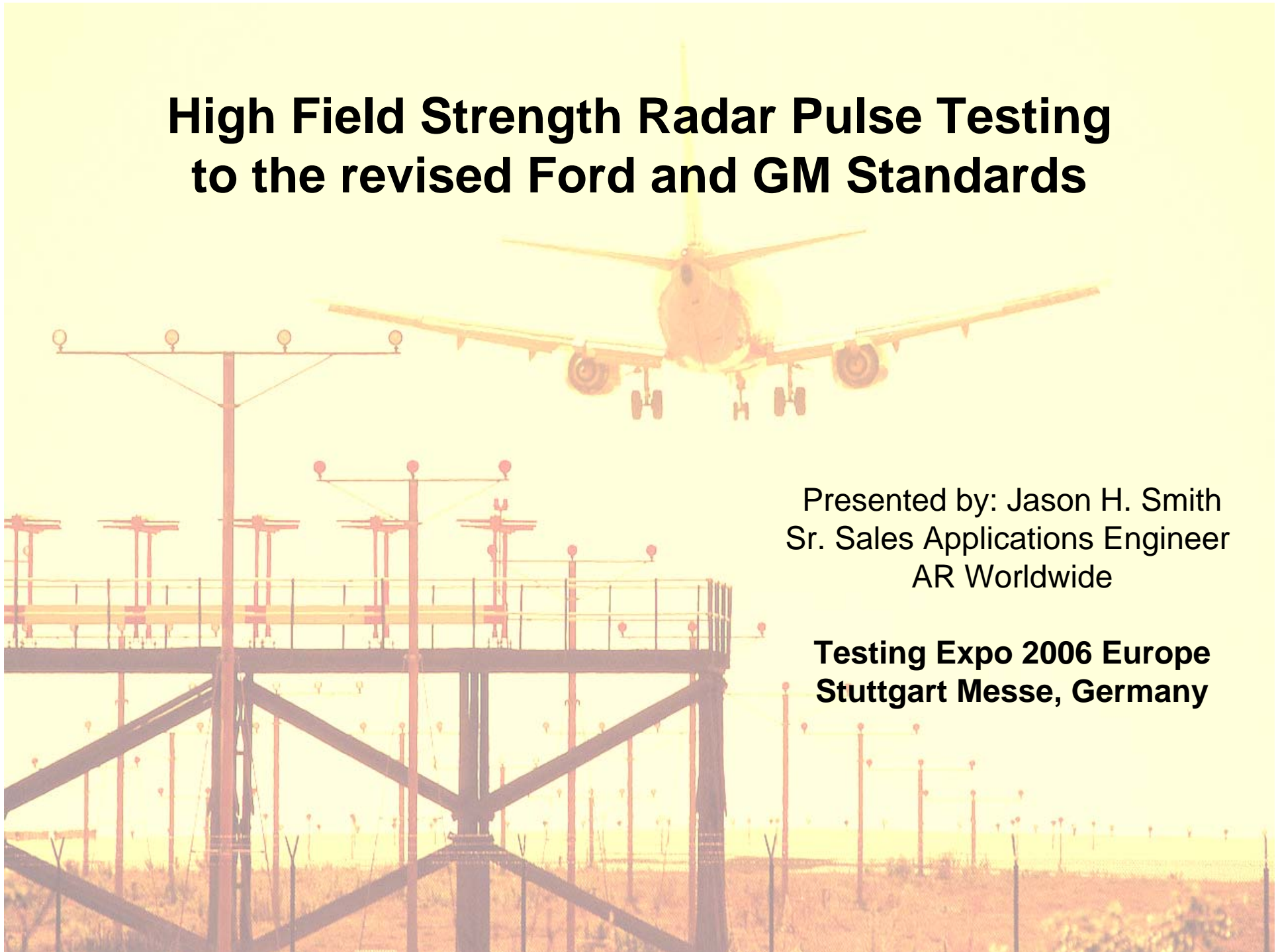


High Field Strength Radar Pulse Testing to the revised Ford and GM Standards

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This presentation is available in electronic format if needed and also as an Application Note, #38A

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Overview



- Overview of Radar Pulse testing
- Review Ford's ES-XW7T-1A278-AC and GM's GMW3097 Sections that deal with radar pulse testing
- Explain the reason for recent changes to the Ford standard
- Selecting equipment



High Power Radar Pulse

- Radar pulses are a man-made energy source used to track Commercial and Military Aircraft
- Normally directed into the sky but has been detected on the ground.
- Has been found to affect automobile electronics.





Locations where high field radar pulses can be found

- On bridges where military / commercial ships pass underneath
 - On ship radar could be turned on early before the ship reaches the sea. Disrupting automobile traffic on the bridge as the ship passes below
- Near military or commercial airports or ship ports
 - These high fields have been recorded in a parking lot of a restaurant at levels up to 600 to 750V/m.

(Parking lot outside airbase in Missouri, USA)



Why was 600V/m chosen

- Normally US auto manufacturers apply a safety margin
 - In this case this is extremity cost prohibitive to the suppliers
- 600V/m includes no safety margin
 - Ford has lowered levels of some non safety electronics to 300V/m
 - GM has no intention of reducing levels



How does this effect you!



- All Ford/GM electronic components must meet these standards.
- This includes most of the manufacturer's other divisions in Europe and elsewhere.
- Other manufacturers in the world are starting to now accept this high intense field testing.
- If auto manufacturers are selling into the US market this is a real threat to each automobile which should be dealt with.



The Standards

Component Testing

Manufacturer Spec	Band	Frequency	Field Level		Pulse modulation
GM GMW3097		1.2 – 1.4 GHz		600V/m	300Hz Pulse Repetition Rate (PRR) 3 μ s Pulse Duration (PD) ⁽³⁾ Dwell time 1 sec
FORD ES-XW7T-1A278-AC	6 7	1.2 – 1.4 GHz 2.7 – 3.1 GHz	300V/m ⁽¹⁾	600V/m ⁽²⁾	

1 Level for most electronic equipment

2 Level for selected components associated with supplemental restraints including frontal crash

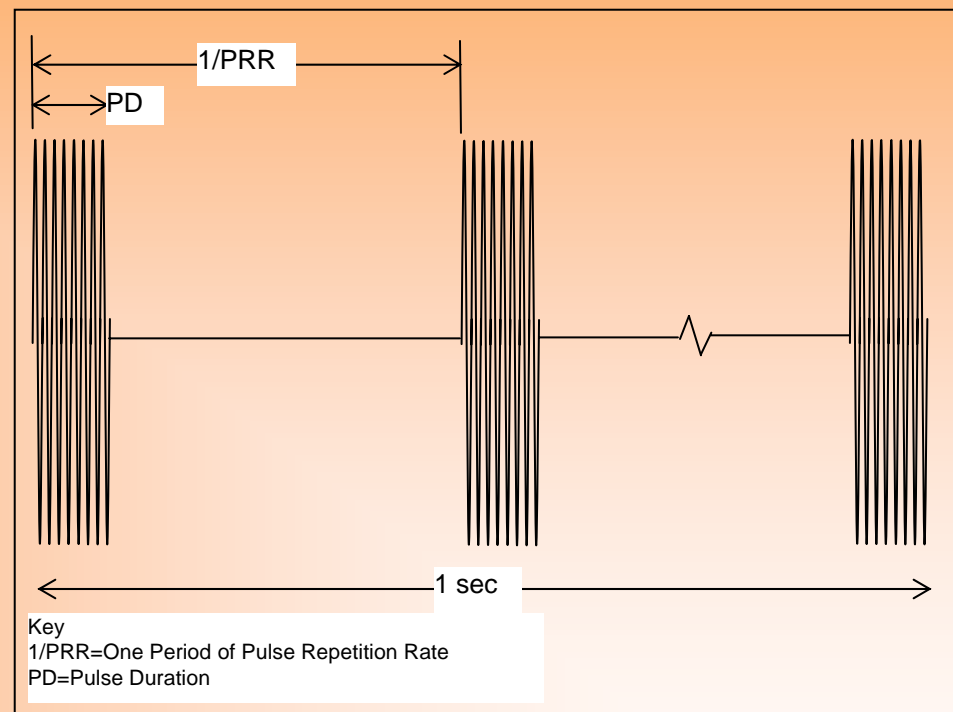
3 6 μ s Pulse duration used when testing in a Reverberation Chamber





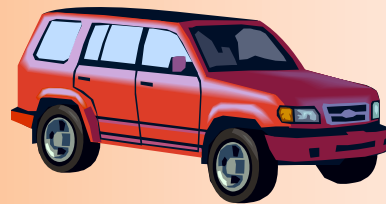
• Pulsed Field

- 300Hz Pulse Repetition Rate (PRR)
3.3ms
- 3 μ s Pulse Duration (PD) (ALSE)
or
- 6 μ s Pulse Duration (PD) (Reverb)
- Dwell time 1 second





Ford has issued changes to the
standard: ES-XW7T-1A278-AC
Issued January 30th 2006

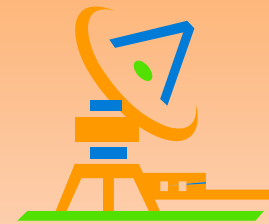


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Ford Changes

- New 300V/m level for most electronics
- New continuous pulsed field
- New 1 second dwell time
- New requirements for ALSE test method
 - No ground plane
 - Must calibrate field at peak power (no scaling)
 - Allow calibration with RF Probe or Receiving antenna
 - Defined calibration and use of RF probe
- No change to mode tuned reverberation chamber setup





GM will be changing their setup to match with Ford.

GM will not be changing their test level from 600V/m.

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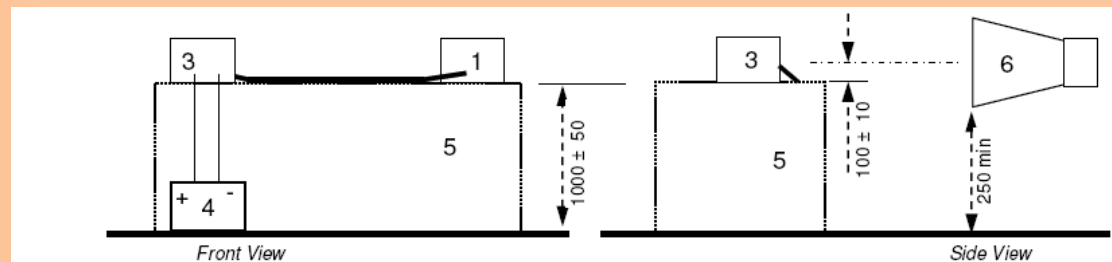
Reasons for changes

- Ford saw vast differences in calibration results from lab to lab
- Differences were found to be mostly due to ground plane and field probe variations



Removal of ground plane

- Removes inconsistencies with different setups
- Requires low permeability material for table
 - Above 1 GHz wood will reflect.



Key:

- | | |
|--|--|
| 1 DUT | 7 Support Equipment |
| 2 Test harness | 8 High quality double-shielded coaxial cable (e.g. RG 223) |
| 3 Test Fixture | 9 Bulkhead connector |
| 4 Automotive Battery | 10 RF Generation Equipment |
| 5 Dielectric Support ($\epsilon_r \leq 1.4$) | 11 RF absorber material |
| 6 Transmit Antenna | |

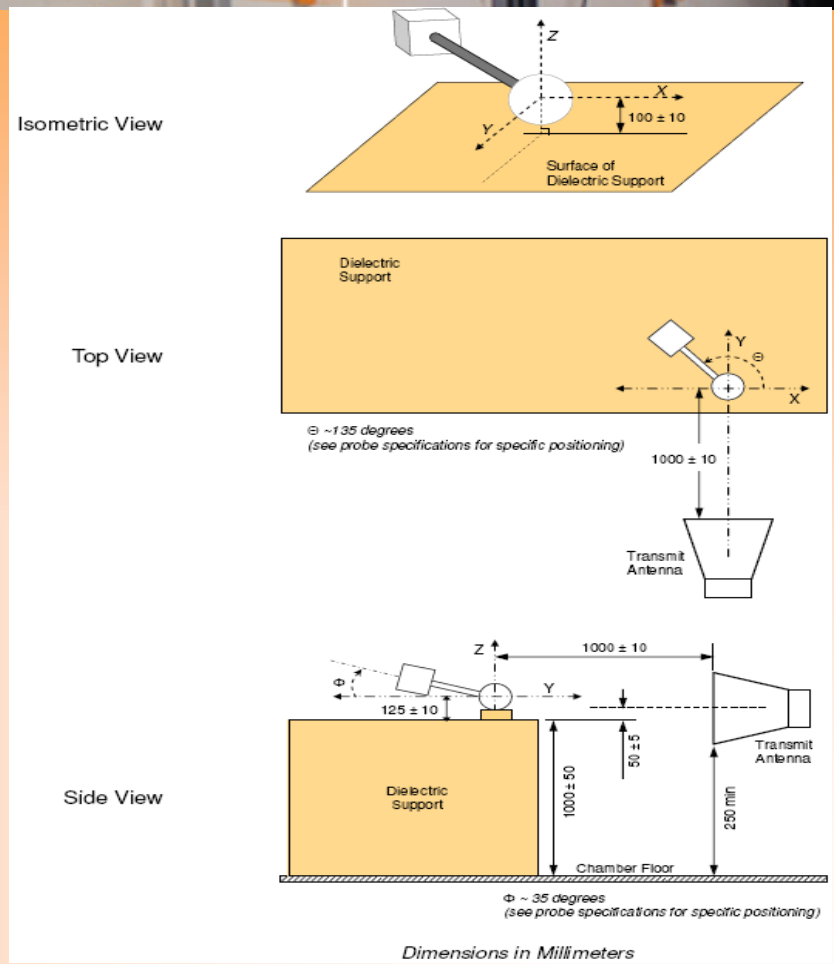
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Calibration

Special field probe requirements

- Probe must be positioned to align each axis with RF field polarity
- Probe needs to have cal-factors at **1.3** and **2.9 GHz**
- Must calibrate field in CW at full field strength



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Calibration

**NEW ability to use a receive antenna
w/ spectrum analyzer instead of a
field probe**

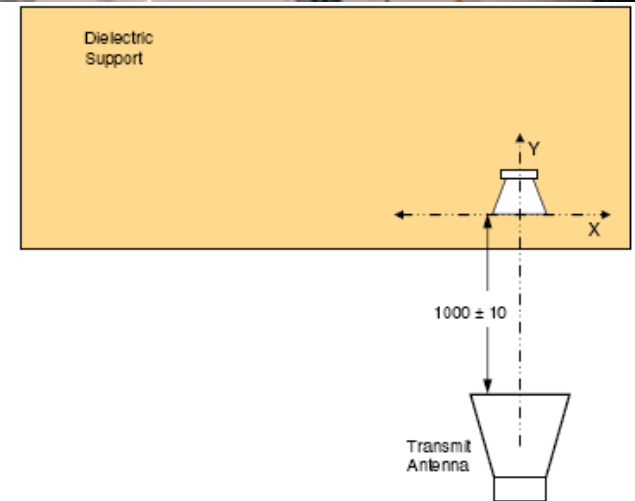
This allows the used of either a pulsed amplifier or a
CW amplifier



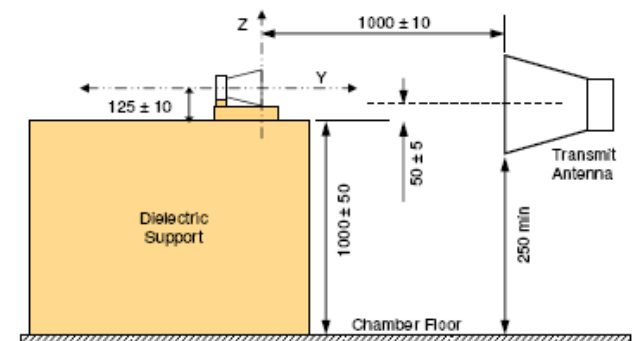
Receiving antenna requirements

- Can calibrate both a CW or pulsed field
- Ford specifies specific receive antennas
 - To keep antenna size small and similar
- Receiving antenna is now allowed since the affects of the ground plane are no longer of consequence

Top View



Side View

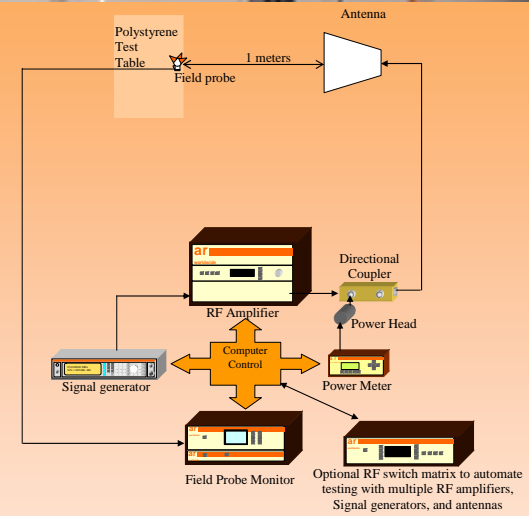


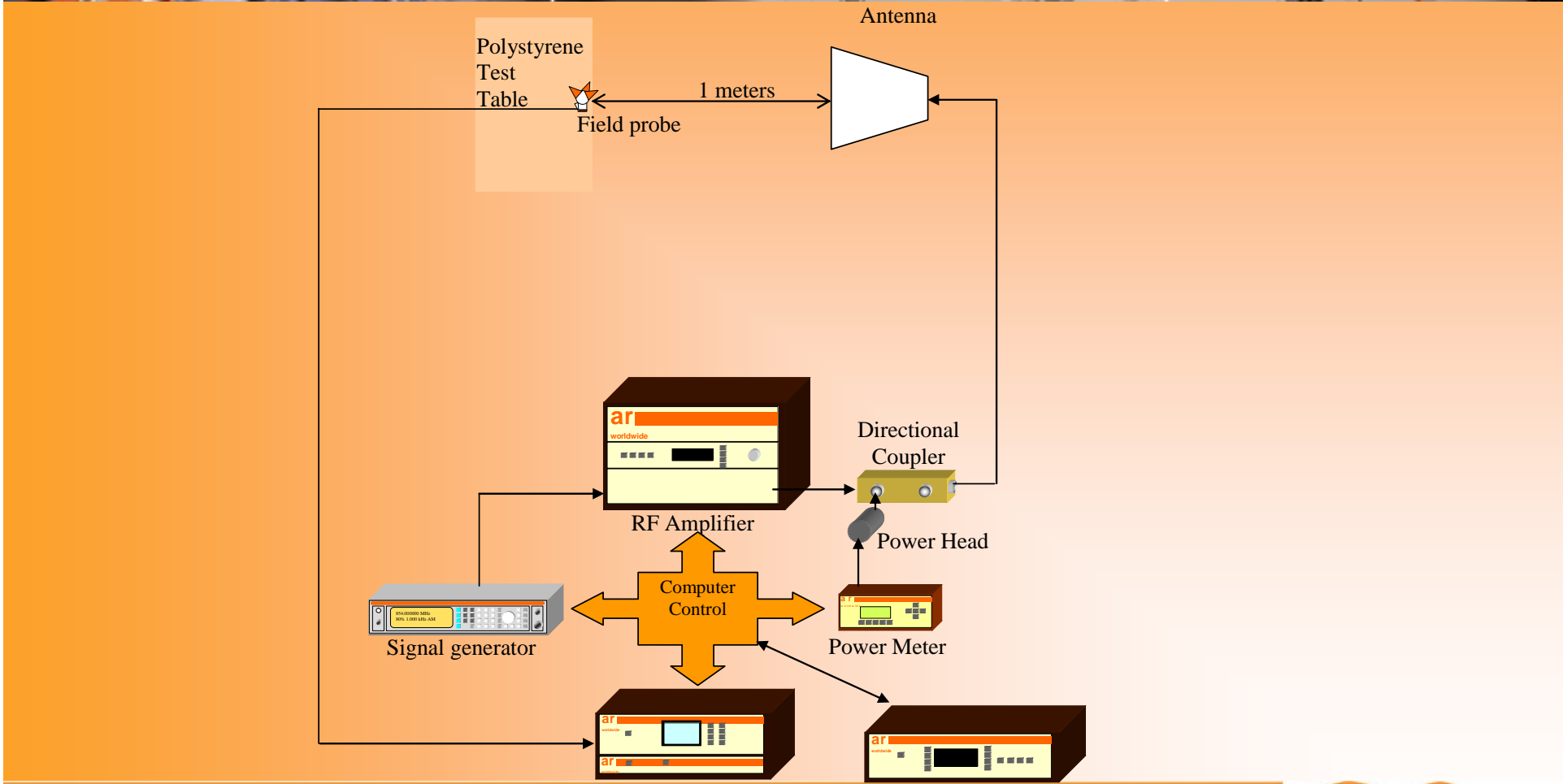
Dimensions in Millimeters



Equipment needed

- Pulsed Signal Generator
- High powered RF amplifier
 - CW amplifier either solid-state or TWT
 - or
 - Pulsed TWT amplifier
- Directional coupler
- Power meter and power head able to read peak pulse power
- High gain and high compression RF antenna
- RF field Monitor
 - RF Field probe and monitor able to read individual axis
 - or
 - RF receiving antenna and spectrum analyzer
- Setup equipment: Test Table, RF Cables, Connectors,





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Optional RF switch matrix to automate testing with multiple RF amplifiers, Signal generators, and antennas



CW Amplifier size can be difficult to determine

- Here is check for labs to with capability in this frequency range but not the correct power requirements.



Quick Check for power

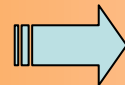
- Using the same setup as per the standards
 - Antenna, cabling, positioning
- Only difference is the amplifier
- Run the test in the intended frequency ranges
 - At a level you have the ability to reach (exp. 70V/m, 200V/m)
 - In both polarities
 - Record forward power (Watts) for each frequency step
- Using the standard gain equation we can calculate a power factor and scale the power up to your needs.
 - 70V/m => 600V/m you will need 73.5 times more power
 - 200V/m => 600V/m you will need 9 times more power



Power factor equation

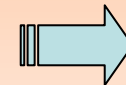
Standard Gain Equation

$$E = \frac{\sqrt{30PG_n}}{D}$$



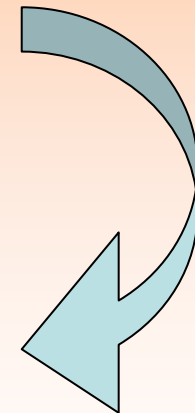
Turn into a ratio

$$\frac{E_1}{E_2} = \frac{\frac{\sqrt{30P_1G_n}}{D}}{\frac{\sqrt{30P_2G_n}}{D}}$$



Square & Cancel

$$\frac{(E_1)^2}{(E_2)^2} = \frac{P_1}{P_2}$$



E = field intensity in V/m,
P = power in Watts
G_n = numerical antenna gain.
D = Distance in Meters

$$P_2 = \frac{(P_1)(E_2)^2}{(E_1)^2}$$



Amplifier choices

Solid state – Pro: Extended frequency range
Very good harmonic content
Very good linearity
CW testing covers other testing requirements
Scalable power

TWT Pro: lower Cost
CW testing covers other testing requirements
Con: High harmonic content required filters
Require 2 amplifiers to cover both ranges
poor linearity

Pulsed TWT Pro: lowest Cost
One amp to cover both levels
Con: Can only be used for pulsed applications.
Same as TWT



Suggested equipment requirements

300V/m

Frequency range	Antenna	Amplifier, direction coupler (DC), filter if needed (TF)		
		Solid State	TWTA	Pulsed TWTA
1.2 – 1.4 GHz	AT4510	200S1G4A+ w/DC7144A	250T1G3 w/DC7144A w/TF1002*	1000TP1G3 Or 750TP1G3/200T
2.7 – 3.1 GHz			200T2G4 w/DC7144A w/TF1001*	w/DC7154A w/TF1005*

+Please refer to Application Note # 40 Scalable Power, which explains the ability of these amplifiers to be combined to increase power and/or separated to use sections in different locations of the facility.

* RF filters are needed for TWTAs to meet ISO 11452-1 requirement for a better than -6dBc harmonic content.



Suggested equipment requirements

600V/m

Frequency range	Antenna	Amplifier, direction coupler (DC), filter if needed (TF)		
		Solid State	TWTA	Pulsed TWTA
1.2 – 1.4 GHz	AT4510	540S1G4+ w/DC7164	500T1G2 w/DC7128A w/TF1002*	1000TP1G3 Or 750TP1G3/200T w/DC7154A w/TF1005*
2.7 – 3.1 GHz			300T2G8 w/DC7280A w/TF1001*	

+Please refer to Application Note # 40 Scalable Power, which explains the ability of these amplifiers to be combined to increase power and/or separated to use sections in different locations of the facility.

* RF filters are needed for TWTAs to meet ISO 11452-1 requirement for a better than -6dBc harmonic content.



Additional equipment:

CW Calibration:

- E-Field Probe that can be used to meet the specification and can read individual Isotropic axis readings:
- *FP7018/Kit* Isotropic “E” Field diode probe, 3MHz-18GHz, 0.6-1000V/m CW
- *FM7004* Field monitoring kit can except up to 4 probes.

CW or Pulsed calibration:

- Use spectrum analyzer and calibrated receive antenna as specified in Ford’s update.

Power meter / power head capable of reading pulsed signals
Cables and connectors.



Any questions?

Thank you for your attention!!!

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