HIGH PRESSURE ANTENNAS

FOR SUBMARINE

ESM APPLICATIONS

Dr. DIRK BAKER
Grintek Antennas
P O Box 8613
Centurion
0046

Presented at the Military Information and Communications Symposium of South Africa (MICSSA), 11 – 13 November 2003, Pretoria, South Africa

1. SUBMARINE ANTENNAS FOR ESM APLICATIONS

SEVERE ENVIRONMENT:

- High external pressure - typically 63 bar test, 50 bar operating

- High shock (100g) and wave slap (5 tons/m^2)

REQUIREMENTS ARE FOR:

- Omni antennas (with or without GPS)

- DF antennas (spiral antennas OR HORNS)
  - Amplitude comparison
  - Phase interferometry

- Spinning DF antennas (16 to 40 GHz)
- All systems must be extremely compact

GRINTEK ANTENNAS

2. PROTECTING ANTENNAS ON SUBMARINES

- **Antennas with external radomes**

  - High strength (thick) radome
  - High frequency performance compromised (often whole band compromised)

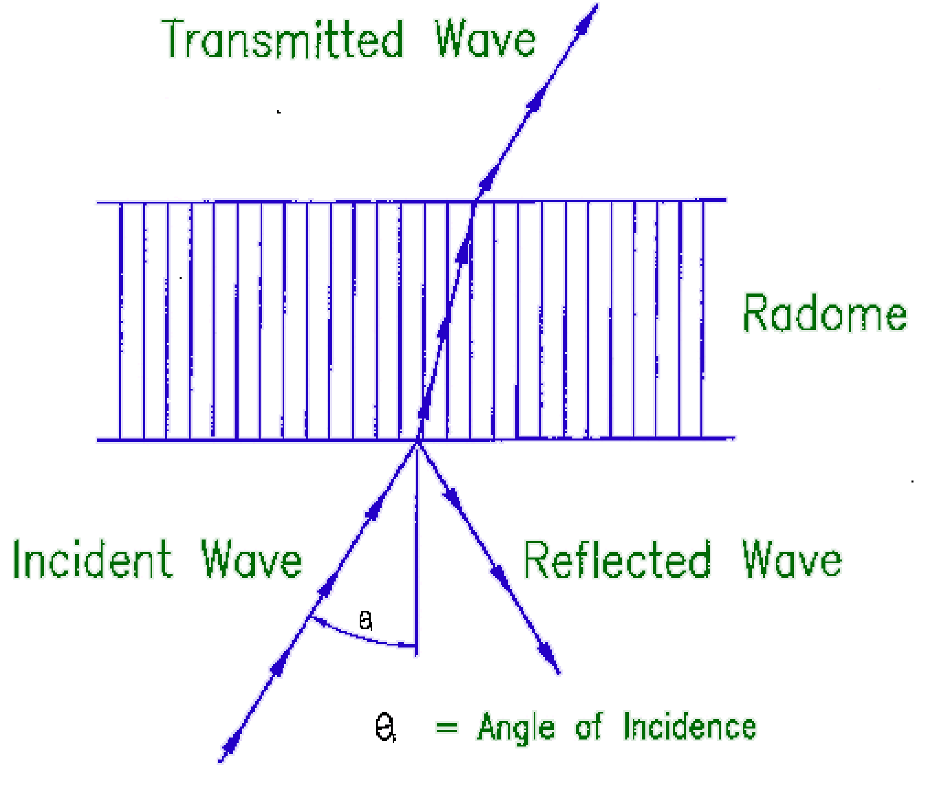
- **Antennas directly exposed to environment**

  - High strength construction techniques
  - Environmental conditions extreme

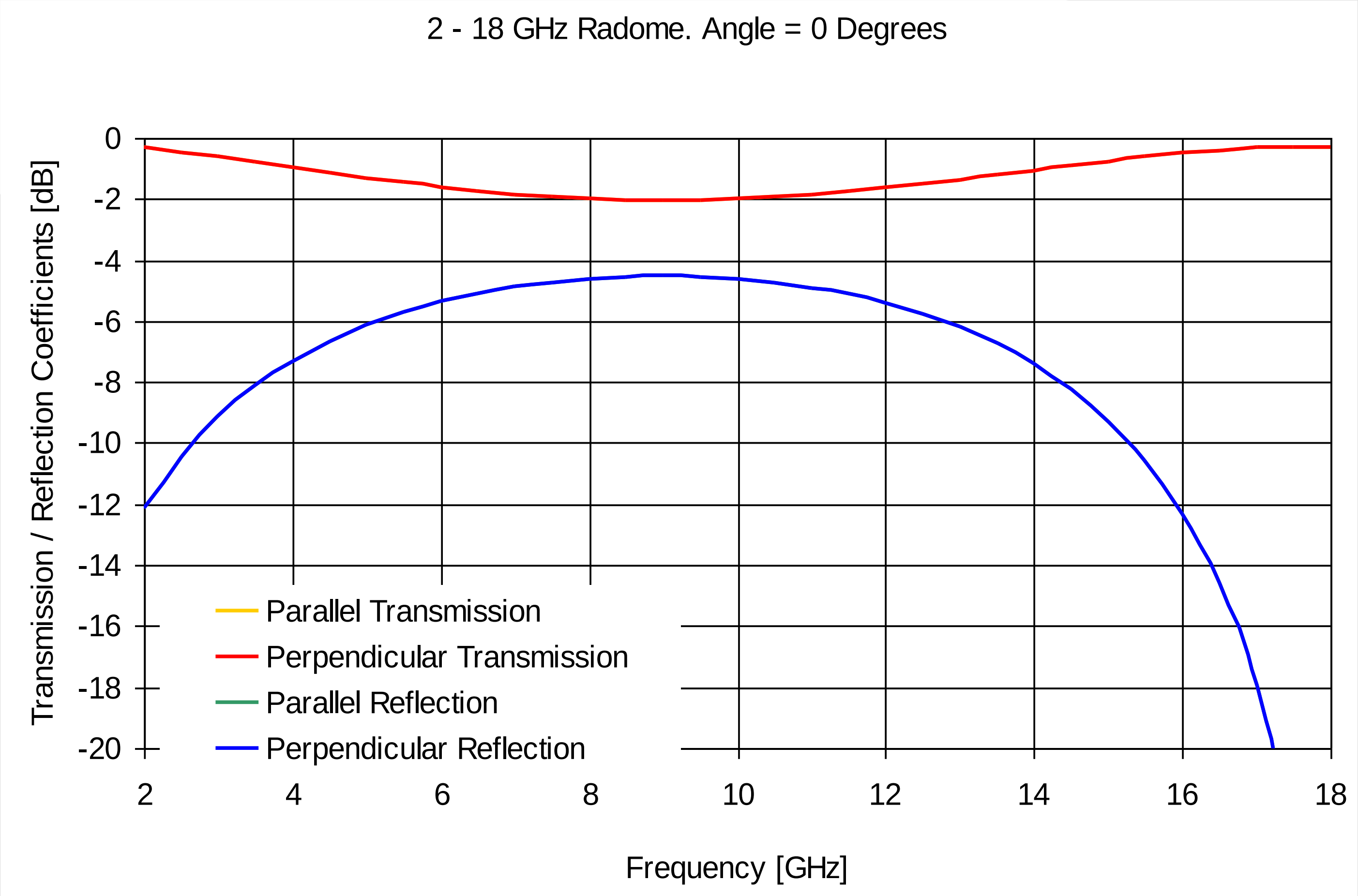
3. CONSIDERATIONS FOR EXTERNAL RADOMES

- If structural analysis allows it, use a radome wall of thickness $\lambda/_2$ at highest frequency.

- Sandwich radomes give better performance, but they are much more difficult to manufacture.

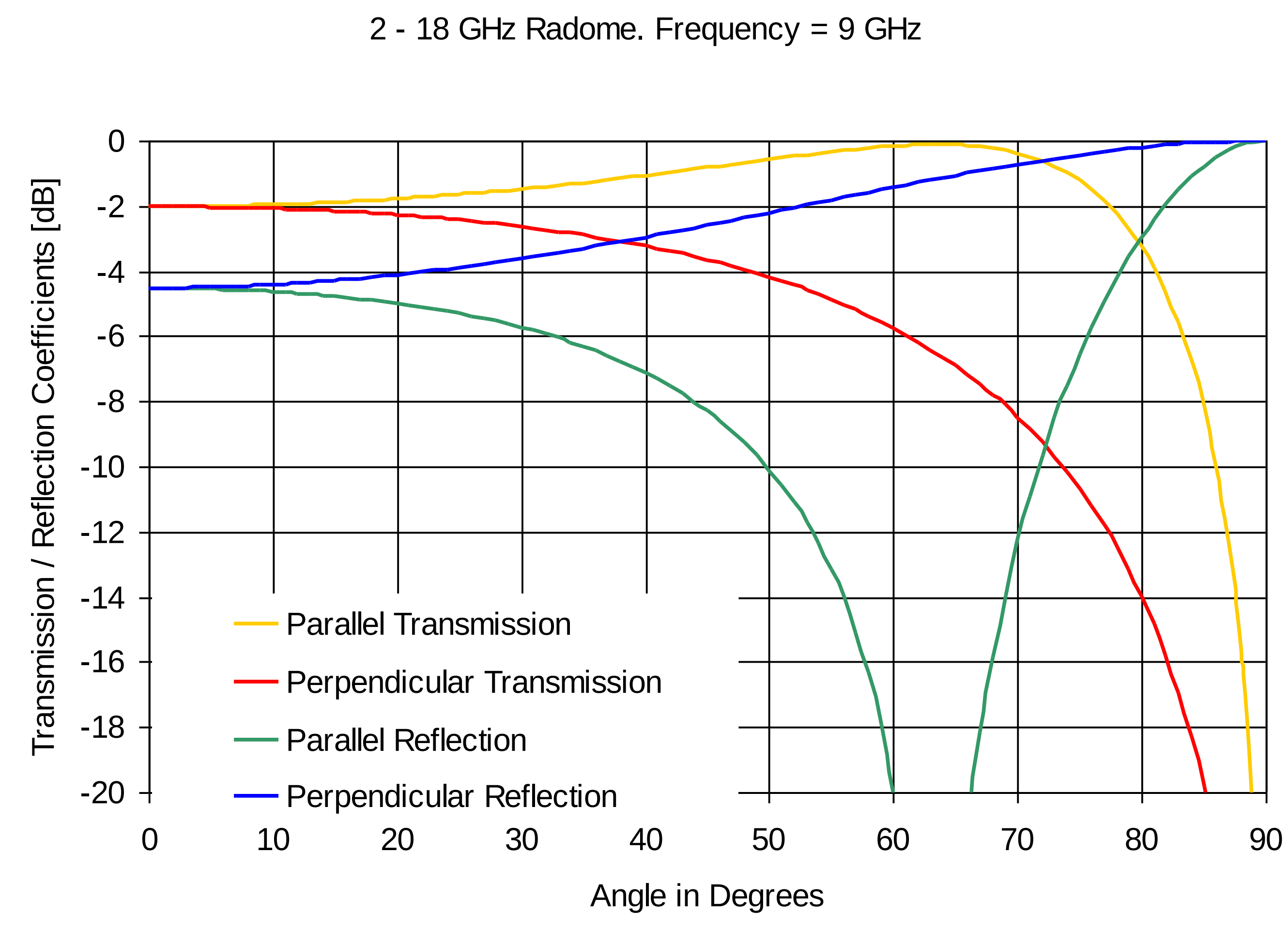


3. ANTENNAS WITH EXTERNAL RADOMES (cont.)



Layer 1
eps = 4.000
tanD = 0.017
t (mm) = 4.167

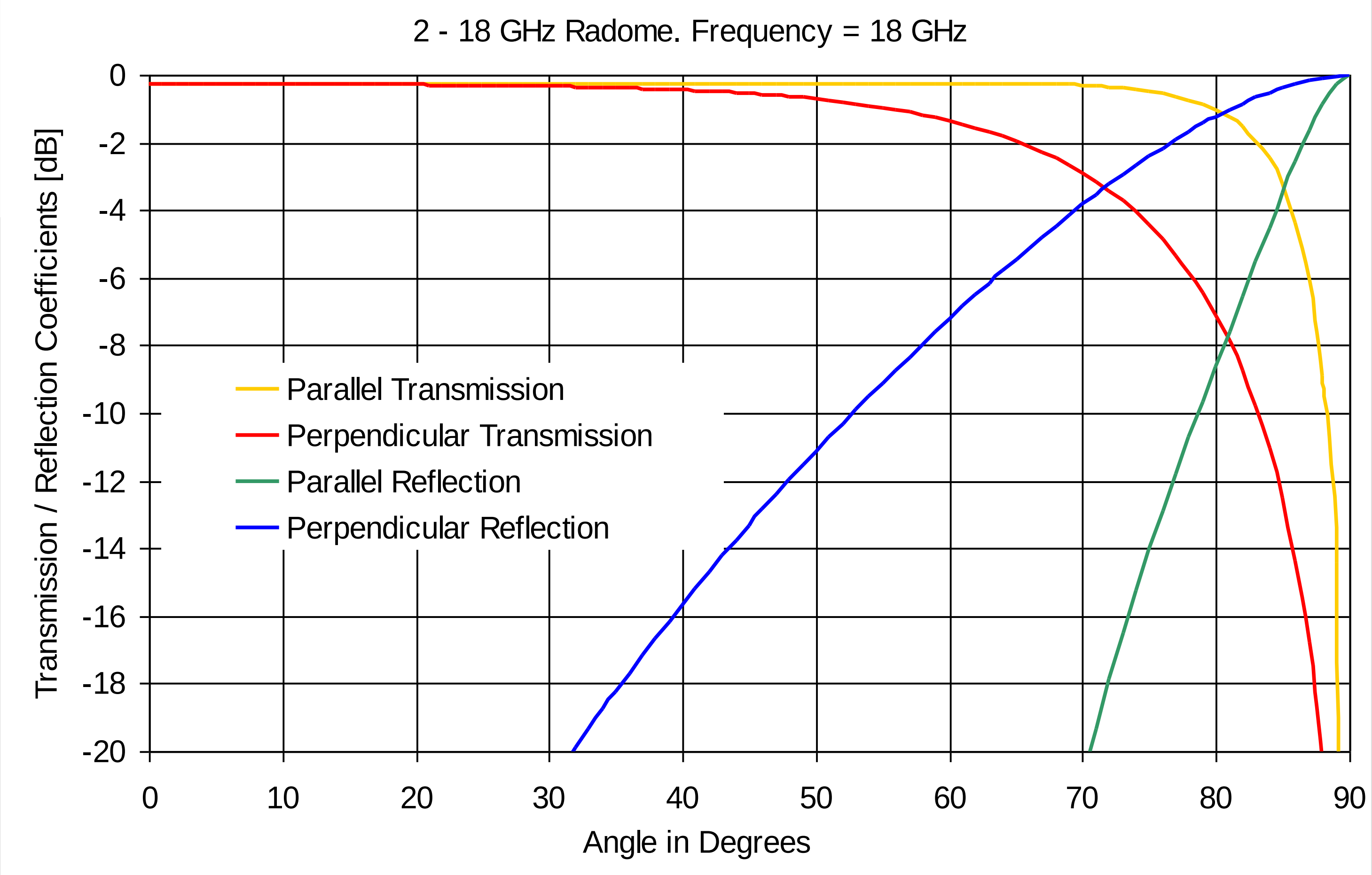
3. ANTENNAS WITH EXTERNAL RADOMES (cont.)




```
Layer 1
 eps   = 4.000
 tanD  = 0.017
 t(mm) = 4.167
```

GRINTEK
ANTENNAS

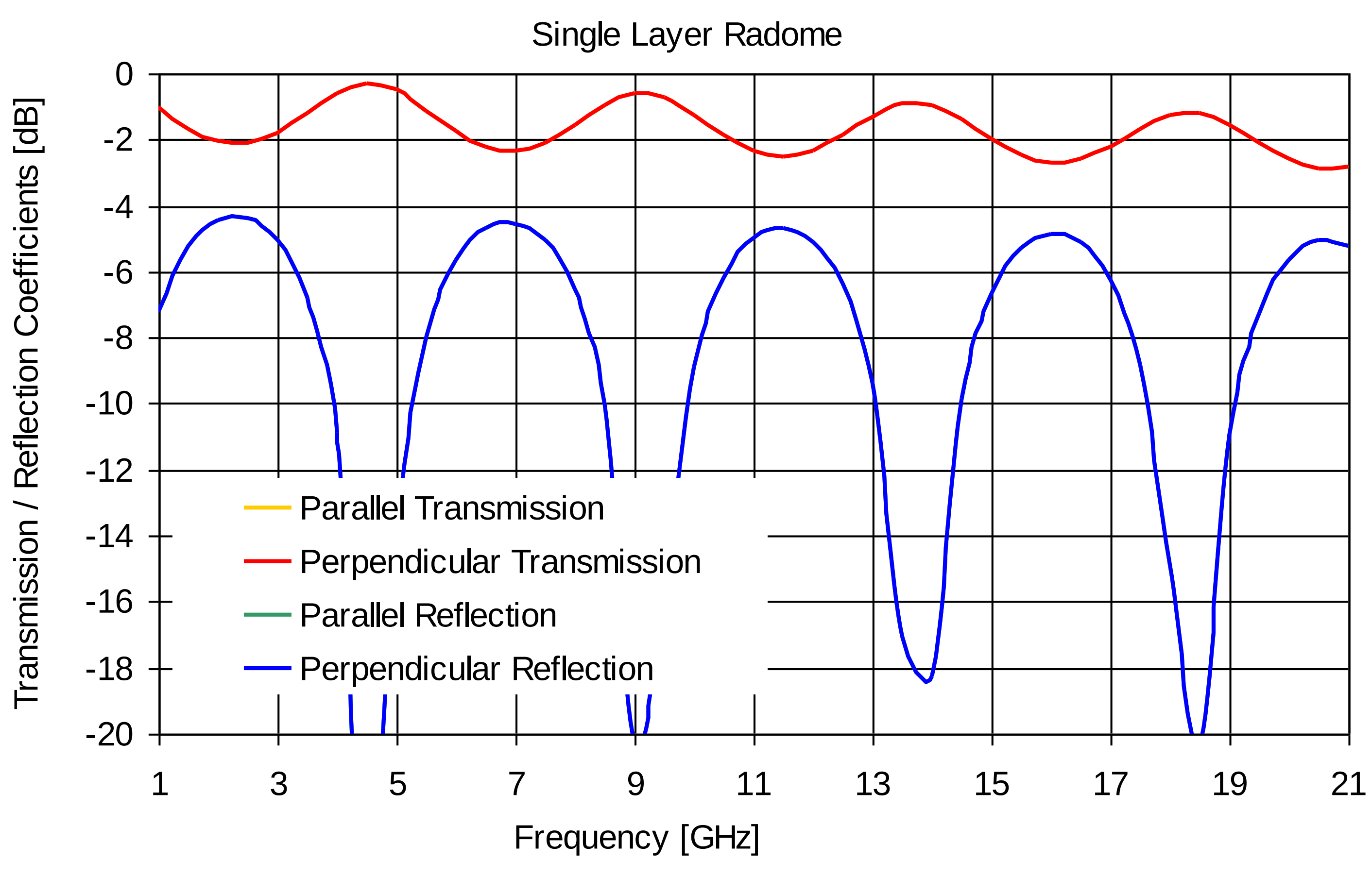
3. ANTENNAS WITH EXTERNAL RADOMES (cont.)



eps = 4.00
tanD = 0.017
t (mm) = 16 mm

GRINTEK ANTENNAS

3. ANTENNAS WITH EXTERNAL RADOMES (cont.)



eps = 4.17
tanD = 0.017
t (mm) = 16 mm

4. 2 - 18 GHz OMNI/GPS WITH EXTERNAL RADOME

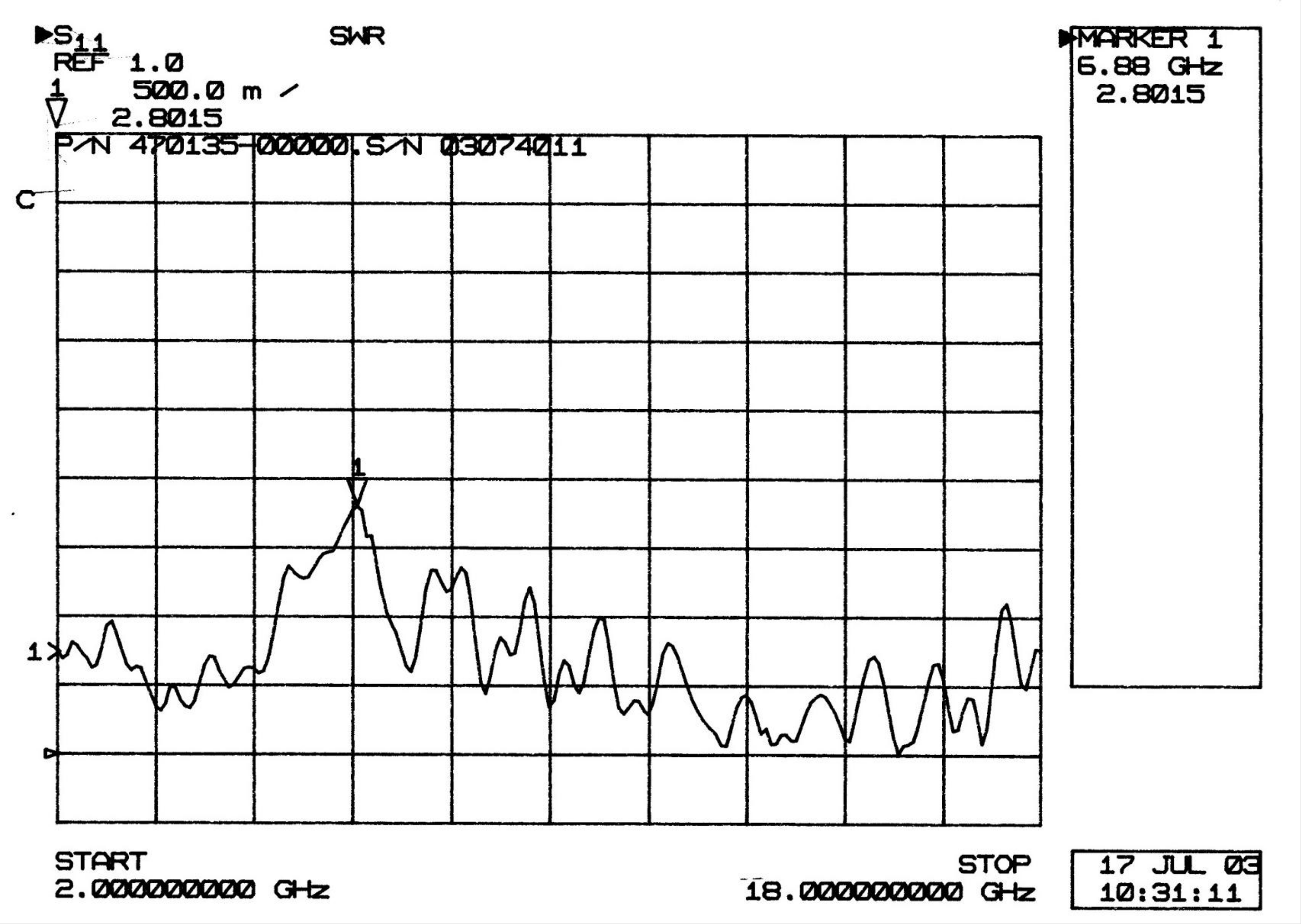
ANTENNA ASSEMBLY COMPRISES:

- GPS (L1/L2)
- 2 - 18 GHz biconical omni antenna
- 2 - 18 GHz slant 45 ° polarizer
- Titanium base with BMA connectors for GPS and omni
- High strength radome with special external coating

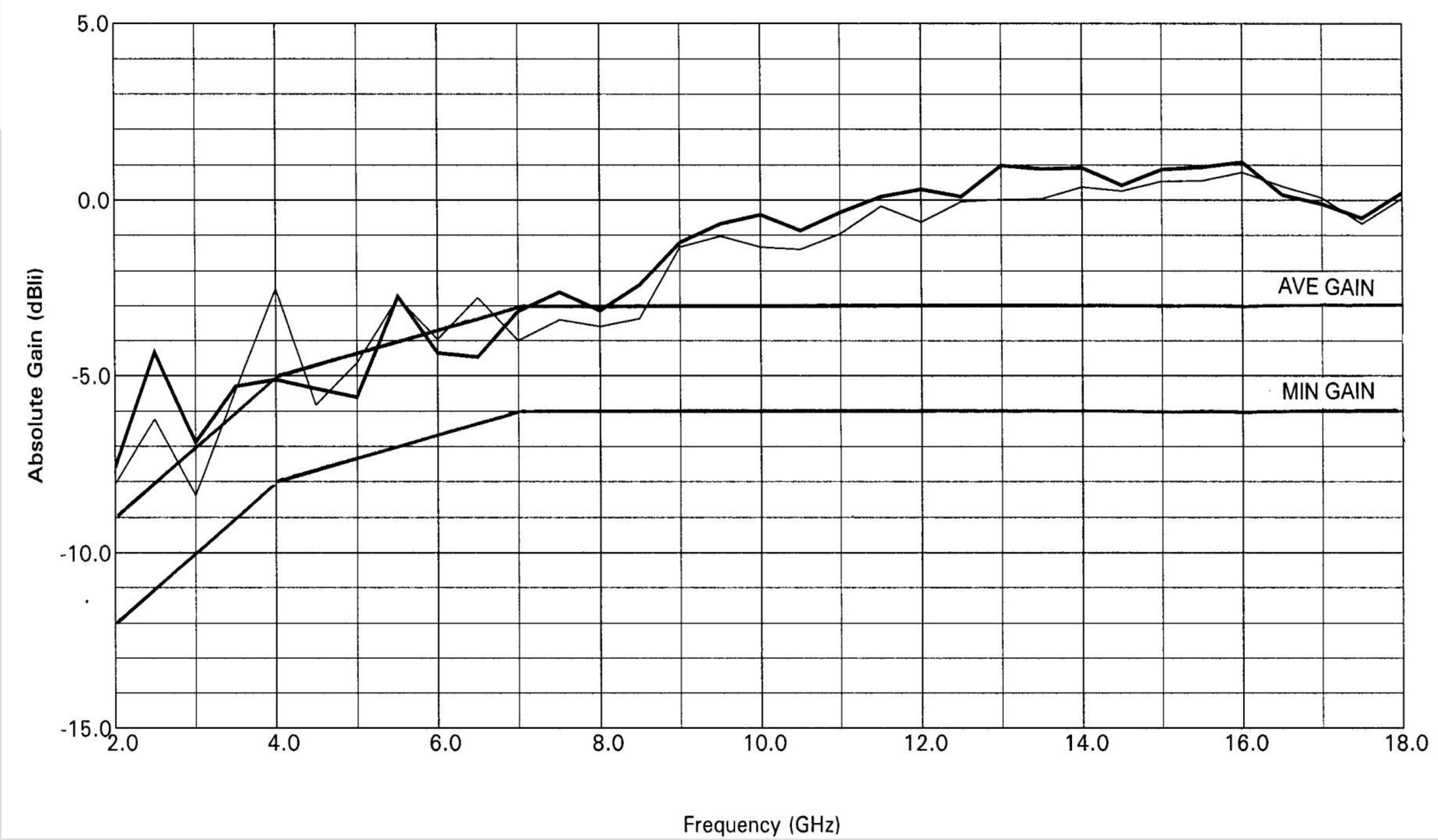
5. PHOTOGRAPH OF FOUR GPS/2-18GHz SLANT 45º OMNI ANTENNAS WITH RADOMES.

GRINTEK
ANTENNAS

6. MEASURED VSWR OF OMNI AT BASE OF ASSEMBLY



7. MEASURED GAIN OF OMNI FOR V AND H POLARIZATIONS AT BASE OF ASSEMBLY

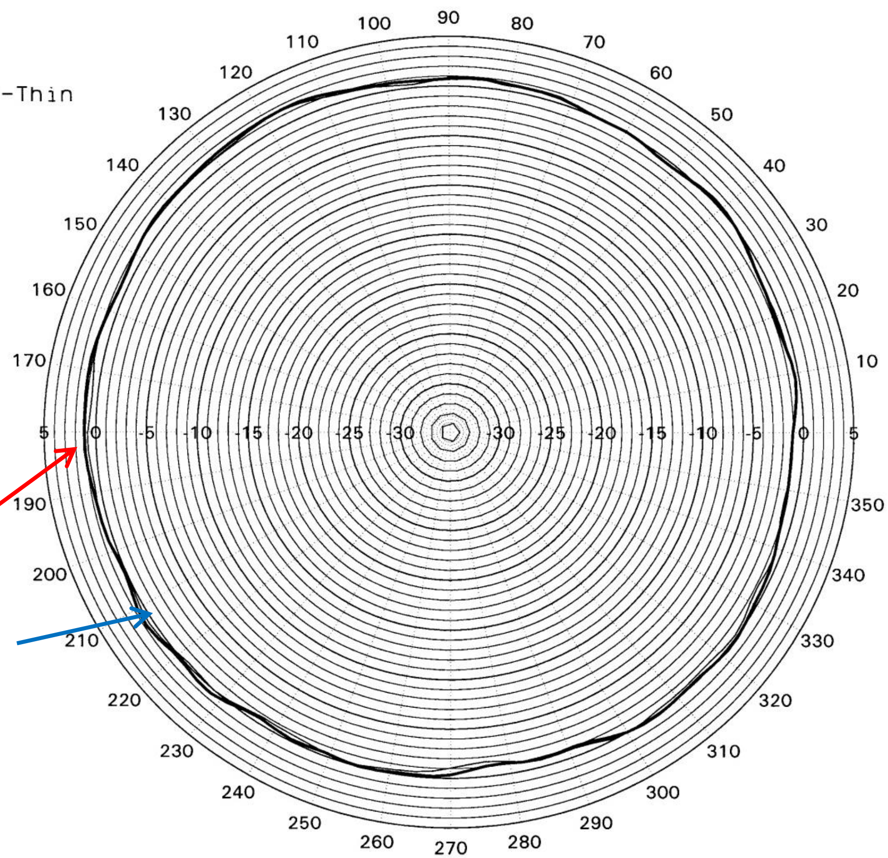


ANTENNA : - 03074011
FREQUENCY : - 2-18 GHz
POLARISATION : - Vert-thick/Hor-thin
PLANE OF CUT : - Azimuth
FIGURE

GRINTEK
ANTENNAS

8. MEASURED AZIMUTH PLANE PATTERN FOR V AND H POLARIZATIONS AT 18 GHz

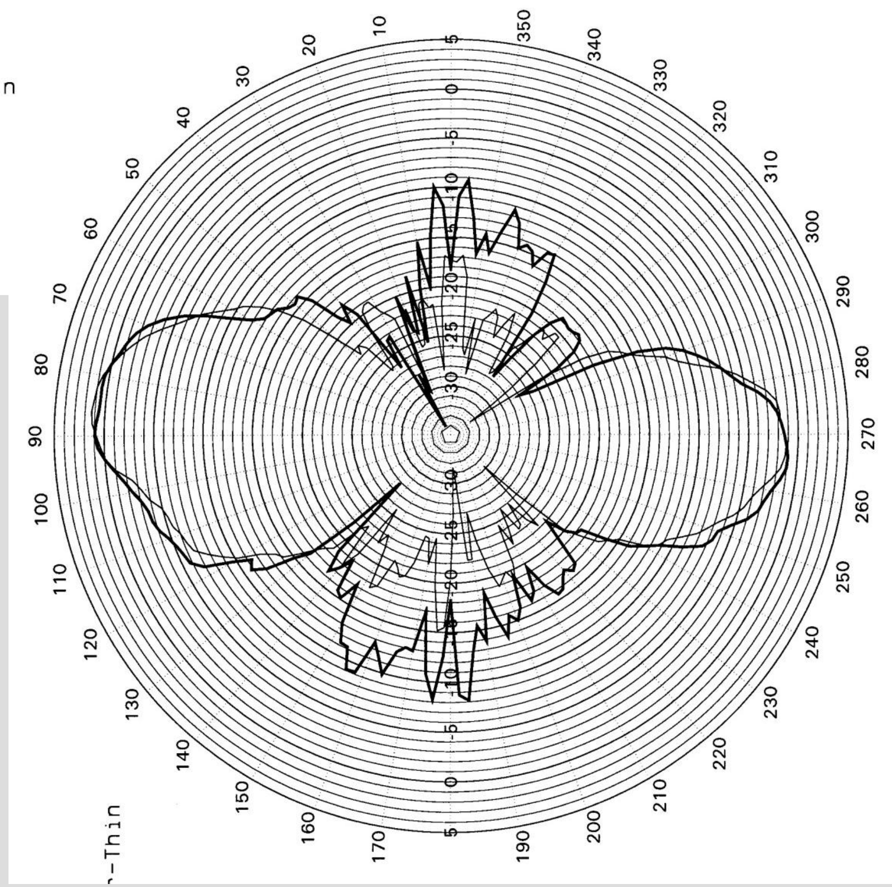
ANTENNA : - 03074011
FREQUENCY : - 18.000 GHz
POLARISATION : - Vert-Thick/Hor-Thin
PLANE OF CUT : - Azimuth
MIN. VALUE dB : -1.15
MAX. VALUE dB : 1.55
AVE. VALUE dB : 0.19
P-P. VALUE dB : 2.70
MIN. VALUE dB : -1.50
MAX. VALUE dB : 1.48
AVE. VALUE dB : 0.03
P-P. VALUE dB : 2.98



Note V and H polarisations

9. MEASURED ELEVATION PLANE PATTERN FOR V AND H POLARISATIONS AT 18 GHz

ANTENNA : - 03074011
FREQUENCY : - 18.000 GHz
POLARISATION : - Vert-Thick/Hor-Thin
PLANE OF CUT : - Elevation
-90 3 dB BW : 25.49
+90 3 dB BW : 28.11
-90 3 dB BW : 24.02
+90 3 dB BW : 24.77



GRINTEK
ANTENNAS

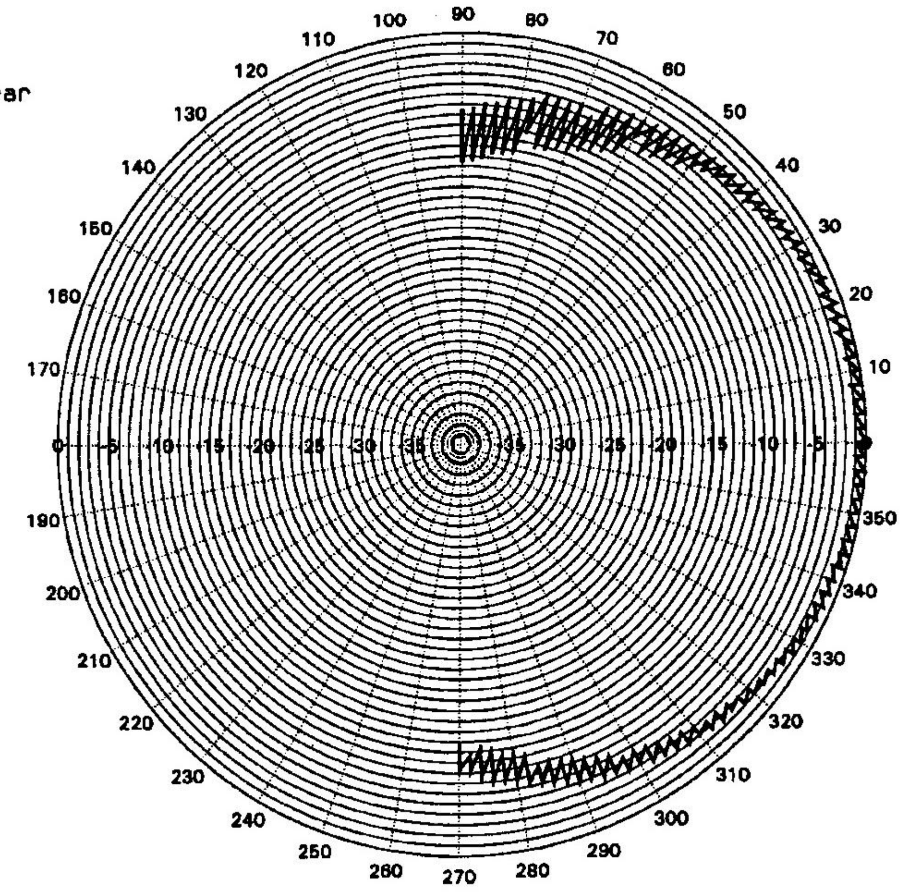
10. ANTENNAS CAPABLE OF WITHSTANDING HIGH PRESSURE

2 to 18 GHz high
pressure spiral antenna

11. MEASURED PERFORMANCE OF HIGH PRESSURE SPIRAL ANTENNA, 2 GHz

ANTENNA :- 02034013
FREQUENCY :- 2.000 GHz
POLARISATION :- Spinning Linear
PLANE OF CUT :- Azimuth
SQUINT : -2.81 DEG.
3 dB BW : 95.18 DEG.
10 dB BW : 0.00 DEG.
Peak Pos. : 0.00 DEG.

AZ (deg)	AR (dB)
0.0	0.9
45.0	1.2
60.0	1.4
80.0	5.2

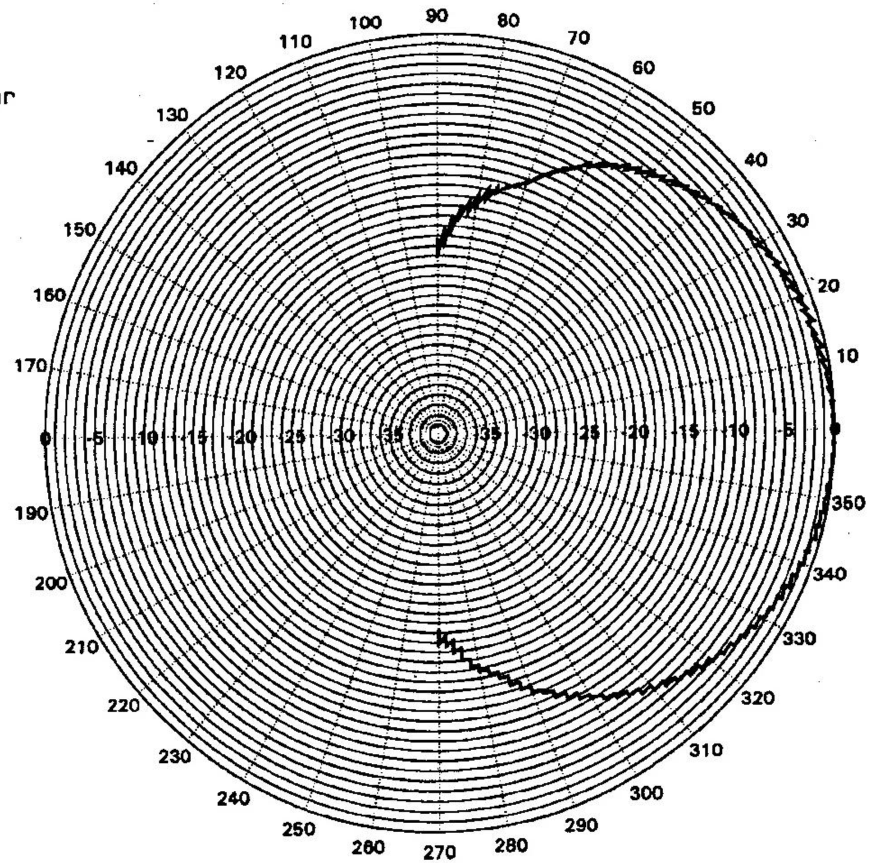


GRINTEK
ANTENNAS

12. MEASURED PERFORMANCE OF HIGH PRESSURE SPIRAL ANTENNA, 10 GHz

ANTENNA	:-	02034013
FREQUENCY	:-	10.000 GHz
POLARISATION	:-	Spinning Linear
PLANE OF CUT	:-	Azimuth
SQUINT	:	-0.10 DEG.
3 dB BW	:	68.76 DEG.
10 dB BW	:	124.92 DEG.
Peak Pos.	:	0.00 DEG.

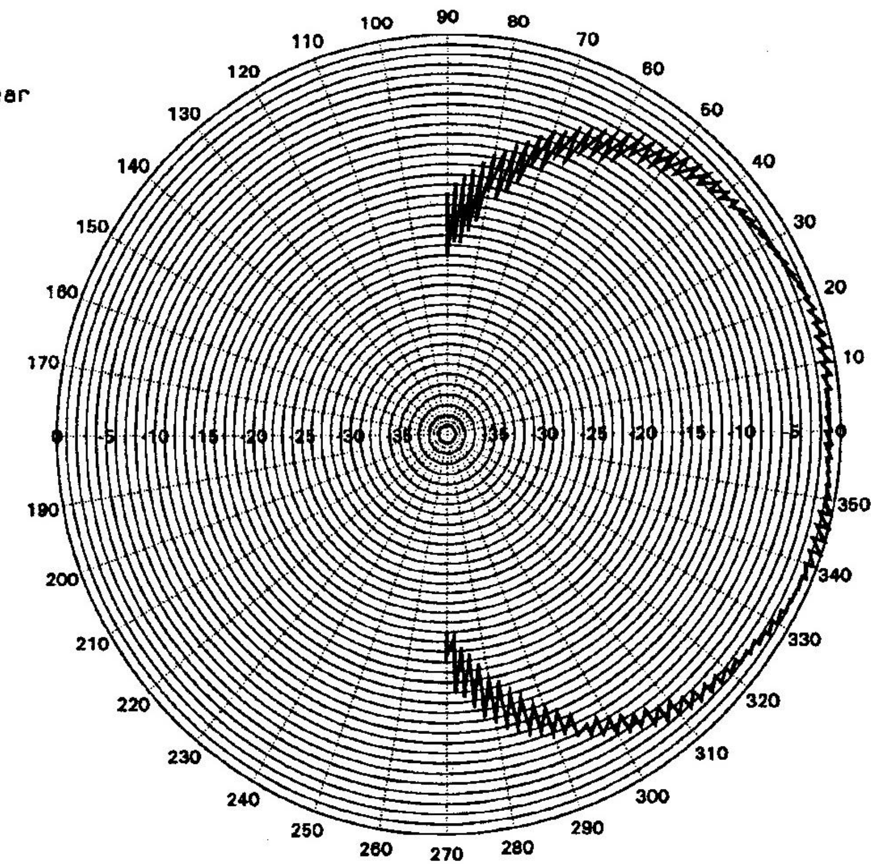
AZ (deg)	AR (dB)
0.0	0.2
45.0	0.5
60.0	0.4
80.0	1.0



13. MEASURED PERFORMANCE OF HIGH PRESSURE SPIRAL ANTENNA, 18 GHz

ANTENNA : - 02034013
FREQUENCY : - 18.000 GHz
POLARISATION : - Spinning Linear
PLANE OF CUT : - Azimuth
SQUINT : -1.62 DEG.
3 dB BW : 93.40 DEG.
10 dB BW : 146.69 DEG.
Peak Pos. : -16.00 DEG.

AZ (deg)	AR (dB)
0.0	0.6
45.0	1.5
60.0	2.5
80.0	4.0



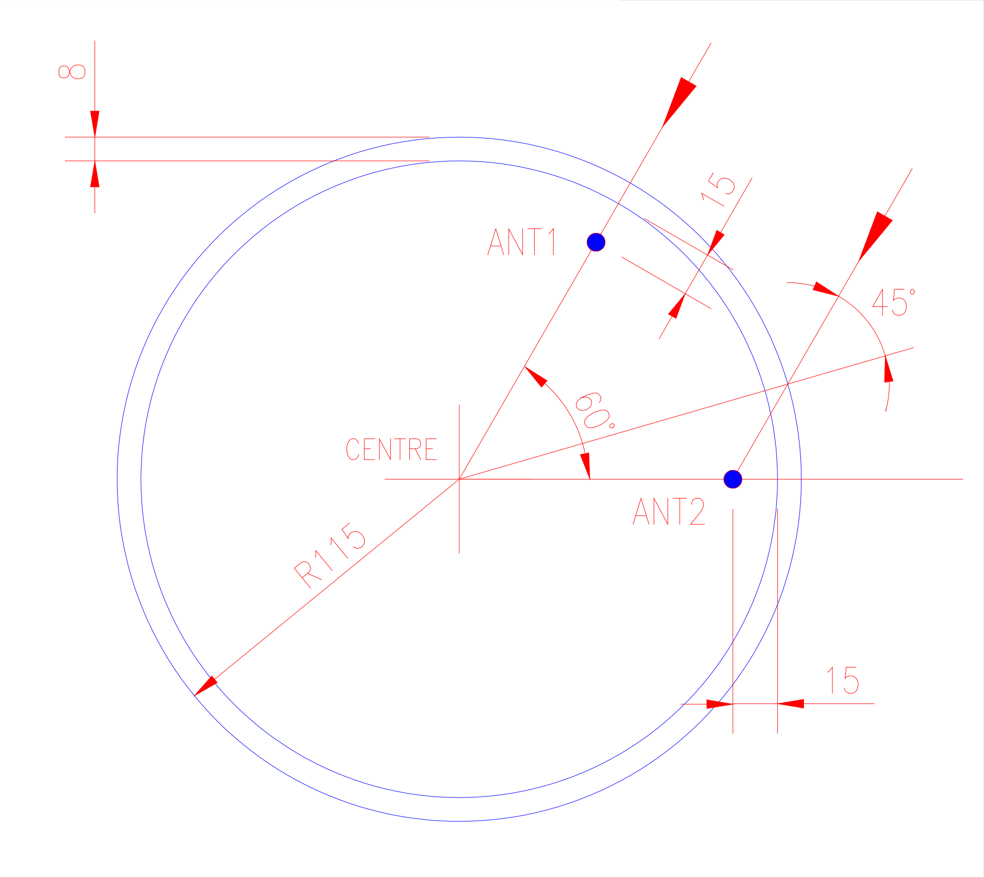
14. AMPLITUDE COMPARISON AND PHASE INTERFEROMETER DF WITH EXTERNAL RADOME

ASSEMBLY COMPRISES

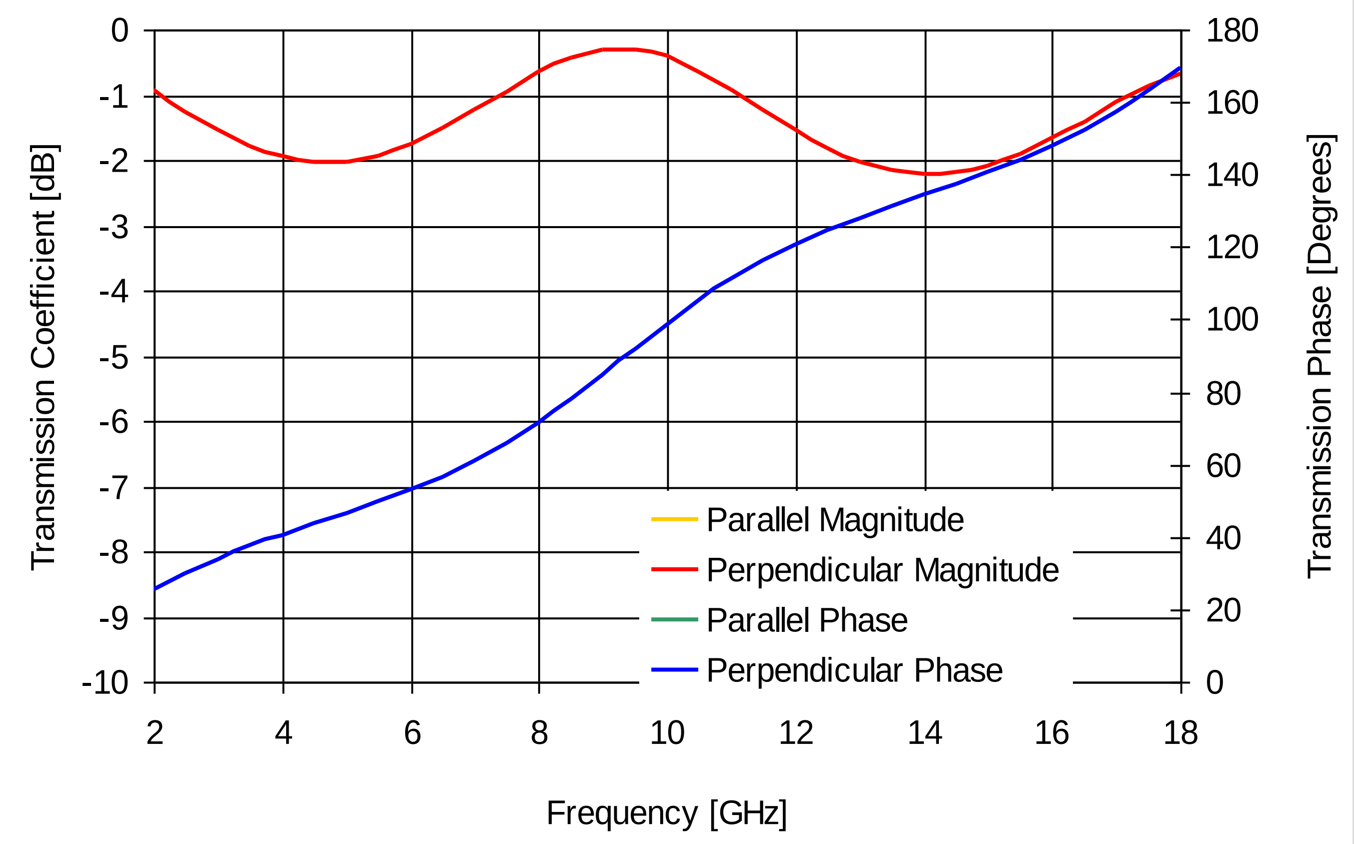
- 2 - 18 GHz phase/amplitude tracking spirals
- configured in two sub-bands (break points typically at 6 or 8 GHz
- GPS
- 2 - 18 GHz slant 45 omnidirectional antenna
- Titanium base with BMA connectors
- High strength radome
- Diameter 230 mm, height 260 mm

GRINTEK
ANTENNAS

15. INCIDENT RAYS ON TWO ANTENNAS, ONE AT 0° AND THE OTHER AT 45° ANGLE OF INCIDENCE



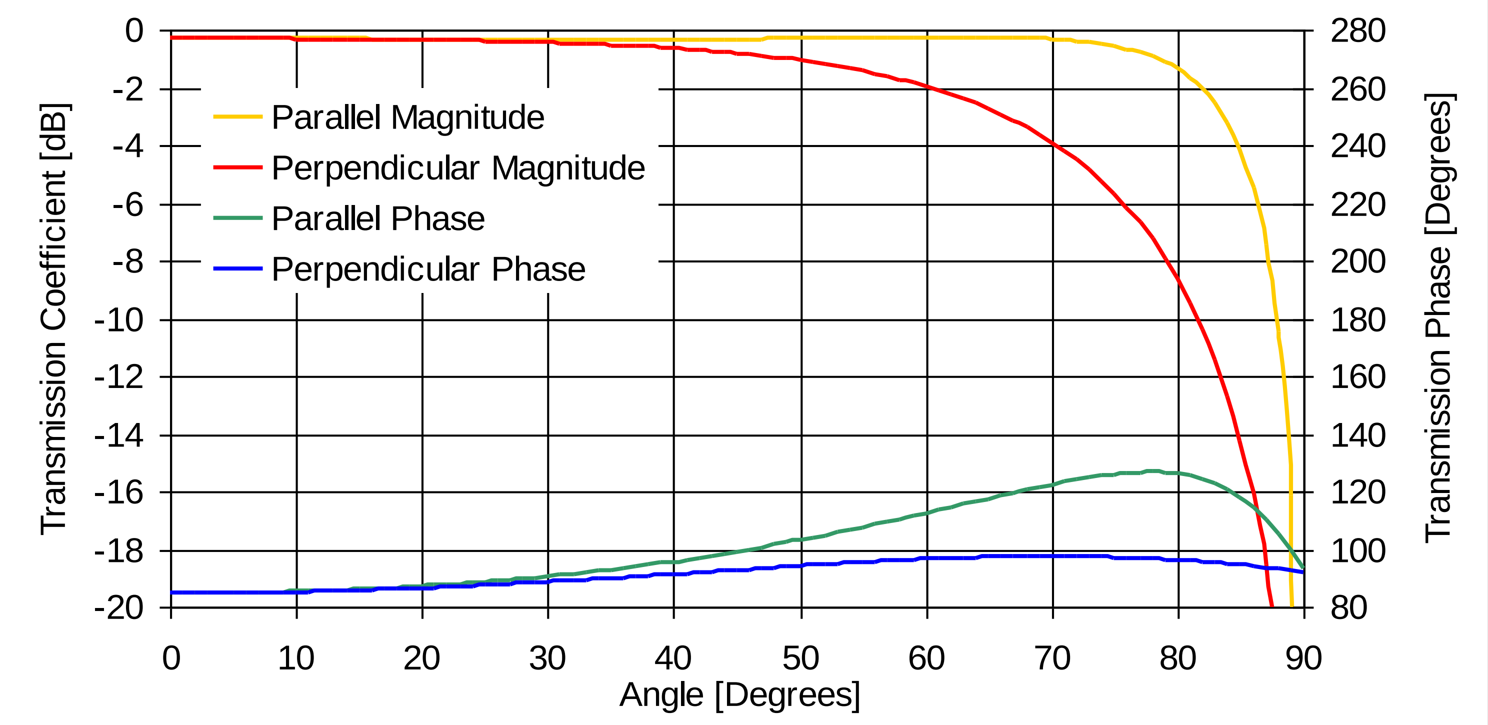
16. TRANSMISSION PHASE CHARACTERISTICS OF HIGH PRESSURE RADOMES



eps = 4.00
tanD = 0.017
t (mm) = 8.00

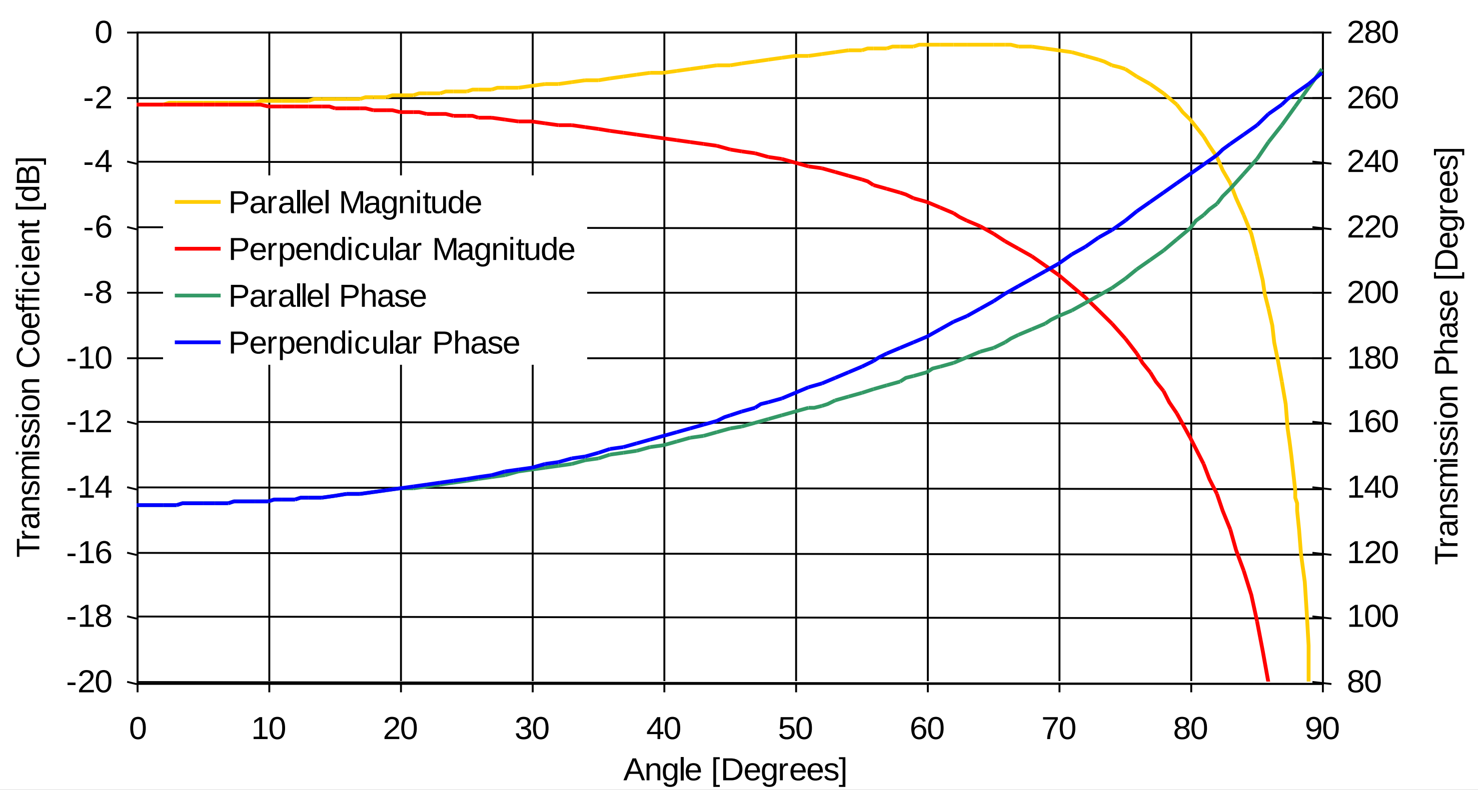
GRINTEK
ANTENNAS

16. TRANSMISSION PHASE CHARACTERISTICS AT 9 GHz AS FUNCTION OF ANGLE (CONTINUED)



eps = 4.00
tanD = 0.017
t (mm) = 8.00

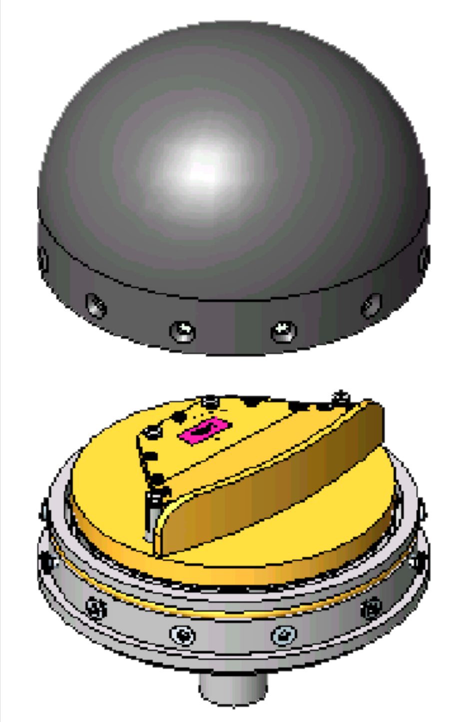
16. TRANSMISSION PHASE CHARACTERISTICS AT 14 GHz AS FUNCTION OF ANGLE (CONTINUED)



eps = 4.00
tanD = 0.017
t (mm) = 8.00

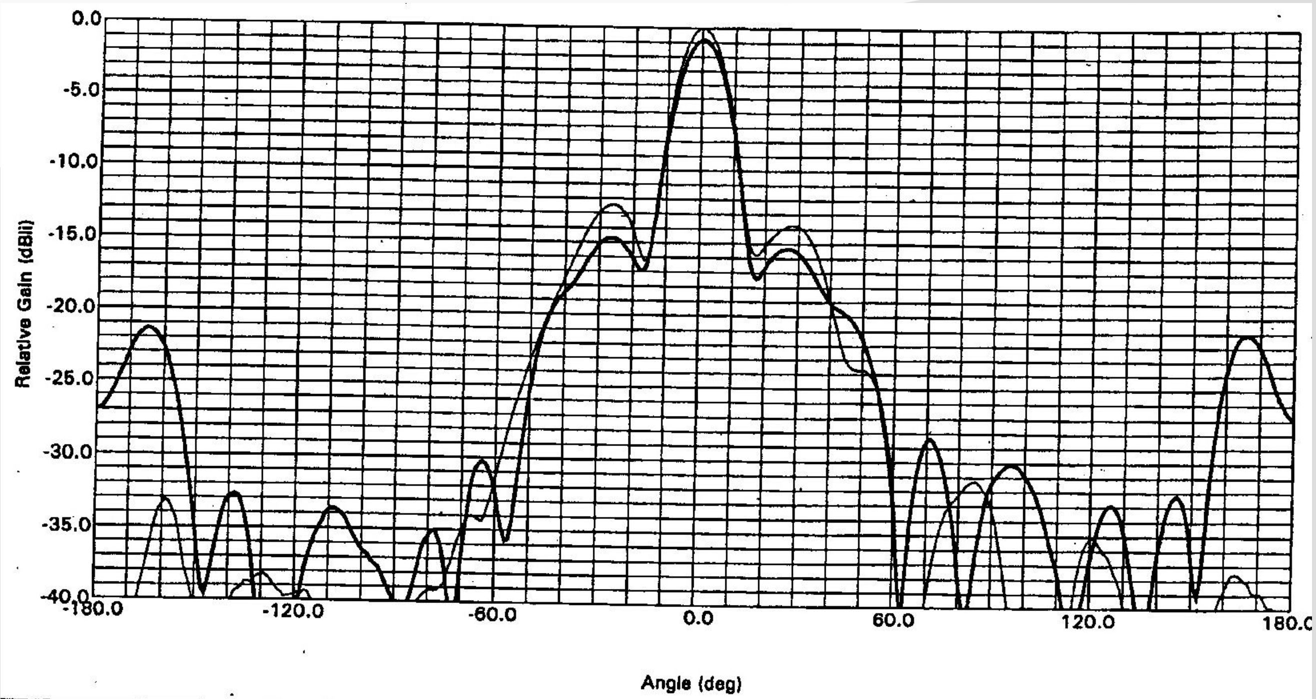
GRINTEK ANTENNAS

17. 16 – 40 GHz SPINNING DF ANTENNA WITH SLANT 45º POLARISER IN HIGH PRESSURE RADOME



GRINTEK
ANTENNAS

18. MEASURED PERFORMANCE OF SPINNING DF ANTENNA: AZIMUTH PATTERN AT 16 GHz

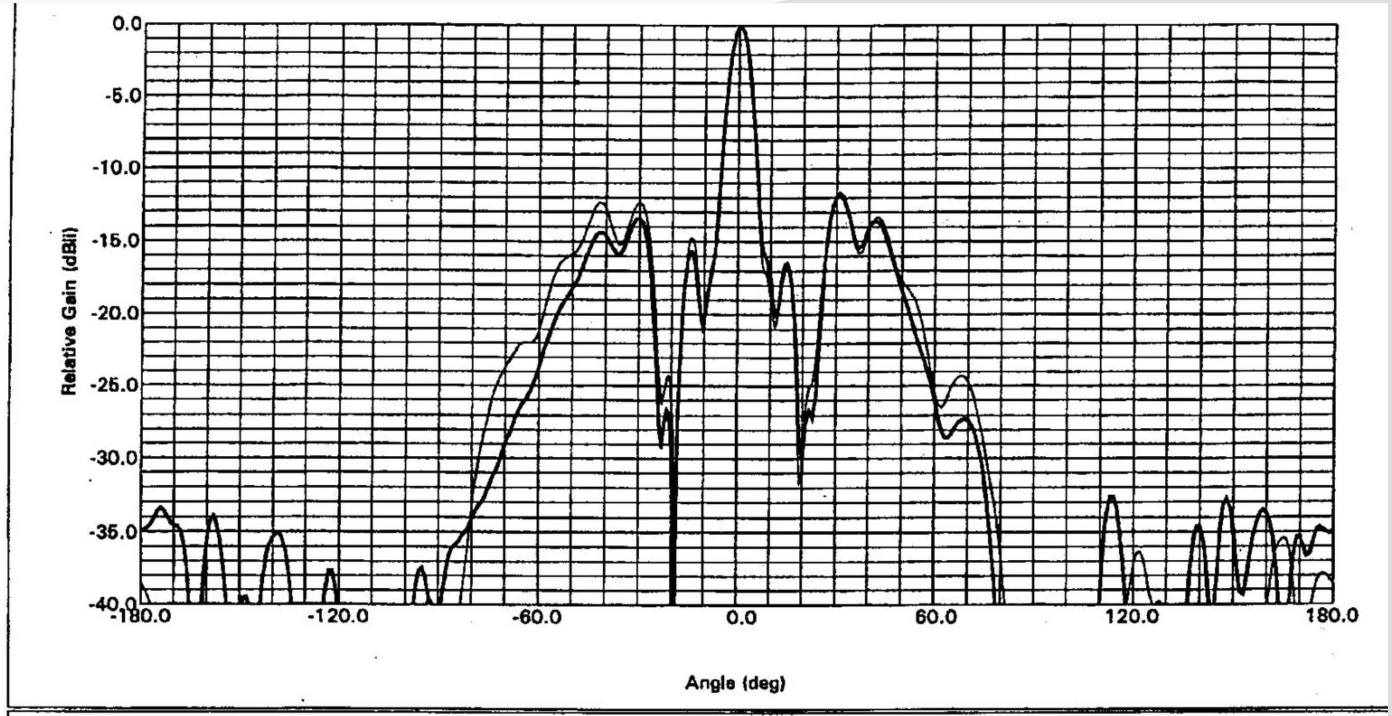


ANTENNA : - 03084001
FREQUENCY : - 16.000 GHz
POLARISATION : - Vert-thick/Hor-thin
PLANE OF CUT : - H-Plane
FIGURE

SQUINT	:	0.23 DEGREES	0.12 DEGREES
3 dB BW	:	13.41 DEGREES	13.41 DEGREES
10 dB BW	:	23.98 DEGREES	23.78 DEGREES
Peak Pos.	:	0.00 DEGREES	0.00 DEGREES

GRINTEK
ANTENNAS

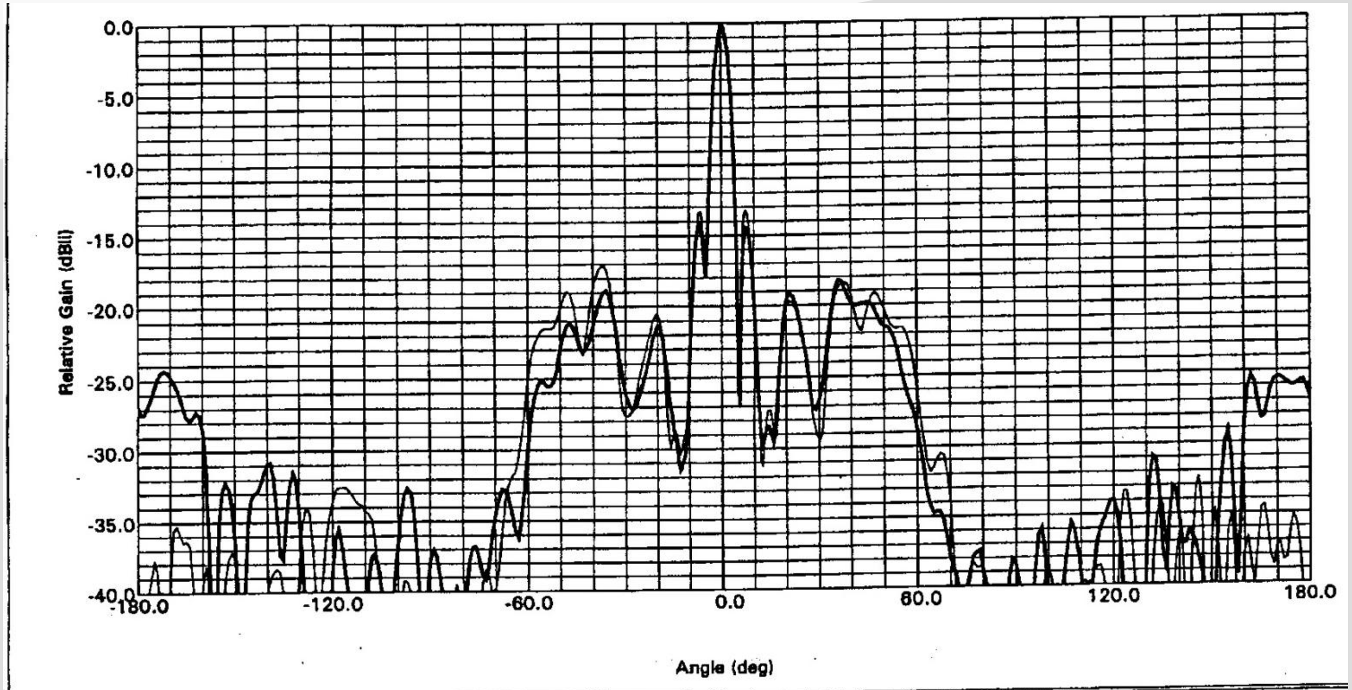
19. MEASURED PERFORMANCE OF SPINNING DF ANTENNA: AZIMUTH PATTERN AT 30 GHz



ANTENNA	:- 030B4001	SQUINT	:	0.32 DEGREES	0.33 DEGREES
FREQUENCY	:- 30.000 GHz	3 dB BW	:	6.14 DEGREES	5.93 DEGREES
POLARISATION	:- Vert-thick/Hor-thin	10 dB BW	:	10.93 DEGREES	10.61 DEGREES
PLANE OF CUT	:- H-Plane	Peak Pos.	:	0.50 DEGREES	0.50 DEGREES
FIGURE					

GRINTEK ANTENNAS

20. MEASURED PERFORMANCE OF SPINNING DF ANTENNA: AZIMUTH PATTERN AT 40 GHz



ANTENNA	:- 03084001	SQUINT :	0.23 DEGREES	0.27 DEGREES
FREQUENCY	:- 40.000 GHz	3 dB BW :	4.45 DEGREES	4.30 DEGREES
POLARISATION	:- Vert-thick/Hor-thin	10 dB BW :	7.62 DEGREES	7.31 DEGREES
PLANE OF CUT	:- H-Plane	Peak.Pos. :	0.00 DEGREES	0.50 DEGREES
FIGURE				

GRINTEK ANTENNAS

21. CONCLUSIONS

- High pressure radomes can have significant impact on antenna performance - normally significant degradation.
- Careful trade-off between electrical and mechanical requirements is required.
- Phase effects are significant - careful placement of antennas is required inside radome.
- High pressure spiral antennas capable of withstanding external pressure give excellent performance.
- Lightweight spinning direction finding (DF) assembly can extend DF to 40 GHz using a single receiver.