600 v/m Generation and Field Calibration for Automotive Component Testing

Tom Mullineaux

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The Threat

SURVEILLANCE RADAR 1.2-1.4GHz (L-Band)

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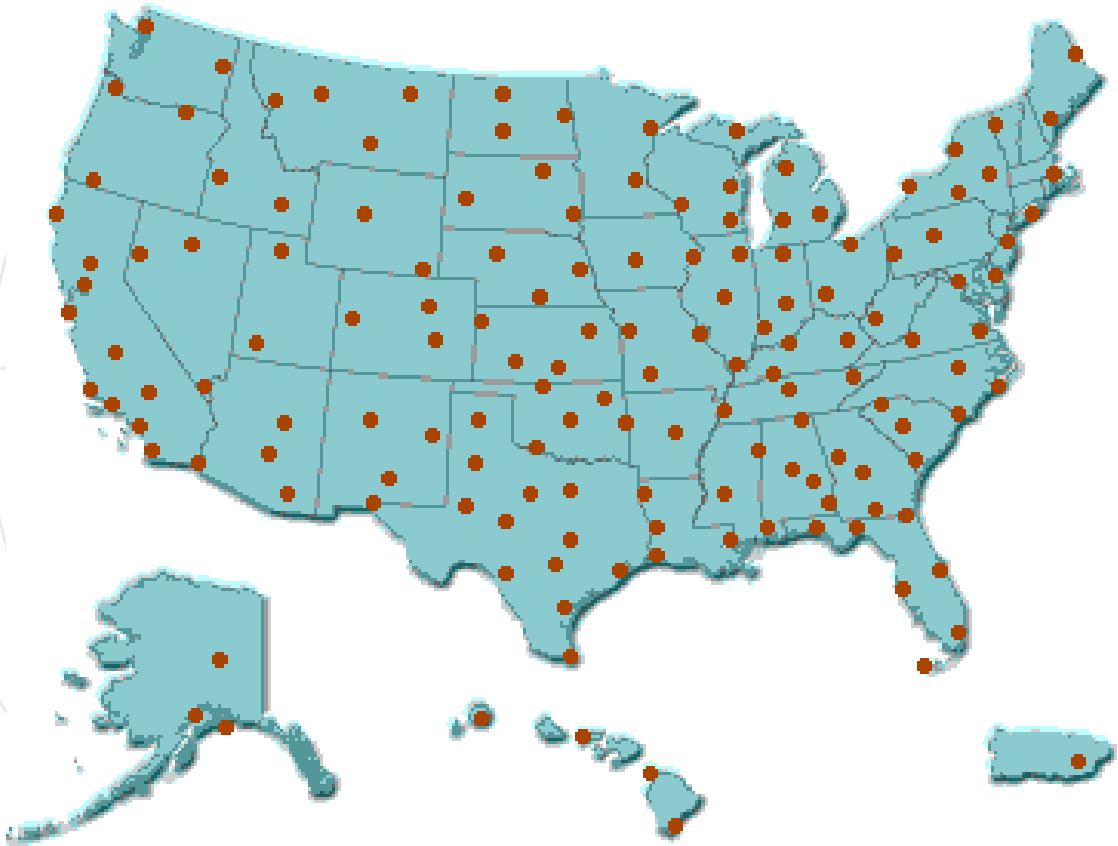


NEXRAD RADAR 2.7-3.1GHz (S-Band)

The Risk

- **ELECTRONIC MALFUNCTION OR FAILURE**
  - **ENGINE MANAGEMENT**
  - **SAFETY CIRCUITS**

Response by Automotive OEMs

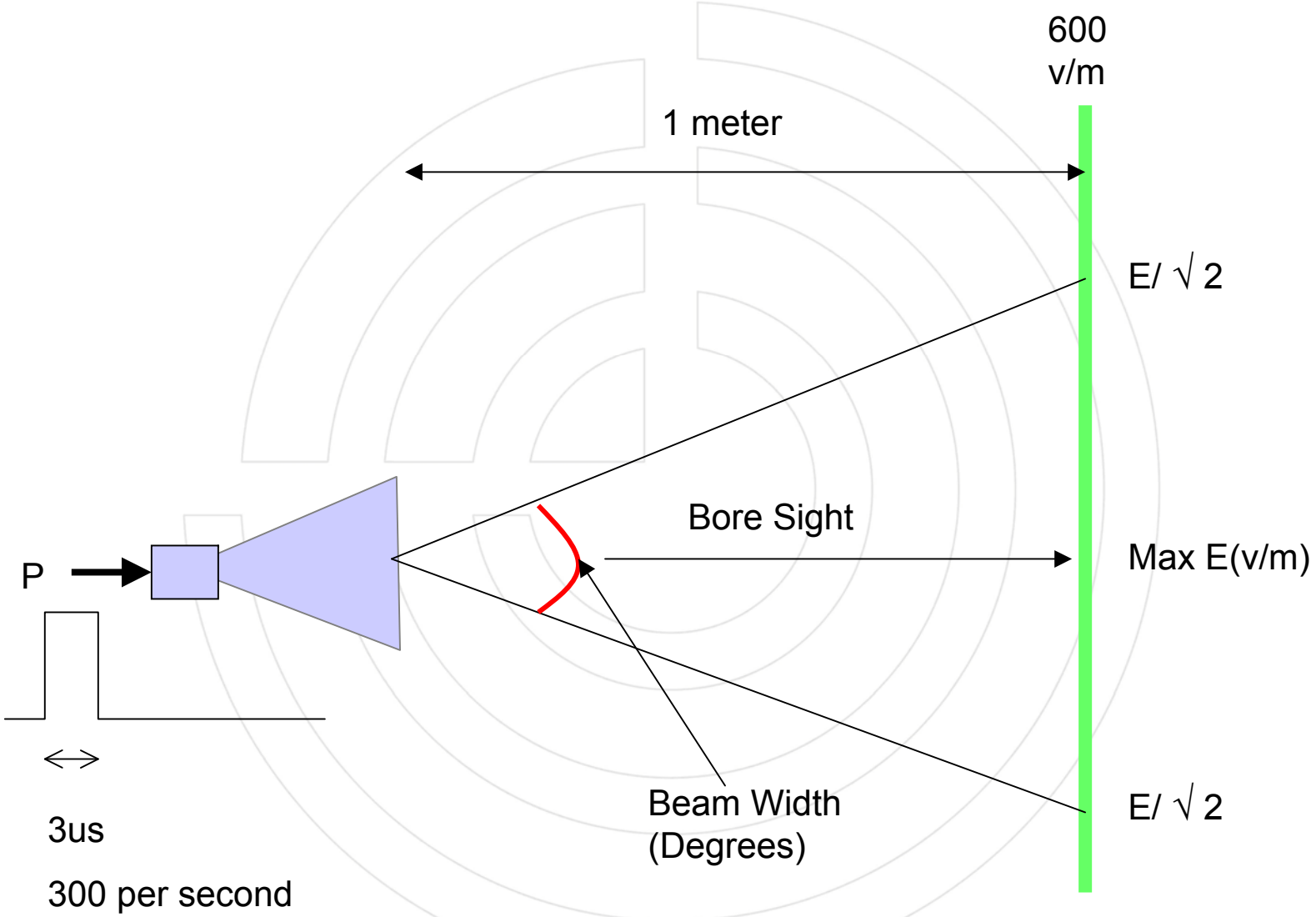
Replicate The Threat

DUT Subjected to High-Power Pulses

Pulses 3 Microseconds Long

Applied at a Rate of 300 Pulses Per Second

Pre-Stipulated Spot Frequencies Covering RADAR Band


600
v/m
1 meter
E/ √ 2
Bore Sight
Max E(v/m)
P
Beam Width
(Degrees)
E/ √ 2
3us
300 per second

GM: L-Band RADAR Only

1.2-1.4GHz 600v/m

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FORD: L-Band and S-Band RADAR

1.2-1.4GHz 300v/m & 600v/m

2.7-3.1GHz 300v/m & 600v/m

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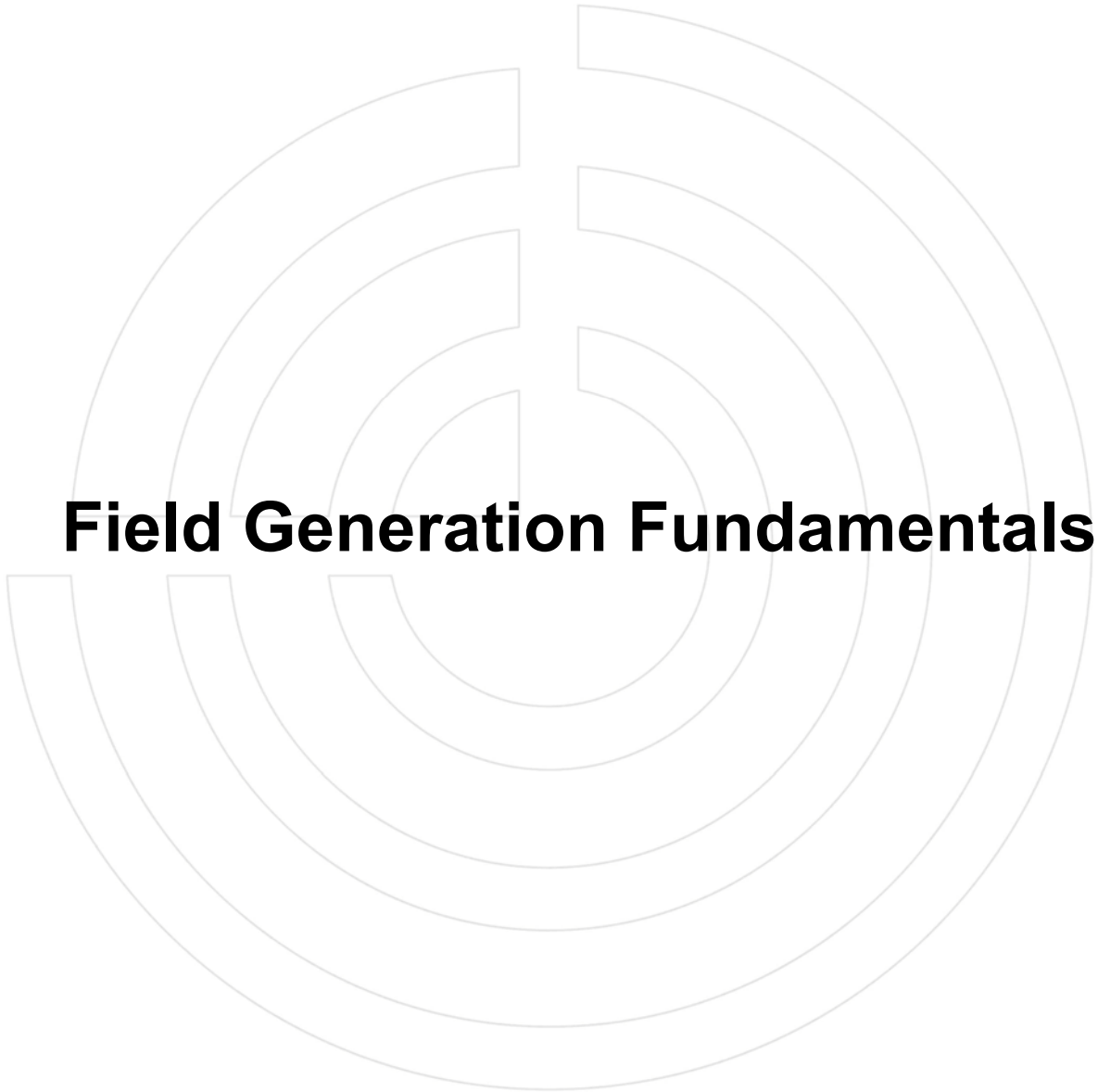
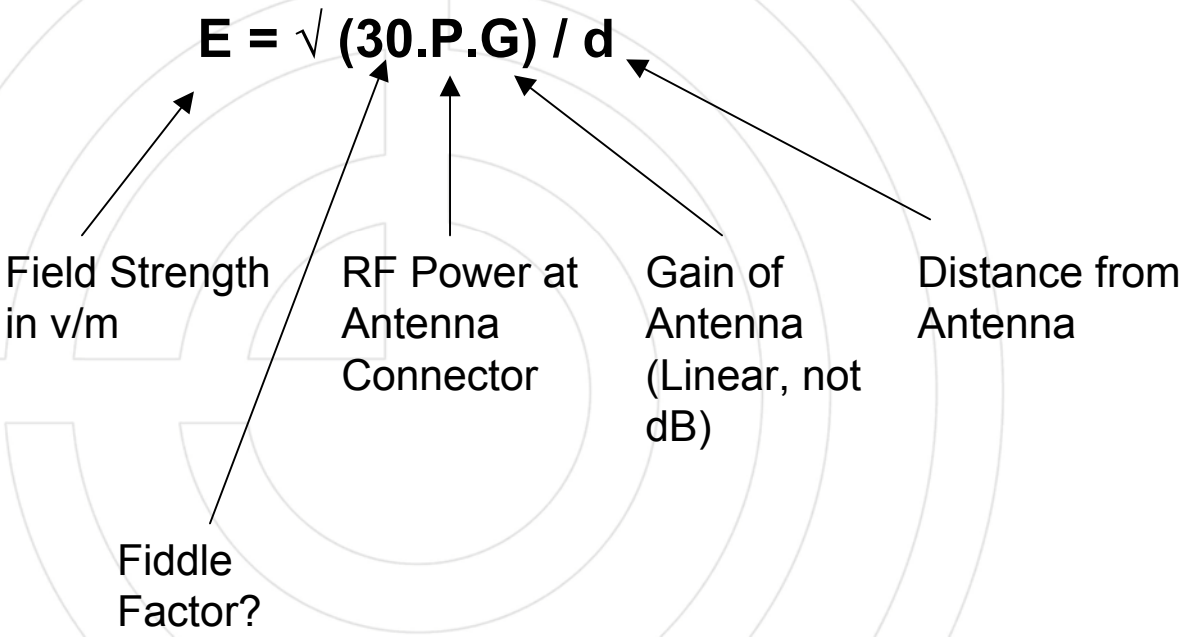
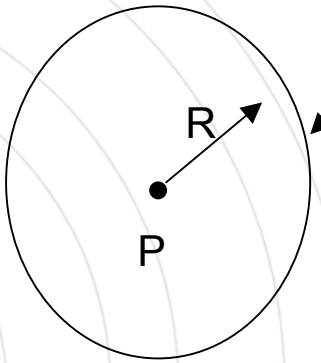
Field Generation Fundamentals




E = √ (30.P.G) / d
Field Strength in v/m
RF Power at Antenna Connector
Gain of Antenna (Linear, not dB)
Distance from Antenna
Fiddle Factor?

Area of Sphere

$4\pi R^2$



$$S = P/4\pi R^2$$

Power Density

$$S = E^2/Z_o$$

$$S = E^2/120\pi$$

Impedance of Free Space Z_o is 120π (377 Ohms)

Watts per Square Meter

$$S = S$$

$$E^2/120\pi = P/4\pi R^2$$

$$E^2 = 120\pi.P / 4\pi R^2$$

$$E^2 = 30.P / R^2$$

$$E = \sqrt{(30.P)} / R$$

$$\boxed{E = \sqrt{(30.P.G)} / d}$$

IMPLICATIONS

$$P = d^2E^2 / 30G$$

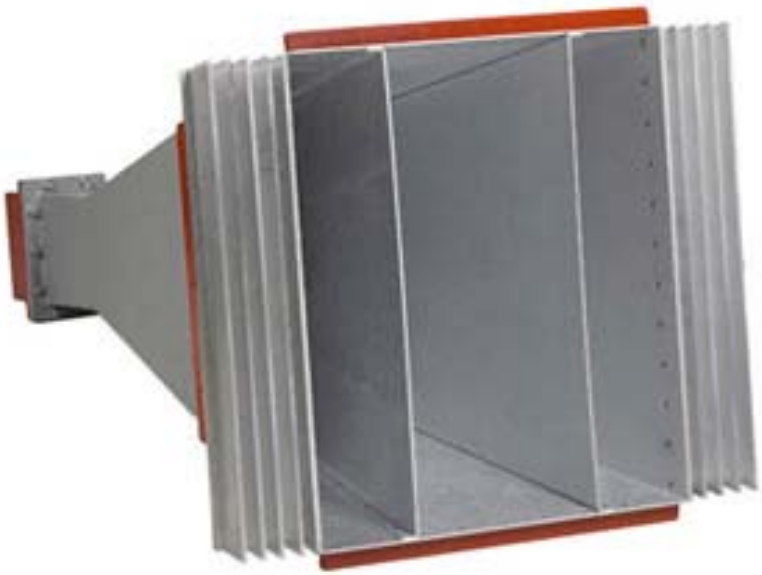
RF Power Required at Antenna Connector

Implication #1: Two Times the Gain Means **HALF** the RF Power is Required

Implication #2: Double the Distance Means **FOUR** times the RF Power is Required

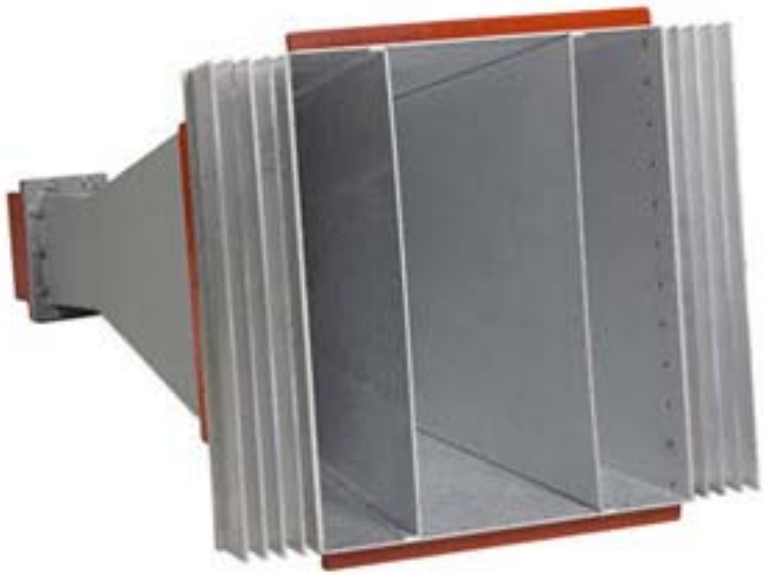
Implication #3: Two Times the Field Strength Means **FOUR** times the RF Power is Required

Possible Antennas

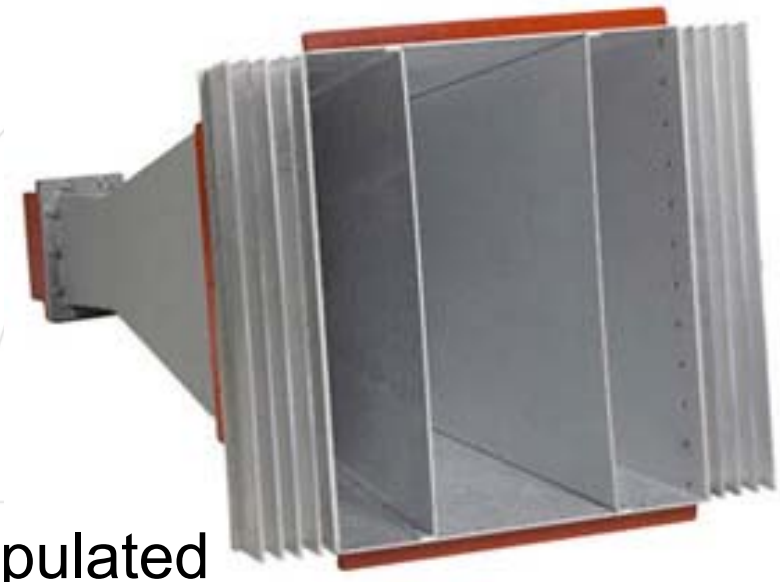


ETS-LINDGREN

Q-PAR ANGUS



ETS 3164-01: Frequency Range: 1.1 GHz–1.5 GHz
Length: 63.1 inches
Width: 25.5 inches
Height: 29.4 inches



Gain not stipulated

Power for L-Band model is about 400W for 600v/m

$P = d^2E^2 / 30G$

$G = d^2E^2 / 30P$

$G = (1)^2600^2 / 30.\ 400$

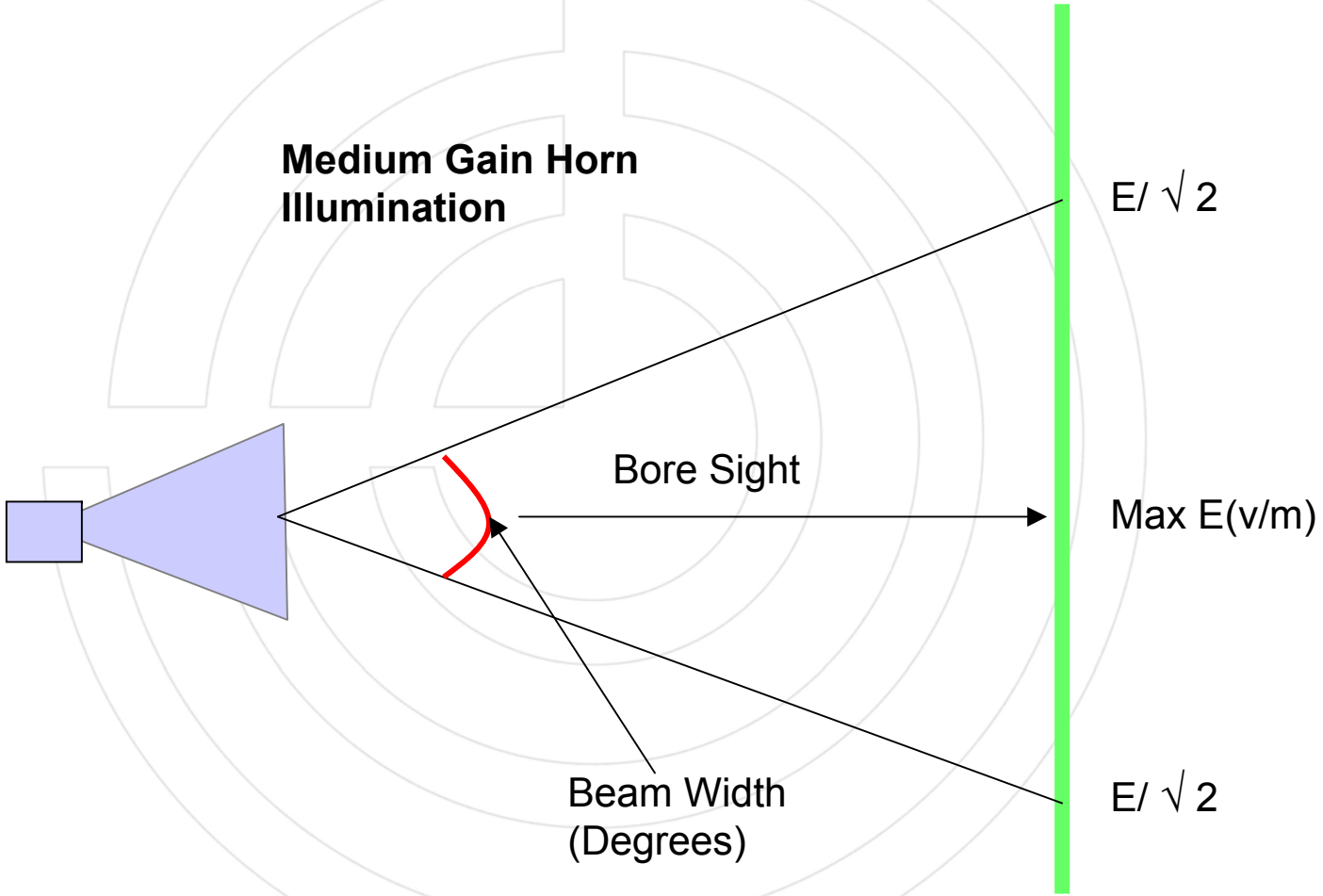
$G = 360000 / 12000$

G = 30 linear, about 15dBi

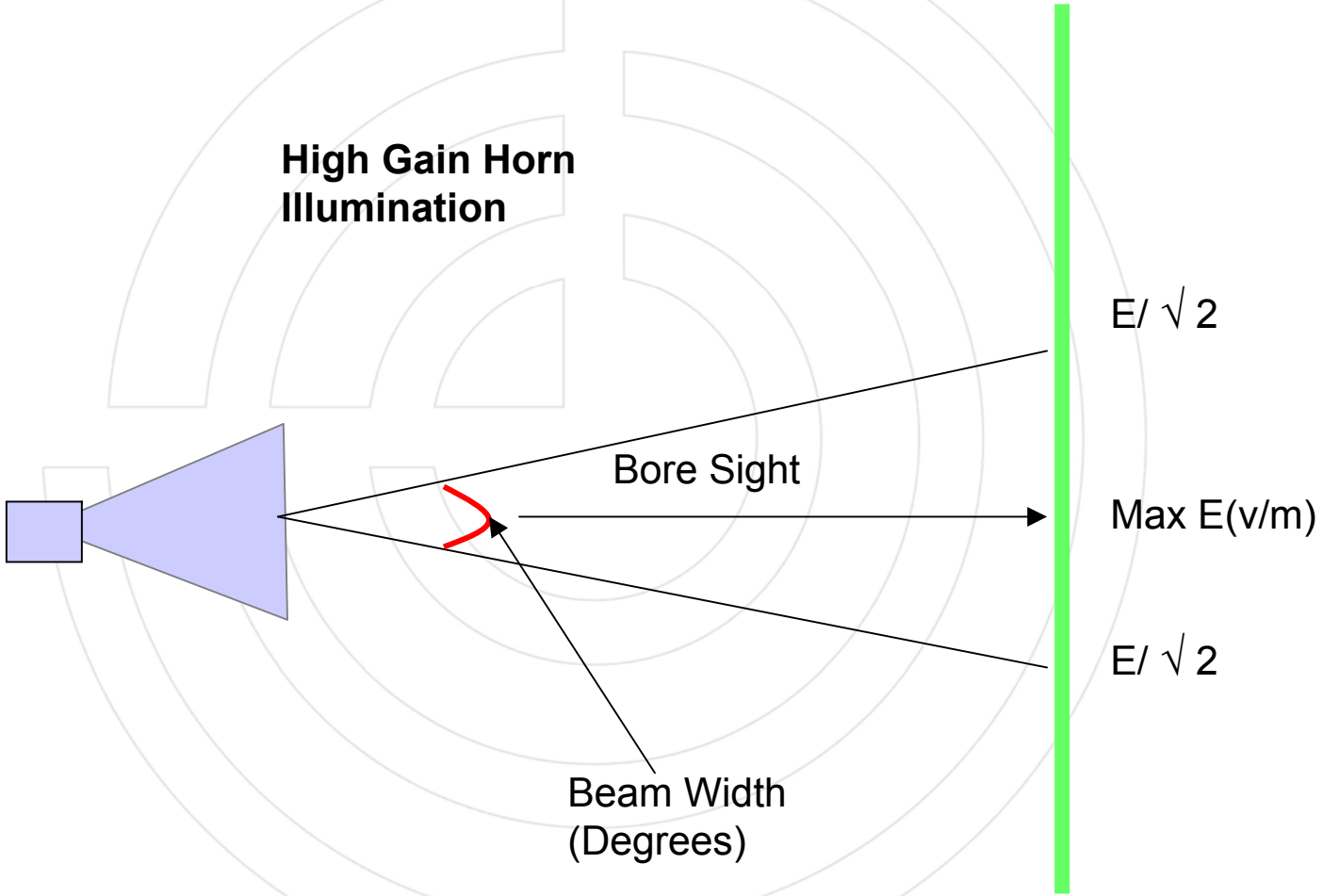
Q-PAR QSH6N20WA: Frequency Range: 1.1 GHz–1.7 GHz
Length: 70.8 inches
Width: 37.8 inches
Height: 27.8 inches

Gain is stipulated at about 18-20dB

Medium Gain Horn Illumination



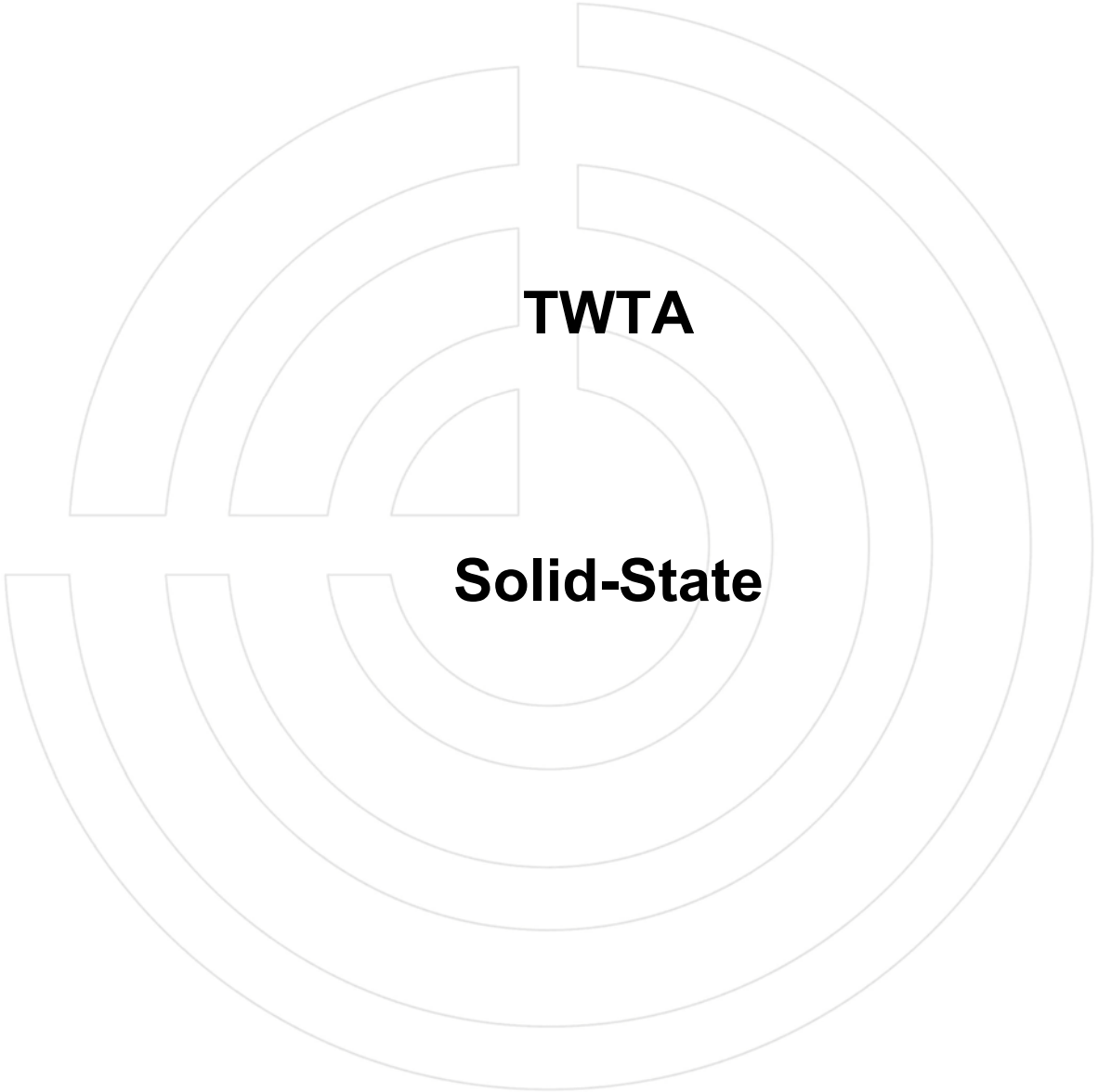
High Gain Horn Illumination



Possible Amplifiers

TWTA

Solid-State



TWTA ADVANTAGE

$ PER WATT
CAN USE OVER BOTH BANDS
(AR 750TP1G3/200T + AR 1000TP1G3)

TWTA DISADVANTAGE

HARMONIC POWER

(FILTER LOSSES)
REFLECTED POWER TOLERANCE
1000 WATT MODEL NO CW OPERATION
LIFE AND REPLACEMENT COST OF TUBE

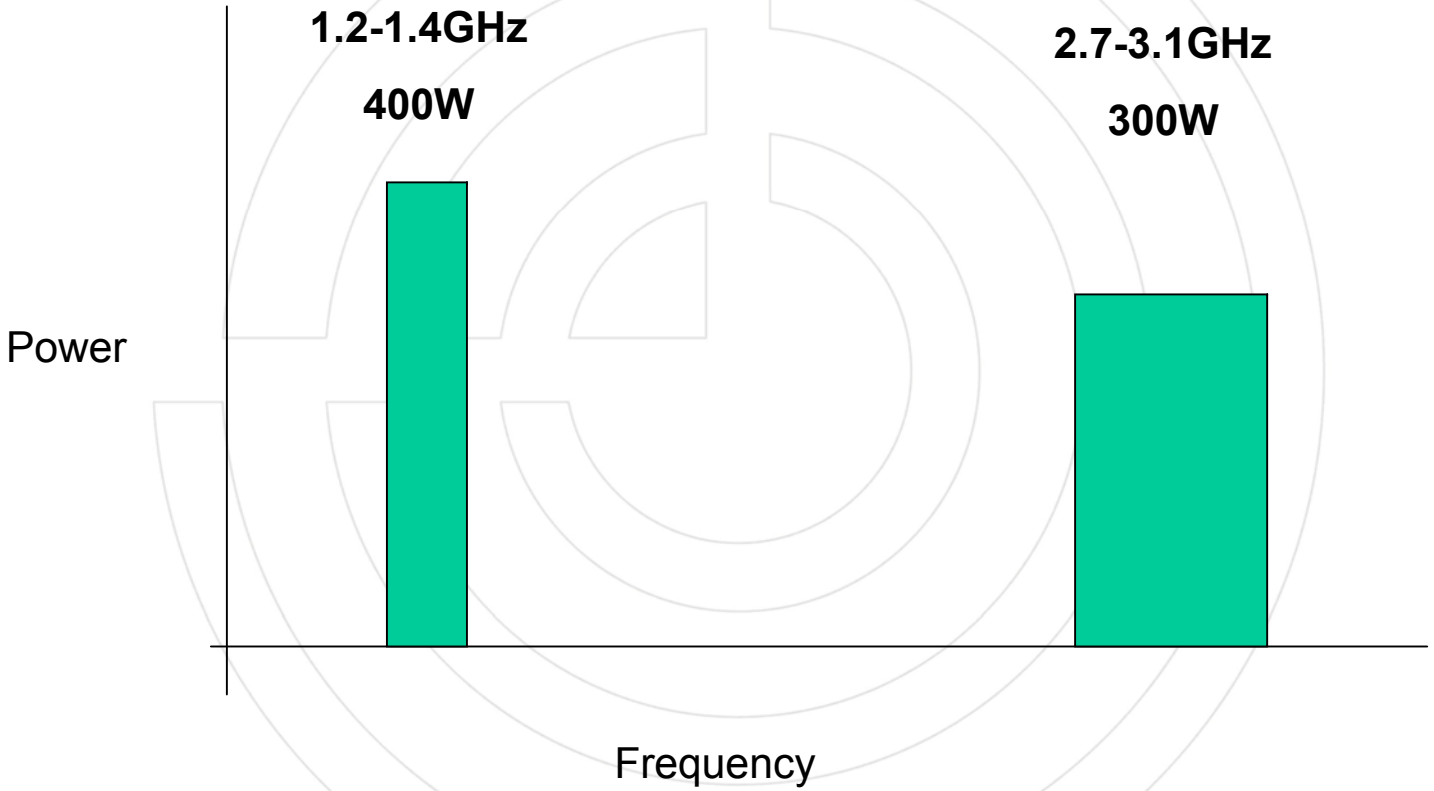
SOLID-STATE ADVANTAGE

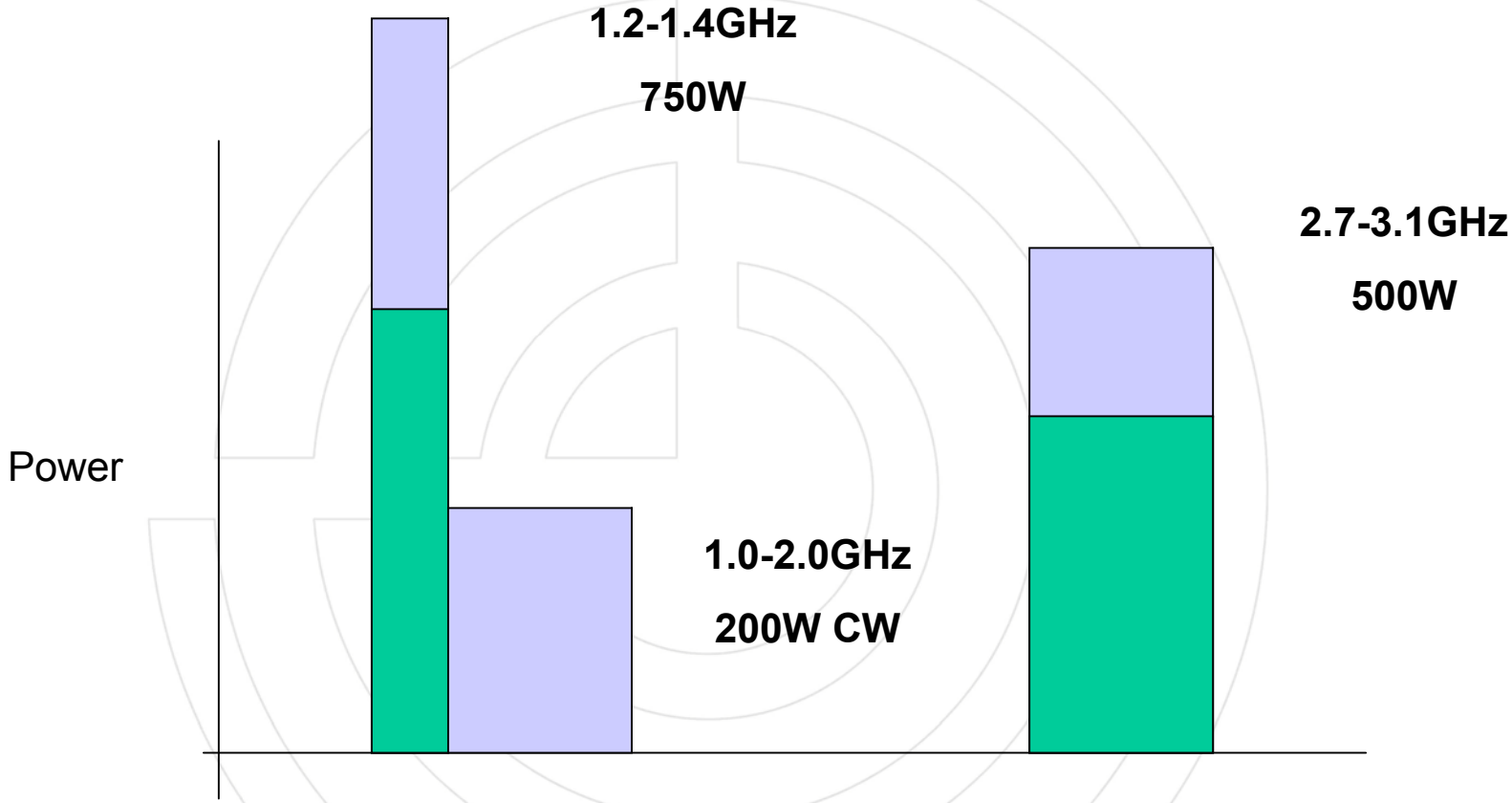
HARMONIC POWER
REFLECTED POWER TOLERANCE
CW OPERATION (USE FOR OTHER TESTS)
LONG WARRANTY

SOLID-STATE DISADVANTAGE

$ PER WATT ACQUISITION COST

What Frequency and Power is Required From the Amplifier?

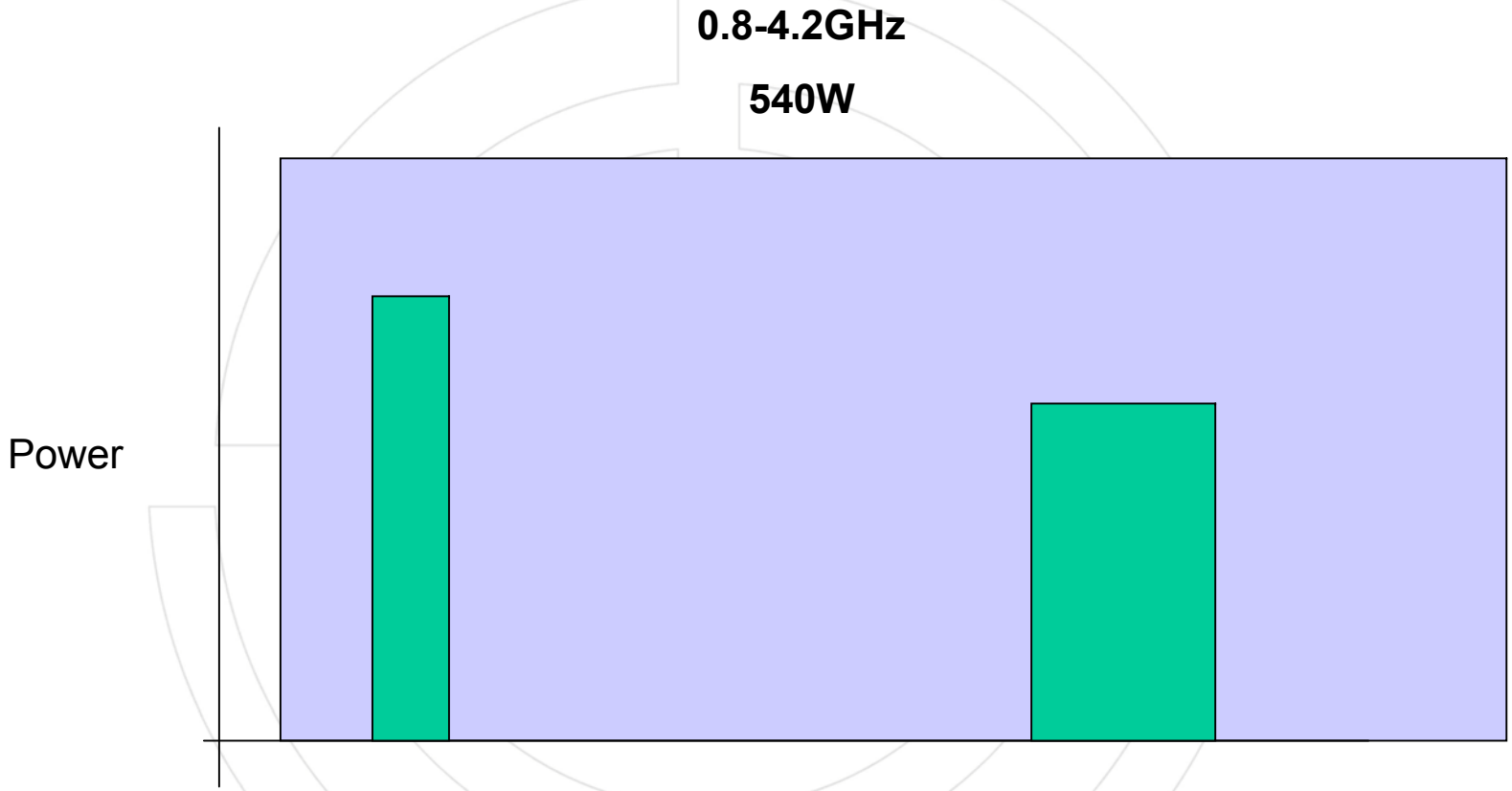

1.2-1.4GHz
400W
2.7-3.1GHz
300W
Power
Frequency



L and S Band TWTA Power*

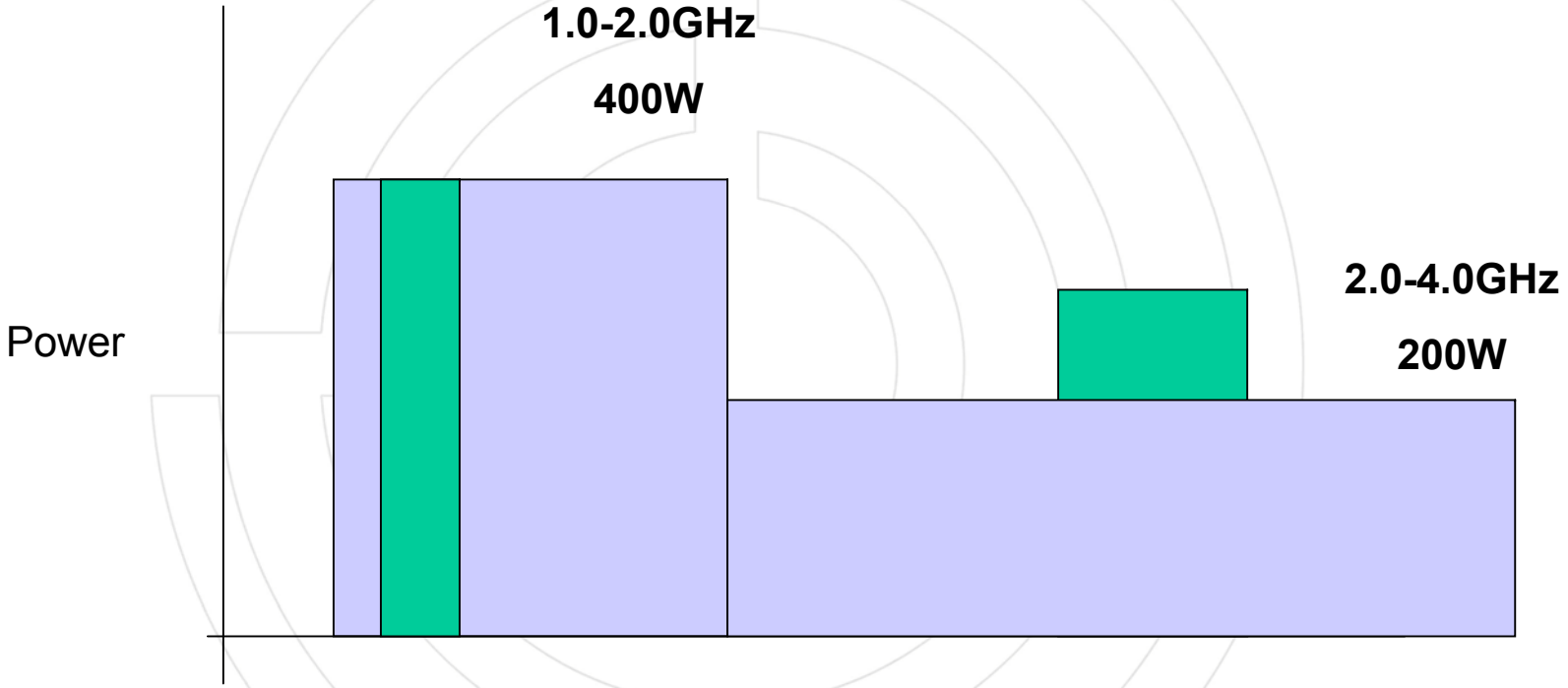
*Data Sheet

750TP1G3/200T
(March 2009)



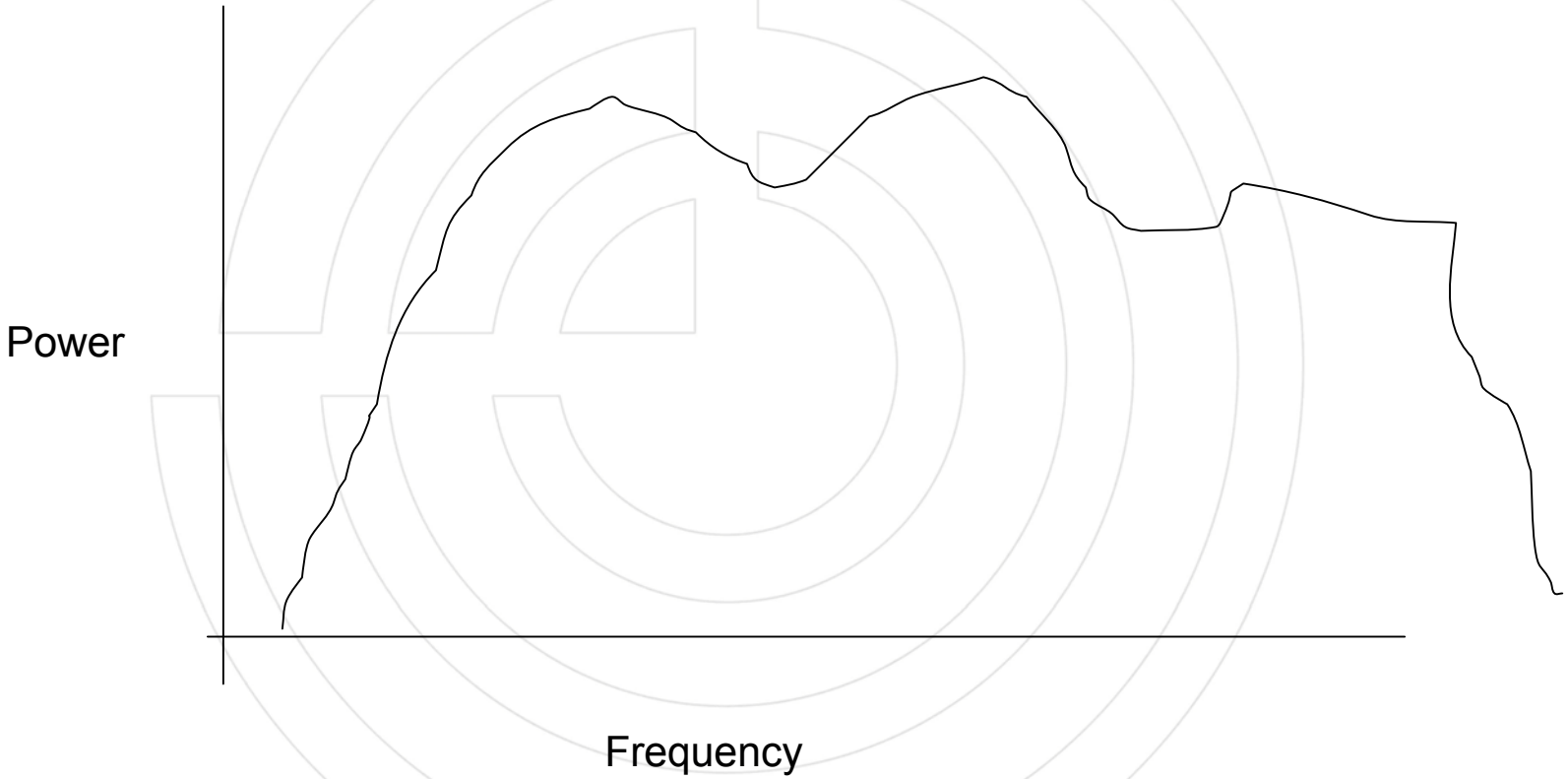
L and S Band Solid-State Power*

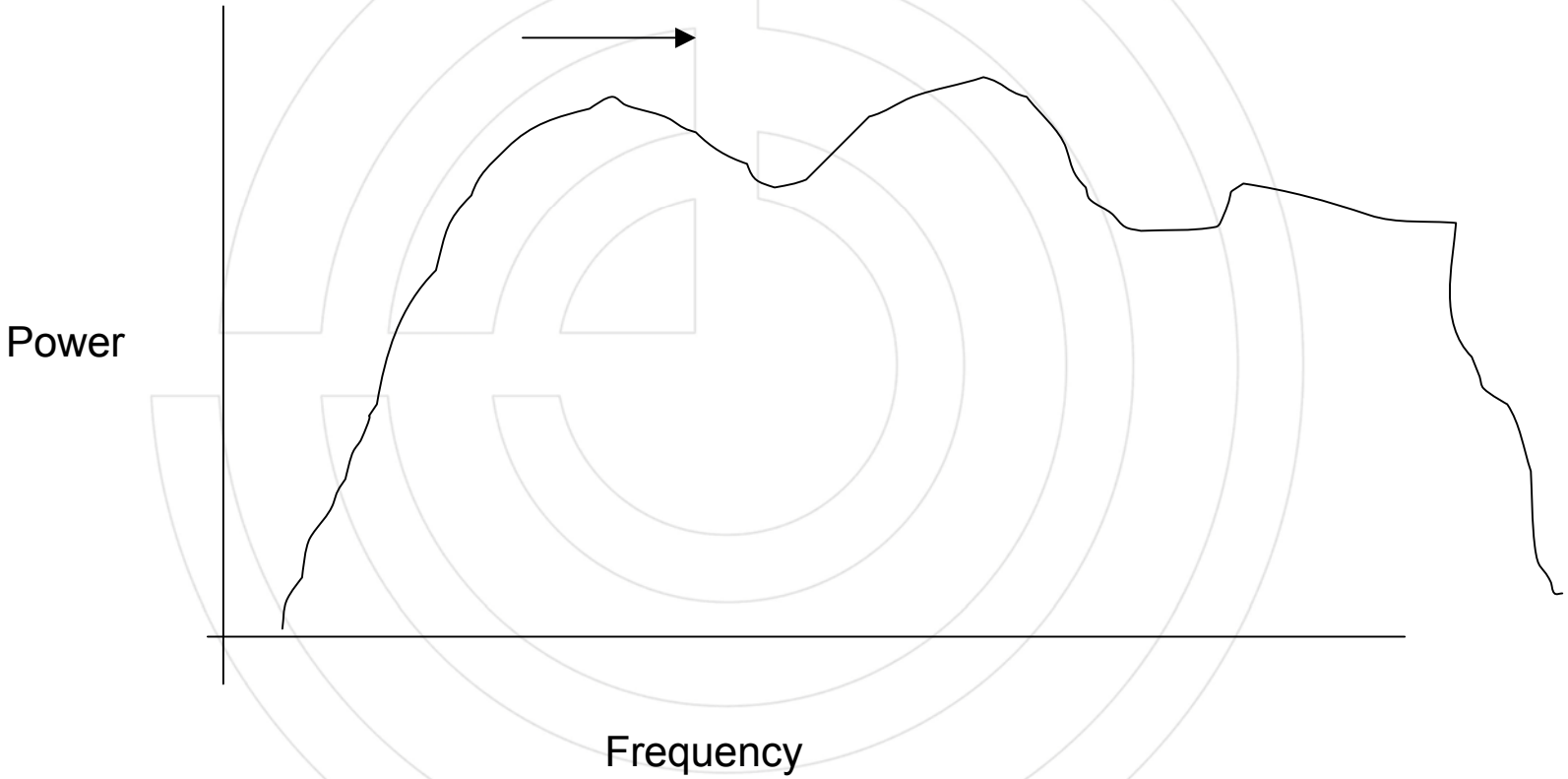
*Data Sheet 540S1G4 (March 2009)

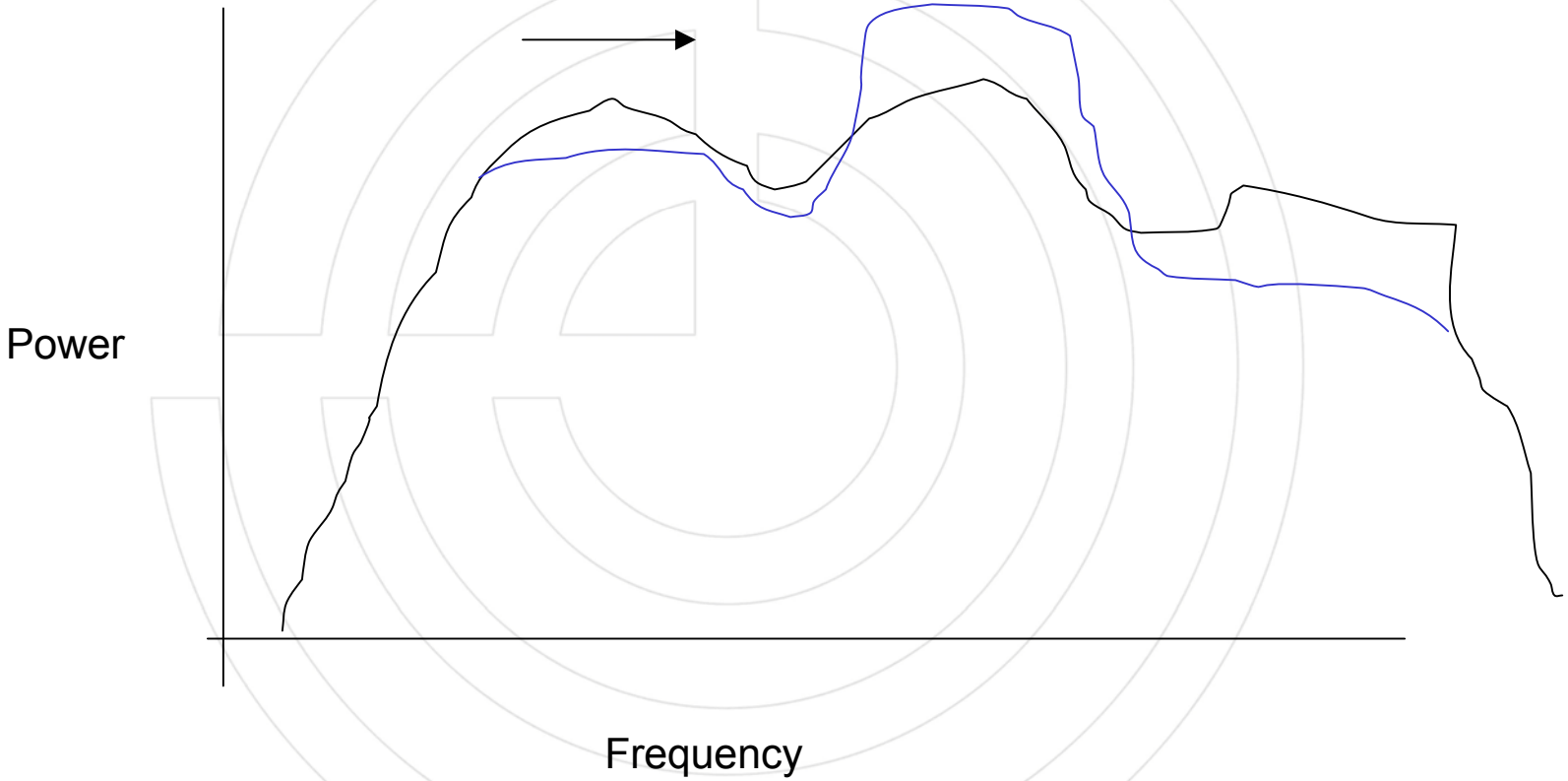


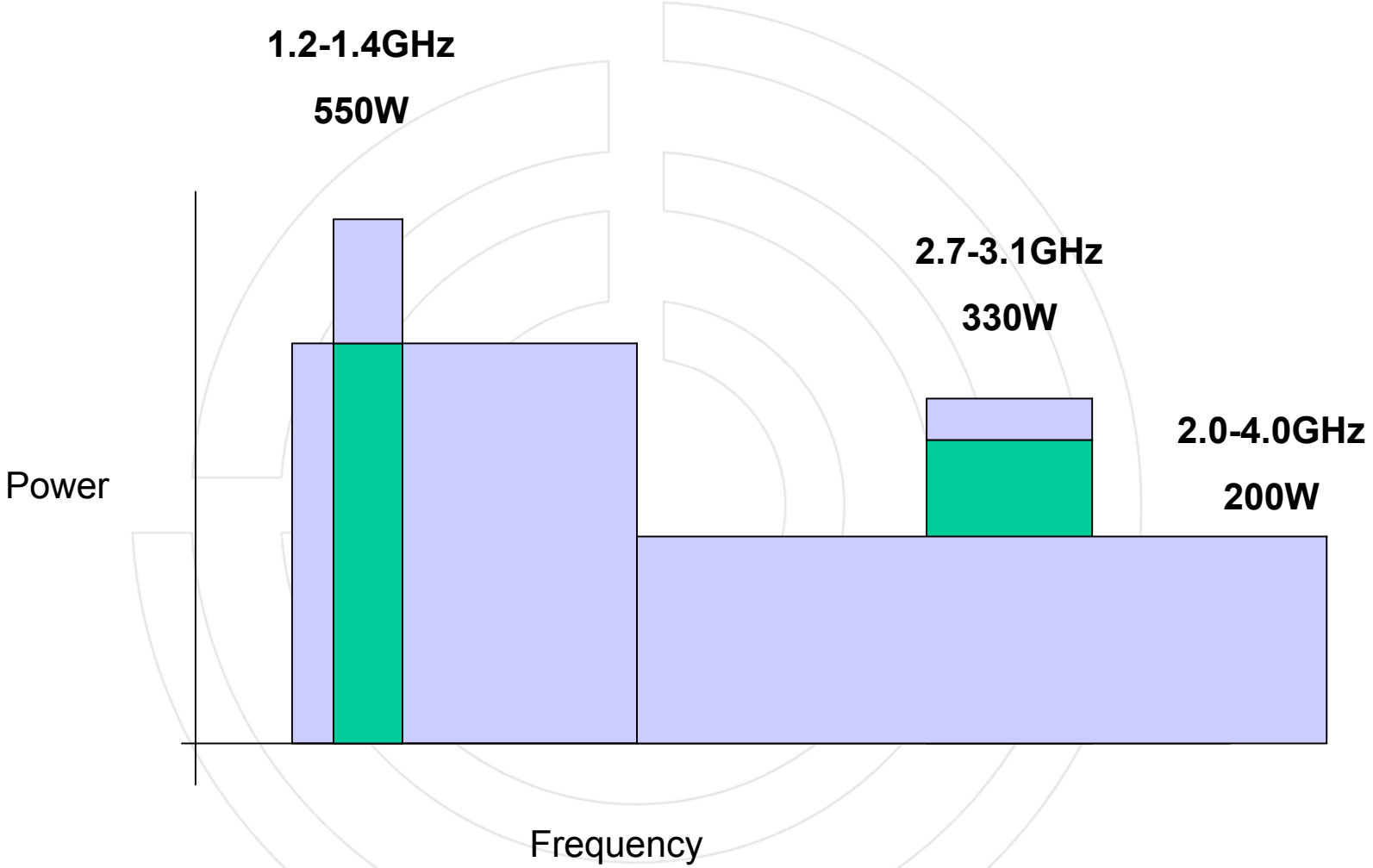
*Data Sheet AS0104-400/200
(March 2009)

L and S Band Solid-State Power*

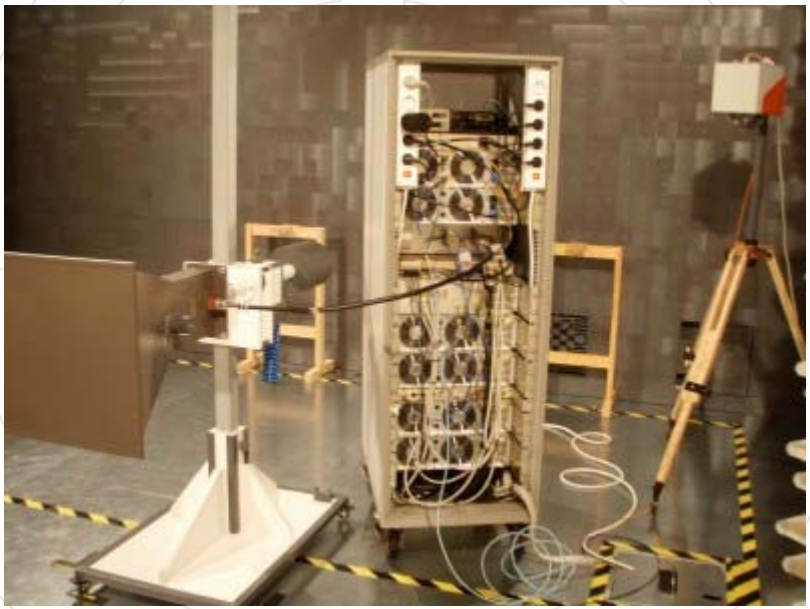

Power
Frequency


Power
Frequency


Power
Frequency



L and S Band Solid-State Power



GPIB
Extender

Seems to be a Move Away from
Reverberation Chambers

Field Calibration using Pulsed Amplifiers

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CAPTURING PULSE V/M

Regular Field Probes too Slow

PL7004 - RMS VALUE

Small Horn Antenna and Receiver / Spectrum Analyser / Oscilloscope

(TDK Software has Capability Built In)

Field Calibration using CW Amplifiers

MILMEGA

CAPTURING CW V/M

Regular Field Probe Good if can Handle High Field Strengths

Calibrate CW

Pulse V/M will be the Same

Issue with Dissipation in Pyramidal Absorber

Overcoming the Dissipation Limitation of Anechoic Material

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Data Sheets on Web State a Maximum of 750 Watts per Square Meter

Some Also Say Maximum 500 v/m

Bore-sight Issue

Was Going to Suggest 5 Seconds ON with Trigger

Systems Houses Say OK Since Rating Historical and Pyramids Heated to High Temperature During Production

Better to Check with Manufacturer

QUESTIONS?