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COMPLIANCE TEST SOLUTIONS

KOTEL EMC-SEMINAR 2025 – TAMPERE

AMPLIFIERS FOR AUTOMOTIVE RADAR PULSE TESTING

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AUTOMOTIVE RADAR PULSE

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- Many establishments use radar systems designed to scan at ground level
- This is used at airports to control aircraft during taxi and take off
- Such systems are also used for security at airports and military establishments
- This represents a severe threat to a vehicle when the high fields impact on safety critical electronic components for example; airbags, ABS, collision avoidance systems
- Field strengths can be very high but the duration of the interference is short
- Radar is a made up of a series of very short pulses
- As the radar antenna rotates the beam will only hit a vehicle for a short time

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RELEVANT STANDARDS

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Standard	Section	Description
ISO 11452	-1	General Principles and Terminology
	-2	Absorber Lined Shield Encloser
	-3	Transverse Electromagnetic (TEM) Cell
	-4	Harness Excitation Methods (BCI)
	-5	Strip Line
	-7	Direct Radio Frequency (RF) Power Injection
	-8	Immunity to Magnetic fields
	-9	Portable Transmitters
	-10	Immunity to Conducted Disturbances in the Extended Audio Frequency Range
	-11	Reverberation Chamber
ISO 11451	-1	General Principles and terminology
	-2	Off- Vehicle radiation Sources
	-3	On boad transmitter Simulation
	-4	Bulk Current Injection (BCI)
SAE J551-11		Referenced against ISO 11452/2

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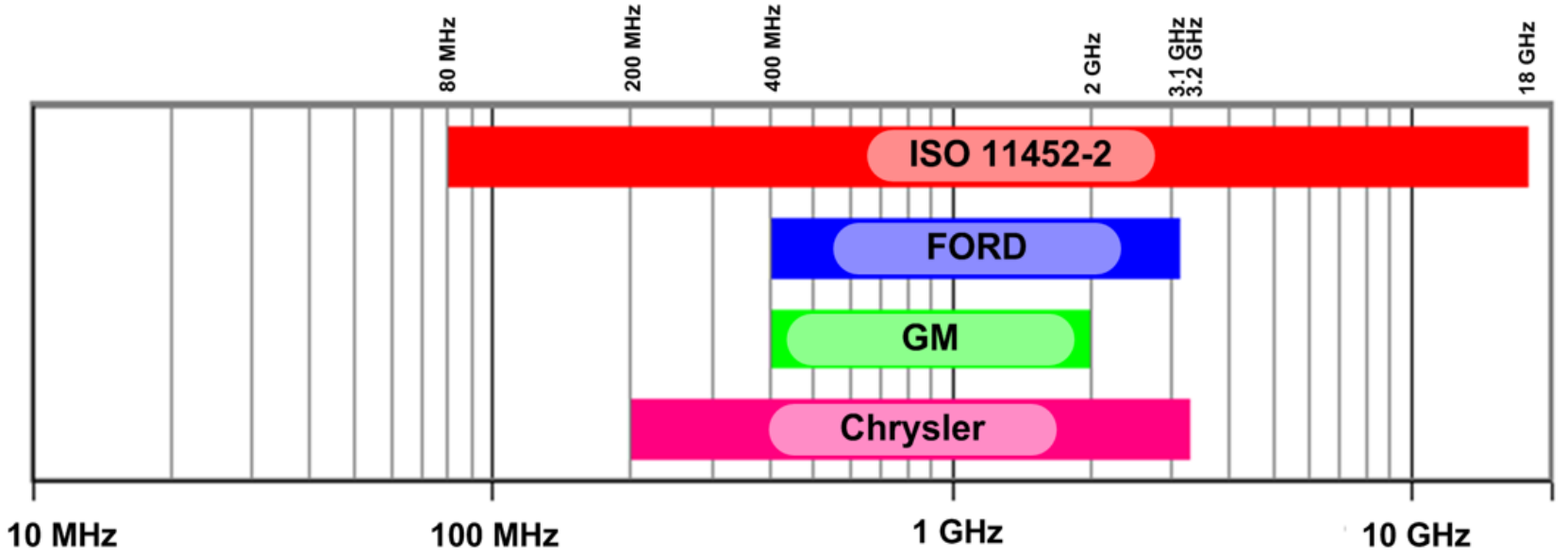
RELEVANT STANDARDS

Standard	Description
ISO 11452-2	Reference Standard Covering 80MHz to 18GHz
Ford Requirements	400MHz to 3.1GHz
GM requirements	400M to 2GHz
Chrysler Requirements	200MHz to 3.2GHz



RELEVANT STANDARDS

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- Standards bodies and automotive manufacturers have defined the test conditions
- Frequencies usually in two bands 1.2-1.4GHz and 2.7-3.1GHz (3.2GHz)
- Test levels 300V or 600V/m at 1 Meter
- Typically amplifier power in the region of 500 – 900 Watts is required depending on test level and the antenna selected
- vehicle testing requires different antenna and much higher power amplifiers

Band	Frequency	Level 1 V/m	Level 2 V/m	Pulse Modulation
4	400-800	50	100	CW, AM 80%, Pulsed PRR = 18 Hz, PD = 28 msec
5	800-2000	50	70	CW, Pulsed PRR = 217 Hz, PD = 0.57 msec
6	1200-1400	n/a	300² 600²	Pulsed PRR = 300 Hz, PD = 3 Usec, with only 50 Pulses output every 1 Sec
7	2700-3100	n/a	300² 600²	

Pulse Modulation limited to 400 – 470 MHz
600 V/m requirements are only applicable to be selected components associated with supplemental restraints systems including frontal crash sensors.
Pulse duration (PD) shall be extended to 6usec when testing using the reverberation (mode tuned) method

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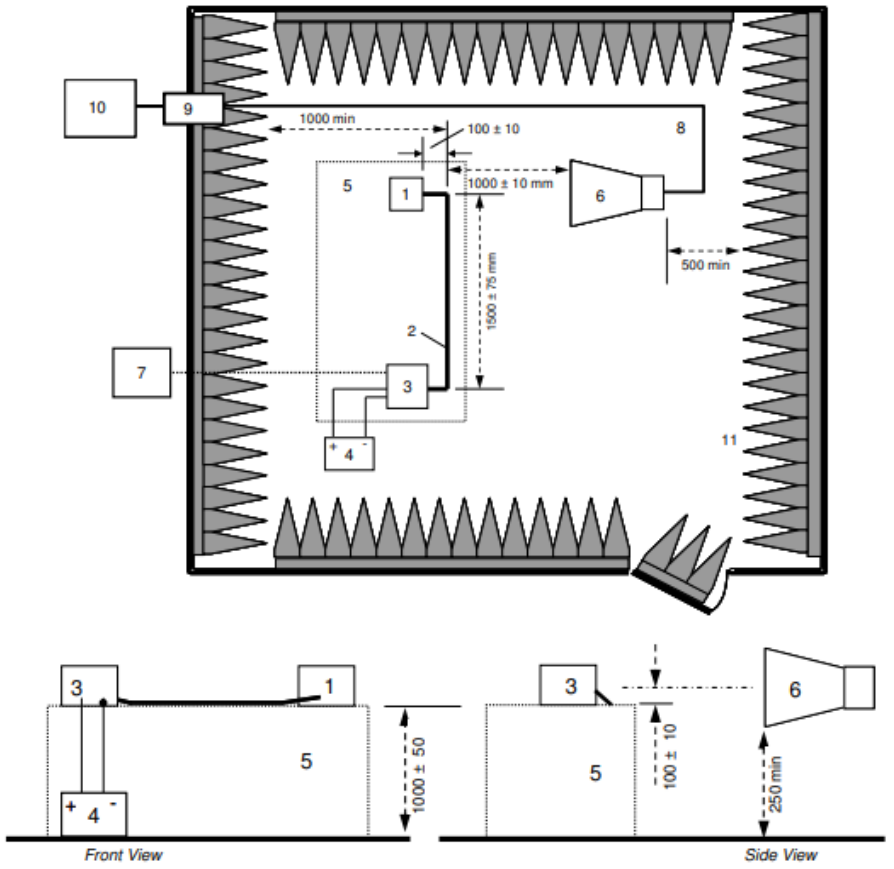
TEST SETUP

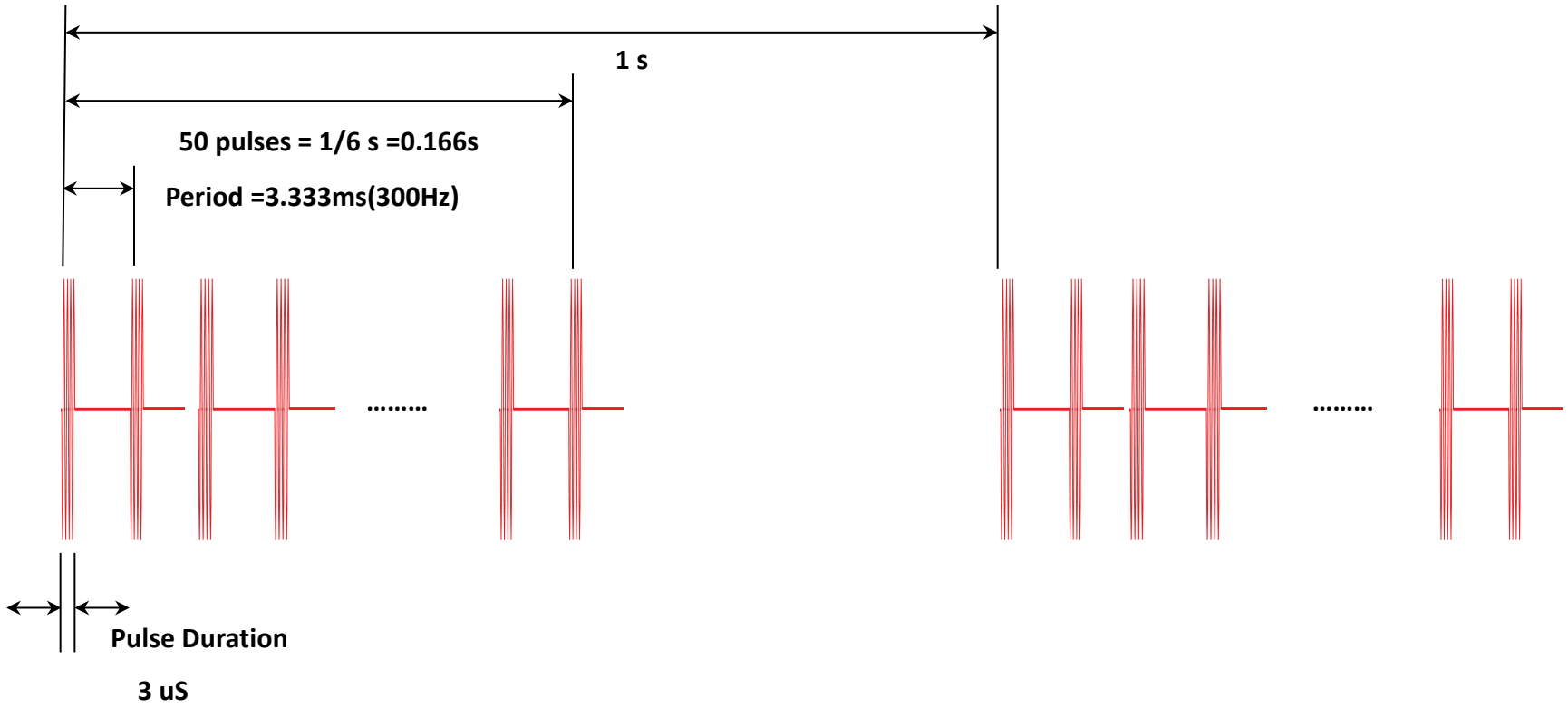
- When performing testing in Bands 6 and 7 using pulse modulation, CW shall not be used for leveling prior to application of pulsed modulation.
- Use the step frequencies listed in Table 11-2. Use the modulation as specified in Table 11-3.
- All modulation dwell time (i.e., time that RF is applied for per modulation type) shall be at least 2 sec. e) The test shall be performed using both horizontal and vertical antenna polarization.
- At test frequencies ≥ 1000 MHz, the DUT shall be tested in a minimum of three (3) orthogonal orientations unless otherwise stated in the EMC test plan. g) If deviations are observed, the field shall be reduced until the DUT functions normally. The field shall then be increased until the deviation occurs. This level shall be reported as deviation threshold.



Key:

1. DUT
2. Test Harness
3. Load Simulator
4. Automotive Battery
5. Dielectric Support ($(\varepsilon_r \leq 1.4)$
6. Transmit Antenna
7. Support Equipment
8. Double Shielded Coaxial Cable (e.g. RG 223)
9. Bulkhead Connector
10. RF Generation Equipment
11. RF absorber Material

TYPICAL RADAR PULSE MODULATION



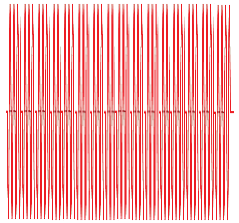
DESIGNING A SYSTEM

Determining what Power Amplifier to select depends on

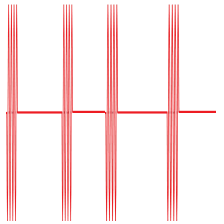
- The test level required by the standard
- The type of modulation required
- The antenna efficiency (Gain) or transducer efficiency
- The test environment
- Cable and other component losses

THREE AMPLIFIER TYPES

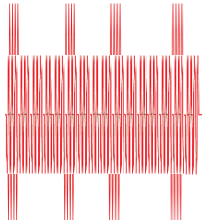
- CW amplifier (are able to output maximum power continuously)



- Pulse Amplifier (can output full power pulses but no CW)

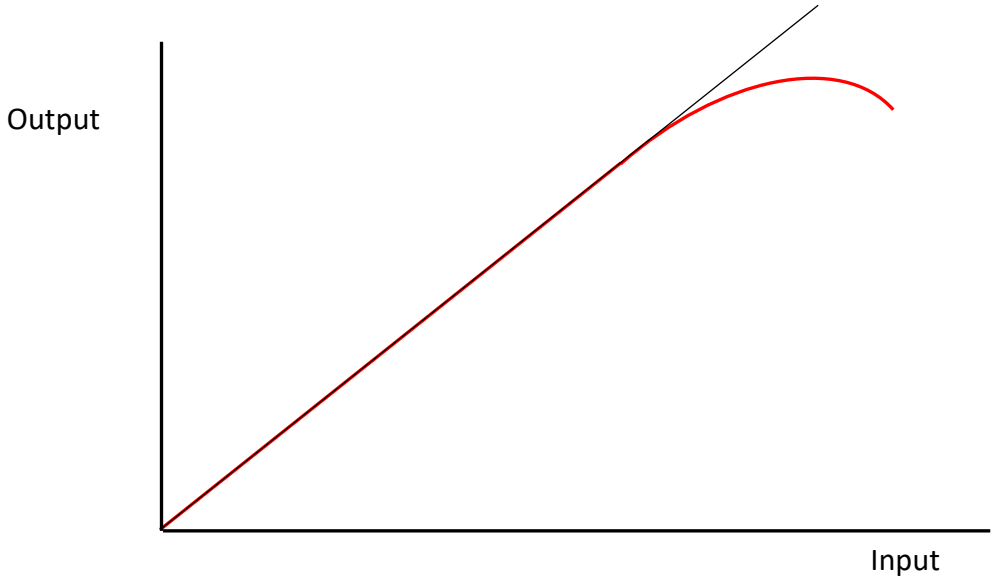


- Pulse/CW amplifier (can output reduced power continuously or full power pulses)

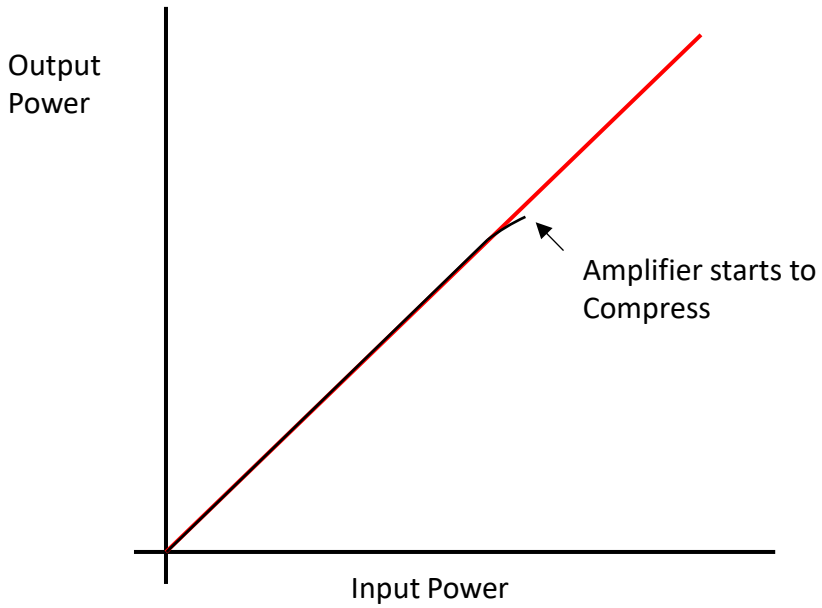


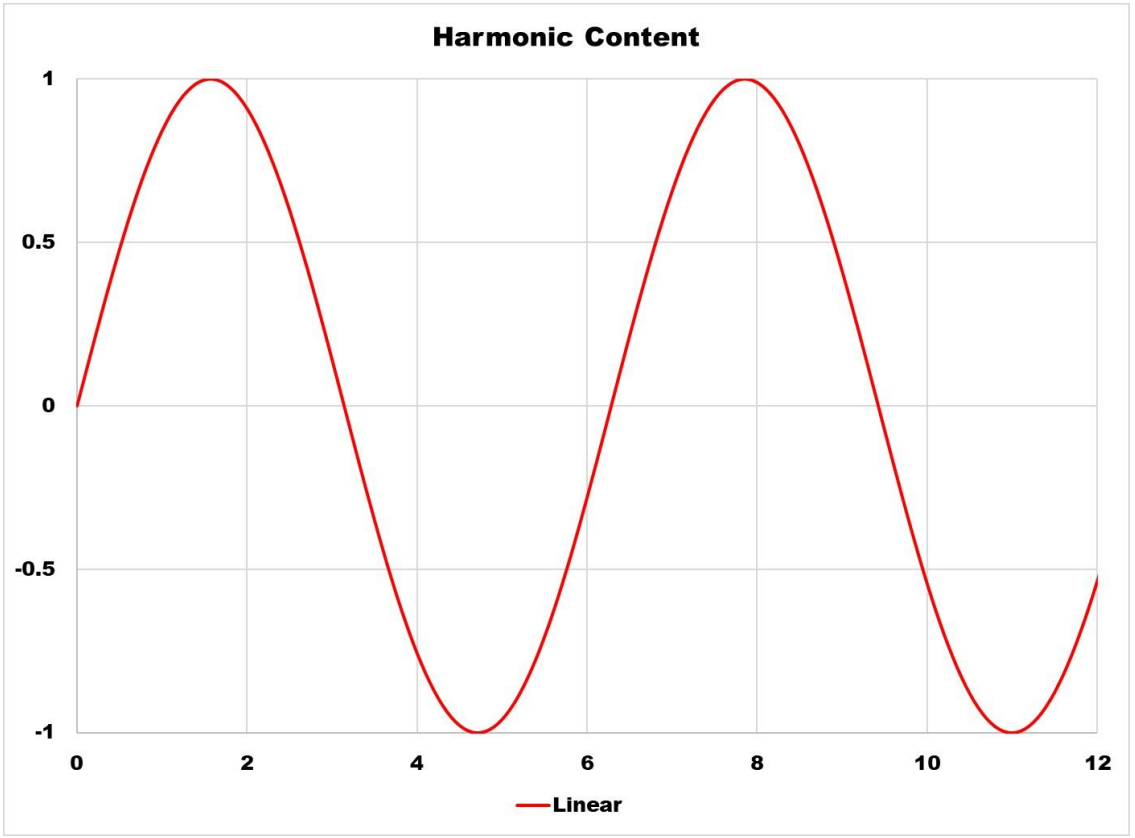
USABLE AMPLIFIER POWER

- Saturated Power (Psat) Vs Linear Power (P1dB)
- Definitions
  - Psat – Highest power that the amplifier can generate
  - P1dB – Highest power where Pin Vs Pout curve is considered to be straight



WHAT HAPPENS TO MODULATION AT AND ABOVE P1DB





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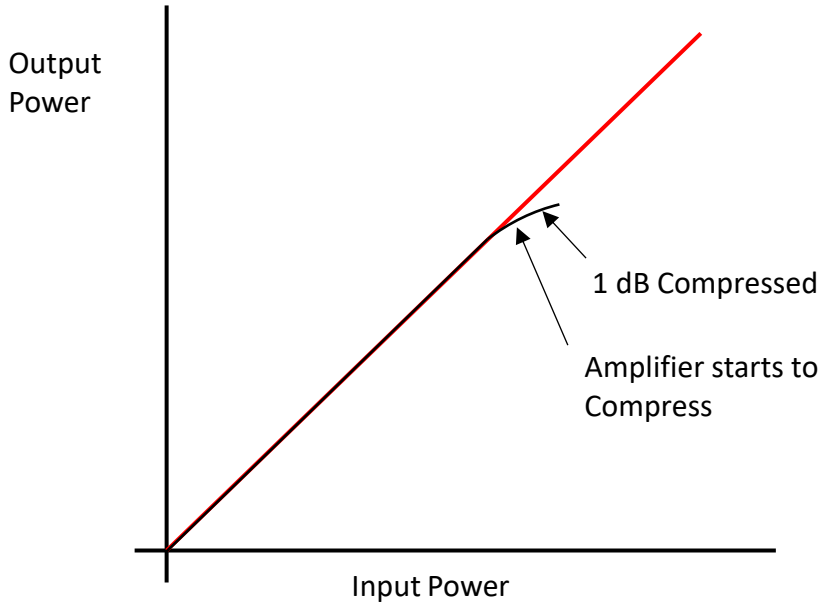

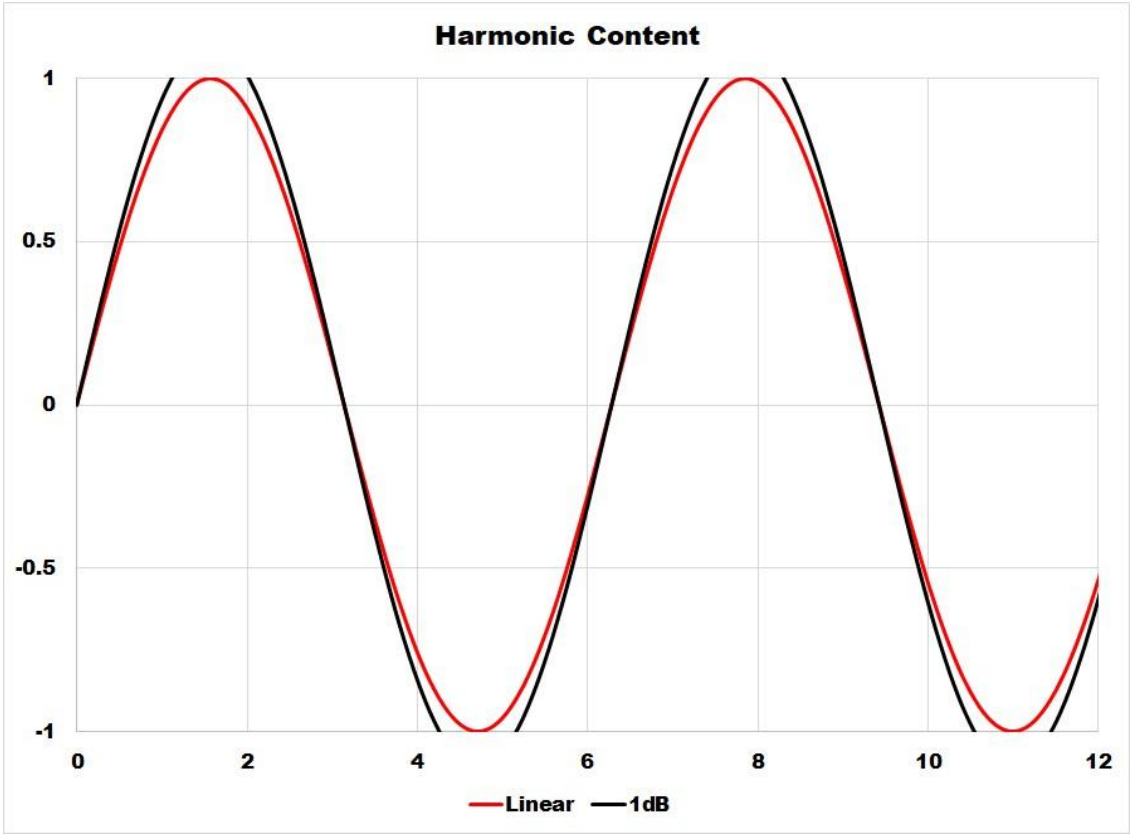

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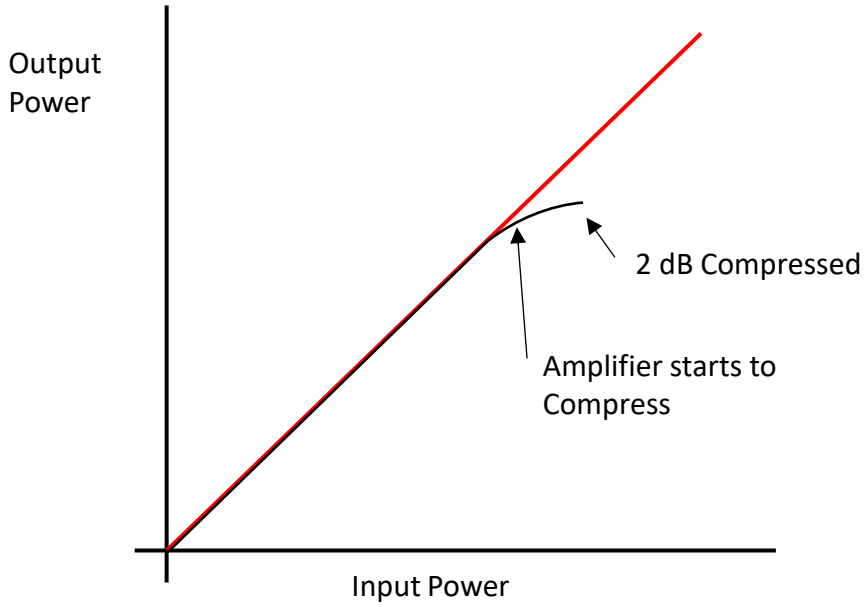

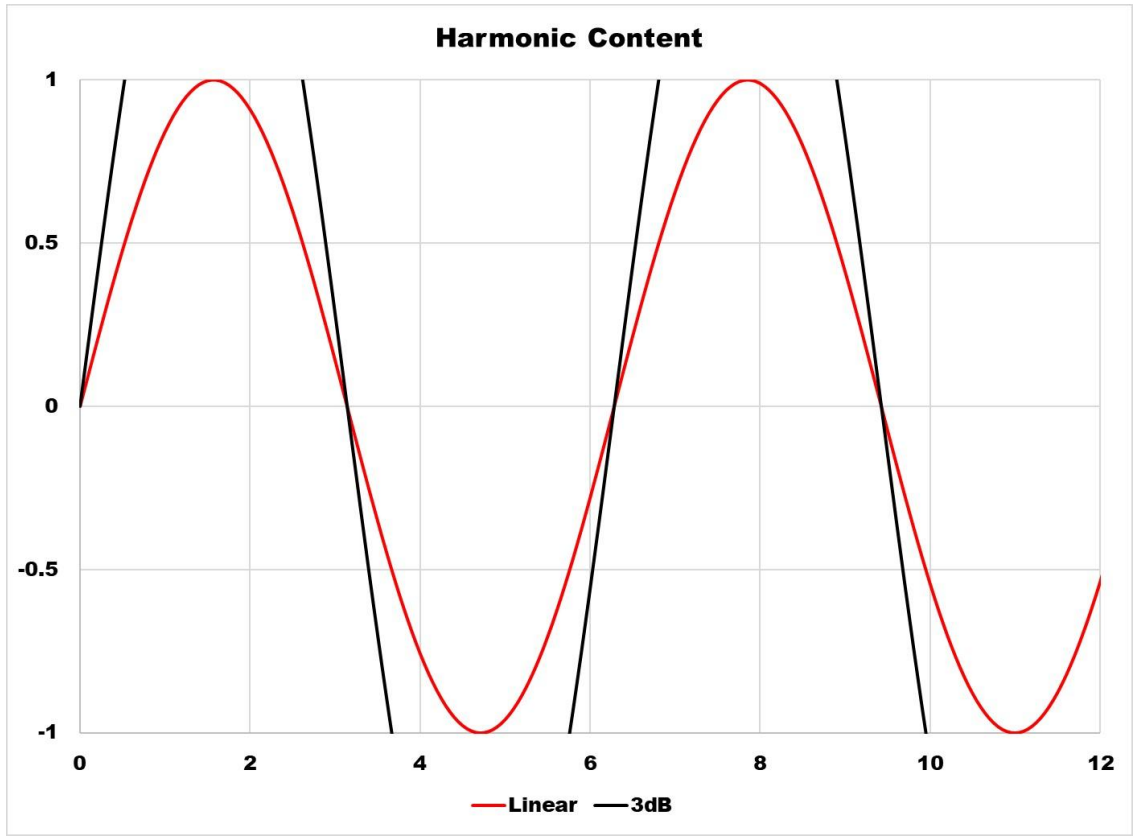

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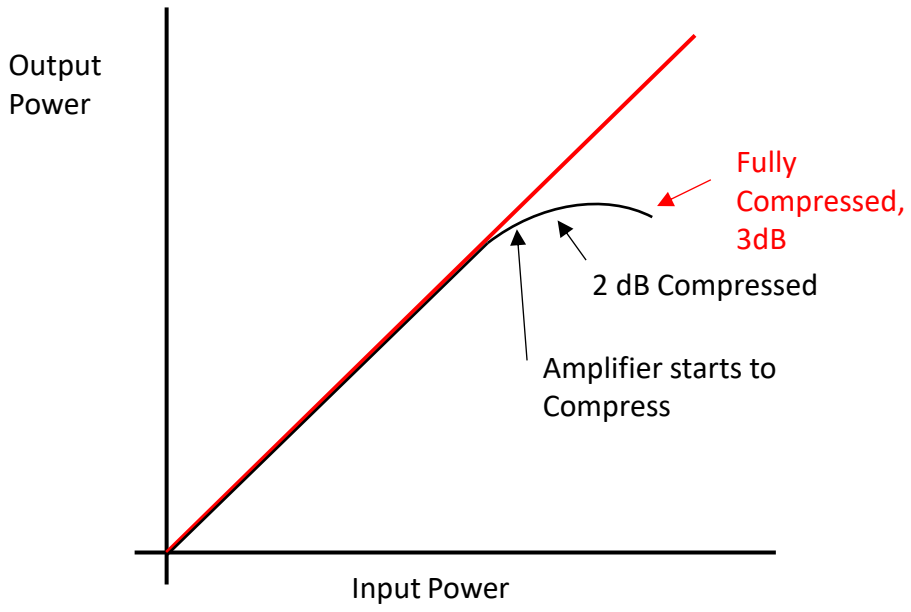
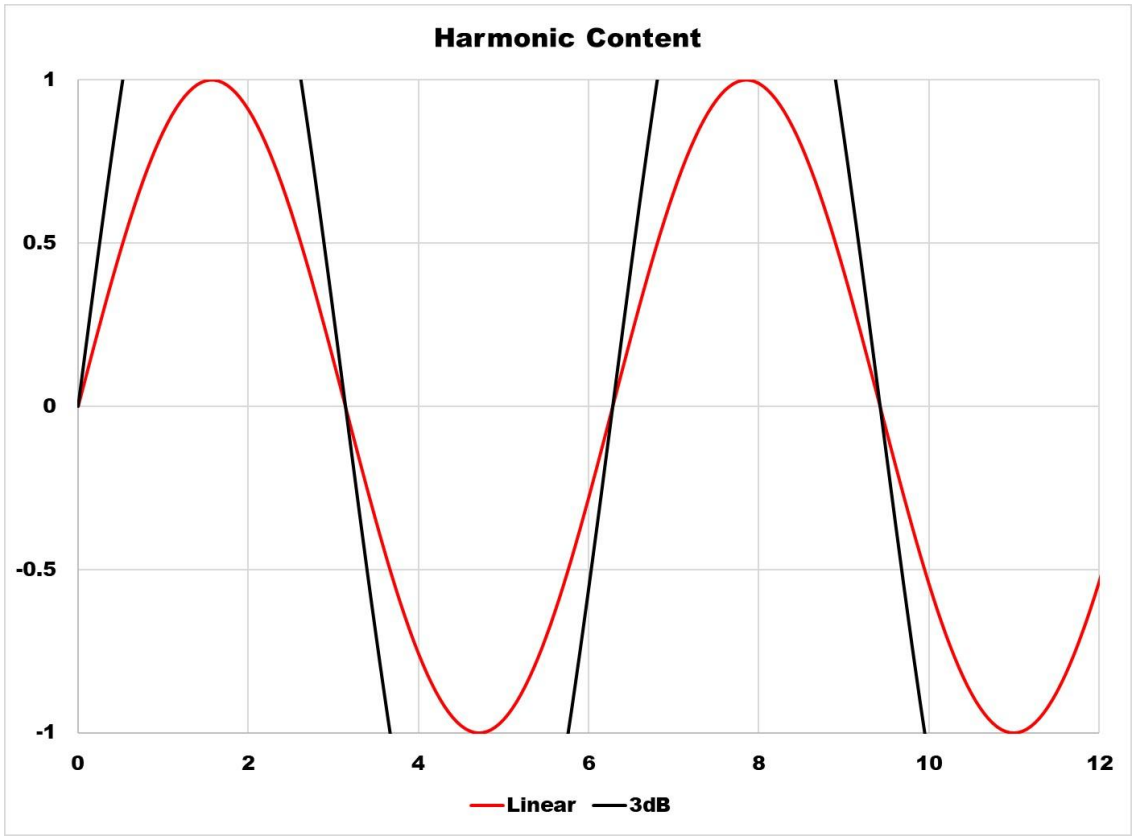
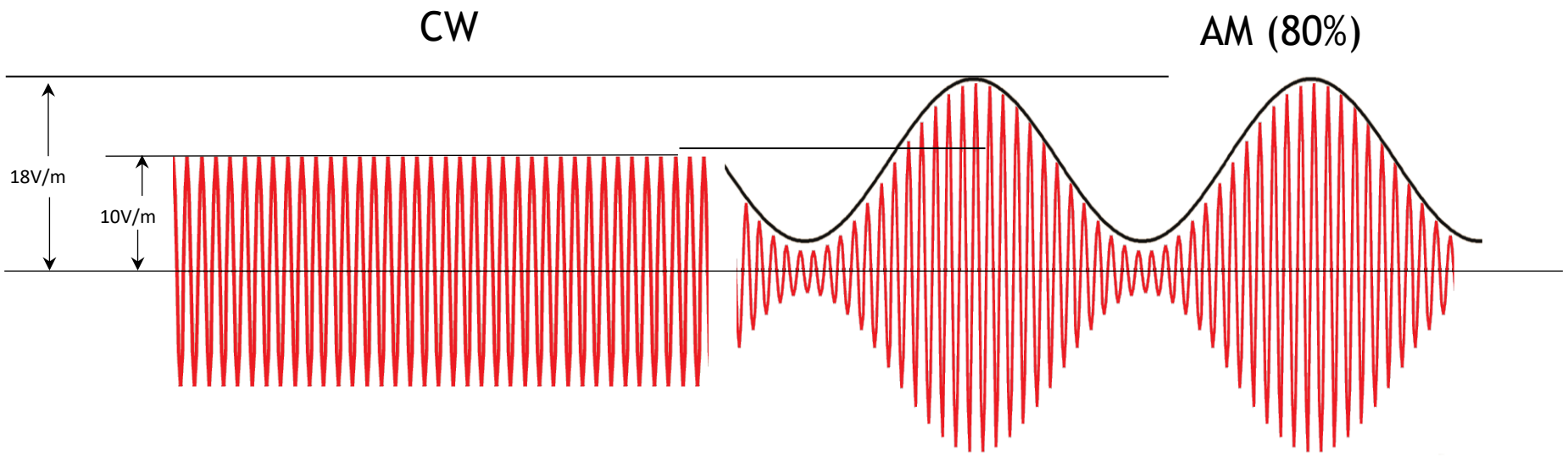
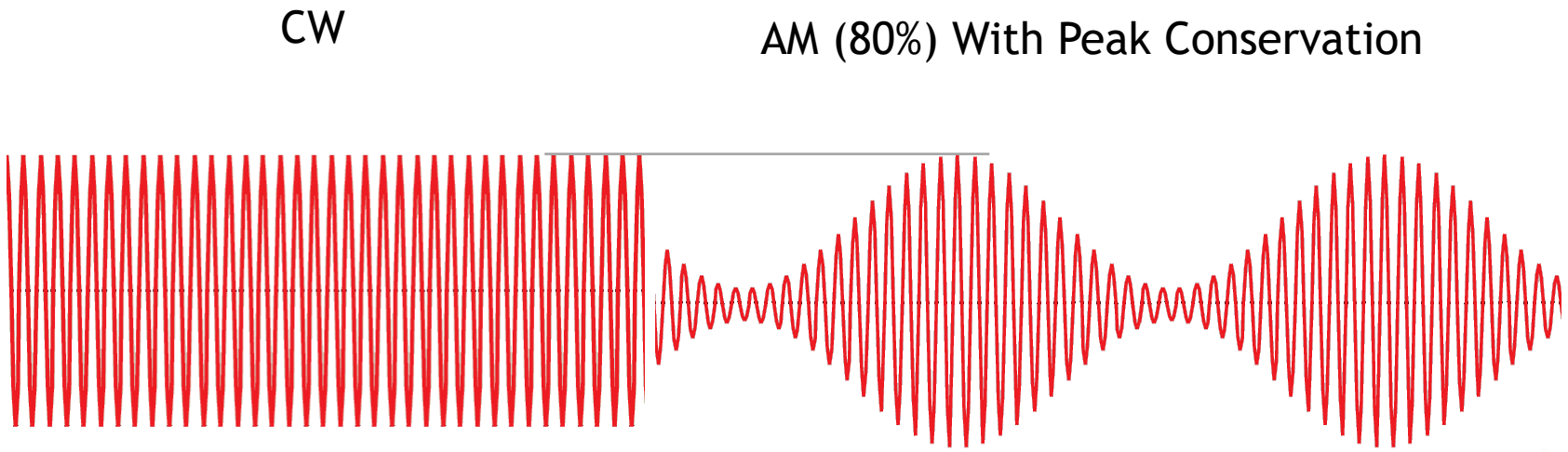




80% AM WITHOUT PEAK CONSERVATION

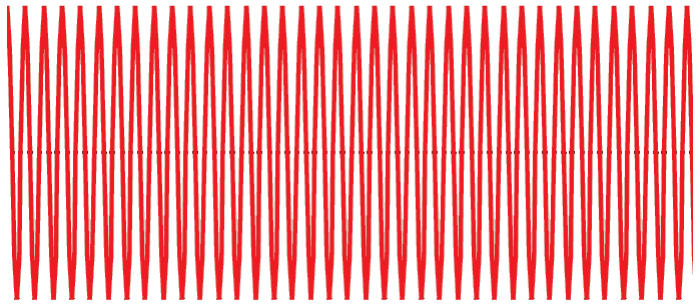


80% MODULATION WITH PEAK CONSERVATION

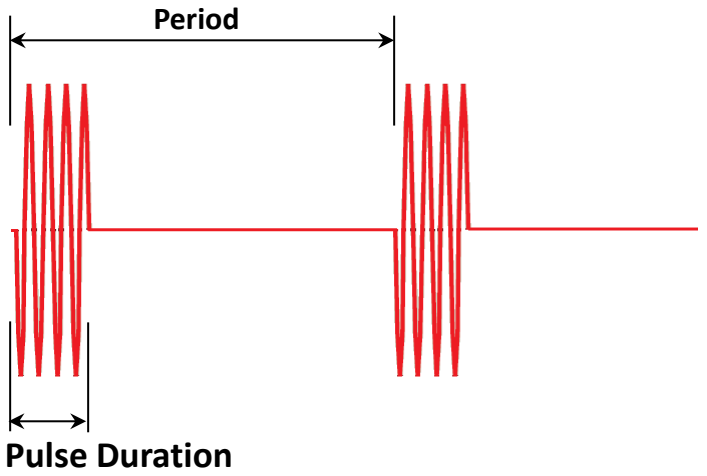


EFFECTS OF PULSE MODULATION

CW (unmodulated signal)



Pulse Modulation



HARMONICS

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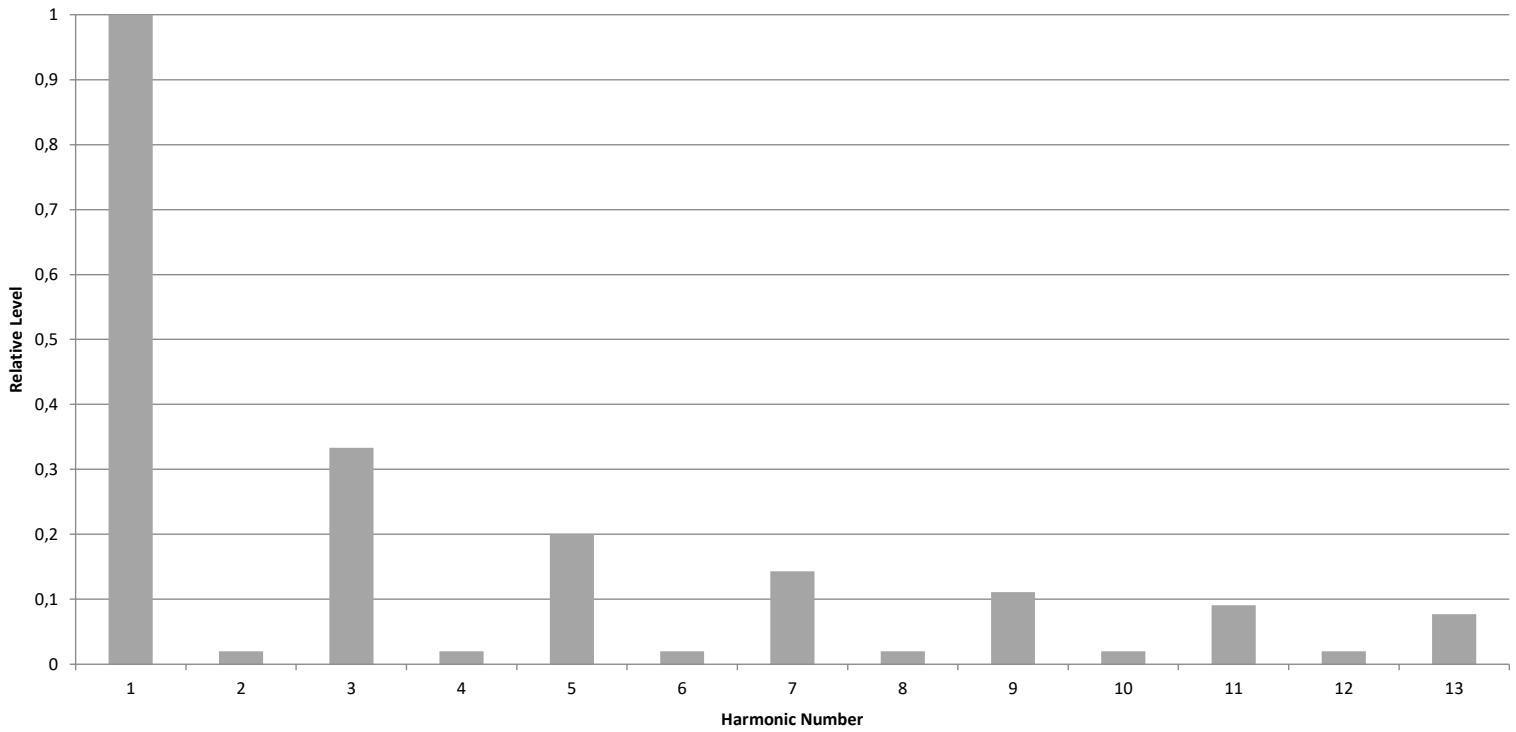
- Unwanted signals produced at multiples of the required fundamental frequency



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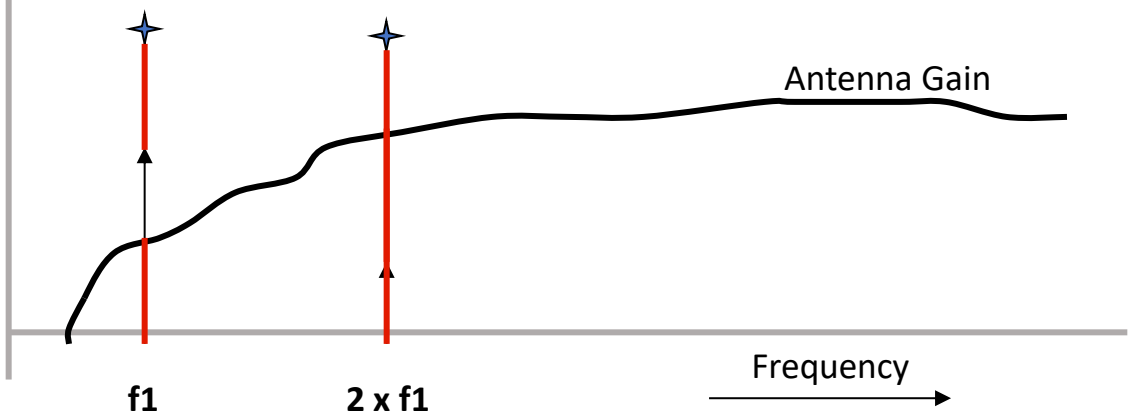
HARMONICS

- 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 can be 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



ANTENNA GAIN

- Antenna gain varies with the separation distance between the antenna and the measuring device
- Close to the antenna the presence of the antenna itself effects the parameters of the environment
- Some antenna suppliers show gain figures at various distance
- Always use the correct values if available or make allowance if not
- Around 3dB gain reduction between 3 and 1 metre values is typical

LOSS IN CABLE AND COMPONENTS

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Standard	Section	Loss
Test Rack to Antenna	1.5M rack to Penetration	0.25 dB @ 1GHz
	5m penetration to floor panel underfloor cable	0.8 dB @ 1GHz
	3m floor panel to antenna	0.5 dB @ 1GHz
Internal to rack	0.4m RF switch output – rack bulkhead	0.1 dB @ 1GHz
	0.4m Directional Coupler output – RF switch input	0.1 dB @ 1GHz
	Directional Coupler	0.1 dB @1GHz
	RF Switch – 2 Way N type	0.1 dB @ 1 GHz
Total Loss		1.95 dB @ 1GHz

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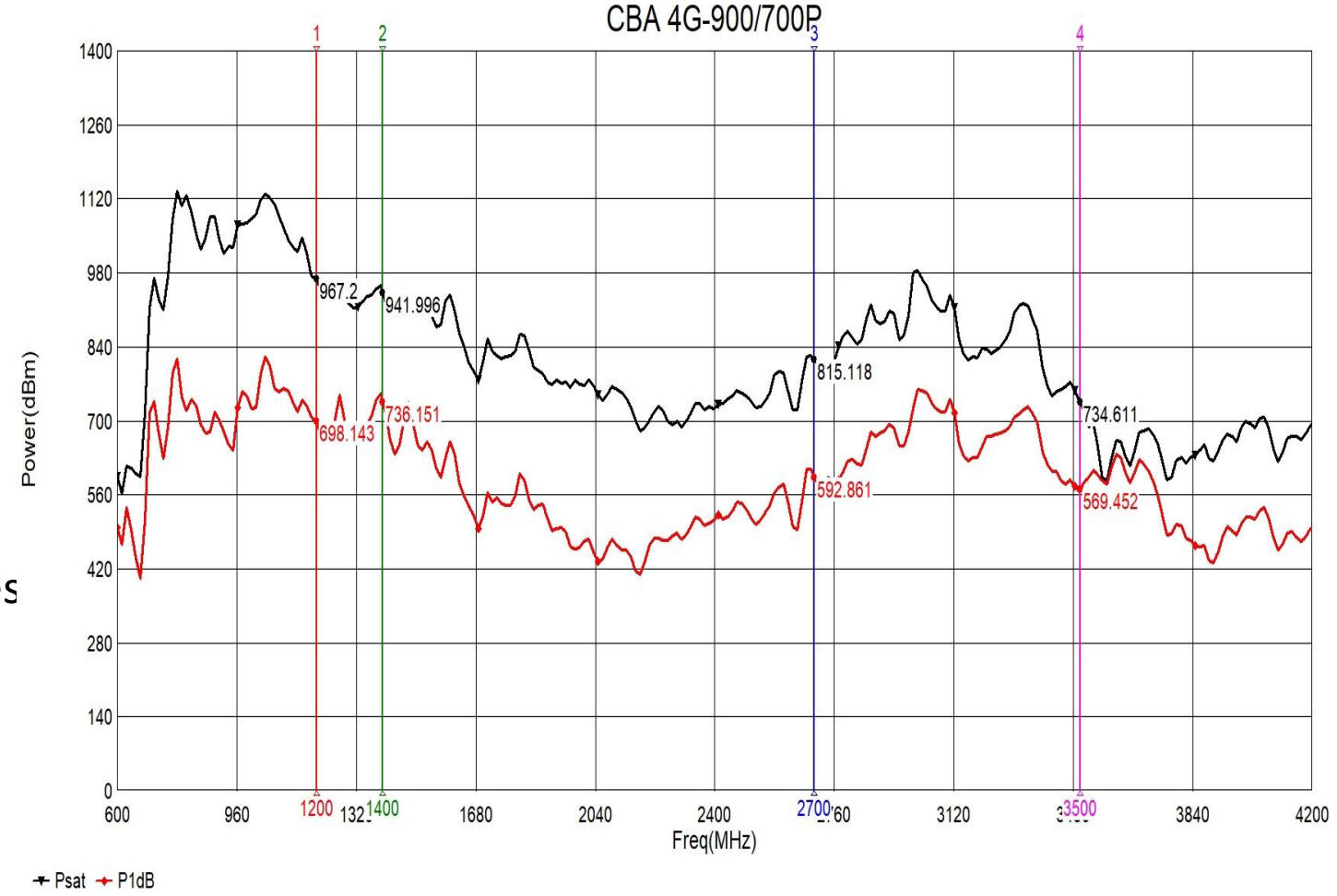
CBA 4G-900/600P

Specification	CW Specification	Pulsed Specification	2.7-3.1GHz Specification
Frequency	0.8 to 4.0GHz	1.2 to 1.4GHz	2.7-3.5GHz
Saturated Power (Min)	500W	900W	600W
P1dB Power (Min)	400W		
Gain	60.0dB		
Gain variation	+/- 3.0dB		
Harmonics @ P1dB	-18dBc		
Input Power (no Damage)	+15dBm		
Stability	Unconditional		
Output Impedance	50 ohm		
Output VSWR	2:1 typical		
Input VSWR	2:1 max		
Spurious (Min)	-70 dBc		
Noise Figure	10.0dB		
Supply Frequency	47 to 63 Hz		
Supply Voltage (typ)	5.5 KVA		
Dimension	19 Inch, 20U		
Weight	160 Kg		

AMPLIFIERS AVAILABLE FROM AMETEK CTS

- New 0.8 to 4.0GHz 900/600W Pulsed
- One amplifier for all EMC applications
- Radar Pulse testing, 900W CW @ 1.2-1.4GHz & 600W 2.7-3.5GHz
- Low Noise floor, suitable for low level (wireless) testing
- Single wide band horn antenna requires around 850W to achieve 600V/m



LATEST NEWS

- New CBA 4G8G Series
- single-band, scalable class A amplifiers
- Frequency range: 4GHz-8GHz
- Powers available:30W-400W
- Meeting automotive manufacturers' increased frequency test demands up to 7.125 GHz for ALSE RI tests aligned to ISO 11452-2 & Mobile Transmitter tests aligned to ISO 11452-9 test methodology. 10-Watt model coming in 2025.

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THANK YOU!

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