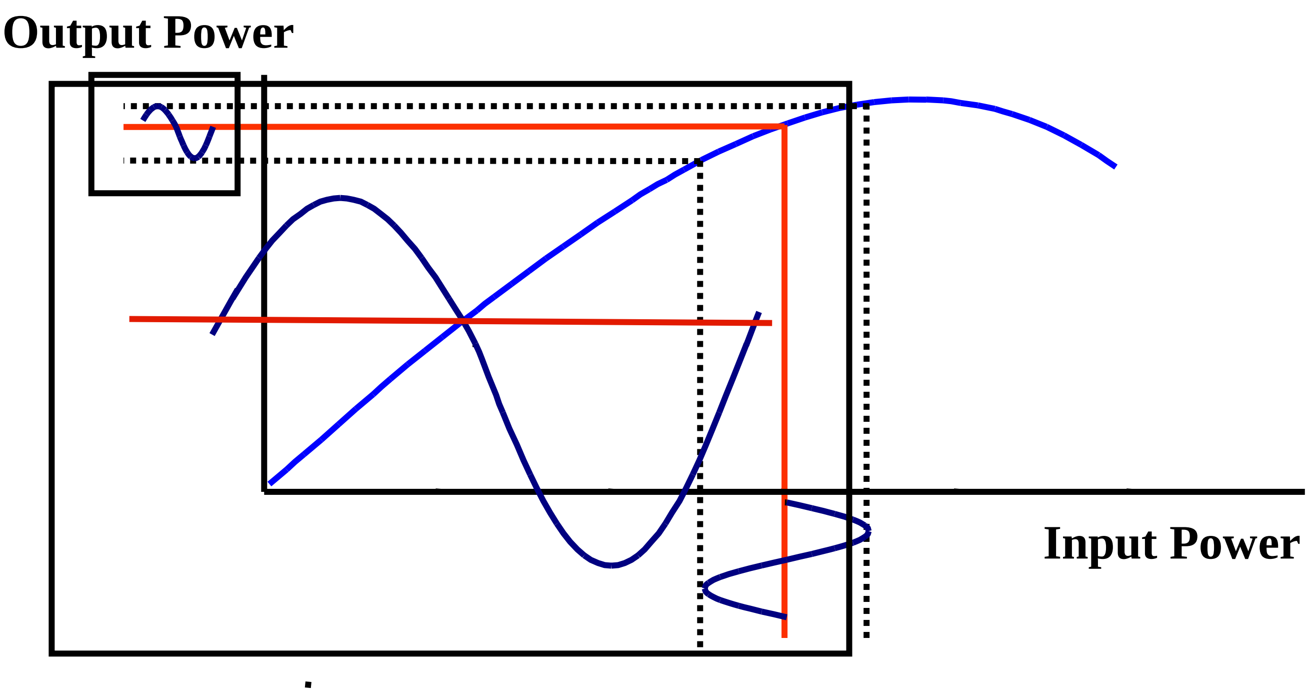


Gain Compression

The
1dB gain
compression
Point



Effect of Saturation on Modulation



Linearity Check required by IEC 61000-4-3

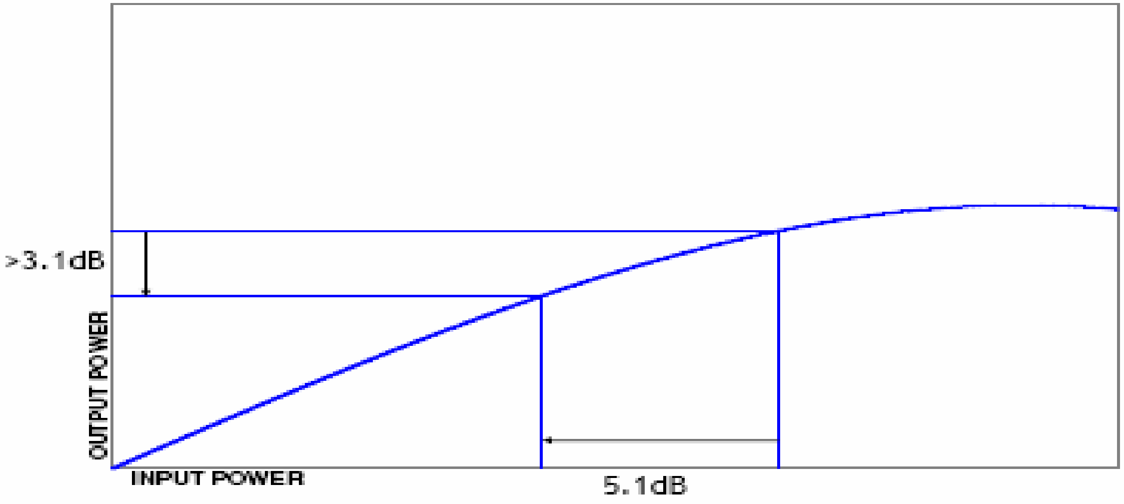


Figure 4 -2dB Linearity Criteria

Similar test now required for IEC 61000-4-6

Linearity Check required by IEC 61000-4-6

Evaluation of the amplifier linearity characteristic

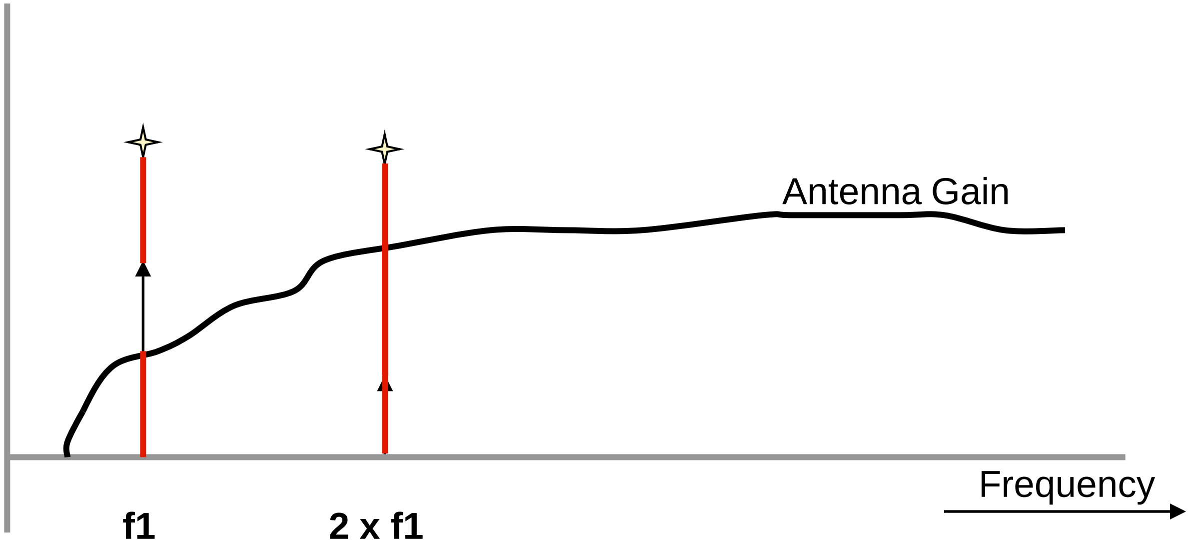
The linearity characteristic of the amplifier should be evaluated over the range of the amplifier that is used for testing. This shall include the minimum level, including the increase from modulation, to the maximum level, including the increase from modulation.

The maximum level is referred to as the maximum level of the CW signal to be measured increased by 5,1 dB to allow for the contribution of modulation.

Harmonics

- Unwanted signals produced at multiples of the required fundamental frequency
  - Broadband, power and field measuring devices cannot distinguish between the fundamental and harmonics
  - Under testing possible
- False failures can be caused
  - It may appear that an DUT has a problem at a frequency but it could be that the problem is at the harmonic frequency
  - User may waste time and money on an incorrect fix
- Most antenna have better gain at higher frequencies
  - This can magnify the level of the harmonic compared to the fundamental

Harmonic Distortion



Mismatch Tolerance

- The VSWR presented to the amplifier is indeterminate
- Some amplifiers need to protect the output devices from reflected power
  - Achieved by either shutting the amplifier down or reducing its gain above a certain critical level of reflected power
  - Both are undesirable effects for a user
- What determines the amplifiers ability to withstand high reflected power
  - It is not determined by the amplifier Class (Class A or Class A/B)
  - It is determined by the thermal design and the maximum dissipation in the output transistors

Conclusion (Amplifier Selection)

- Allowance must be made in selecting the power level required from the amplifier to include overhead for modulation and all losses
- At no point should the amplifier be used beyond the P1dB point
    - Ensure that the peak of the modulation envelop is below P1dB
- Always compare the minimum guaranteed P1dB power on the datasheet and not the headline saturated power

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END
Thank You

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