## INTRODUCTION

This document summarizes the antenna gain measurements performed at MVG Inc. The purpose of this document is to provide a summary of the measurement procedure, traceability information, expanded uncertainties and the calibration data for the Antenna Under Test (AUT).

## MEASUREMENT SYSTEM INFORMATION

### GENERAL INFORMATION

The antenna calibration is performed in a MVG SG-64 system with 63 probe antennas mounted with equal spacing on a circular arch. Electronic switching of the probe antennas provides outstanding measurement speed. The geometry of the setup, with only a Styrofoam column within 1.6 meters of the AUT, ensures minimum interference and low ripple on the measured radiation patterns.

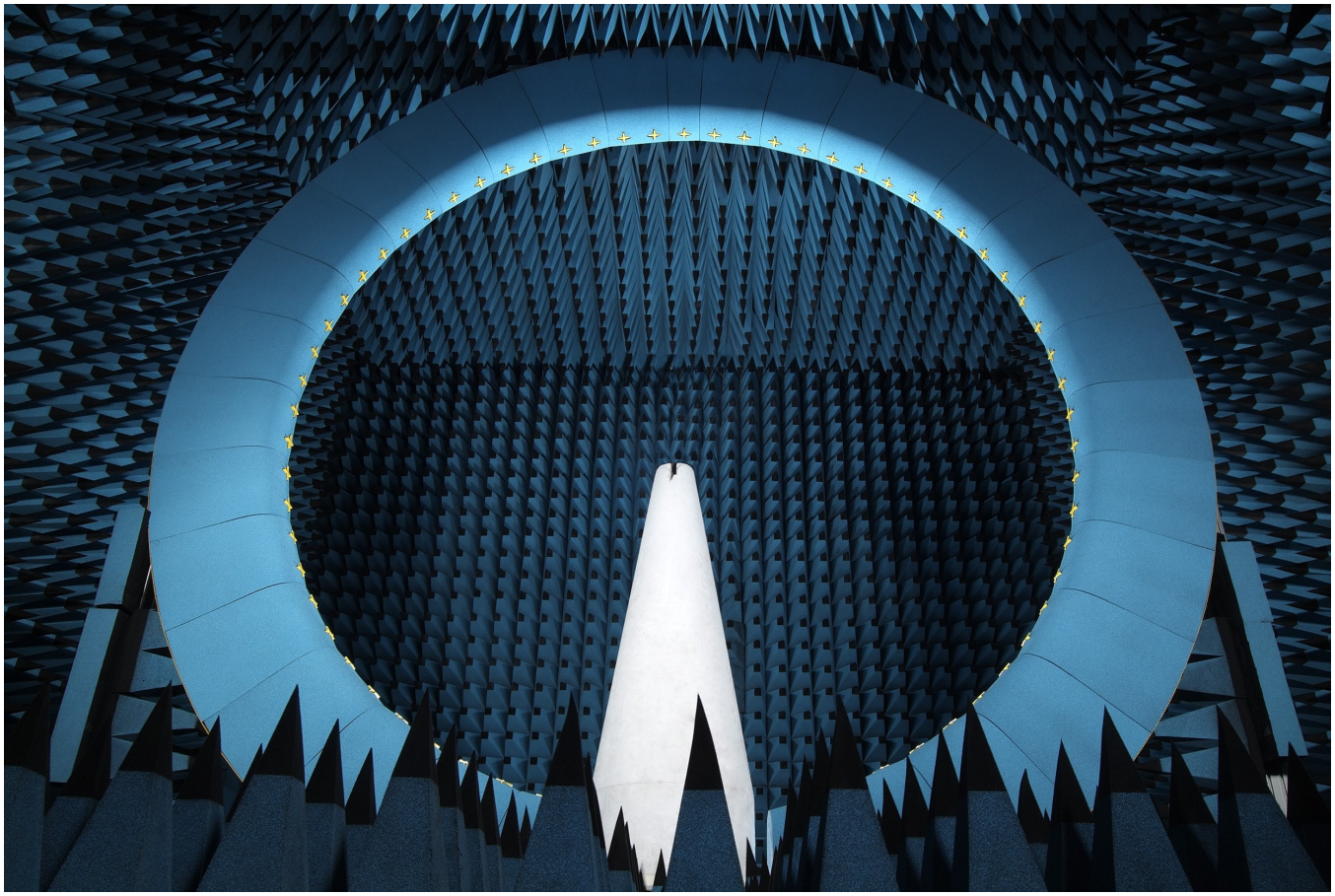

**Figure 1** – *The SG-64. The AUT is placed on top of the pedestal, in the center of the system.*

LIST OF EQUIPMENT

| Equipment Summary Sheet | | | | |
|---|---|---|---|---|
| **Equipment Description** | **Manufacturer** | **Identification No.** | **Current Calibration Date** | **Next Calibration Date** |
| SG-64 Probe Array | MVG | 1102320-0002 | 3/2019 | 3/2020 |
| RF Transmitter/ Receiver Unit (NPAC) | MVG | 1102156-1828 | characterized prior to test and in annual calibration | characterized prior to test and in annual calibration |
| Reference Horn Antenna | MVG | SH400 sn# 0017 | 08/2004 | Verified in monthly checks. No cal required. |
| Reference Horn Antenna | MVG | SH800 sn# 0025 | 08/2004 | Verified in monthly checks. No cal required. |

## GAIN CALIBRATION

### GAIN DEFINITION

The reported boresight antenna ***gain*** is 4π times the ratio of the power radiated per unit solid angle in that direction to the net power delivered to the antenna by a 50Ω generator. This definition is also referred to as ***realized antenna gain*** which is less than the IEEE definition [IEEE Standard Test Procedures for Antennas, ANSI/IEEE Std 149-2021] by the value of the return loss.

### CALIBRATION STANDARD

The calibrated substitution antenna is a dual ridge horn as shown in Figure 2 below. This horn has been calibrated at NIST (Boulder, CO) which ensures direct traceability to a National Metrology Institute.

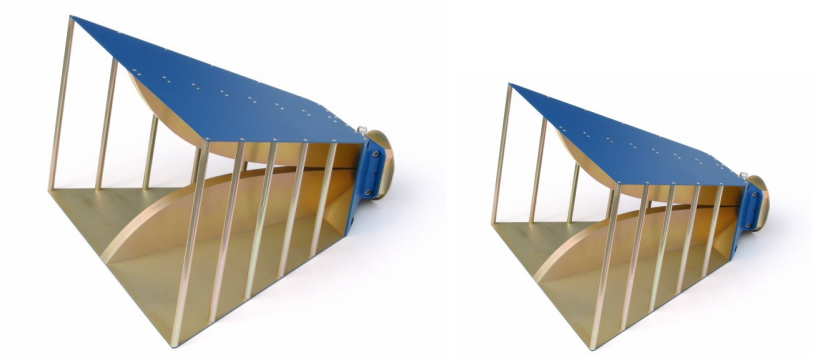

**Figure 2 –** MVG *SH400-SN0017 and SH800-SN0025 horns.*

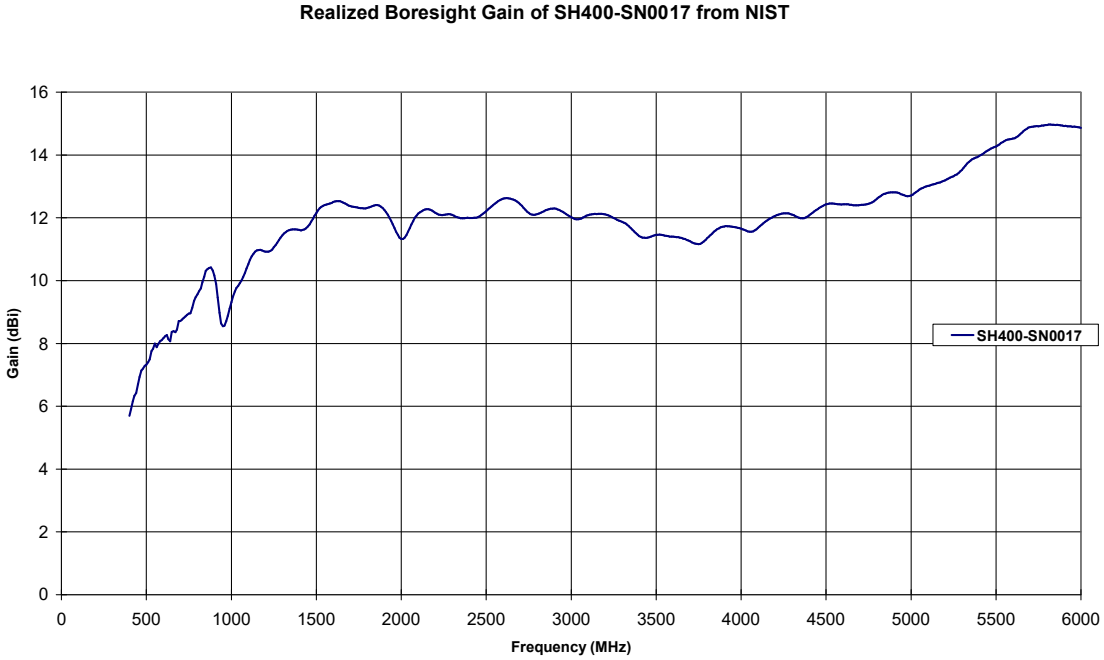


**Figure 3 –** *NIST calibrated boresight gain vs. frequency plot of the MVG SH400-SN0017*

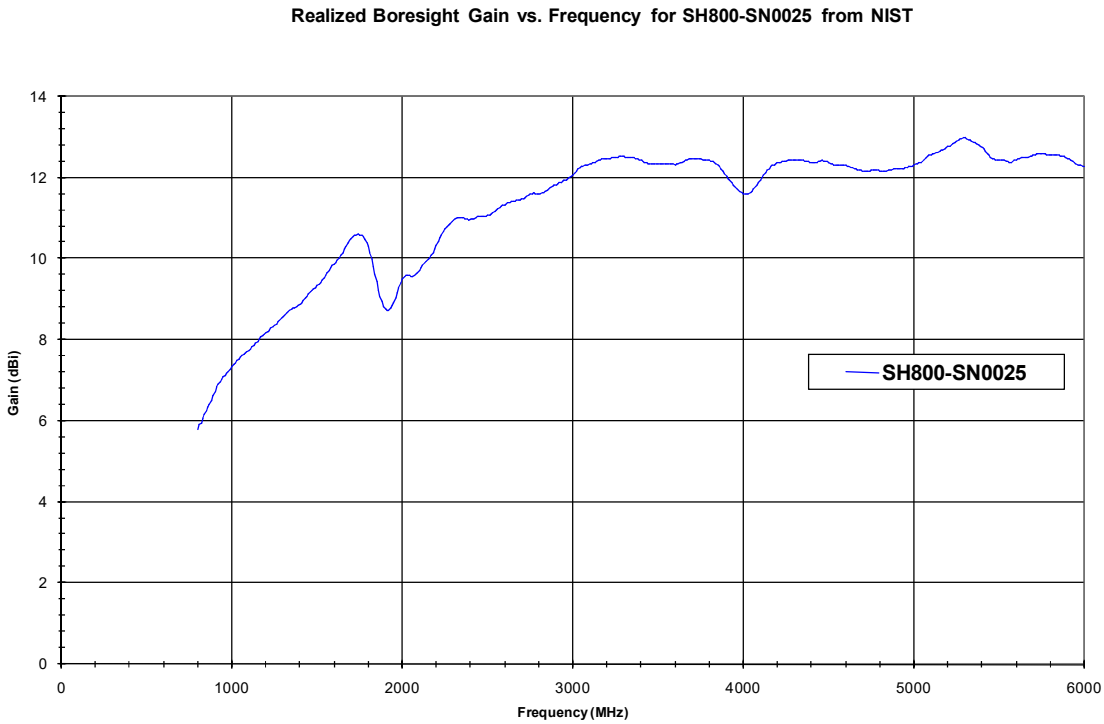


**Figure 4 –** *NIST calibrated boresight gain vs. frequency plot of the MVG SH800-SN0025*

## MEASUREMENT UNCERTAINTY

The following uncertainties apply to the gain measurement:

| Frequency band | Expanded Uncertainty on Gain |
|---|---|
| 400-800 MHz | 0.89 dB |
| 800-1000 MHz | 0.84 dB |
| 1000-6000 MHz | 0.69 dB |

These uncertainties represent an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2 traceable to the Internationally Accepted Guide to Measurement Uncertainty.

## MEASUREMENT SETUP

The AUT is mounted on a Styrofoam column as shown in the picture below.

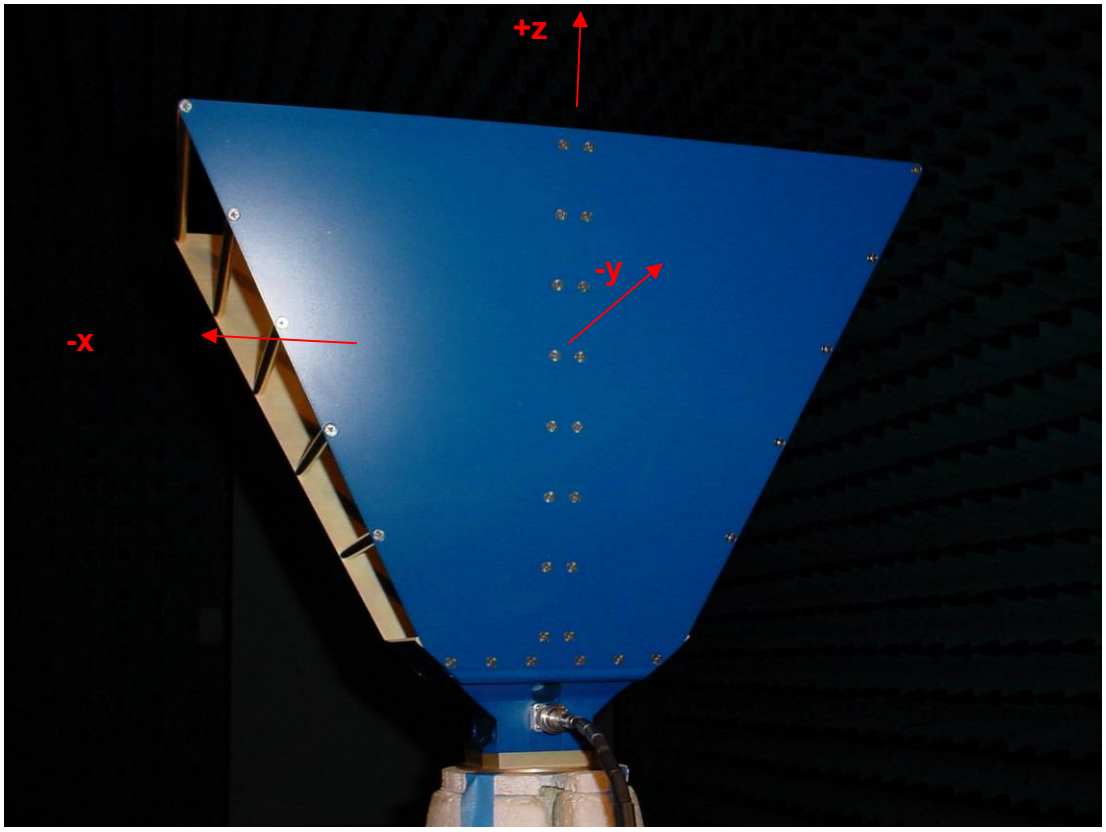


**Figure 5 –** *Photograph illustrating an antenna mounted in the test range. For clarity, a coordinate system has been superimposed on the picture.*

COORDINATE SYSTEM

The system coordinate system is shown in Figure 6.

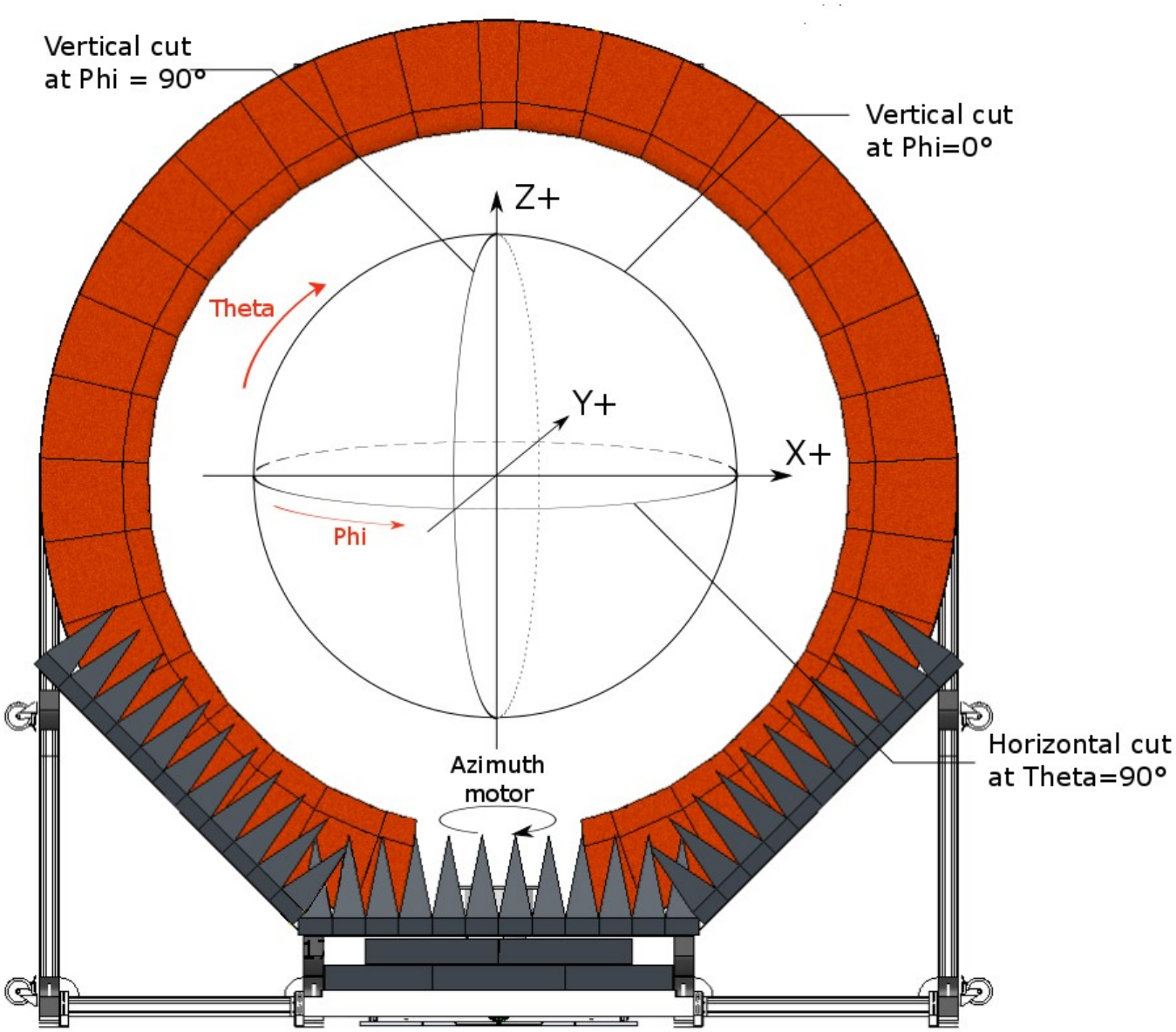


**Figure 6**: Coordinate System

## MEASUREMENT PROCEDURE

1. Setup SATIMO SG-64 chamber for passive measurements.
2. Chamber should be power on for 24 hours before actual testing
3. PRETESTING
4. Attach the reference gain antenna to the coax sma connector in center of chamber
5. Measure the gain of reference antenna with antenna pointing vertical. Confirm gain measures the horn gain +/- tolerance – typically +/- 5%
6. CUSTOMER ANTENNA MODULE TESTING
7. Configure test modules with a u.fl compatible RF coax which allows SATIMO chamber to drive the module antennas
8. Tape modified WIFI module with coax feed in the SG-64 chamber mounted on the Styrofoam support
9. Take pictures of the module for each SATIMO test
10. Attach u.fl connector to u.fl adapter on the sma feedline in center of chamber
11. Run the SATIMO test chamber to sweep 2400-2500 MHz in 20 MHz steps
12. Run the SATIMO test program to sweep 5000-6000 MHZ in 100 MHz steps
13. EXPORT TO CUSTOMER
14. Tester generates the report
15. Export the HTML report to customer to view using a web browser
16. Export the raw data to customer
17. Email zip package to customer
18. Return modules to customer via mail
19. Test SW: Satenv (c) METRAWARE & SATIMO 2001.
20. Test Engineer: Kémi Sule