

# EVALUATION OF HARD GATING IN THE ESA/ESTEC CPTR

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## ABSTRACT

Compact antenna test ranges such as the ESA/ESTEC CPTR are large facilities for the characterization of electrically and physically large antennas as well as end to end radiated payload testing. To achieve high accuracy measurements, time gating is used to filter out as many room effects as possible. The most common implementation of time gating is to perform a frequency sweep, Fourier transformation to the time domain followed by windowing, gating and back transformation to the frequency domain. All of this is at a time penalty. An alternative is to have a synchronised switching system to switch on and off the transmit power as well as switching on and off the receiver. Such a solution has been devised in a cooperative effort between EADS Astrium and the Munich University of Applied Sciences. The paper will present the capabilities of the Astrium HG2000 Hard Gate system (1) in the ESA/ESTEC CPTR, its implementation in the facility as well as presenting direct comparison of results obtained by the hard gate system with the conventional soft gate on both low gain and high gain antennas

**Keywords:** Antenna Measurements, Gating, Time Domain, Compact Range

## 1. Introduction

Compact Antenna Test Ranges such as the ESA/ESTEC CPTR represent large test facilities for antenna and payload testing. Improvements in measurement accuracy through error correction techniques can be applied to eliminate the direct interference effects which include:

- Range coupling
- Direct test object illumination by range feed

- Residual reflection and diffraction in the range
- Test object/positioner interaction

These error sources have been handled to date in the ESA/ESTEC facilities by exploiting the “time domain” capability of commercially available receiving equipment and software. The process involves a frequency sweep over a suitable bandwidth to achieve range resolution and with sufficient frequency samples to have an effective alias free window around the test object. While this is accurate, it is time consuming. Other test techniques are potential compliments to this tried and tested technique such as pulsed techniques and the AAPC(2).

Another recently developed alternative is what is called the hard gate solution and, in particular, the solution as proposed by EADS Astrium GmbH in the form of their HG2000 system. The implementation in the ESTEC CPTR was carried out under an ESA study contract in 2003.

## 2. The ESA/ESTEC CPTR

The CPTR at the ESTEC facilities of the European Space Agency can be seen in figure 1 below and a schematic showing the principal interference sources is given shown in figure 2.

For a typical single azimuth scan  $-45^\circ \leq \theta \leq 45^\circ$  with a step size of  $0.5^\circ$  results in a total of 181 measurement points. For enhanced accuracy, the gating parameters below are applied:

Gating parameters:

Bandwidth:	200 Mhz
Resolution:	1.5 m
Alias free range:	>150 m
No. of freq.:	101

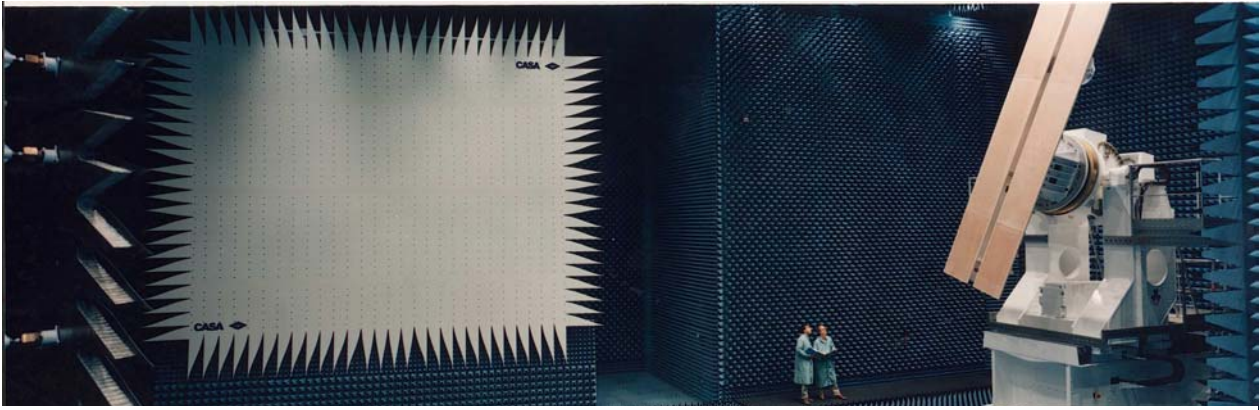


Figure 1. ESTEC CPTR view from feed room

Taking in addition 32 averages per point, will lead to an acquisition time for each individual measurement point long enough to possibly require the antenna tower to stop at each sample point leading to an excessive total measurement time.

### 3. The Hard Gate Solution

The ray paths shown in figure 2 can be related to corresponding delay times and perceived angles of arrival at the antenna under test. These are summarized in table 1.

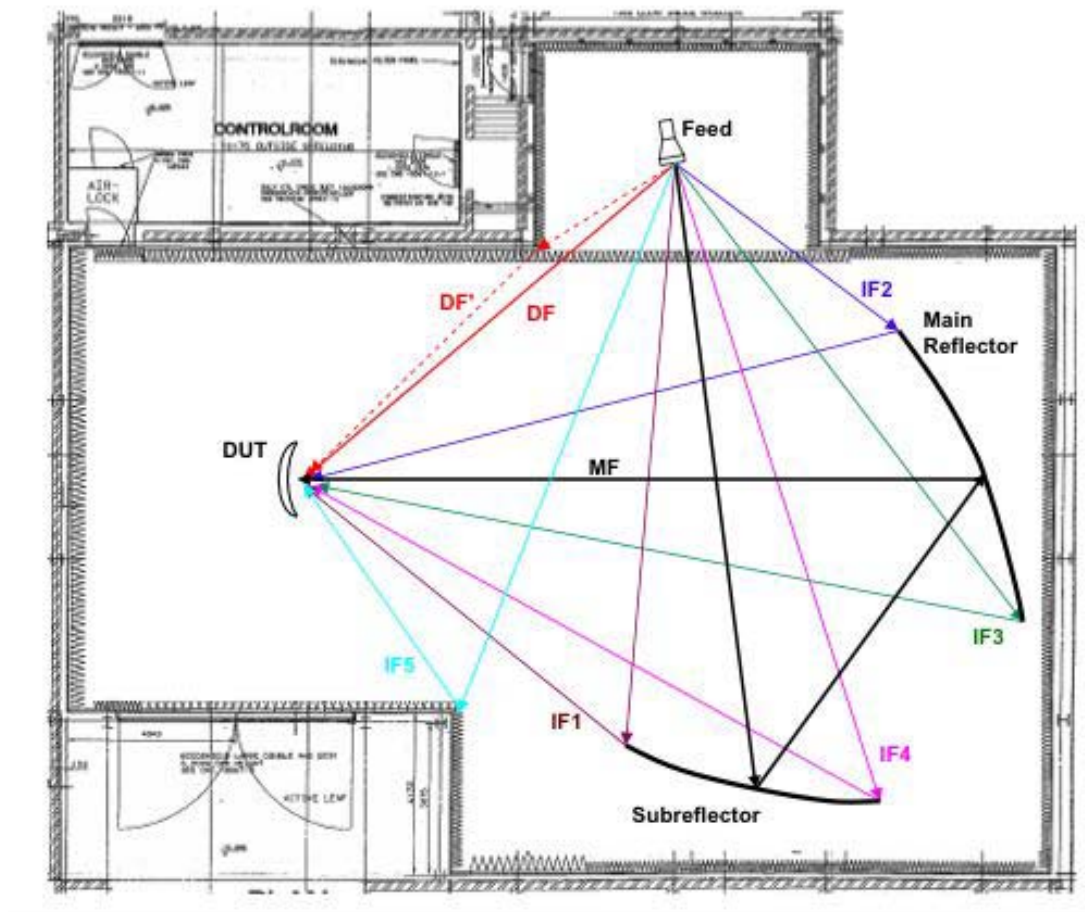
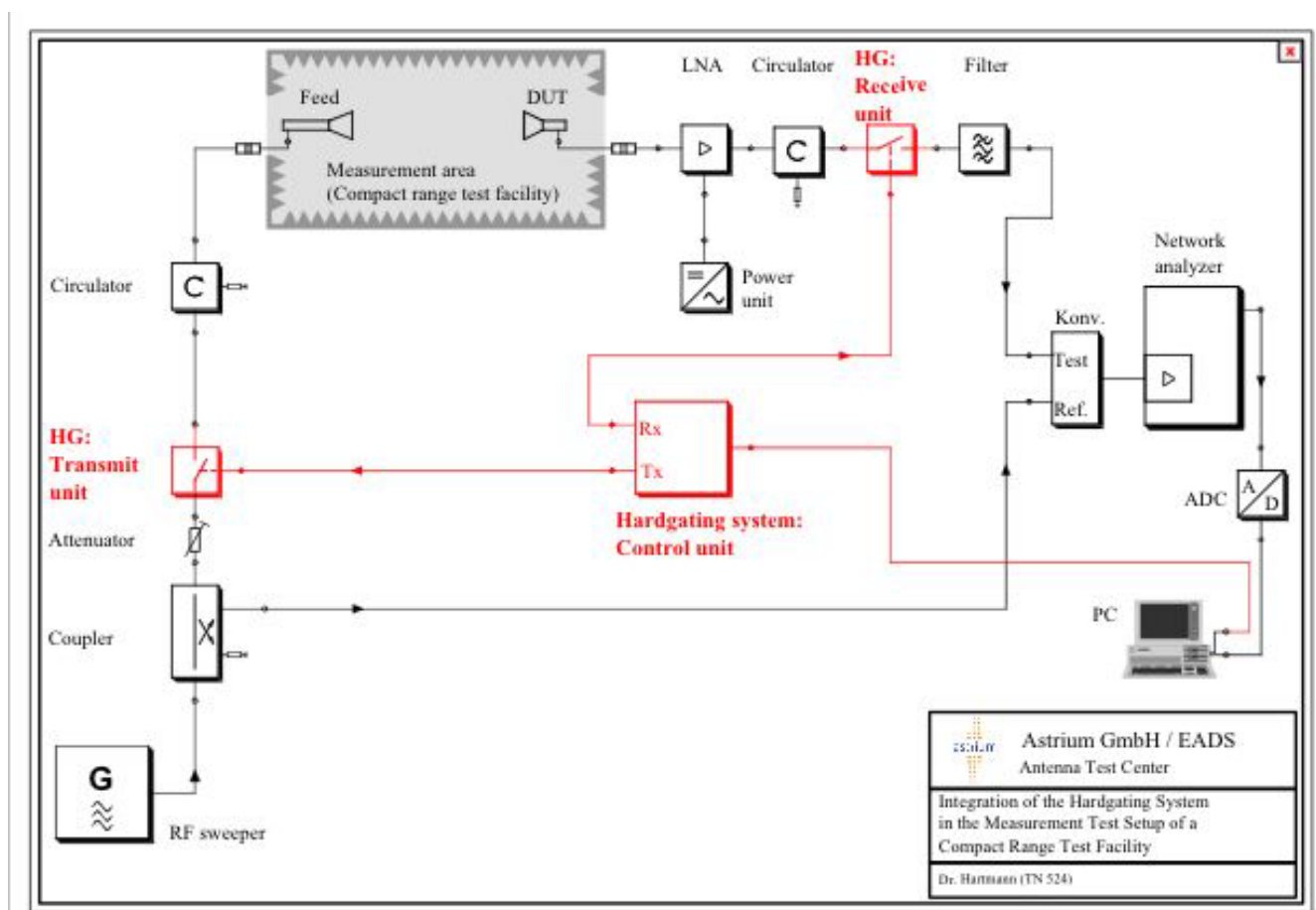


Figure 2. Schematic of main sources of disturbance

Ray Path	Description	Delay Time (ns)	Incident Angle in QZ
MF	Main Field	145.0	0.0
DF	Direct Field	42.4	-40.0
DF'	Feed room diffraction corner	43.0	-44.0
IF1	Subreflector – right edge serrations	85.4	38.5
IF2	Main reflector – left edge serrations	77.8	-13.0
IF3	Main reflector – right edge serrations	111.8	11.0
IF4	Subreflector – left edge serrations	114.6	29.0
IF5	Near in diffraction corner	71.7	54.0

**Table 1. Ray path delay times and angles of arrival**



**Figure 3. Schematic**

The hardware of the HG2000 system consists of a control unit directly interfaced to the facility data acquisition and control computer through an RS232 bus and two hard gate switch boxes, one at the transmit end of the facility and the other at the receive end of the facility as shown in figure 3.

#### 4. The Experiment

The goal of the experiment was to be able to test the hard gate system applicability in the ESTEC CPTR and compare the results with the accepted soft gate procedure. Two types of antenna were used as test objects.

One was a directive antenna with an elliptical shaped beam, 29 dBi directivity operating at 12 Ghz (VAST-12)(2), figure 12. The second antenna was a standard gain horn working at 3.6 Ghz. (Narda 644). Typical hard gating configurations are given in tables 2 and 3 for the VAST-12 and Narda horn respectively and, derived from the data shown in table 1. The lengths of cables at the CPTR feed and at the antenna to the respective Tx and Rx switch units of the hard gating system are taken into account.

<b>Configuration Field Detection</b>	<b>HG1 MF</b>
Pulse repetition time	174 ns
Pulse width at transmitter	10 ns
Pulse width at receiver	20 ns
Measurement point	169 ns

**Table 2. VAST-12 timing settings**

<b>Configuration Field Detection</b>	<b>HG2 MF</b>
Pulse repetition time	177 ns
Pulse width at transmitter	20 ns
Pulse width at receiver	30 ns
Measurement point	172 ns

**Table 3. Narda SGH timing settings**

It is possible to set up the hard gate time parameters to directly reveal/isolate and study individual measurement disturbances in a fast and efficient manner. Baseline measurements were carried out in CW mode to establish the time baseline as well as including in the measurement all disturbances. Measurements were then carried out in the conventional frequency swept mode to provide the soft gating result, followed by hard gated measurements.

Note that the internal gating feature of the HP8530A is not being used. Instead, the receiver is used in a pure data acquisition mode with stepped sweep and the data sent to the control computer to allow for time gating to be done offline. This allows adjustment of the gate parameters without having to redo a measurement which is a time driver in soft gated measurements.

## 5. Results

Figures 4 through 11 present a brief overview of the results obtained from the multitude of measurements performed in the ESTEC CPTR to evaluate the efficacy of the Astrium HG2000 hard gate system. Figure 4 shows the basic comparison between a gated and non-gated measurement. To note is the presence of a strong down range coupling which has severe effects on the main beam at boresight with little as the antenna is scanned off

axis. The various timing sequences were studied as well as the effect of the size of the pulse widths used as seen in figure 5. Here there is a direct analogy with the gating window in a soft gating scenario. Figure 6 shows the same results as in figure 4 only this time with the E-Plane of the VAST-12 antenna.

Figure 7 shows the degree of similarity in measurement results obtained from soft and hard gating. Any differences here are more attributable to reproducibility of a measurement than any differences in the gating scenarios. However, the comparison cannot tell you that the hard gated measurement was an order of magnitude faster than the soft gated measurement and with no appreciable loss in signal to noise ratio as witness by the results of measurement of the cross polar patterns.

Figures 8 through 11 summarize the results of similar measurements on a 15 dBi Nards standard gain horn at 3.6 GHz. The results shown there mimic the results of measurements on the VAST-12 antenna.

## 6. Conclusion

A measurement campaign as part of a study to evaluate the applicability of a hardware gating system in the ESTEC CPTR has been carried out. The results show that it works and works very well with a measurement speed improvement of at least an order of magnitude when compared to a soft gating scenario in the same facility. Signal to noise ratio does not appear to have been appreciably affected.

It is not to be concluded that the hard gate is to supplant the soft gate at all times. The idea is to maintain both as options in the facility. When circumstances allow use of the hard gate, then it should be used to its speed advantage. However, there may be situations where a swept response, or many frequencies are required which argue for the soft gate.

The applicability of the hard gate unit in a RCS scenario is to be evaluated.

## References

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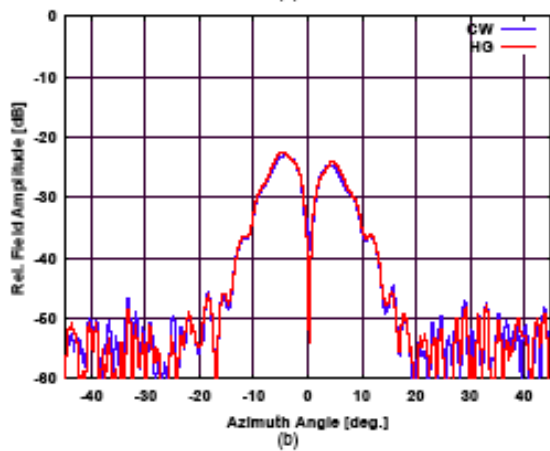
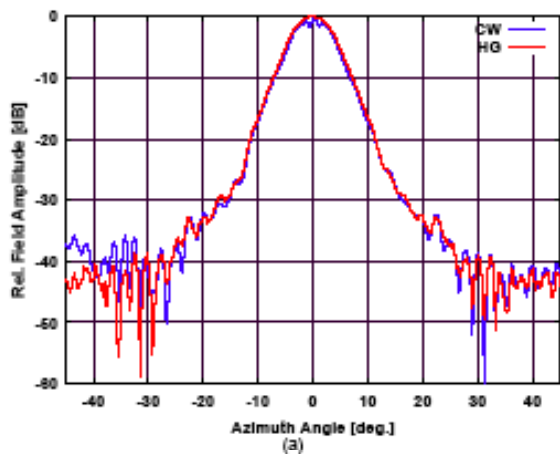


Figure 4. H-Plane patterns of the VAST-12 antenna at 12 GHz with hard gating (HG) and without (CW) any gating, a) copolar and b) crosspolar components

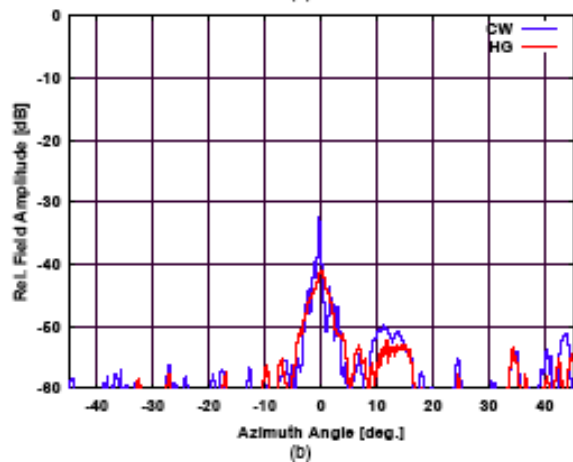
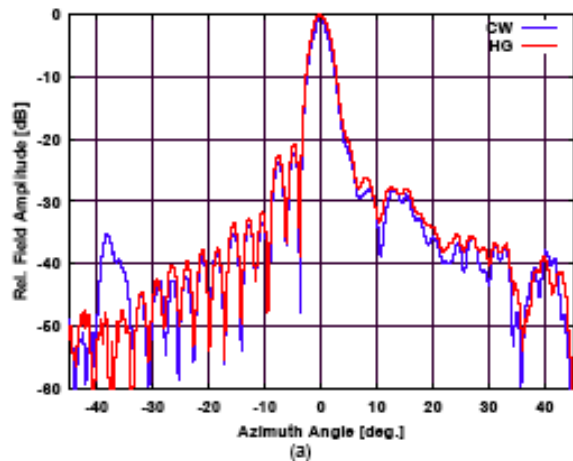


Figure 6. E-Plane patterns of the VAST-12 antenna at 12 GHz with hard gating (HG) and without (CW) any gating, a) copolar and b) crosspolar components

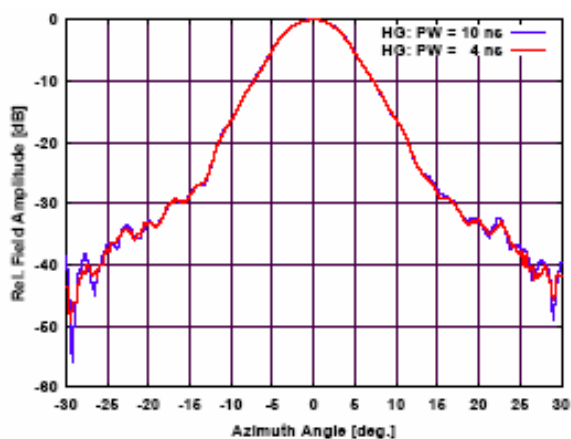


Figure 5. Copolar H-Plane patterns of the VAST-12 antenna at 12 GHz with hard gating with two different pulse widths, 4ns and 10 ns.

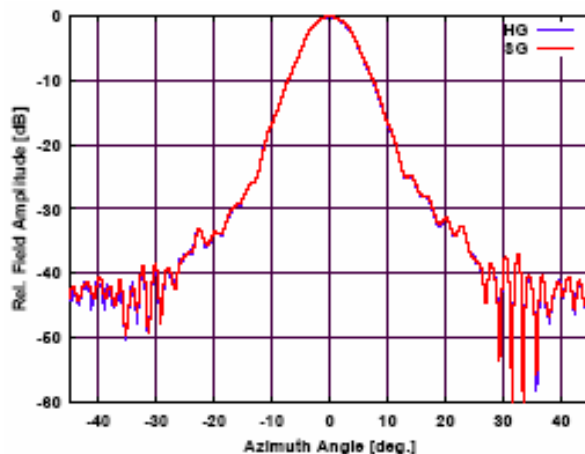


Figure 7. Comparison of the H-Plane patterns of the VAST-12 antenna at 12 GHz using both hard gating (HG) and soft gating (SG)

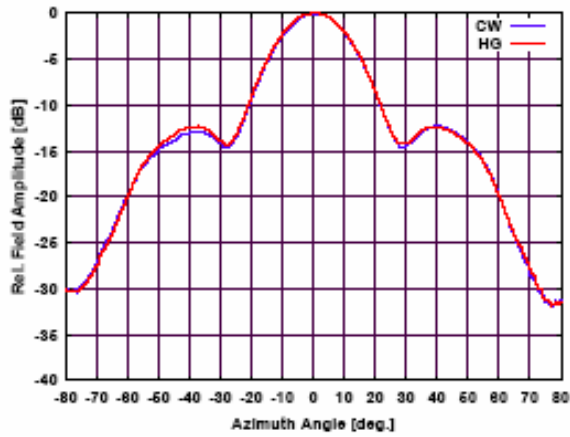


Figure 8. Copolar E-plane patterns of the Narda SGH at 3.6 GHz comparing the hard gated result (HG) with the direct measurement (CW)

at 3.6 GHz comparing the hard gated result (HG) with the soft gated result (SG)

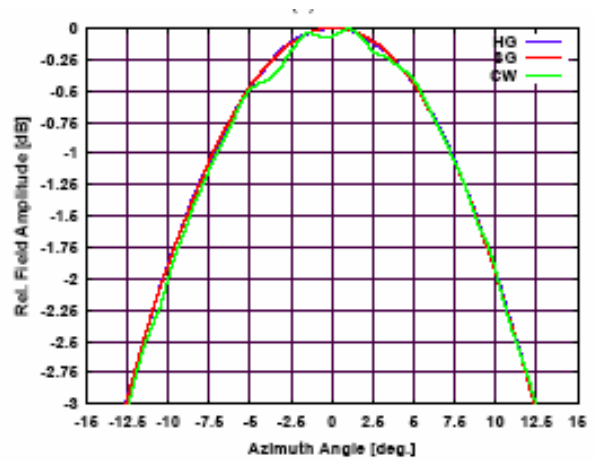


Figure 11. Expanded view of the copolar H-Plane pattern of the Narda SGH at 3.6 GHz showing the results of the direct measurement (CW), the hard gating result (HG) and the soft gating result (SG)

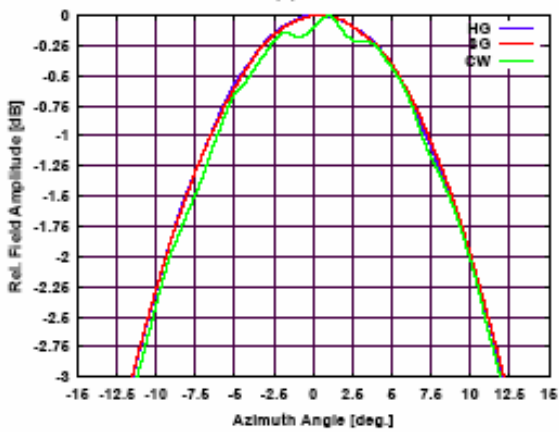


Figure 9. Expanded view of the copolar E-Plane pattern of the Narda SGH at 3.6 GHz showing the results of the direct measurement (CW), the hard gating result (HG) and the soft gating result (SG)

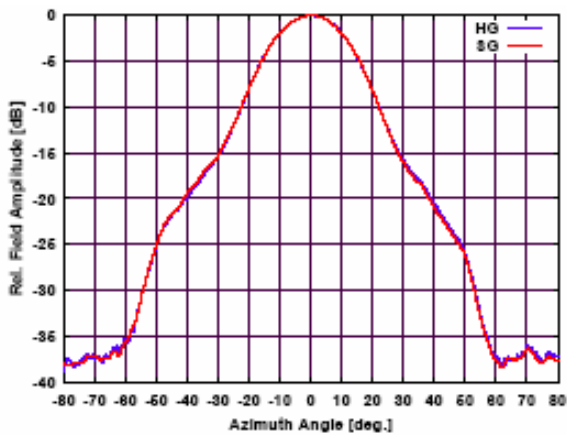


Figure 10. Copolar H-plane patterns of the Narda SGH



Figure 12. The VAST-12 antenna