



Insights and best practice

# EMC COMPLIANCE KNOW-HOW



TECHNICAL NOTE 0106

## RADAR PULSE TESTING

### WHAT ARE YOUR OPTIONS?

#### The challenge

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; air-bags, ABS, collision avoidance systems.

Field strengths can be very high but the duration of the interference is short. Radar is 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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AMETEK CTS

*“We created this document to help test engineers understand the different accepted methods of performing radar pulse testing”*



# RELEVANT STANDARDS

STANDARD	CW FREQUENCY REQUIREMENT	CW FIELD STRENGTH	RADAR PULSE FREQUENCY REQUIREMENT	RADAR PULSE FIELD STRENGTH
Ford FMC1278:2015	400MHz - 3.1GHz	100V/m	1.2-1.4GHz, 2.7-3.1GHz	300/600V/m
GMW3097:2019 General Motors	400MHz - 2GHz	100V/m	1.2-1.4GHz	300V/m
FCA CS-00054:2015	200MHz - 3.2GHz	150V/m	N/A	N/A
VW TL81000:2018	200MHz - 6GHz	140/50V/m	N/A	N/A
Volvo 318503329-004-2014	200MHz 6GHz	100V/m	1.2-1.4GHz, 2.7-3.1GHz	600V/m
PSA Group B21 7110 D:2012 French Multinational	200MHz - 3.2GHz	200V/m	1.2-1.4GHz	600V/m
CEVT 8888621495-2:2018 China Euro vehicle Technology	80MHz -6GHz	100V/m	1.2-1.4GHz, 2.7-3.1GHz	600M/m
YIQI Q/FC-CC06-001A-2015	100MHz - 3.2GHz	70/140V/m	1.2-1.4GHz, 2.7-3.2GHz	140V/m
GreatWall Q/CHTS 04002-2017	100MHz -2.5GHz	100V/m	1.2-1.4GHz, 2.7-3.2GHz	300V/m
Dongfeng EQC-1204-2007	200MHz -2.5GHz	200V/m	1.2-1.4GHz, 2.7-3.2GHz	200V/m



# AUTOMOTIVE RADAR PULSE TEST

- ▶ 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, amplifier location and antenna selection.
- ▶ Whole vehicle testing requires different antenna and much higher power amplifiers

## FORD FMC1278 EXTRACT

BAND	FREQUENCY	LEVEL 1 V/M	LEVEL 2 V/M	PULSE MODULATION
5	360-806	50	100	CW, AM 80%, Pulsed PRR = 18 Hz, PD = 28 msec (Note: 1)
6	806-2000	50	n/a	CW, Pulsed PRR = 217 Hz, PD = 0.57 msec
7	1200-1400	n/a	300 <sup>2</sup> 600 <sup>2</sup>	Pulsed PRR = 300 Hz, PD = 3 Usec, with only 50 Pulses output every 1 Sec (Note: 3)
8	2700-3100	n/a	300 <sup>2</sup> 600 <sup>2</sup>	

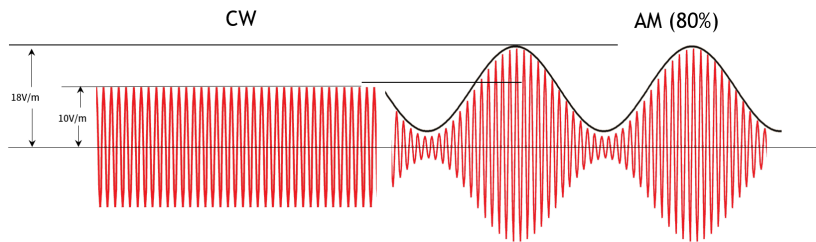
1. Pulse Modulation limited to 400 – 470 MHz. CW and AM modulation apply over the entire band (360 – 806 MHz).
2. 600 V/m requirements are only applicable to be selected components associated with supplemental restraints systems including frontal crash sensors.
3. Pulse duration (PD) shall be extended to 6usec when testing using the reverberation (mode tuned) method.





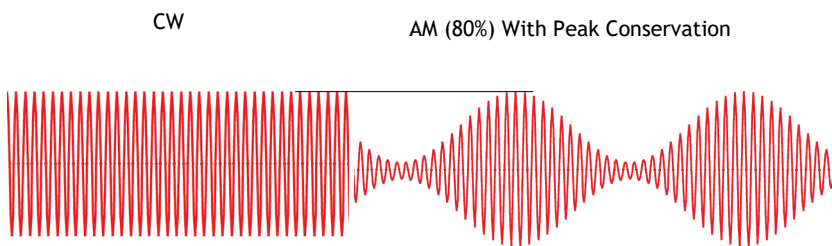
## AUTOMOTIVE RADAR PULSE TEST

### 80% am (Commercial)



Testing with 80% AM, the output power from the amplifier shall not exceed the P1dB limit. AM requires approximately 3.3 times the CW power

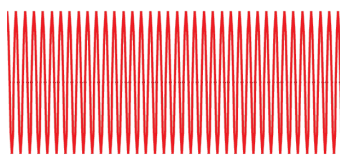
### 80% am with Peak Conservation (Automotive)



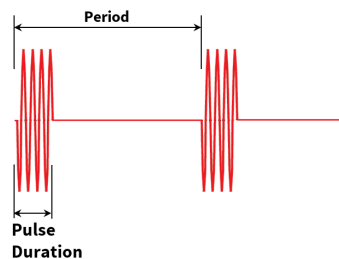
For Radiated Immunity testing peak conservation of ISO 11452-1 is used for application of AM and Pulse modulation

### Effects of Pulse modulation

CW (unmodulated signal)

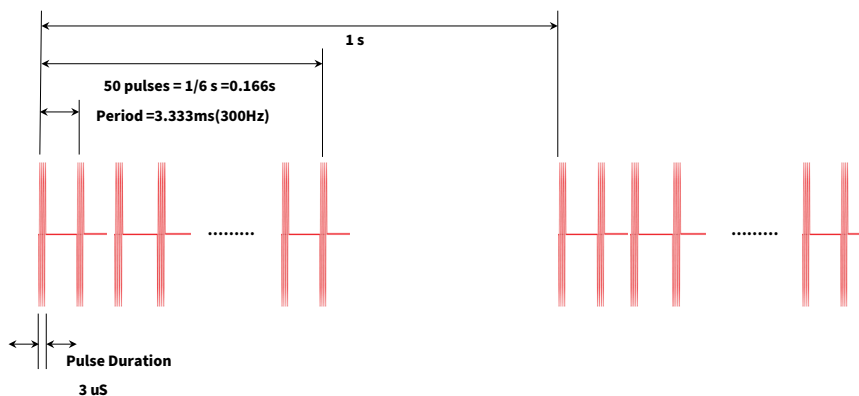


Pulse Modulation



For CW pulse modulation requirements the output power from the amplifier can exceed the P1dB limit.

### Typical radar pulse modulation



Pulse burst the amplifier is required to replicate. A CW amplifier has no duty cycle limitation so can handle any PRF desired by the standards.



## RF POWER AND FIELD LEVELS

Below are top level calculations of the RF input power required to produce a field level of 600V/m at a distance of 1 m using an antenna with an minimum isotropic gain of 12dBi. An RF signal in the region of 750 watts will be required to produce a 600 V/m at a distance of 1 m from the antenna.

Note: The amplifier will require sufficient margin to compensate for additional losses within the RF system associated with externally mounted dual directional couplers, interconnecting RF cables and chamber performance.

### CW Field Calculations

600 V/m at 1M

Antenna Gain - G(dBi) = 12

Antenna Gain -G(linear) = 16

Field Strength =  $P_t = E^2 \times R^2 / 30 \times G(\text{linear})$  = Required RF Power at the antenna.

E(V/m) E field Level = **600 V/M**

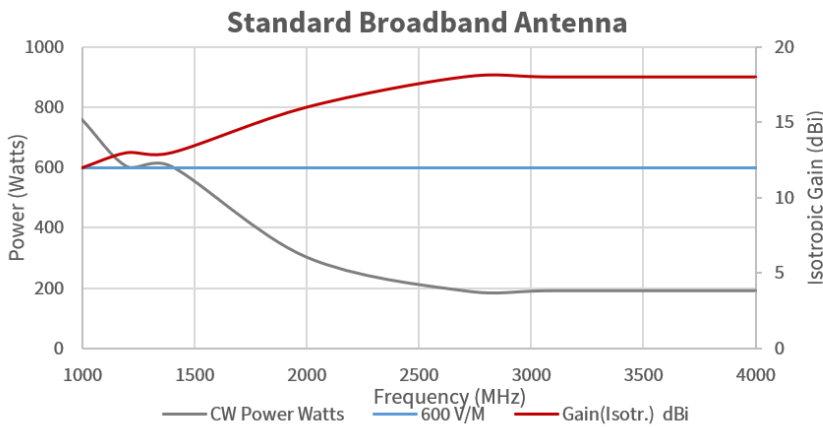
R(m) Distance in meters = **1M**

Pt(W) Required RF power Input to antenna

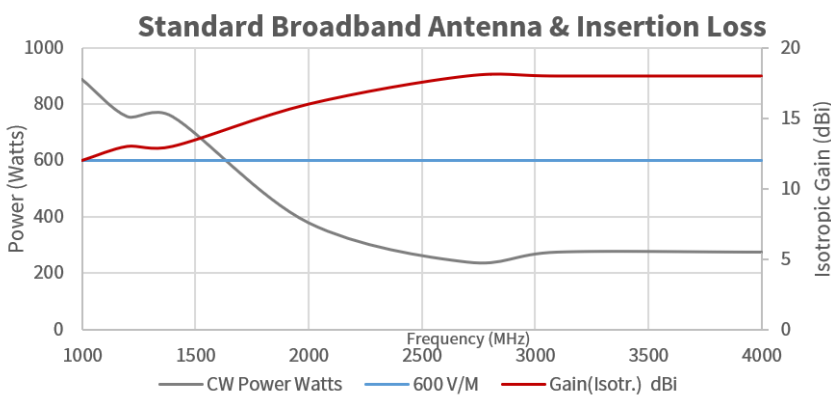
**Calculation,**  $P_t = (600)^2 \times (1)^2 / (30 \times 16) = 750 \text{ watts}$



## EFFECT OF INSERTION LOSS ON AMPLIFIER POWER REQUIREMENT



Frequency MHz	Gain(Isotr.) dBi	Cable Loss dB	CW Power Watts	600 V/M
1000	12	0	757	600
1200	13	0	601	600
1400	13	0	601	600
2000	16	0	301	600
2700	18	0	190	600
3100	18	0	190	600
4000	18	0	190	600



Frequency MHz	Gain(Isotr.) dBi	Cable Loss dB	CW Power Watts	600 V/M
1000	12	0.7	889	600
1200	13	1	757	600
1400	13	1	757	600
2000	16	1	379	600
2700	18	1	239	600
3100	18	1.6	275	600
4000	18	1.6	275	600



## USABLE AMPLIFIER POWER

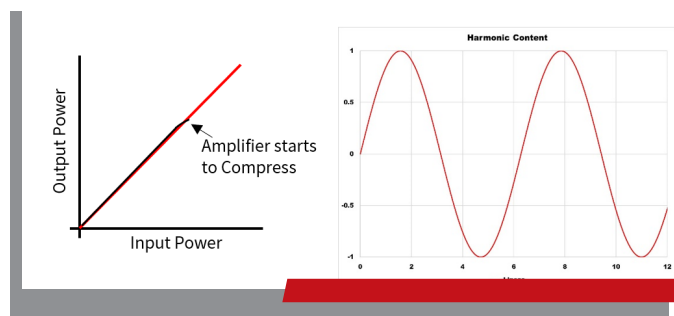
### Saturated Power (Psat) Vs Linear Power (P1dB)

#### Definitions

- ▶ Saturated – Highest power that the amplifier can generate
- ▶ P1dB – Highest power the amplifier can generate where the linear relationship between the input and output power is in error by less than 1dB of the fixed gain value

## WHAT HAPPENS TO AM MODULATION AT AND ABOVE P1DB

1



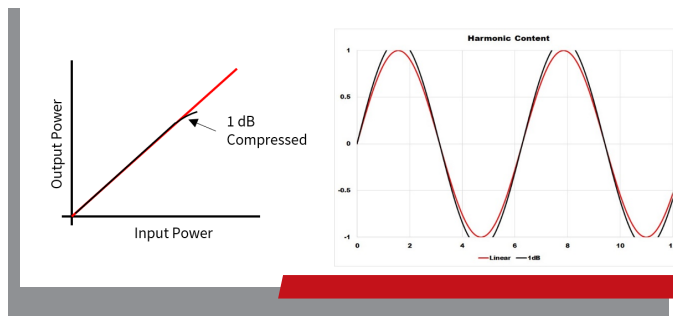
The amplifier is operating in the linear region with no modulation distortion between the input and output AM signals





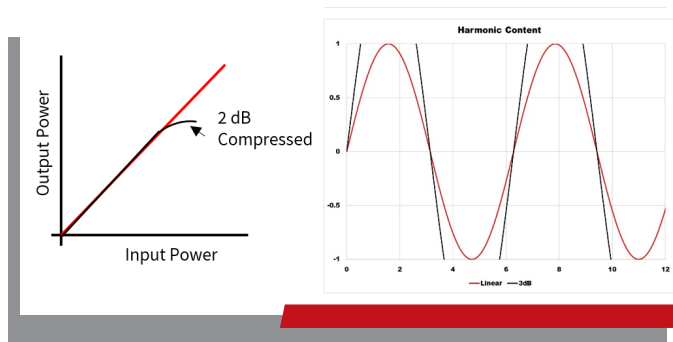
**WHAT HAPPENS TO AM MODULATION AT AND ABOVE P1DB** continued...

**2**



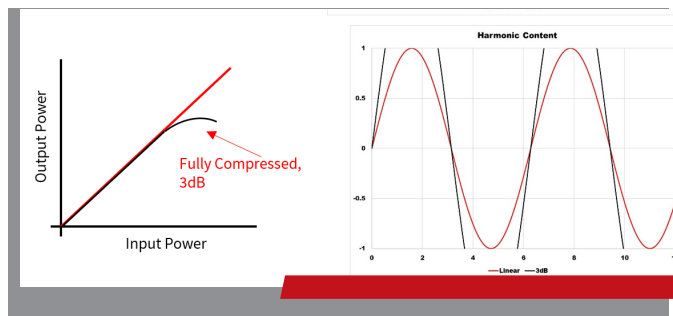
The amplifier is compressed to 1dB. Acceptable power limit with minimal amount of distortion between the input and output AM signal.

**3**



The amplifier is driven further into compression where the distortion between the input and output AM signal is becoming undesirable causing the amplifier to become unsuitable for AM testing.

**4**



The amplifier is fully compressed (P3dB) where the distortion between the input and output AM signal can cause undesirable 2nd & 3rd harmonic content and the amplifier completely unsuitable for AM testing.



## 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)
- ▶ The test environment
- ▶ Cable and other component losses

### Antenna Selection Example

Horn antenna are the most efficient antenna in these frequency ranges

Broad band 1GHz -6GHz horn antenna.

- ▶ Only one setup required saving lab time
- ▶ 600V/m, full band in one sweep
- ▶ No limit to general broadband testing

Narrow band horn antenna 1.2-1.4GHz and 2.7-3.2GHz

- ▶ Will be more efficient for required RF power
- ▶ More complicated setup required with RF switches incurring additional losses and time
- ▶ Can't be used for broadband testing

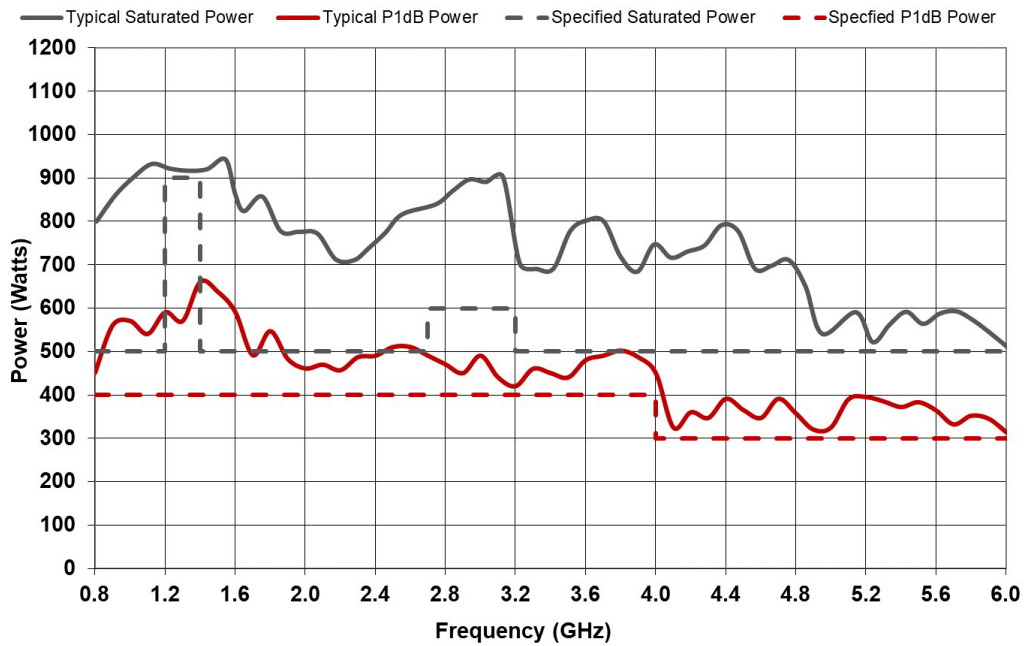


## A SIMPLIFIED RF IMMUNITY SYSTEM

### Only two Amplifiers required

CBA 1G-1200D & CBA 6G-900-600R

- ▶ Automotive pulse level can be met 600V/m, full band in one sweep
- ▶ No limit to general broadband testing 200V/m AM



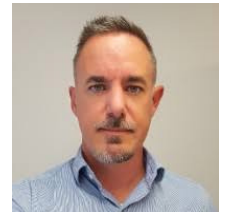


## About Nick Jones

Nick is the Amplifier Product Manager for Ametek CTS. With 20 years of experience in the RF & Microwave amplifier industry, Nick has a comprehensive understanding, from tuning and aligning amplifiers through to application expertise.

Nick has a HND in electronic engineering and has held many positions including product testing and production engineering before finally landing in product management.

Based in the UK with his wife and three daughters and one crazy (male) dog, Nick has spent the last four years managing, launching and presenting amplifier products to global audiences.



## About AMETEK CTS

AMETEK CTS is a global leader in EMC compliance testing and RF power amplifiers. AMETEK has been designing and manufacturing precision instruments for more than 30 years. Under the brand names of EM Test, Teseq, IFI and Milmega the company produce a wide range of specialist solutions aligned to the individual needs of equipment manufacturers across a variety of industries. These include:

- Automotive
- Aerospace and Defense
- Consumer electronics
- Household appliances
- Medical devices
- Renewable energy

From its design and manufacturing facilities in Switzerland, Germany, the United States and the UK, AMETEK CTS provides customers with innovative solutions to the complex requirements of EMC compliance standards.

