

## Appendices

### Calibration documents

### Antenna Information

# NCL CALIBRATION LABORATORIES

Calibration File No: DC-890  
Project Number: APREL-ALSAS 10U

## C E R T I F I C A T E   O F   C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

APREL Validation Dipole

Manufacturer: APREL Laboratories

Part number: ALS-D-5258-S-2

Frequency: 5.2GHz to 5.8GHz

Serial No: 5258-235-00802

Customer: APREL

Serial Number: ALS-BB-001

Calibrated: 24<sup>th</sup> May 2008  
Released on: 24<sup>th</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

***NCL*** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4162

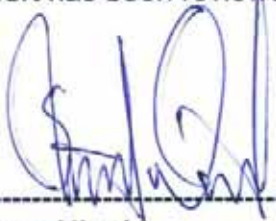
## Conditions

Dipole 5258-235-00802 was new and taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

We the undersigned attest that to the best of our knowledge the calibration of this device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.



Stuart Nicol



C. Teodorian

## Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

### Mechanical Dimensions

**Length:** 23.3 mm

**Height:** 20.3 mm

### Electrical Specification

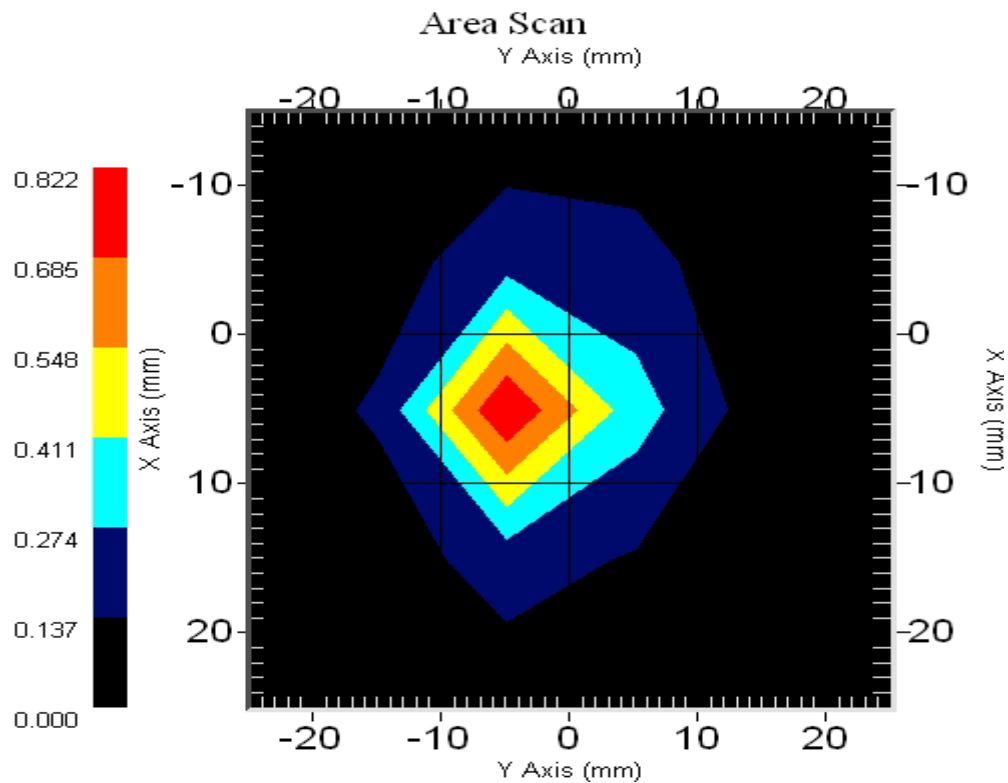
**SWR:** 1.22 U

**Return Loss:** -20.0 dB

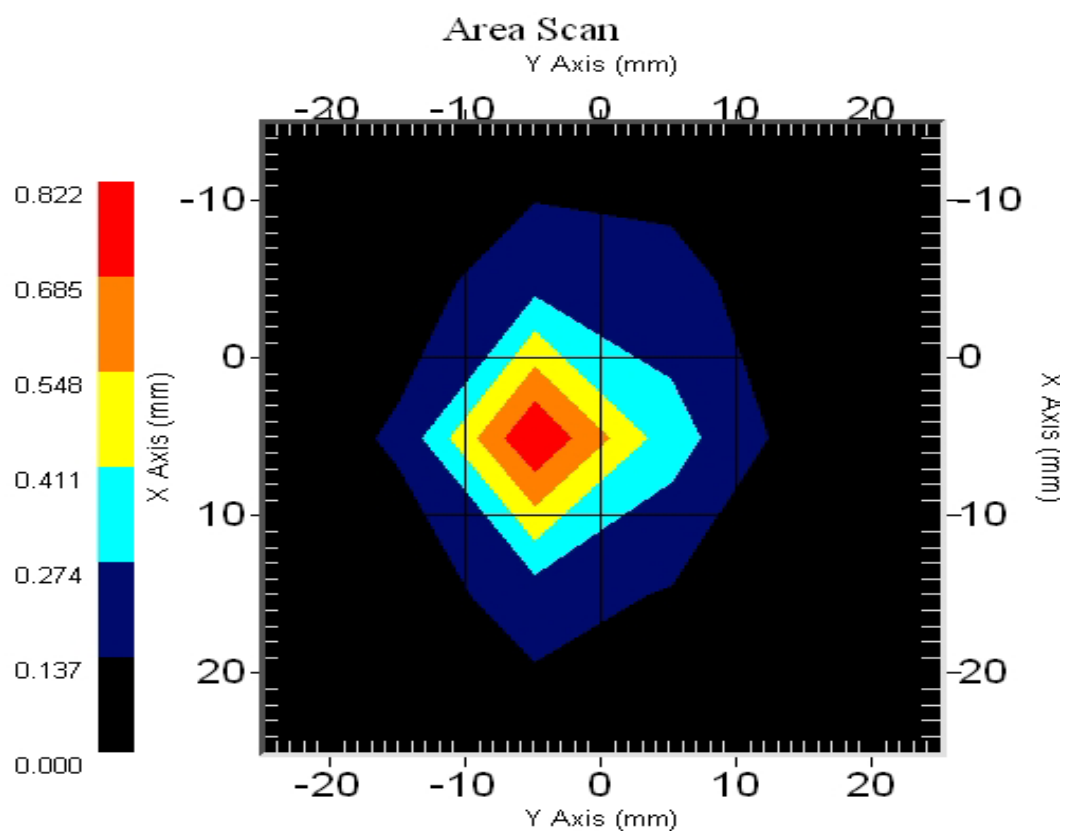
**Impedance:** 50.0  $\Omega$

### System Validation Results

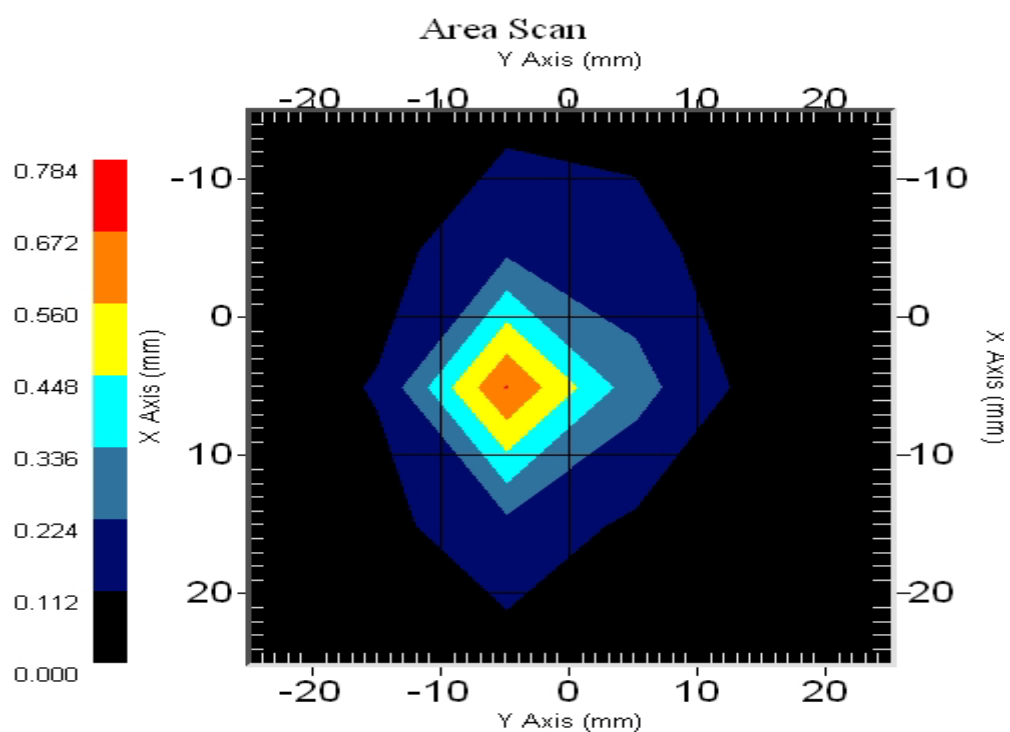
Frequency	1 Gram	10 Gram	Peak
5200 MHz	51.9	17.9	223.1



Frequency	1 Gram	10 Gram	Peak
5600 MHz	52.97	18.2	243.1



Frequency	1 Gram	10 Gram	Peak
5800 MHz	48.97	17.2	207.1



## **Introduction**

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 5258-235-00802. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-030 018 E-Field Probe.

## **References**

SSI-TP-018-ALSAS Dipole Calibration Procedure

SSI-TP-016 Tissue Calibration Procedure

IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"

## **Conditions**

Dipole 5258-235-00802 was new taken from stock.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 20 °C +/- 0.5°C

## Dipole Calibration Results

### Tissue Validation

Head Tissue 5200 MHz	Measured
Dielectric constant, $\epsilon_r$	47.0
Conductivity, $\sigma$ [S/m]	5.30

Head Tissue 5600 MHz	Measured
Dielectric constant, $\epsilon_r$	46.1
Conductivity, $\sigma$ [S/m]	5.78

Head Tissue 5800 MHz	Measured
Dielectric constant, $\epsilon_r$	46.7
Conductivity, $\sigma$ [S/m]	6.22

### Mechanical Verification

APREL Length	APREL Height	Measured Length	Measured Height
23.1 mm	20.7 mm	23.3 mm	20.3 mm

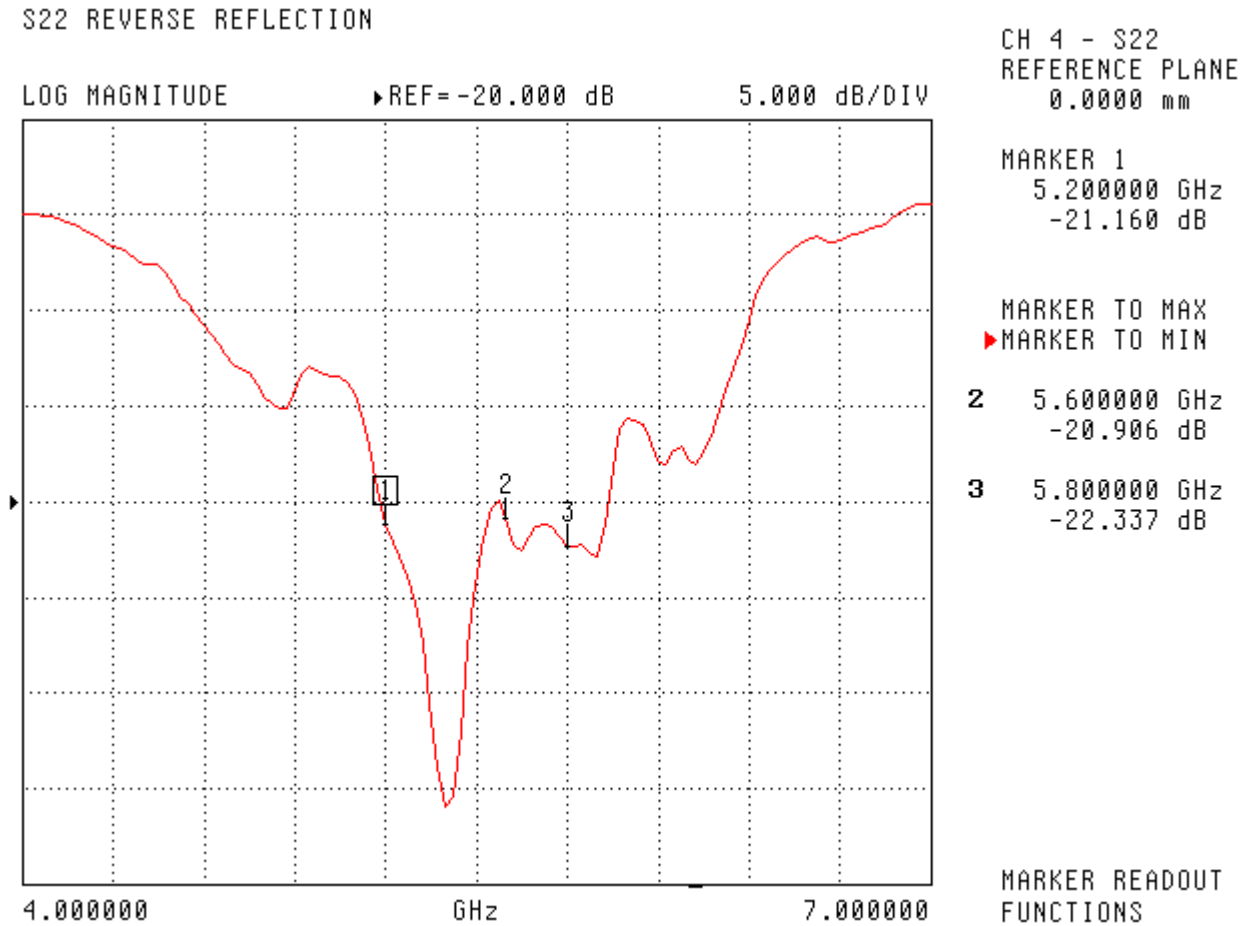
### Electrical Calibration

S11	5200MHz	5800MHz
RL (dB)	-21.16	-22.34
SWR	1.2	1.17
Impedance (ohms)	51.38	43.92



The Following Graphs are the results as displayed on the Vector Network Analyzer.

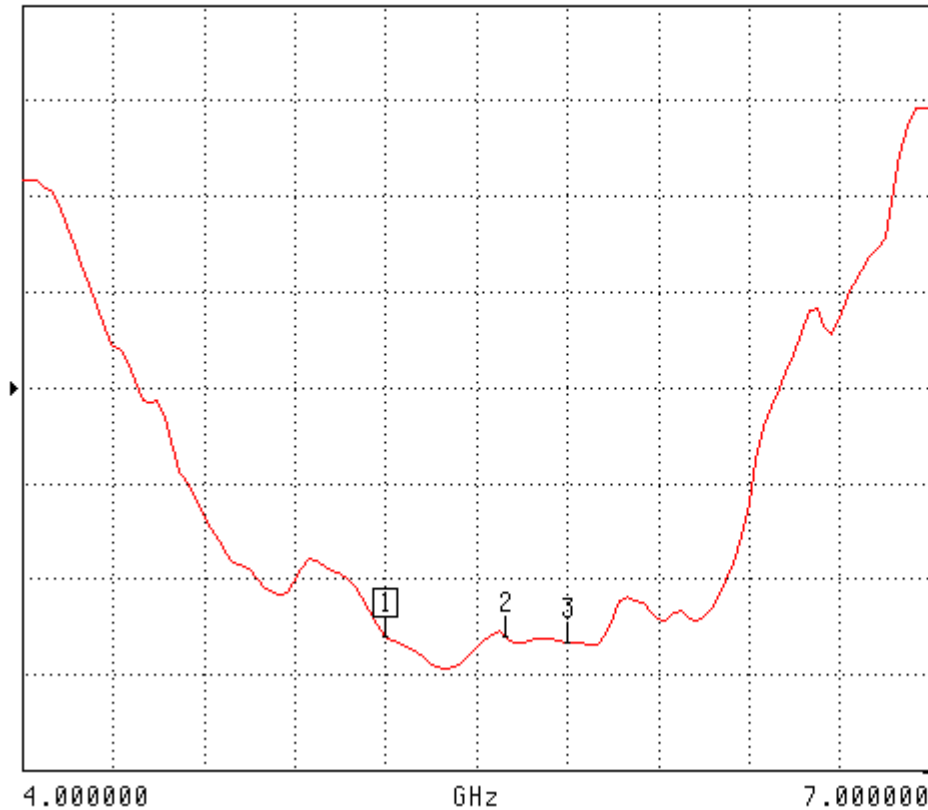
### S11 Parameter Return Loss



## SWR

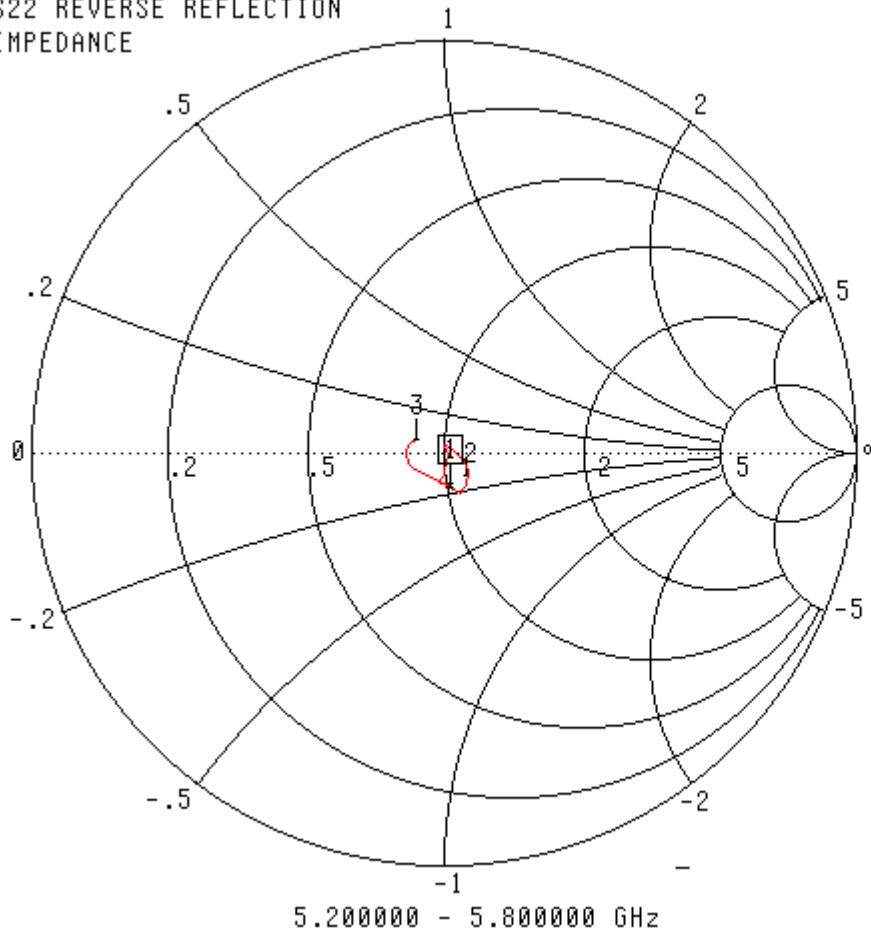
S22 REVERSE REFLECTION

SWR REF=2.500 U 500.000 mU/DIV



## Smith Chart Dipole Impedance

S22 REVERSE REFLECTION  
IMPEDANCE



CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

MARKER 1  
5.200000 GHz  
51.382  $\Omega$   
-8.263 j $\Omega$

MARKER TO MAX  
▶ MARKER TO MIN

2 5.600000 GHz  
51.084  $\Omega$   
-9.223 j $\Omega$   
3 5.800000 GHz  
43.924  $\Omega$   
2.683 j $\Omega$

MARKER READOUT  
FUNCTIONS

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.

# NCL CALIBRATION LABORATORIES

Calibration File No: DC-889  
Project Number: APREL-ALSAS10U

## C E R T I F I C A T E   O F   C A L I B R A T I O N

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

APREL Validation Dipole

Manufacturer: APREL Laboratories

Part number: ALS-D-2450-S-2

Frequency: 2450 MHz

Serial No: 301581

Customer: APREL

Calibrated: 4<sup>th</sup> May 2008  
Released on: 4<sup>th</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

**NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4162

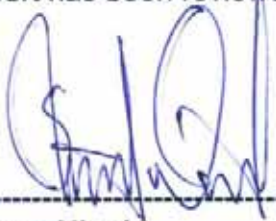
## Conditions

Dipole 301581 was new and taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

We the undersigned attest that to the best of our knowledge the calibration of this device has been accurately conducted and that all information contained within this report has been reviewed for accuracy.



Stuart Nicol



C. Teodorian

## Calibration Results Summary

The following results relate the Calibrated Dipole and should be used as a quick reference for the user.

### Mechanical Dimensions

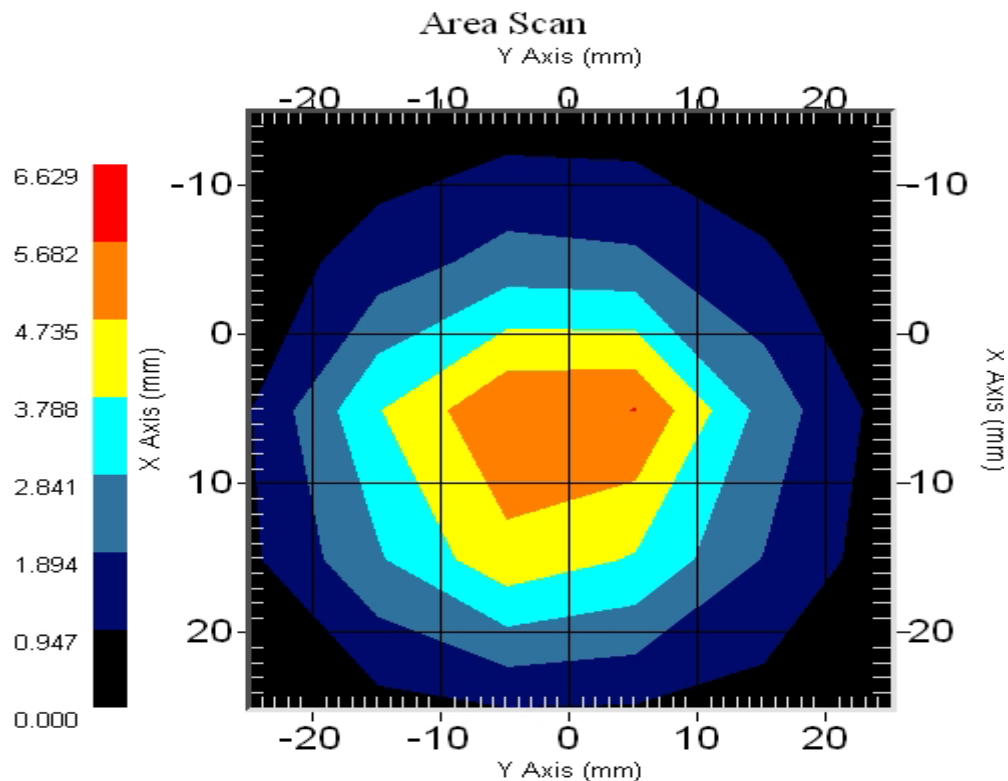
**Length:** 52.4 mm  
**Height:** 30.3 mm

### Electrical Specification

**SWR:** 1.056 U  
**Return Loss:** -32.0 dB  
**Impedance:** 50.2  $\Omega$

### System Validation Results

Frequency	1 Gram	10 Gram	Peak
2450 MHz	53.1	24.4	101.8



## Introduction

This Calibration Report has been produced in line with the SSI Dipole Calibration Procedure SSI-TP-018-ALSAS. The results contained within this report are for Validation Dipole 301581. The calibration routine consisted of a three-step process. Step 1 was a mechanical verification of the dipole to ensure that it meets the mechanical specifications. Step 2 was an Electrical Calibration for the Validation Dipole, where the SWR, Impedance, and the Return loss were assessed. Step 3 involved a System Validation using the ALSAS-10U, along with APREL E-020 130 MHz to 26 GHz E-Field Probe Serial Number 212.

## References

SSI-TP-018-ALSAS Dipole Calibration Procedure

SSI-TP-016 Tissue Calibration Procedure

IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"

IEC-62209 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures"

Part 1: "Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 300 MHz to 3 GHz)"

IEC-62209 "Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures"

Part 2 *Draft*: "Procedure to determine the Specific Absorption Rate (SAR) for hand-held devices used in close proximity of the ear (frequency range of 30 MHz to 6 GHz)"

## Conditions

Dipole 301581 was new taken from stock.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 20 °C +/- 0.5°C



## **Dipole Calibration Results**

### **Mechanical Verification**

<b>APREL Length</b>	<b>APREL Height</b>	<b>Measured Length</b>	<b>Measured Height</b>
51.5 mm	30.4 mm	52.4 mm	30.3 mm

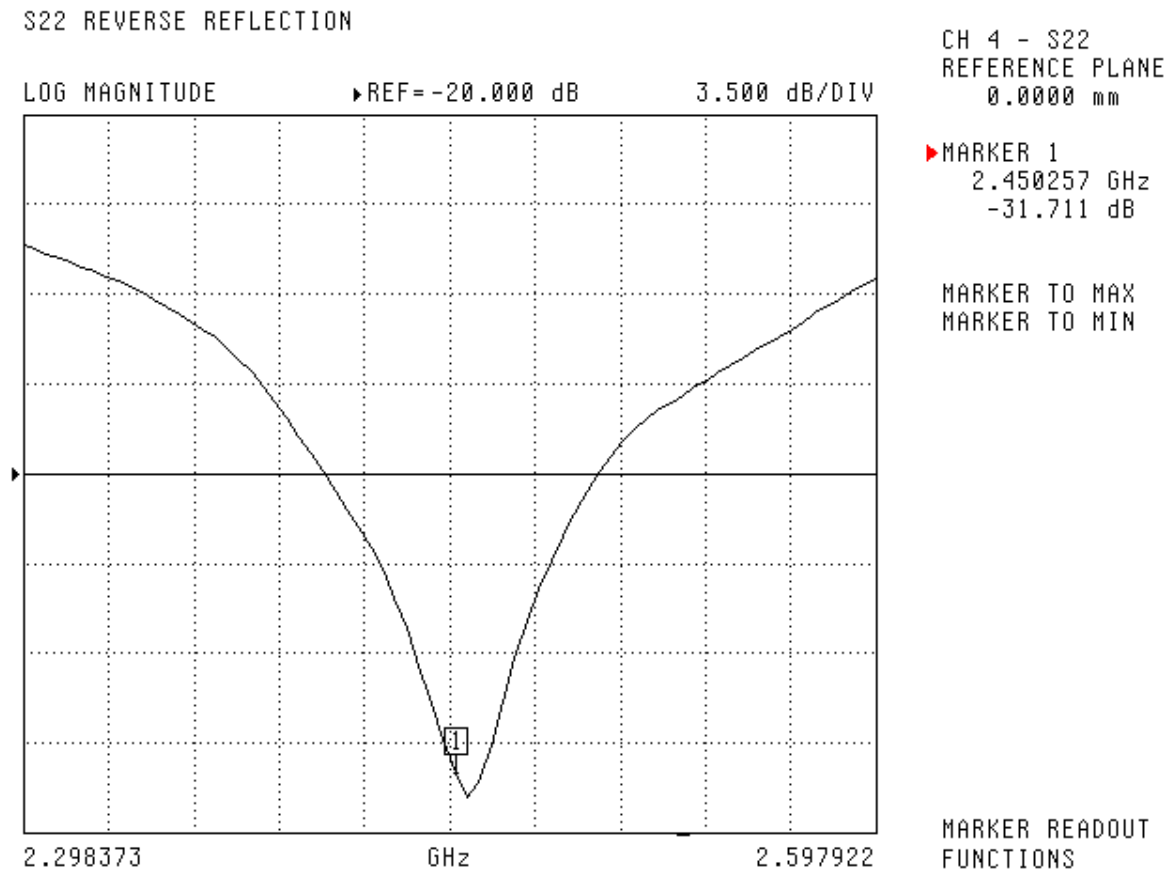
### **Tissue Validation**

<b>Head Tissue 2450 MHz</b>	<b>Measured</b>
<b>Dielectric constant, <math>\epsilon_r</math></b>	39.2
<b>Conductivity, <math>\sigma</math> [S/m]</b>	1.80

**Electrical Calibration**

Test	Result
S11 R/L	-32.0 dB
SWR	1.05 U
Impedance	50.2 $\Omega$

The Following Graphs are the results as displayed on the Vector Network Analyzer.

**S11 Parameter Return Loss**

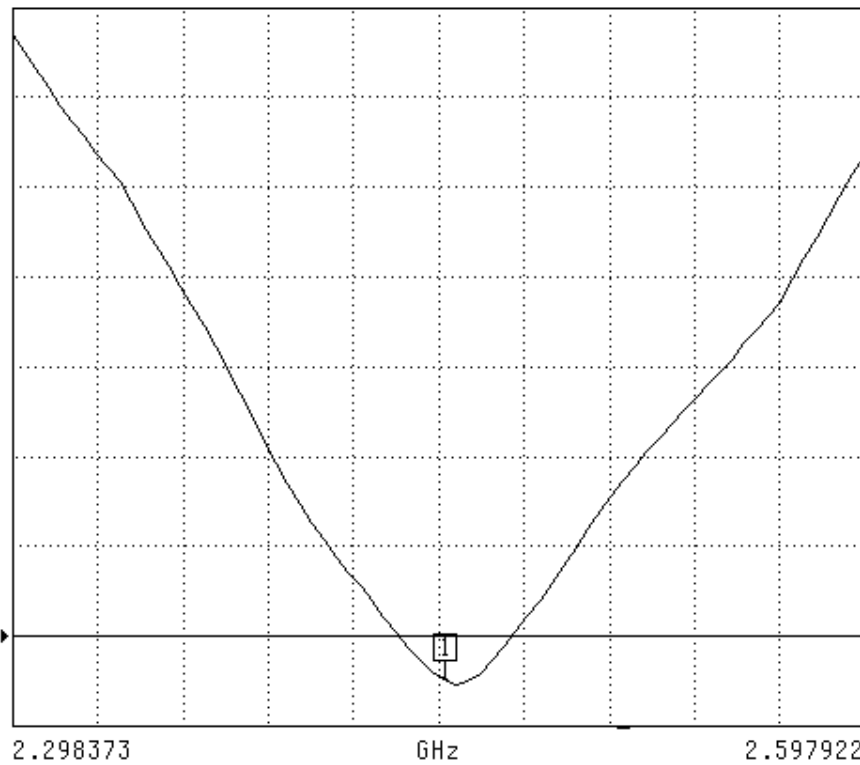
## SWR

S22 REVERSE REFLECTION

SWR

REF=1.100 U

100.000 mU/DIV



CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

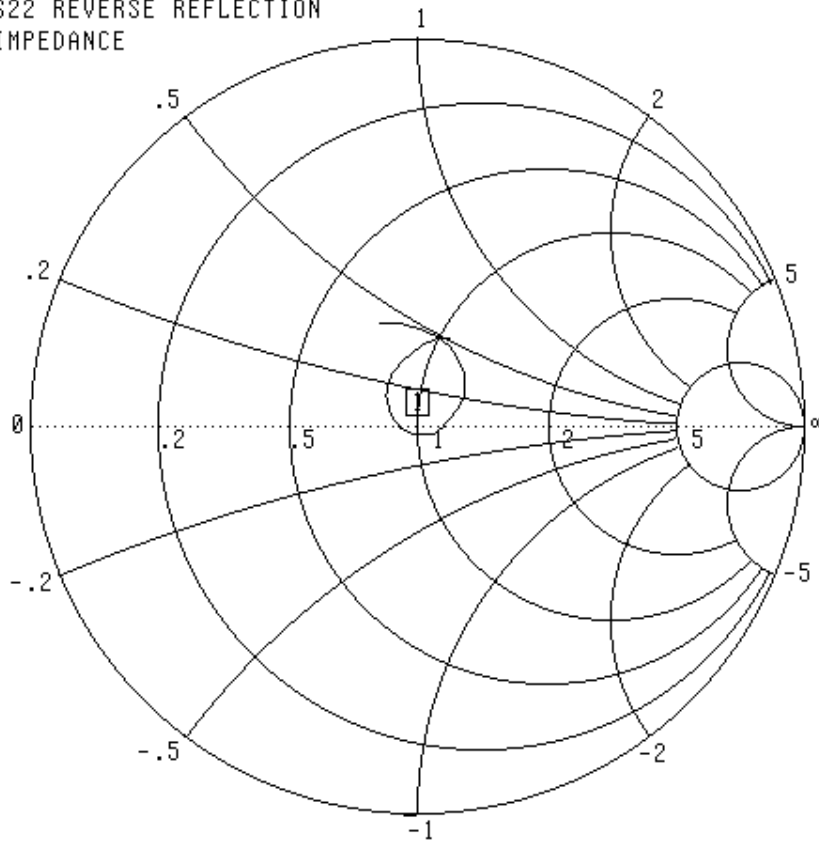
MARKER 1  
2.450257 GHz  
1.051 U

MARKER TO MAX  
MARKER TO MIN

MARKER READOUT  
FUNCTIONS

## Smith Chart Dipole Impedance

S22 REVERSE REFLECTION  
IMPEDANCE



CH 4 - S22  
REFERENCE PLANE  
0.0000 mm

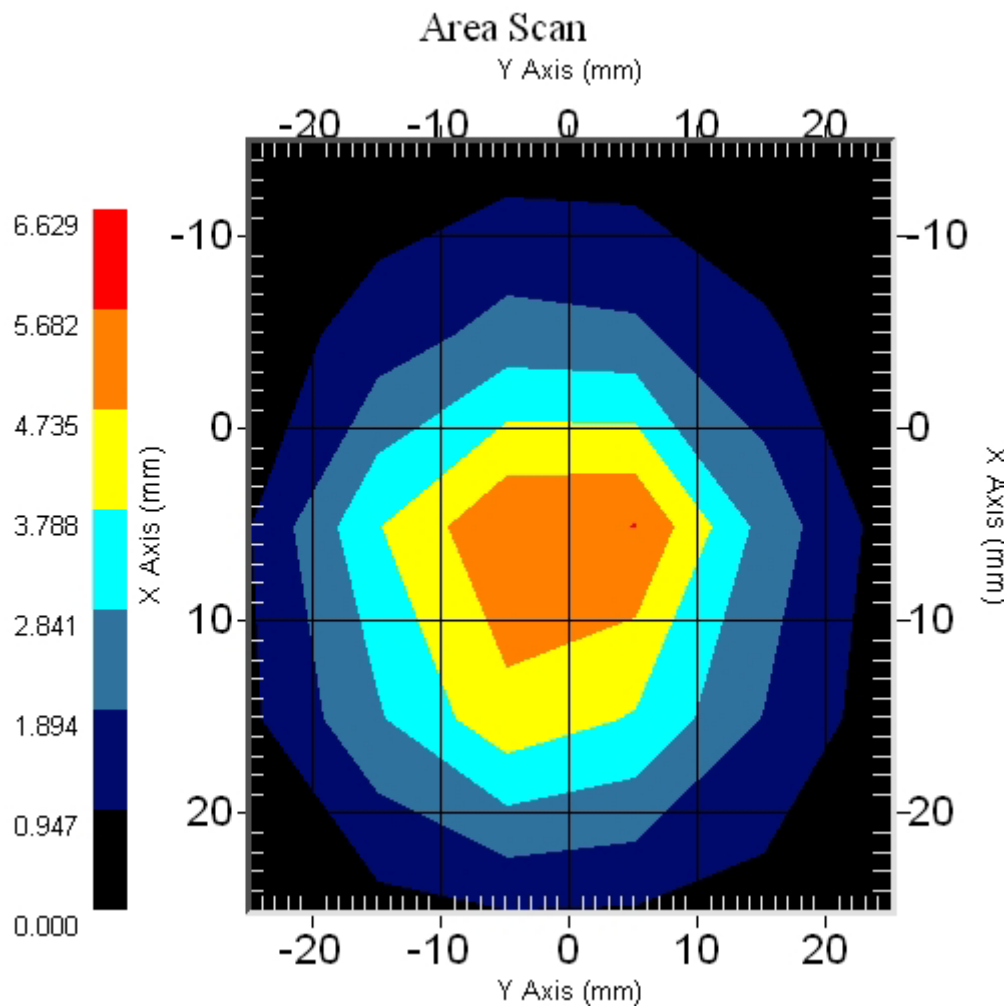
▶ MARKER 1  
2.450257 GHz  
50.225  $\Omega$   
-2.500  $j\Omega$

MARKER TO MAX  
MARKER TO MIN

MARKER READOUT  
FUNCTIONS

### System Validation Results Using the Electrically Calibrated Dipole

Frequency	1 Gram	10 Gram	Peak
2450 MHz	53.1	24.4	101.8



## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-887

Client.: APREL

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 5600 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008  
Released on: 3<sup>rd</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

**NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4161

## Introduction

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-030 018.

## References

SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

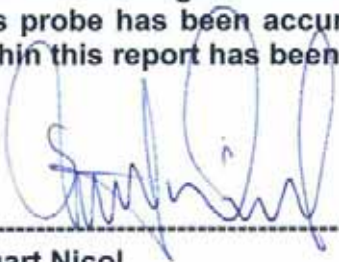
## Conditions

Probe 018 was a new probe taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

**We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**

  
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**Stuart Nicol**

  
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**Jesse Hones**



## **Calibration Results Summary**

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5600 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	≤2.9 mm
<b>Tip Length:</b>	60 mm
<b>Total Length:</b>	290 mm

\*Resistive to recommended tissue recipes per IEEE-1528

## **Sensitivity in Air**

<b>Channel X:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Y:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Z:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Diode Compression Point:</b>	95 mV

## **Sensitivity in Body Tissue Measured**

**Frequency:** 5600 MHz

**Epsilon:** 46.0 (+/-10%)      **Sigma:** 5.85 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.3

**Channel Y:** 3.3

**Channel Z:** 3.3

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq.

## **Boundary Effect:**

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

## **Spatial Resolution:**

The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

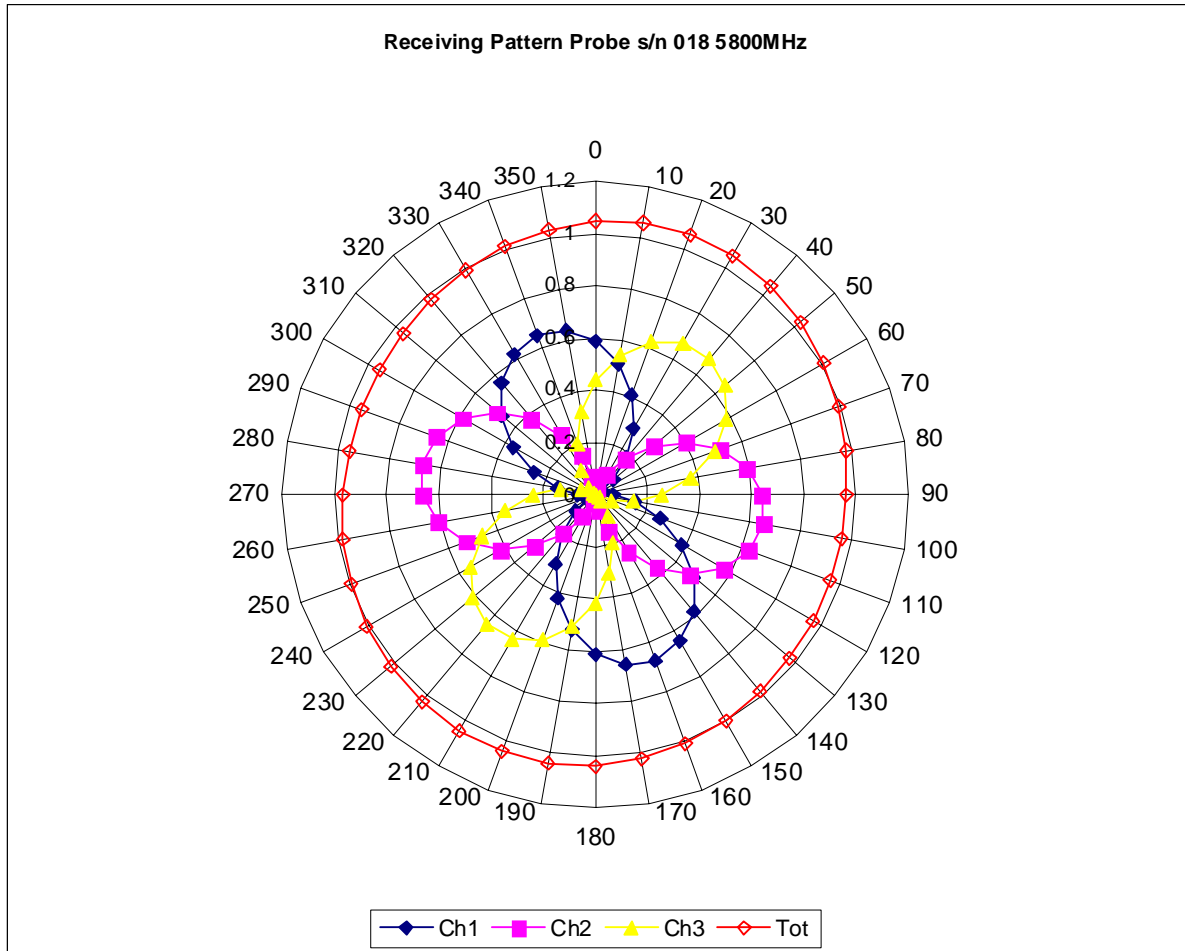
## **Broad Band Calibration:**

The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

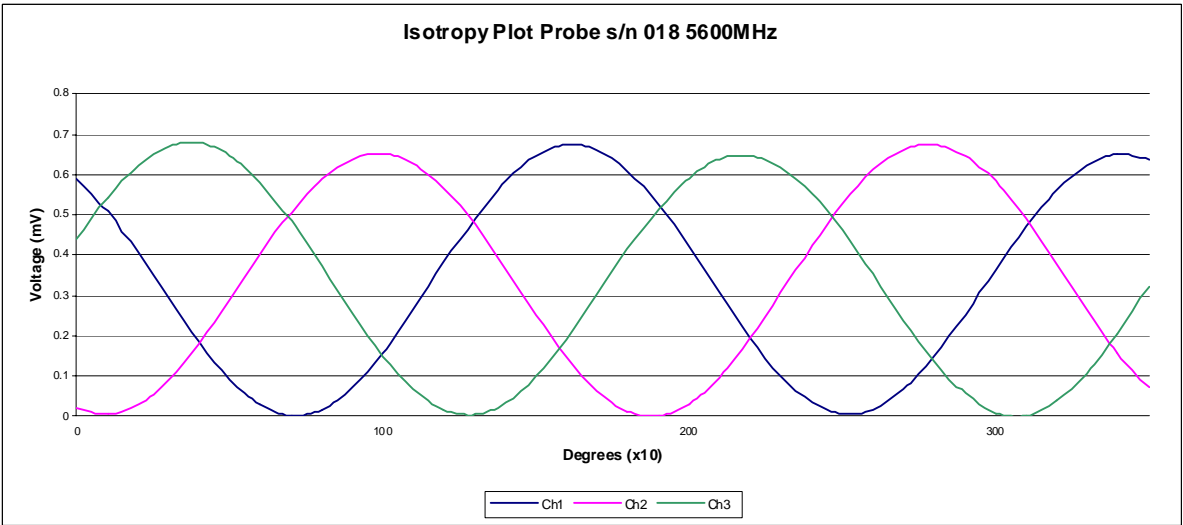
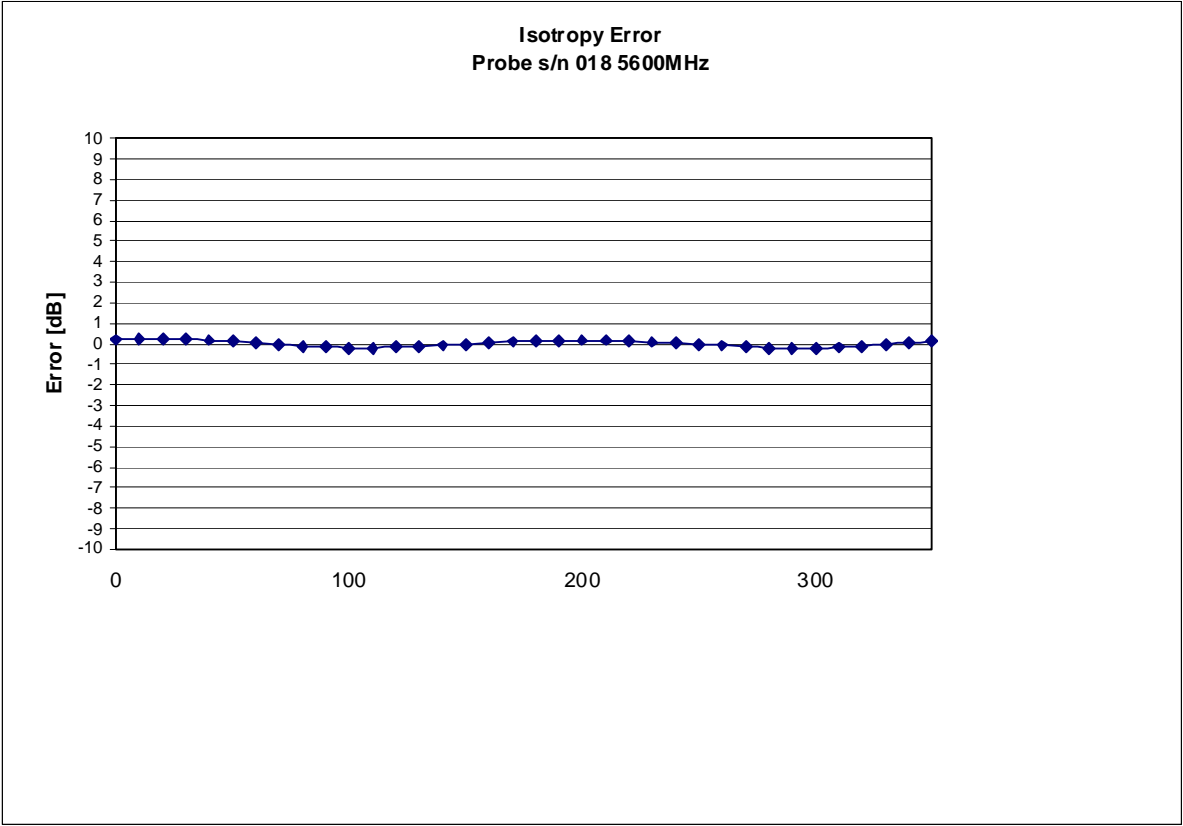
**Deviation at -40MHz:** -3.77%

**Deviation at +40MHz:** +4.28%

## Receiving Pattern 5600 MHz (Air)



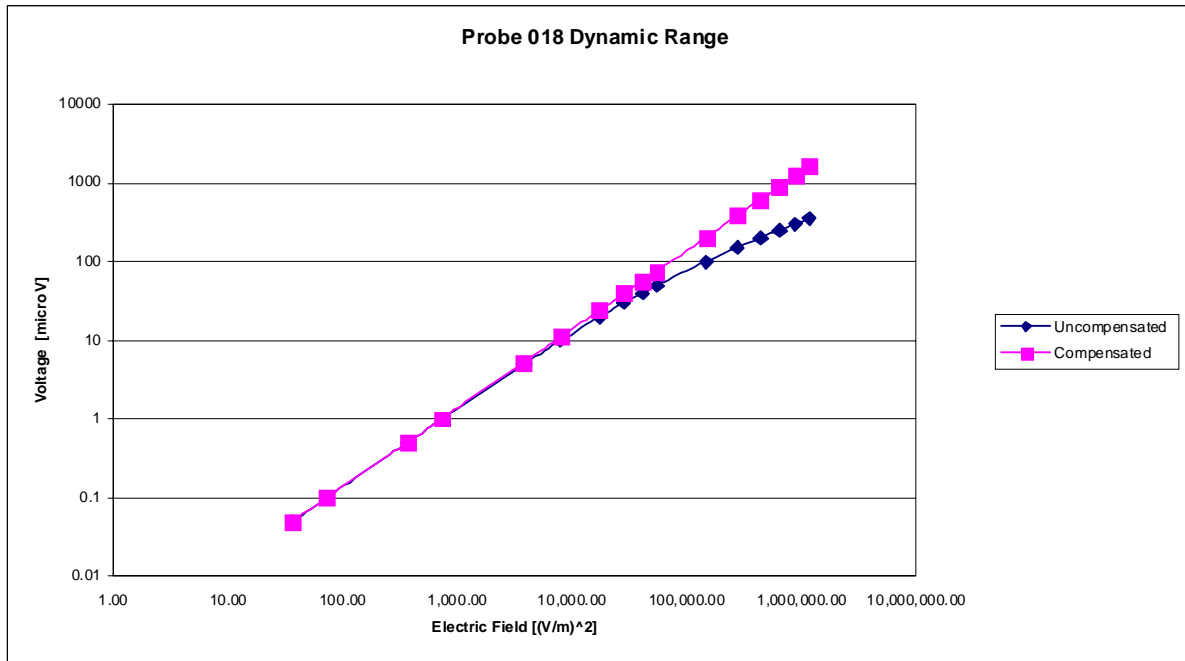
Isotropy Error 5600 MHz (Air)



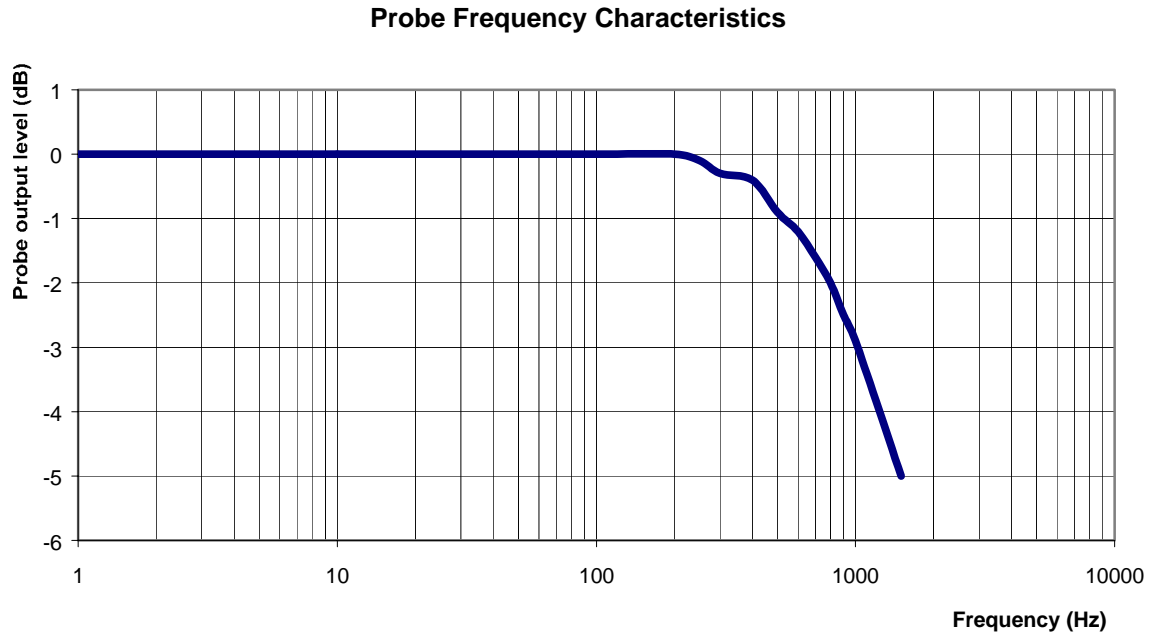
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



**Video Bandwidth at 500 Hz**                      1 dB  
**Video Bandwidth at 1.02 KHz:**                3 dB

## **Conversion Factor Uncertainty Assessment**

### **Sensitivity in Body Tissue Measured**

**Frequency:** 5600 MHz

**Epsilon:** 46.0 (+/-10%)

**Sigma:** 5.85 S/m (+/-10%)

#### **ConvF**

**Channel X:** 3.3 7%(K=2)

**Channel Y:** 3.3 7%(K=2)

**Channel Z:** 3.3 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 M $\Omega$ .

#### **Boundary Effect:**

For a distance of 0.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.



# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-886

Client.: APREL

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 5200 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008  
Released on: 3<sup>rd</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

**NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4161

## Introduction

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-030 018.

## References

SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

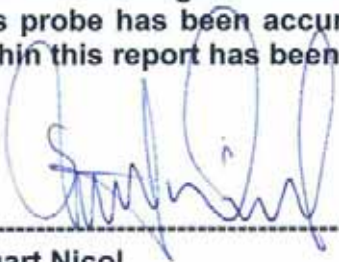
## Conditions

Probe 018 was a new probe taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.

  
-----

**Stuart Nicol**

  
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**Jesse Hones**

## **Calibration Results Summary**

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5200 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	≤2.9 mm
<b>Tip Length:</b>	60 mm
<b>Total Length:</b>	290 mm

\*Resistive to recommended tissue recipes per IEEE-1528

## **Sensitivity in Air**

<b>Channel X:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Y:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Z:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Diode Compression Point:</b>	95 mV

## **Sensitivity in Body Tissue**

**Frequency:** 5200 MHz

**Epsilon:** 43.0 (+/-10%)      **Sigma:** 5.75 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2

**Channel Y:** 3.2

**Channel Z:** 3.2

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq.

## **Boundary Effect:**

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

## **Spatial Resolution:**

The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

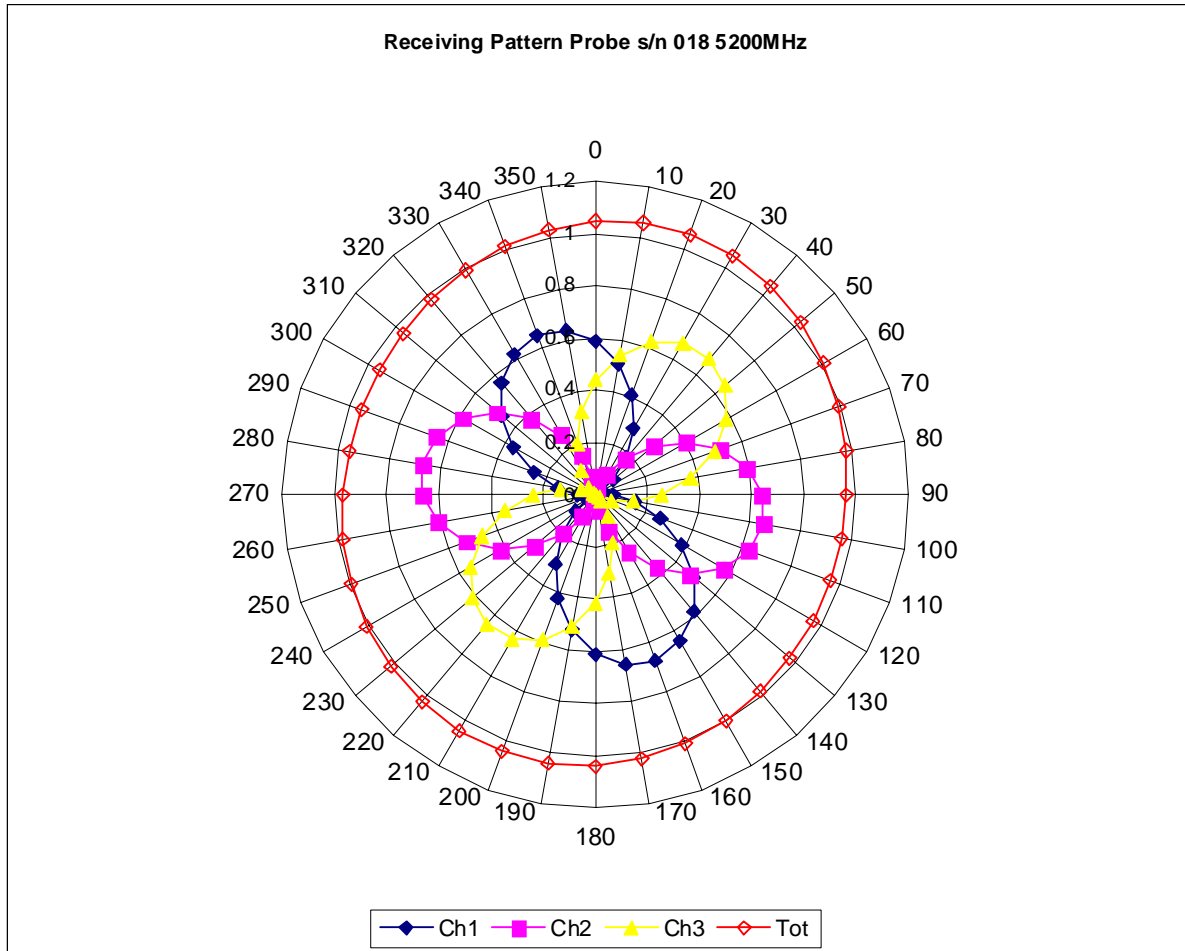
## **Broad Band Calibration:**

The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

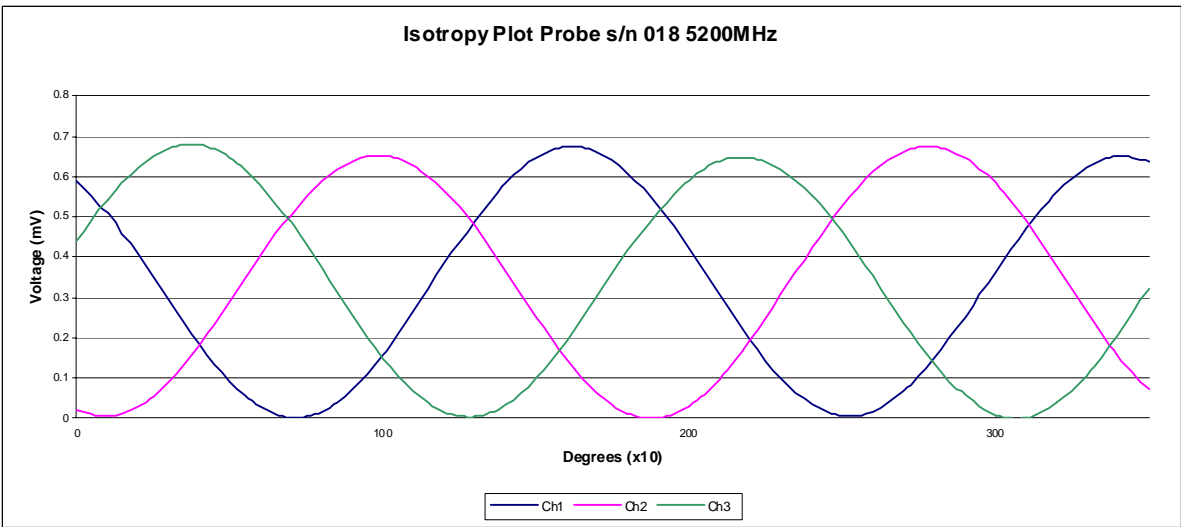
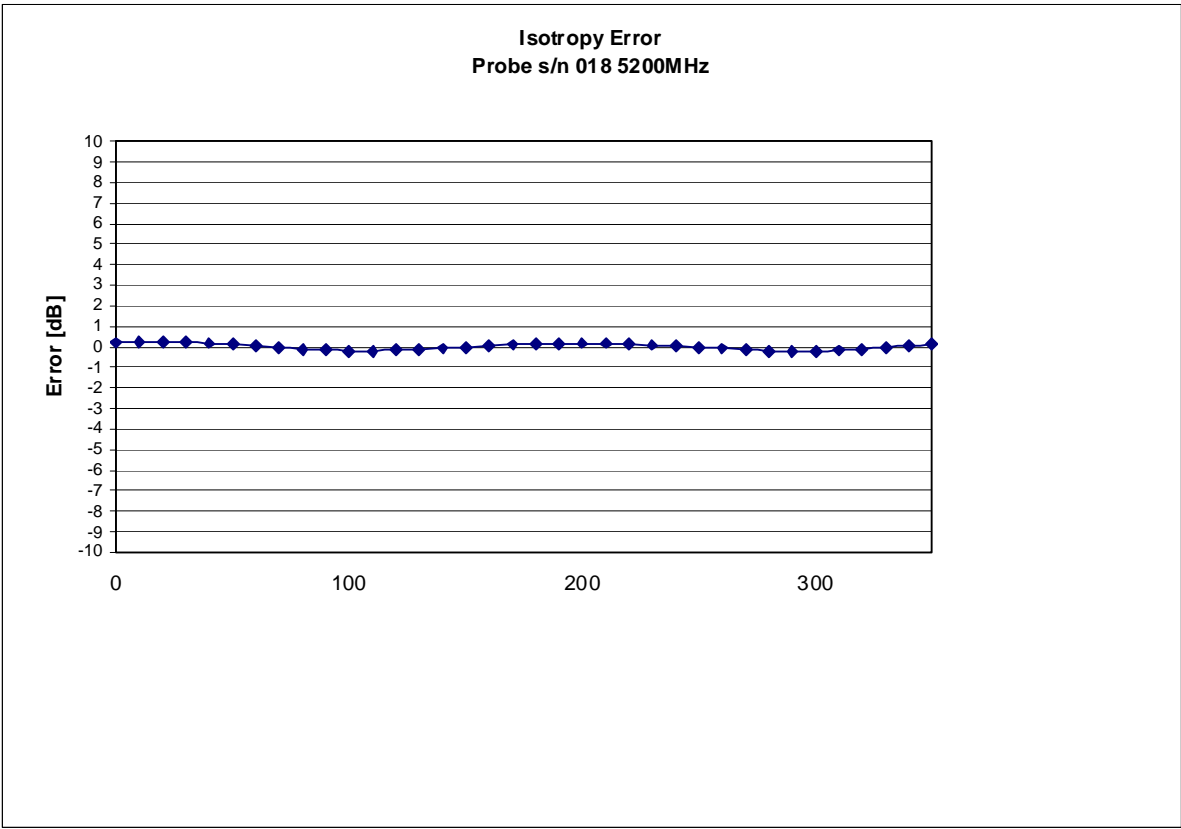
**Deviation at -40MHz:** -4.16%

**Deviation at +40MHz:** +2.78%

## Receiving Pattern 5200 MHz (Air)



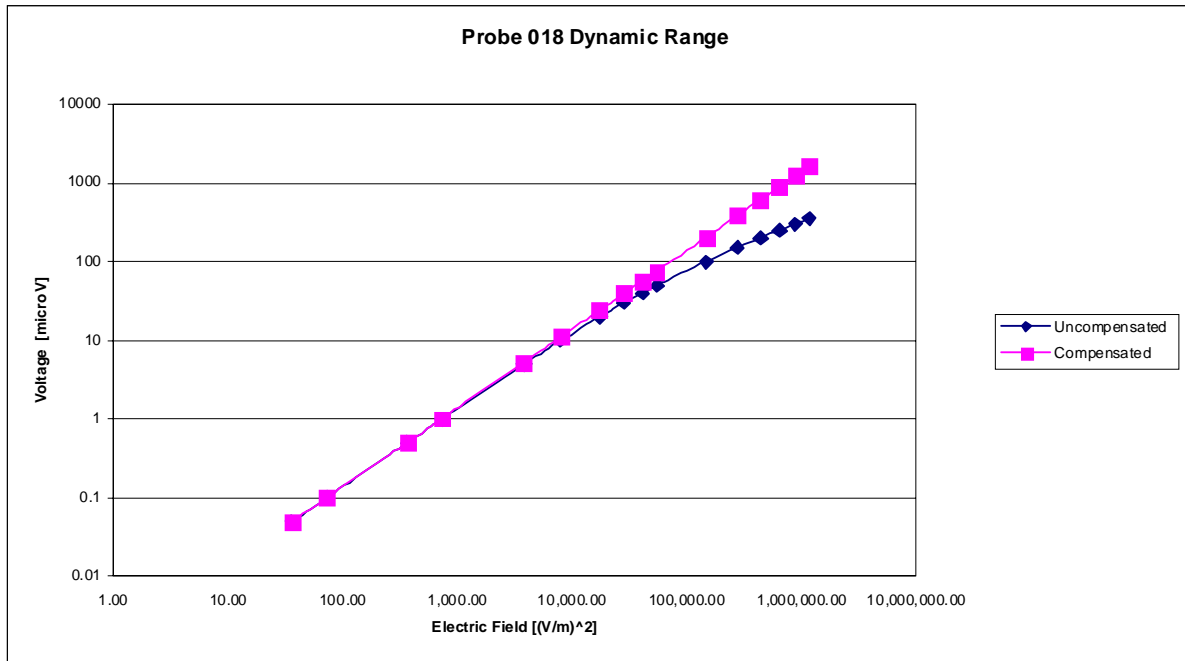
Isotropy Error 5200 MHz (Air)



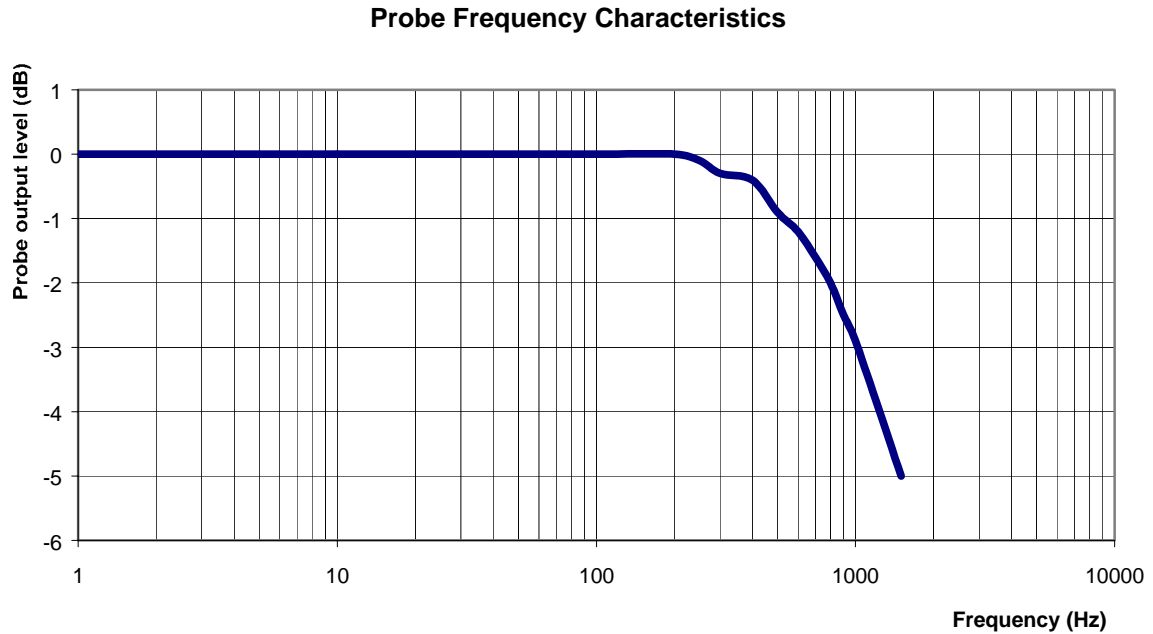
Isotropicity in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



<b>Video Bandwidth at 500 Hz</b>	<b>1 dB</b>
<b>Video Bandwidth at 1.02 KHz:</b>	<b>3 dB</b>



## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5200MHz

**Epsilon:** 43.0 (+/-10%) **Sigma:** 5.75 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2 7%(K=2)

**Channel Y:** 3.2 7%(K=2)

**Channel Z:** 3.2 7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 M $\Omega$ .

### **Boundary Effect:**

For a distance of 0.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-885

Client.: APREL

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 2450 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008  
Released on: 3<sup>rd</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

**NCL** CALIBRATION LABORATORIES

51 SPECTRUM WAY  
NEPEAN, ONTARIO  
CANADA K2R 1E6

Division of APREL Lab.  
TEL: (613) 820-4988  
FAX: (613) 820-4161

## Introduction

This Calibration Report reproduces the results of the calibration performed in line with the SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure. The results contained within this report are for APREL E-Field Probe E-030 018.

## References

SSI/DRB-TP-D01-032-E020-V2 E-Field Probe Calibration Procedure  
IEEE 1528 "Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques"  
SSI-TP-011 Tissue Calibration Procedure

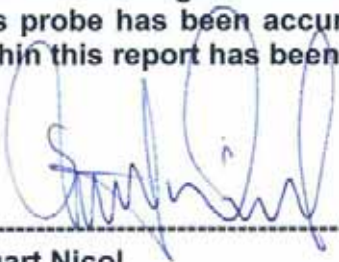
## Conditions

Probe 018 was a new probe taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

**We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**

  
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**Stuart Nicol**

  
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**Jesse Hones**

## **Calibration Results Summary**

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	2450 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	≤2.9 mm
<b>Tip Length:</b>	60 mm
<b>Total Length:</b>	290 mm

\*Resistive to recommended tissue recipes per IEEE-1528

## **Sensitivity in Air**

<b>Channel X:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Y:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Z:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Diode Compression Point:</b>	95 mV

## **Sensitivity in Body Tissue**

**Frequency:** 2450 MHz

**Epsilon:** 52.7 (+/-5%)      **Sigma:** 1.95 S/m (+/-5%)

### **ConvF**

**Channel X:** 4.01

**Channel Y:** 4.01

**Channel Z:** 4.01

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq and corrected for broadband calibration factor.

## **Boundary Effect:**

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 1.44mm.

## **Spatial Resolution:**

The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

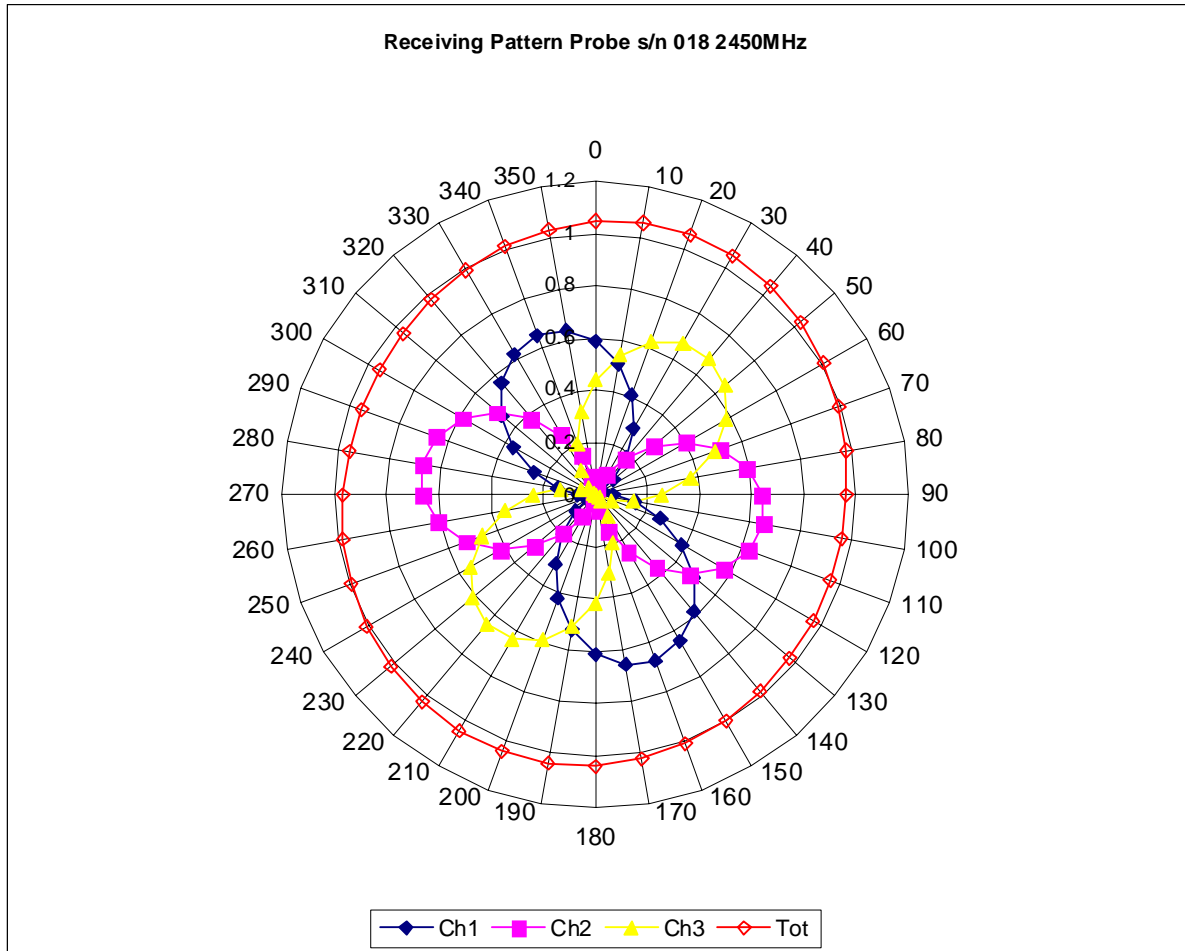
## **Broad Band Calibration:**

The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

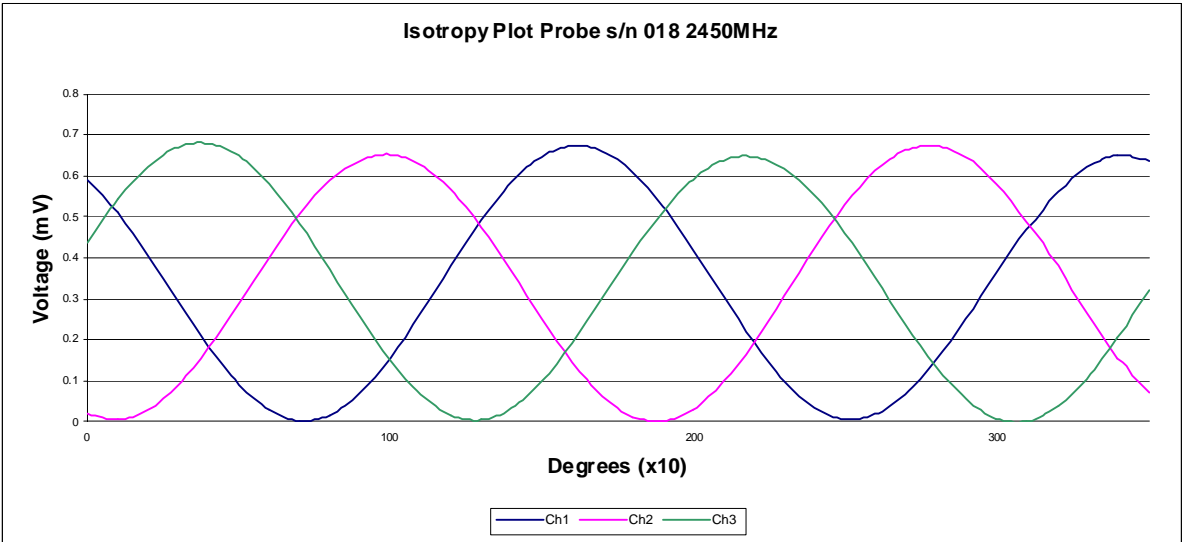
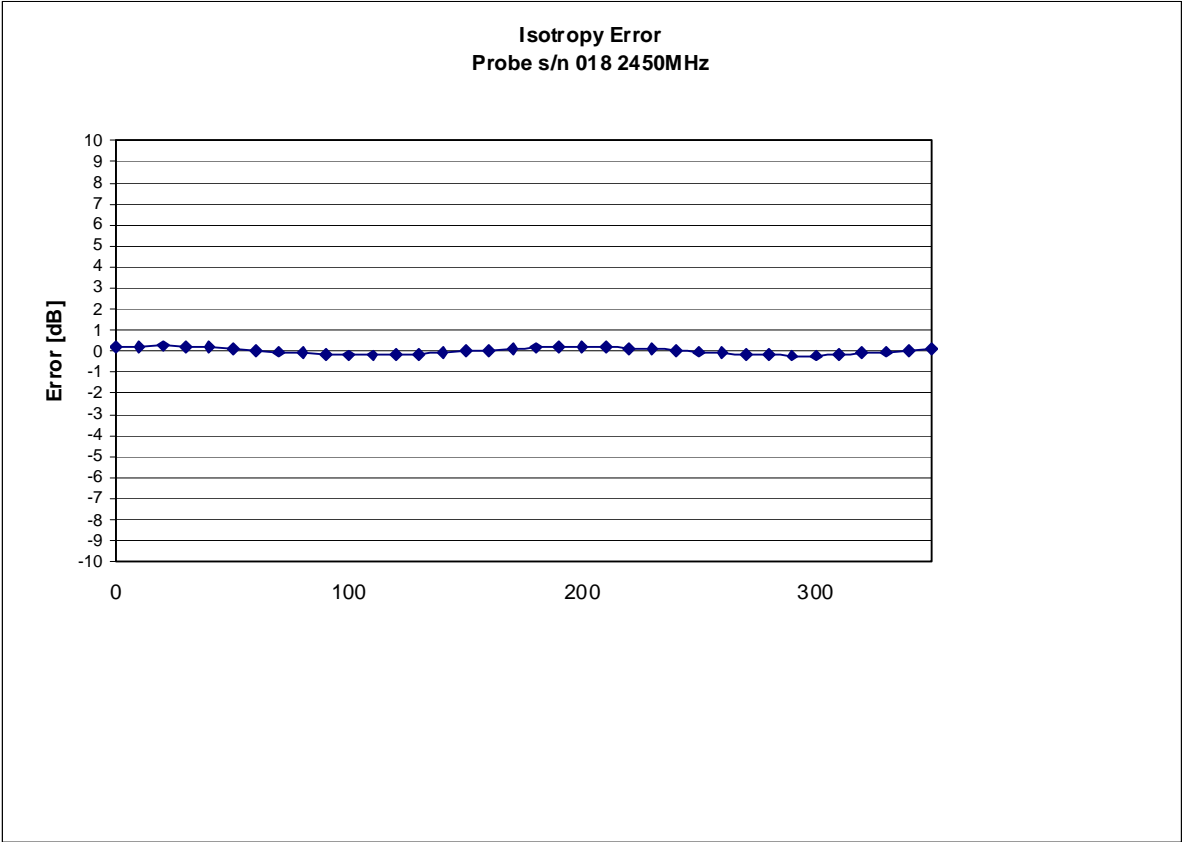
**Deviation at -40MHz:** -1.56%

**Deviation at +40MHz:** +1.3%

## Receiving Pattern 2450 MHz (Air)



Isotropy Error 2450 MHz (Air)

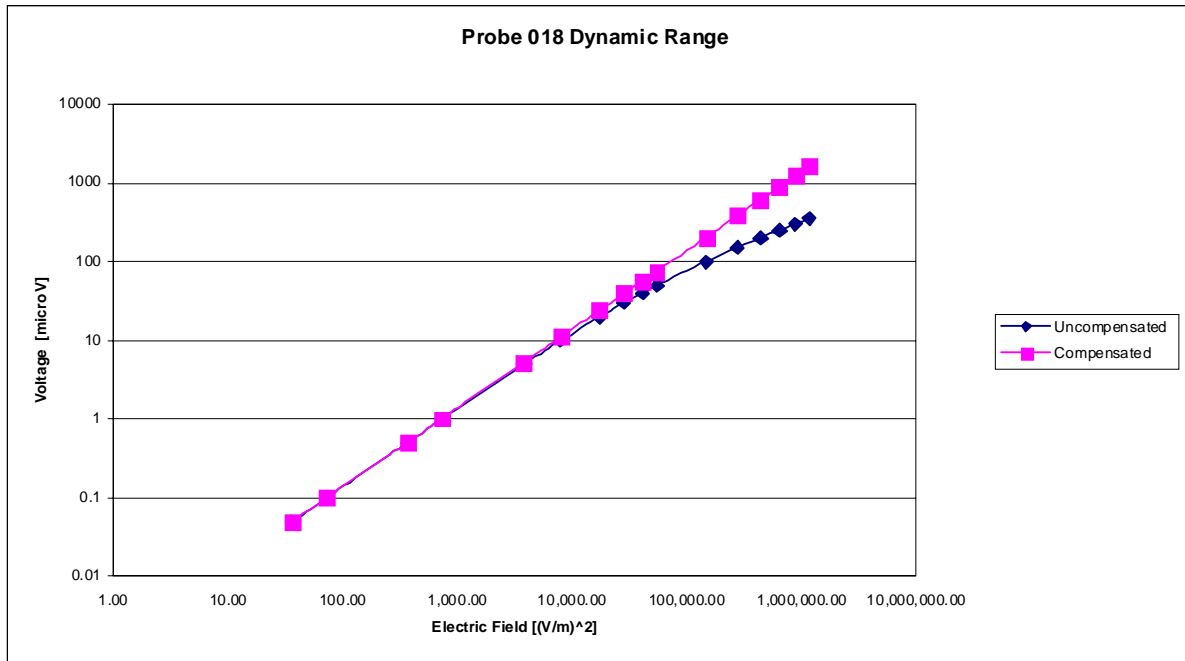


Isotropicity in Tissue:

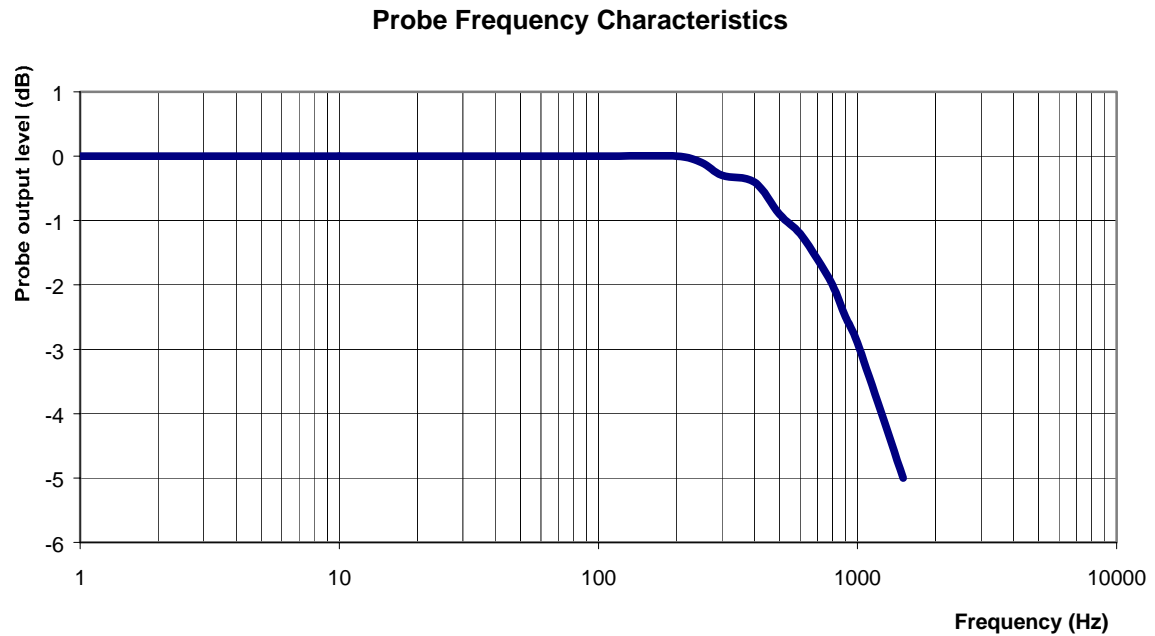
0.10 dB



## Dynamic Range



## Video Bandwidth



**Video Bandwidth at 500 Hz**                      1 dB  
**Video Bandwidth at 1.02 KHz:**                3 dB

## **Conversion Factor Uncertainty Assessment**

<b>Frequency:</b>	2450MHz
<b>Epsilon:</b> 52.7 (+/-5%)	<b>Sigma:</b> 1.95 S/m (+/-5%)

### **ConvF**

<b>Channel X:</b> 4.01	7%(K=2)
<b>Channel Y:</b> 4.01	7%(K=2)
<b>Channel Z:</b> 4.01	7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 M $\Omega$ .

### **Boundary Effect:**

For a distance of 0.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.

# NCL CALIBRATION LABORATORIES

Calibration File No.: CP-888

Client.: APREL

## CERTIFICATE OF CALIBRATION

It is certified that the equipment identified below has been calibrated in the  
**NCL CALIBRATION LABORATORIES** by qualified personnel following recognized  
procedures and using transfer standards traceable to NRC/NIST.

Equipment: Miniature Isotropic RF Probe 5800 MHz

Manufacturer: APREL Laboratories

Model No.: E-030

Serial No.: 018

Calibration in Body Tissue

Calibration Procedure: SSI/DRB-TP-D01-032-E020-V2

Project No: Internal APREL

Calibrated: 3<sup>rd</sup> May 2008  
Released on: 3<sup>rd</sup> May 2008

This Calibration Certificate is Incomplete Unless Accompanied with the Calibration Results Summary

Released By: \_\_\_\_\_

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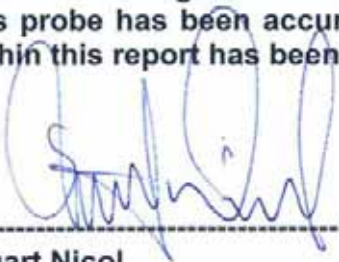
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Probe 018 was a new probe taken from stock prior to calibration.

**Ambient Temperature of the Laboratory:** 22 °C +/- 0.5°C

**Temperature of the Tissue:** 21 °C +/- 0.5°C

**We the undersigned attest that to the best of our knowledge the calibration of this probe has been accurately conducted and that all information contained within this report has been reviewed for accuracy.**

  
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**Stuart Nicol**

  
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**Jesse Hones**

## **Calibration Results Summary**

<b>Probe Type:</b>	E-Field Probe E-030
<b>Serial Number:</b>	018
<b>Frequency:</b>	5800 MHz
<b>Sensor Offset:</b>	0.44 mm
<b>Sensor Length:</b>	2.5 mm
<b>Tip Enclosure:</b>	Ertalyte*
<b>Tip Diameter:</b>	≤2.9 mm
<b>Tip Length:</b>	60 mm
<b>Total Length:</b>	290 mm

\*Resistive to recommended tissue recipes per IEEE-1528

## **Sensitivity in Air**

<b>Channel X:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Y:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Channel Z:</b>	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
<b>Diode Compression Point:</b>	95 mV

## **Sensitivity in Body Tissue**

**Frequency:** 5800 MHz

**Epsilon:** 48.2 (+/-10%)      **Sigma:** 6.0 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2

**Channel Y:** 3.2

**Channel Z:** 3.2

Tissue sensitivity values were calculated using the load impedance of the APREL Laboratories Daq-Paq and corrected for broadband calibration factor.

## **Boundary Effect:**

Uncertainty resulting from the boundary effect is less than 2% for the distance between the tip of the probe and the tissue boundary, when less than 2.44mm.

## **Spatial Resolution:**

The measured probe tip diameter is 2.9 mm (+/- 0.01 mm) and therefore meets the requirements of SSI/DRB-TP-D01-032 for spatial resolution.

## **Broad Band Calibration:**

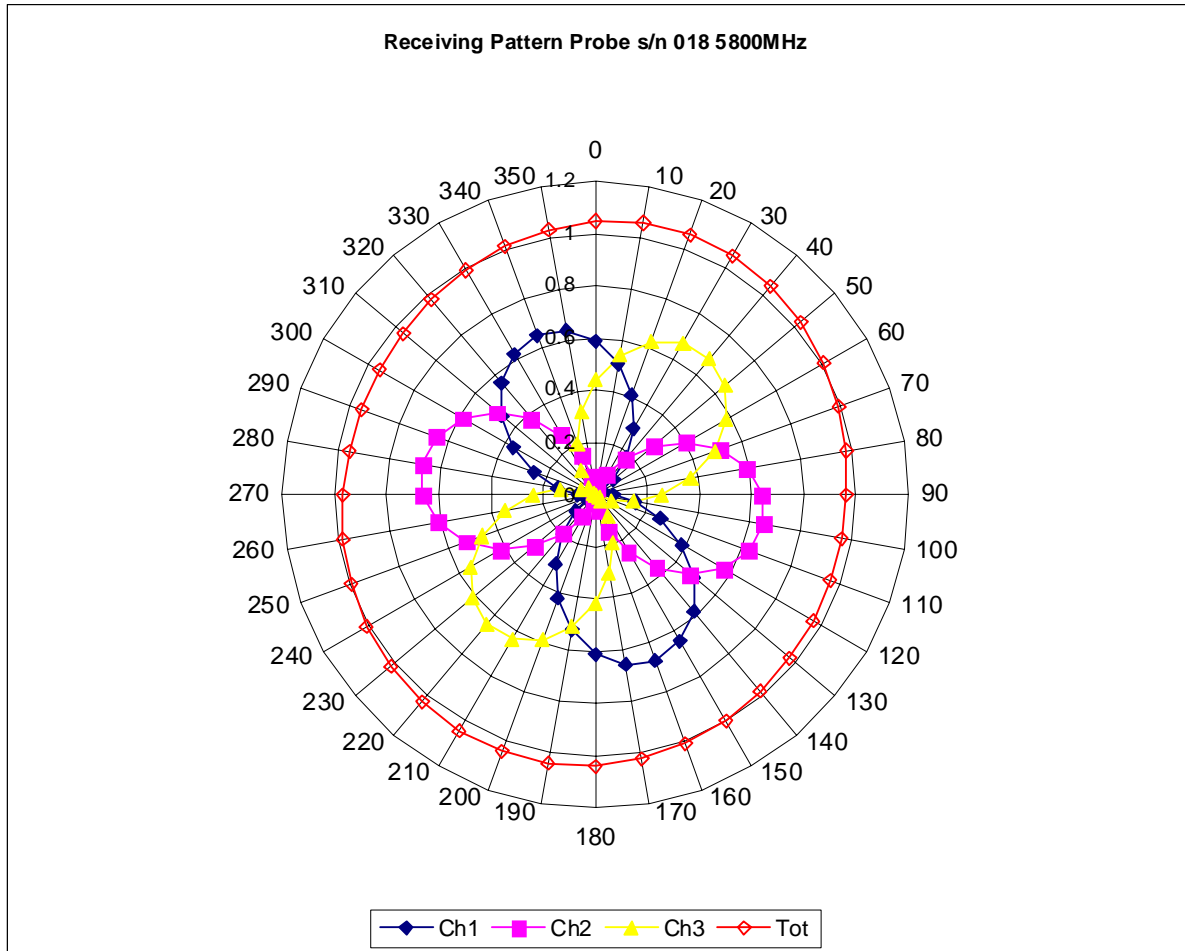
The probe was assessed for sensitivity and conversion factor using a +/- 40MHz deviation from the centre frequency.

**Deviation at -40MHz:** -3.07%

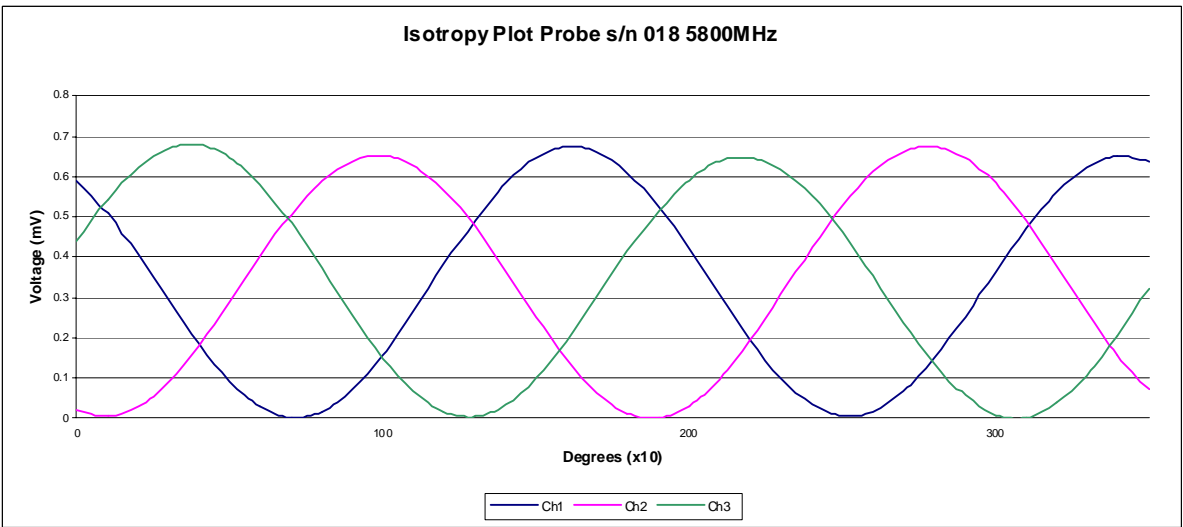
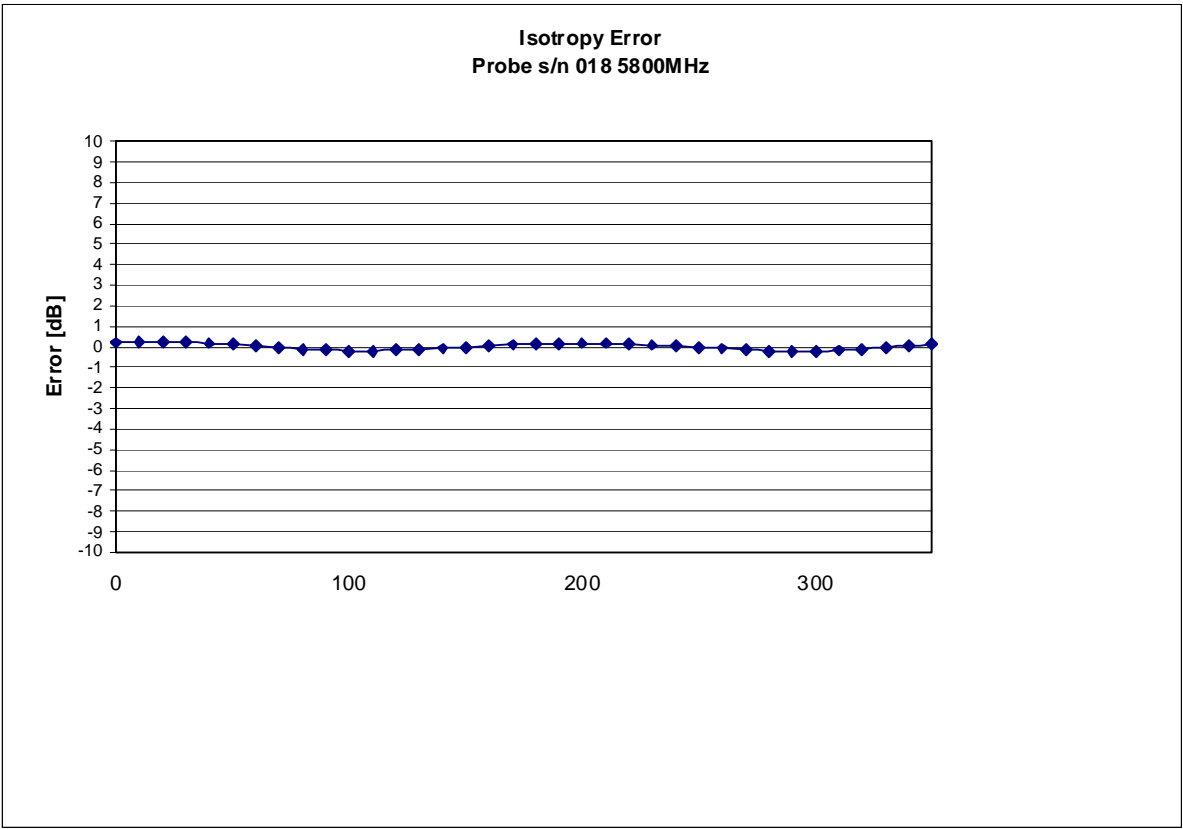
**Deviation at +40MHz:** +3.22%



## Receiving Pattern 5800 MHz (Air)



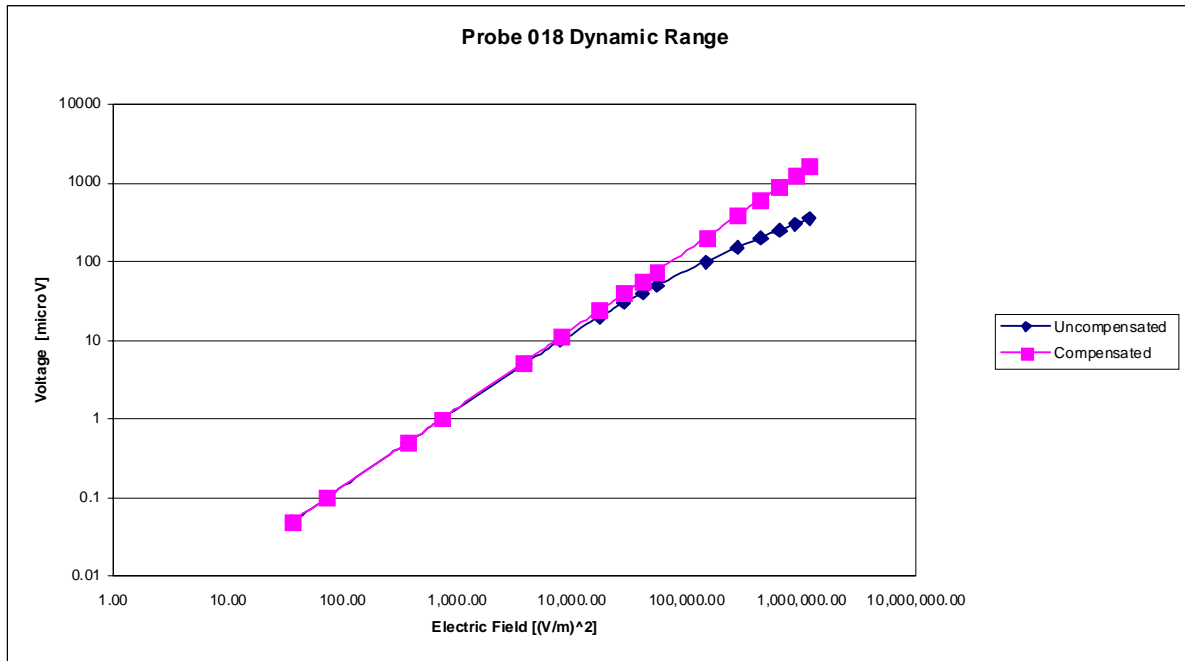
Isotropy Error 5800 MHz (Air)



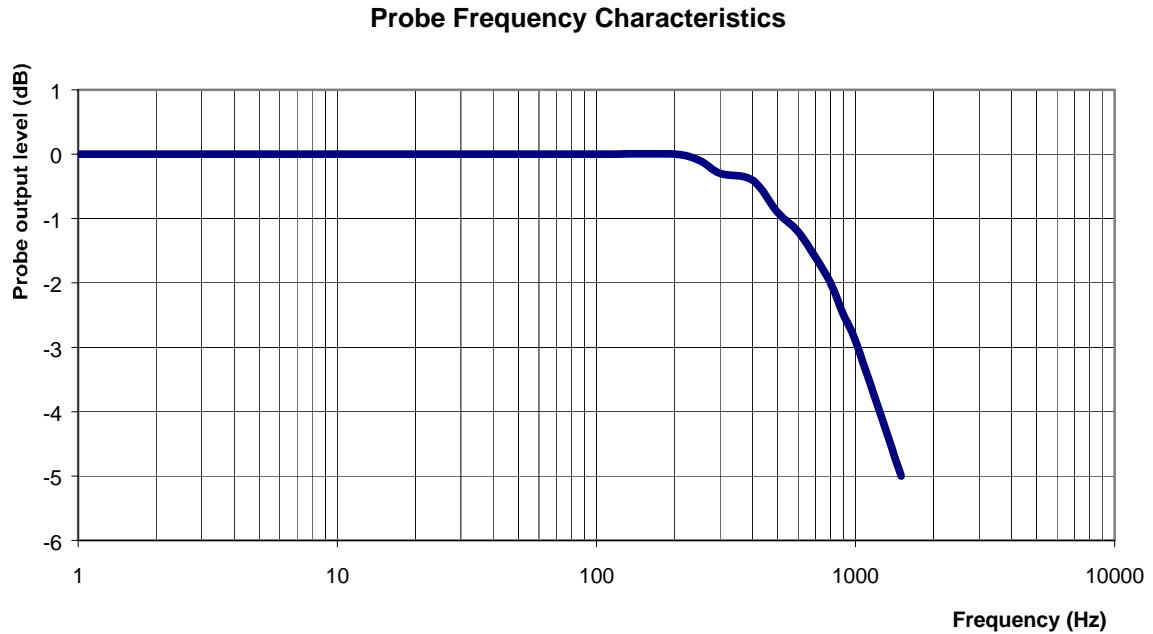
Isotropy in Tissue:

0.10 dB

## Dynamic Range



## Video Bandwidth



**Video Bandwidth at 500 Hz**                      1 dB  
**Video Bandwidth at 1.02 KHz:**              3 dB

## **Conversion Factor Uncertainty Assessment**

**Frequency:** 5800MHz

**Epsilon:** 48.2 (+/-10%)      **Sigma:** 6.0 S/m (+/-10%)

### **ConvF**

**Channel X:** 3.2      7%(K=2)

**Channel Y:** 3.2      7%(K=2)

**Channel Z:** 3.2      7%(K=2)

To minimize the uncertainty calculation all tissue sensitivity values were calculated using a load impedance of 5 M $\Omega$ .

### **Boundary Effect:**

For a distance of 0.4mm the evaluated uncertainty (increase in the probe sensitivity) is less than 2%.

## **Test Equipment**

The test equipment used during Probe Calibration, manufacturer, model number and, current calibration status are listed and located on the main APREL server R:\NCL\Calibration Equipment\Instrument List May 2008.

# Regulatory WLAN Antenna Information

## 2.4/5GHz Dell Diaz Series Multiple Band Antennas with Cable & Connector For IEEE802.11 a/g/n

(English Language Required for Intel Regulatory Review / Approval)

<b>Platform</b>	
Platform Owner	DELL
Brand Name	DELL
Model Name	Diaz
ODM	
Target Launch Date	2008/02/22
<b>Antenna</b>	
Brand Name	
Part Number	■ Tx1 Antenna: Main -2023816-1
	■ Tx2 Antenna:Aux – 2023816-1
	■ Tx3 (or Rx3) Antenna : MIMO – 2023816-1
<b>Module</b>	■ 512AN_HMW
With WLAN Module	■ 533AN_HMW
(Check Box)	

## Antenna Sample / Antenna Data

### Requirements for worldwide regulatory approval

Section	Description of Required OEM / ODM Antenna Information	US / IC	EU	Japan	Taiwan	S.Korea
1A	Part Number for Antenna only	Required	Required	Required	Required	Required
1B	Antenna Manufacturer Name	Required	Required	Required	Required	Required
1C	Description of Antenna Type	Required	N/A	N/A	N/A	N/A
1D	Part number of Antenna Assembly / cable impedance, length & diameter.	Required	Desired	Desired	Desired	Desired
1E	Tx1, Tx2 & Tx3 antenna (Peak Gain W/ cable loss) *	Required	Required	Required	Required	Required
	1E OR 1F, 1G, 1H					
1F	Tx1, Tx2 & Tx3 antenna (Peak Gain only) *	Required	Required	Required	Required	Required
1G	VSWR of cable including connector	Required	Required	Required	Required	Required
1H	Tx1, Tx2 & Tx3 antenna (Cable loss W/ connector) *	Required	Required	Required	Required	Required
2	Dimensioned Photographs and Drawings of Tx1, Tx2, and Tx3 (or Rx3) antennas	Required	Required	Required	Required	Required
3	Radiation patterns of antennas loaded in the host platform.	Required	Desired	Required	N/A	Required
4	Platform model name / number - correlated to antenna manufacturer and antenna part number	Required	Required	Desired	Required	Desired
5	Photograph(s) or Drawings showing location of antennas in platform. (S. Korea requires photographs of antennas for approval submission). Taiwan requires pictures of each antenna type shown in the system.	Required	Required	Desired	Required (Photos)	Required (Photos)
6	Mech. drawings / photos with dimensions of antenna locations and distance from end-user (For evaluation of SAR testing requirement).	Required	N/A	N/A	N/A	N/A
7	Photograph(s) or Drawings showing the location of all antennas (WLAN, other) and distance between those transmitting antennas. Information will be used to evaluate whether co-location testing is required.	Required	N/A	N/A	N/A	N/A
8	Local representative contact information for LMA/ PARS process.	Required	N/A	N/A	N/A	N/A

## NOTE:

(\*) if 3<sup>rd</sup> antenna is Rx only (e.g. receive only for 4965AGN) then peak gain and cable loss not required



# Antenna Information

## Section 1. Antenna Assembly Specifications

### Antenna Assembly Summary:

1A Antenna Part Number	1B Manufacture	1C Antenna Type	1D Cable Assembly Part Number and Information	1E *Peak Gain W/ Cable loss (dBi)	1F Peak Gain w/o Cable Loss (dBi)	1G VSWR	1H Cable Loss (dBi)
<b>2023816-1</b> Tx1 Antenna Main White	<b>TYCO</b> <b>Electronics</b>	PIFA	(P/N: U.FL-LP-068) 50 ohm coaxial length: 475mm diameter: 1.13mm Connector: U.FL White	2412-2462MHz <b>-0.67</b> dBi (peak)	2412-2462MHz <b>1.83</b> dBi (peak)	2412-2462MHz __ <b>2</b> __ max	2412-2462MHz <b>2.5</b> dBi (peak)
				2500-2700MHz <b>0.58</b> dBi (peak)	2500-2700MHz <b>3.08</b> dBi (peak)	2500-2700MHz __ <b>2</b> __ max	2500-2700MHz <b>2.5</b> dBi (peak)
				5150-5470MHz <b>0.72</b> dBi (peak)	5150-5470MHz <b>4.32</b> dBi (peak)	5150-5470MHz __ <b>2</b> __ max	5150-5470MHz <b>3.6</b> dBi (peak)
				5725-5850MHz <b>1.21</b> dBi (peak)	5725-5850MHz <b>4.81</b> dBi (peak)	5725-5850MHz __ <b>2</b> __ max	5725-5850MHz <b>3.6</b> dBi (peak)
<b>2023816-1</b> Tx2 antenna Aux Black	<b>TYCO</b> <b>Electronics</b>	PIFA	(P/N: U.FL-LP-068) 50 ohm coaxial length: 475mm diameter: 1.13mm Connector: U.FL black	2412-2462MHz <b>0.58</b> dBi (peak)	2412-2462MHz <b>3.08</b> dBi (peak)	2412-2462MHz __ <b>2</b> __ max	2412-2462MHz <b>2.5</b> dBi (peak)
				2500-2700MHz <b>1.73</b> dBi (peak)	2500-2700MHz <b>4.23</b> dBi (peak)	2500-2700MHz __ <b>2</b> __ max	2500-2700MHz <b>2.5</b> dBi (peak)
				5150-5470MHz <b>0.37</b> dBi (peak)	5150-5470MHz <b>3.97</b> dBi (peak)	5150-5470MHz __ <b>2</b> __ max	5150-5470MHz <b>3.6</b> dBi (peak)
				5725-5850MHz <b>0.11</b> dBi (peak)	5725-5850MHz <b>3.71</b> dBi (peak)	5725-5850MHz __ <b>2</b> __ max	5725-5850MHz <b>3.6</b> dBi (peak)
<b>2023816-1</b> Tx3 (or Rx3) antenna Gray MIMO	<b>TYCO</b> <b>Electronics</b>	PIFA	(P/N: U.FL-LP-068) 50 ohm coaxial length: 275mm  diameter: 1.13mm Connector: U.FL Gray	2412-2462MHz <b>0.16</b> dBi (peak)	2412-2462MHz <b>2.66</b> dBi (peak)	2412-2462MHz __ <b>2</b> __ max	2412-2462MHz <b>2.5</b> dBi (peak)
				2500-2700MHz dBi (peak)	2500-2700MHz dBi (peak)	2500-2700MHz __ max	2500-2700MHz dBi (peak)
				5150-5470MHz <b>2.16</b> dBi (peak)	5150-5470MHz <b>5.76</b> dBi (peak)	5150-5470MHz __ <b>2</b> __ max	5150-5470MHz <b>3.6</b> dBi (peak)
				5725-5850MHz <b>2.30</b> dBi (peak) *	5725-5850MHz <b>5.9</b> dBi (peak) *	5725-5850MHz __ <b>2</b> __ max *	5725-5850MHz <b>3.6</b> dBi (peak) *

#### NOTE:

(\*) If Rx3 only (3<sup>rd</sup> antenna receives only, e.g. for 4965AGN) then the information marked with \* is not required

**Antenna Peak Gain Table:**

Freq. (MHz)	WLAN Antenna–White(MAIN)			WLAN Antenna–Black(AUX)			MIMO Antenna–Gray		
	H	V	H + V	H	V	H + V	H	V	H + V
	dBi	dBi	dBi	dBi	dBi	dBi	dBi	dBi	dBi
2412	–3.46	–3.60	–0.77	–3.81	–4.16	–2.50	–2.21	–0.97	0.16
2437	–3.35	–3.22	–0.71	–2.55	–2.55	–0.82	–2.32	–0.60	0.01
2462	–3.08	–2.80	–0.67	–1.78	–1.28	0.58	–2.66	–0.66	0.11
2500	–2.36	–2.92	0.13	–1.71	–0.26	1.10			
2600	–1.34	–1.95	0.58	–1.33	–0.55	0.63			
2700	–1.20	–1.43	0.15	–0.40	0.30	1.73			
5150	–1.65	–7.40	–1.49	–0.47	–7.58	–0.11	–0.47	–1.03	1.12
5350	–0.50	–5.89	–0.25	–0.08	–5.49	0.37	0.20	0.03	2.16
5470	0.66	–3.53	0.72	–0.58	–4.65	0.11	0.11	–0.58	1.57
5725	1.04	–4.00	1.21	–1.66	–3.61	–0.35	–3.17	–0.35	0.83
5875	0.40	–2.92	0.59	–1.43	–2.56	0.11	–0.04	0.34	2.30

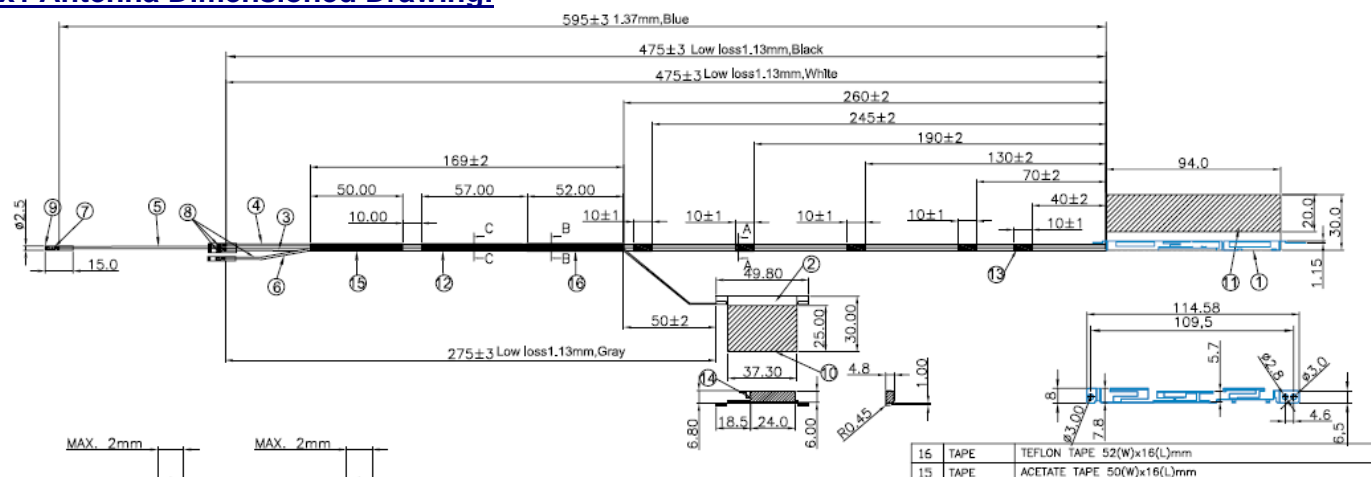
Antenna Peak Gain required being test in system basis.

- 1E frame contend absolutely peak antenna gain include H/V
- If Rx3 only (3<sup>rd</sup> antenna receives only, e.g. for 4965AGN) then the information is not required for Rx3.

## Section 2. Dimensioned Photos or Drawings of Antennas

**Include a dimensioned photo and dimensioned drawing of Tx1 antenna here.**

### Tx1 Antenna Dimensioned Drawing:



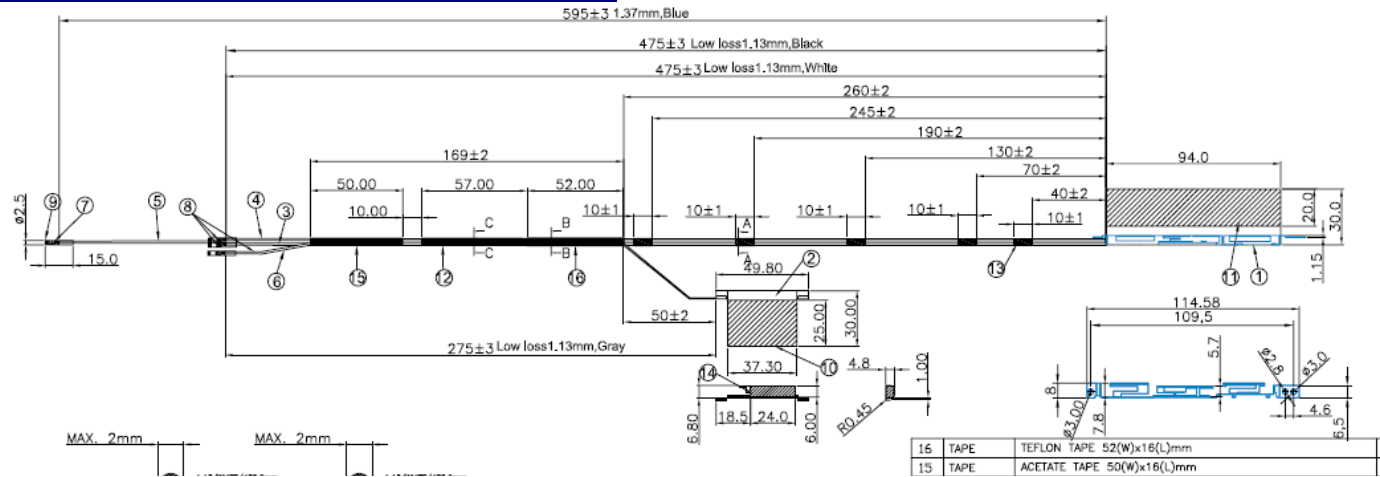
**Tx1 Antenna Photo:-MAIN**



[illegible]

Include a dimensioned photo and dimensioned drawing of Tx3 (or Rx3) antenna here.

Tx3 (or Rx3) Antenna Dimensioned Drawing:



Tx3 (or Rx3) Antenna Photo:



**Include front view photo of all 3 antennas here.**

Antenna Manufacturer: Tyco Electronics

Antenna Part Number:

(Tx1), 2023816-1

(Tx2), 2023816-1

(Rx3), 2023816-1



**Include back view photo of all 3 antennas here.**

Antenna Manufacturer: Tyco Electronics

Antenna Part Number:

(Tx1), 2023816-1

(Tx2), 2023816-1

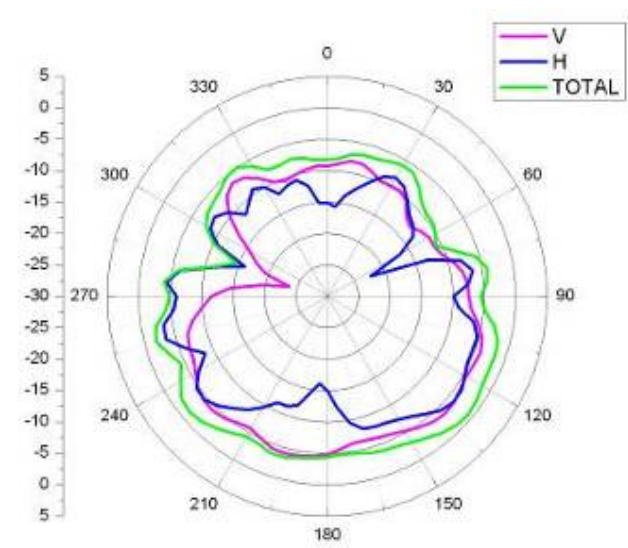
(Rx3), 2023816-1



**Section 3. Radiation characteristics of antennae Loaded in Host Platform**

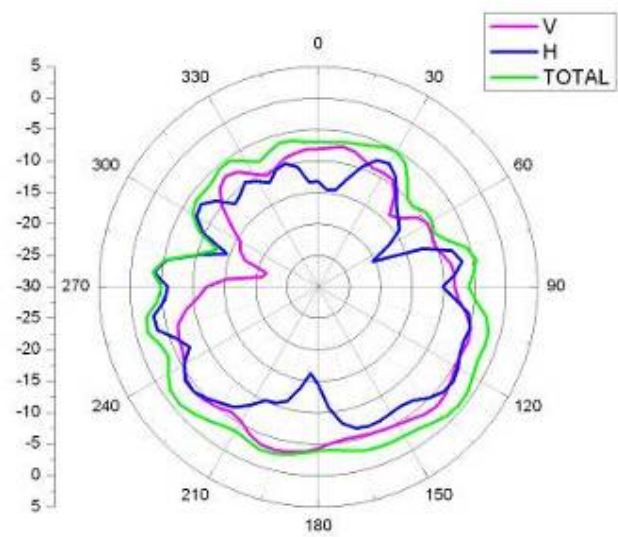
**2412-2562MHz radiation characteristic**

**MAIN antenna: 2412 MHz**



Center Frequency	2412 MHz
Horizontal (dBi) peak	-3.46
Vertical (dBi) peak	-3.59
H+V (dBi) peak	-0.76

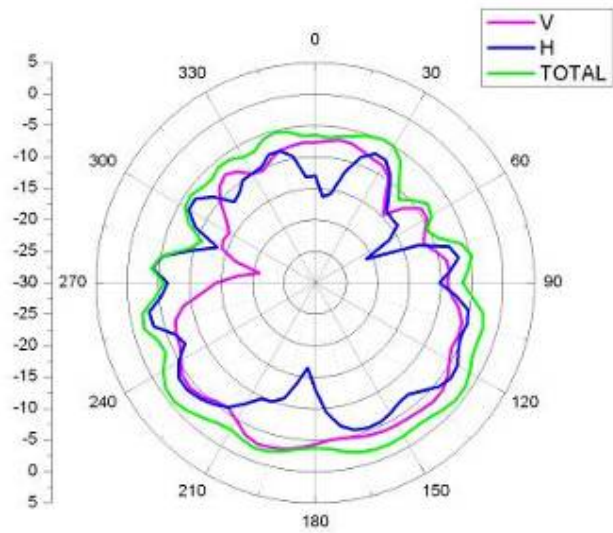
MAIN antenna: 2437 MHz



Center Frequency	2437 MHz
Horizontal (dBi) peak	-3.35
Vertical (dBi) peak	-3.22
H+V (dBi) peak	-0.70

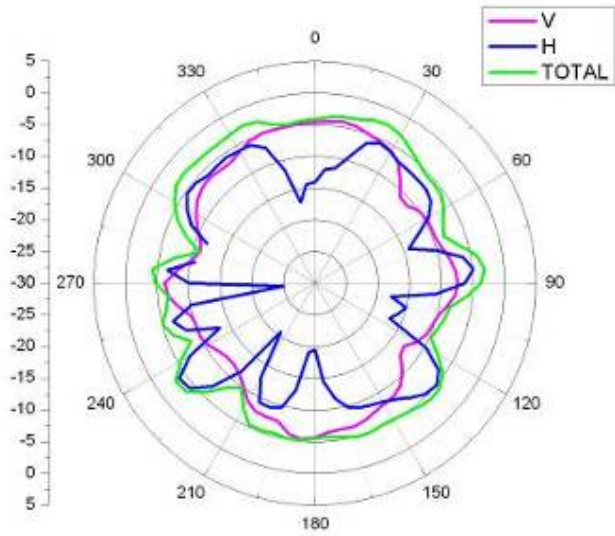


MAIN antenna: 2462 MHz



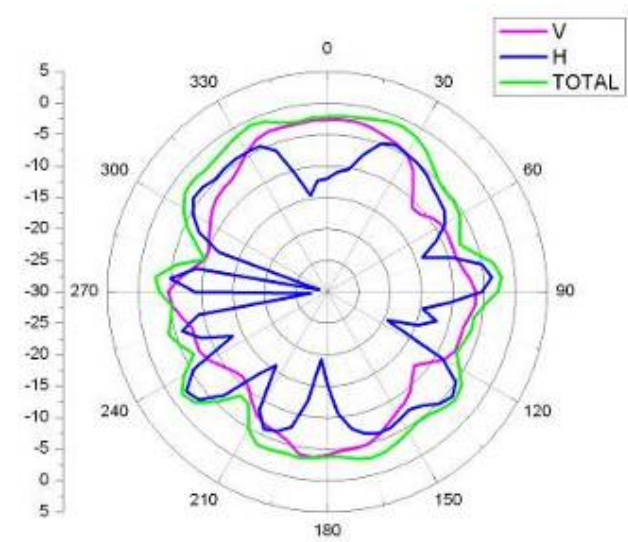
Center Frequency	2462 MHz
Horizontal (dBi) peak	-3.06
Vertical (dBi) peak	-2.80
H+V (dBi) peak	-0.66

AUX antenna: 2412 MHz



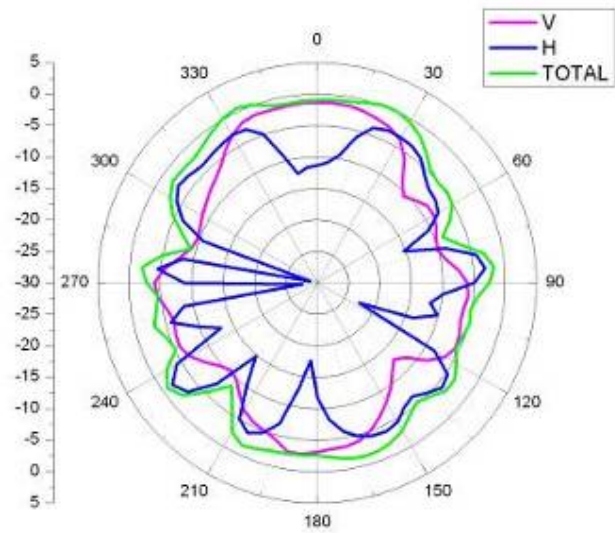
Center Frequency	2412 MHz
Horizontal (dBi) peak	-3.81
Vertical (dBi) peak	-4.16
H+V (dBi) peak	-2.50

AUX antenna: 2437MHz

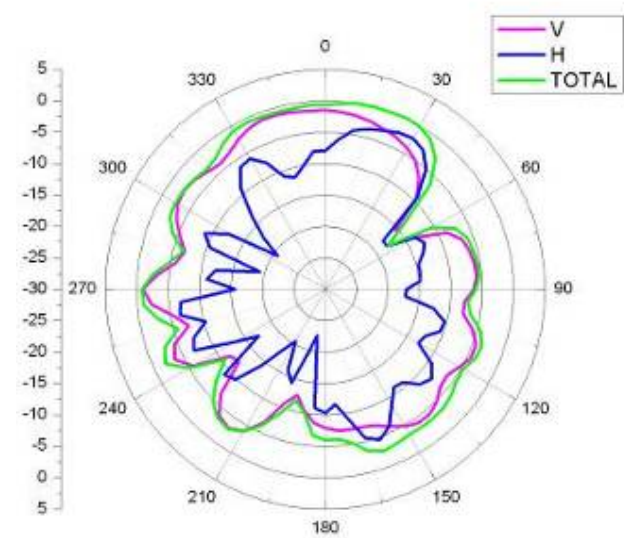


Center Frequency	2437 MHz
Horizontal (dBi) peak	-2.55
Vertical (dBi) peak	-2.54
H+V (dBi) peak	-0.82

AUX antenna: 2462 MHz

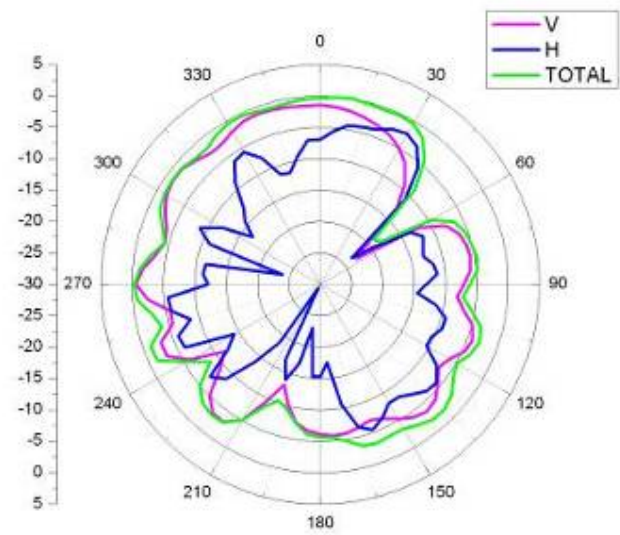


Center Frequency	2462 MHz
Horizontal (dBi) peak	-1.78
Vertical (dBi) peak	-1.28
H+V (dBi) peak	0.57



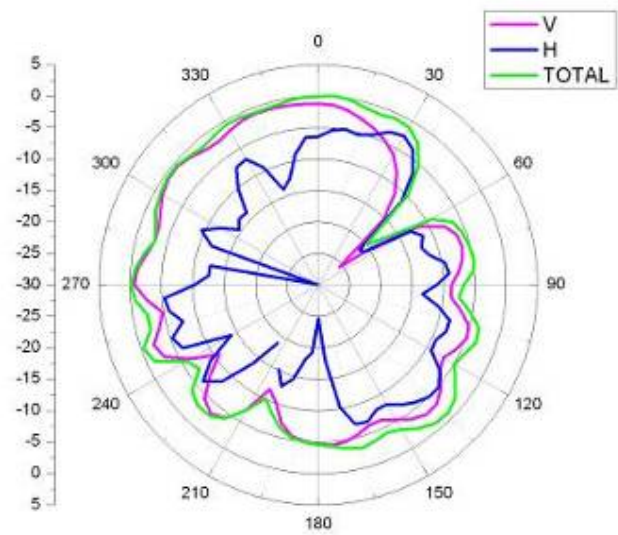
Center Frequency	2412 MHz
Horizontal (dBi) peak	-2.21
Vertical (dBi) peak	-0.96
H+V (dBi) peak	0.15

MIMO antenna: 2437 MHz



Center Frequency	2437 MHz
Horizontal (dBi) peak	-2.31
Vertical (dBi) peak	-0.59
H+V (dBi) peak	0.01

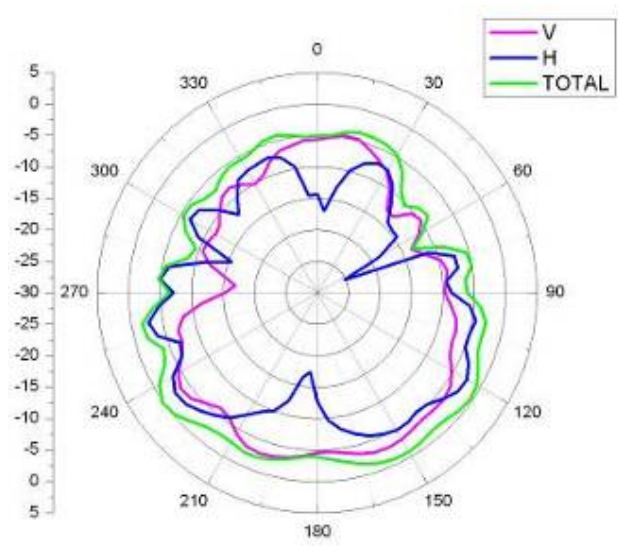
MIMO antenna: 2462 MHz



Center Frequency	2462 MHz
Horizontal (dBi) peak	-2.66
Vertical (dBi) peak	-0.66
H+V (dBi) peak	0.11

2500-2700MHz radiation characteristic

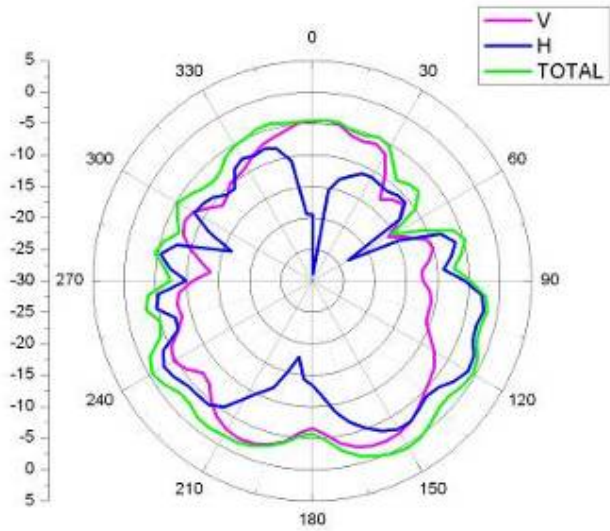
MAIN antenna: 2500MHz



Center Frequency	2500 MHz
Horizontal (dBi) peak	-2.36
Vertical (dBi) peak	-2.91
H+V (dBi) peak	0.12

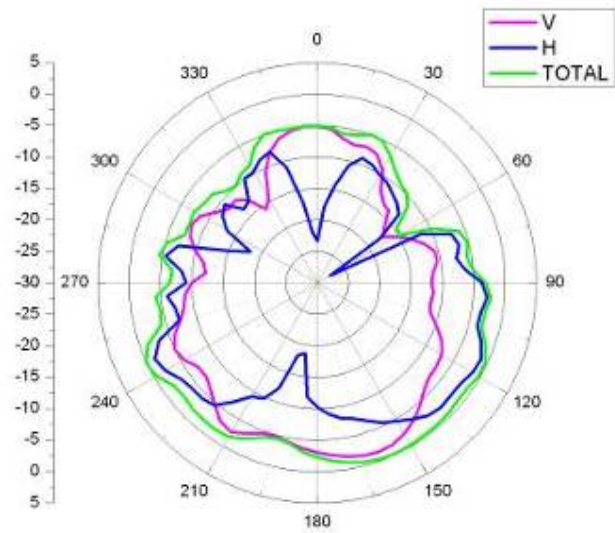


MAIN antenna: 2600 MHz

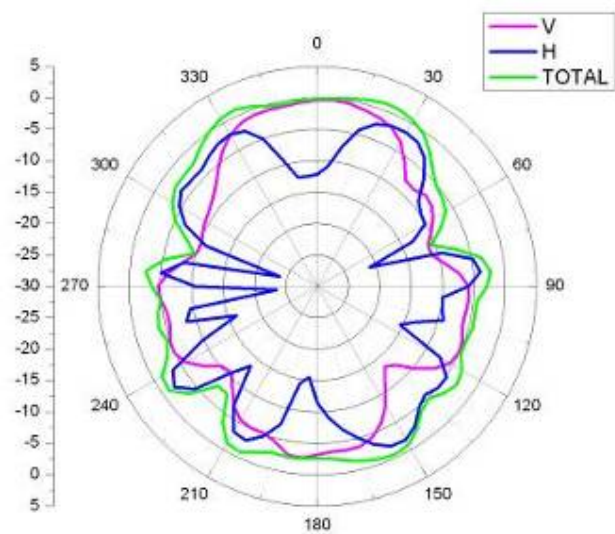


Center Frequency	2600 MHz
Horizontal (dBi) peak	-1.33
Vertical (dBi) peak	-1.94
H+V (dBi) peak	0.58

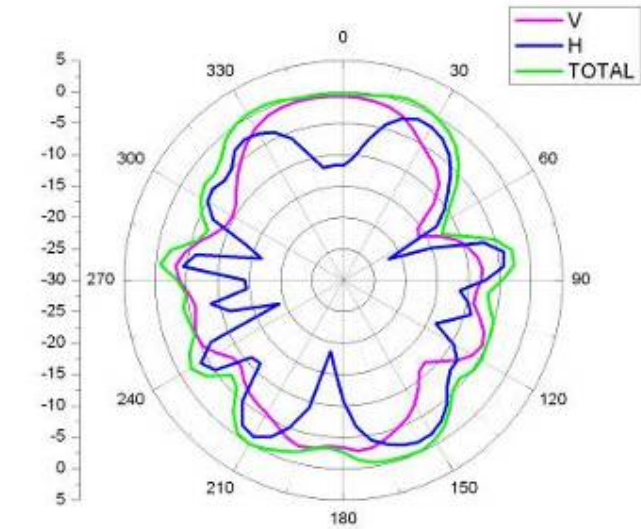
MAIN antenna:2700 MHz



Center Frequency	2700 MHz
Horizontal (dBi) peak	-1.19
Vertical (dBi) peak	-1.42
H+V (dBi) peak	0.14

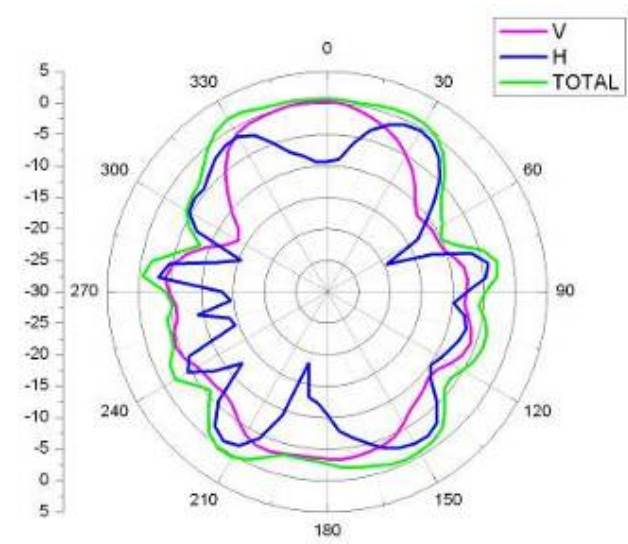


Center Frequency	2500 MHz
Horizontal (dBi) peak	-1.70
Vertical (dBi) peak	-0.26
H+V (dBi) peak	1.10



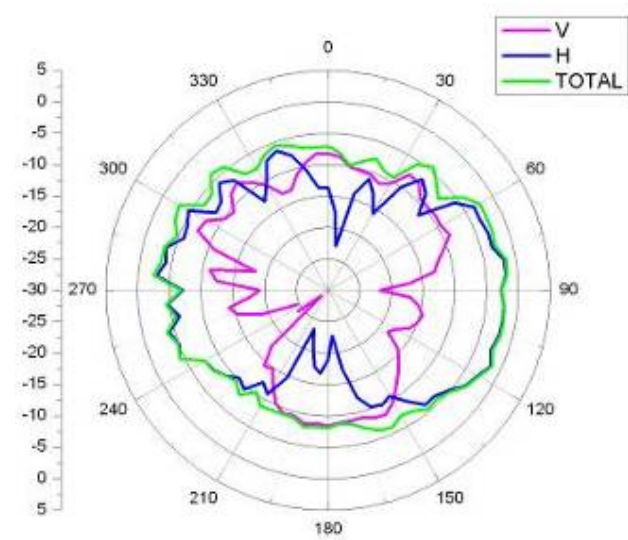
Center Frequency	2600 MHz
Horizontal (dBi) peak	-1.33
Vertical (dBi) peak	-0.54
H+V (dBi) peak	0.62

AUX antenna: 2700 MHz



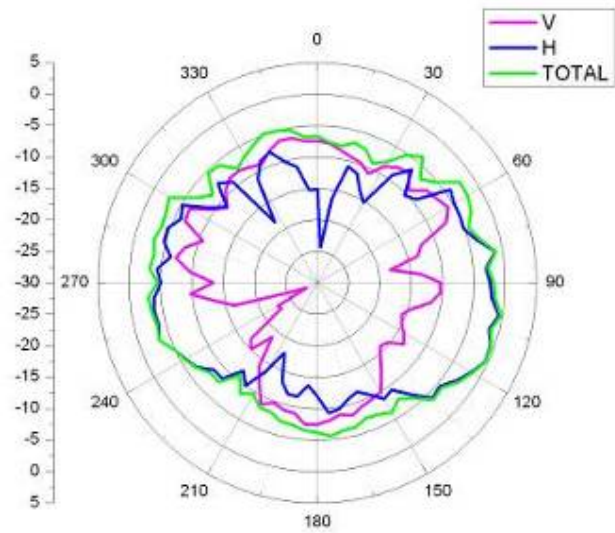
Center Frequency	2700 MHz
Horizontal (dBi) peak	-0.39
Vertical (dBi) peak	0.30
H+V (dBi) peak	1.72

MAIN antenna: 5150 MHz



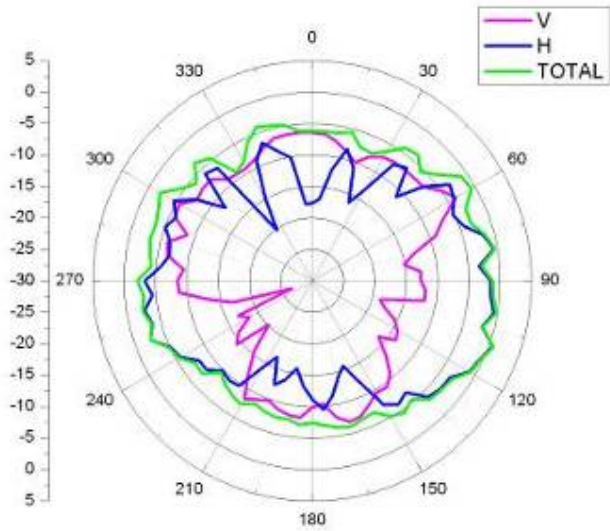
Center Frequency	5150 MHz
Horizontal (dBi) peak	-1.64
Vertical (dBi) peak	-7.40
H+V (dBi) peak	-1.48

MAIN antenna: 5350 MHz



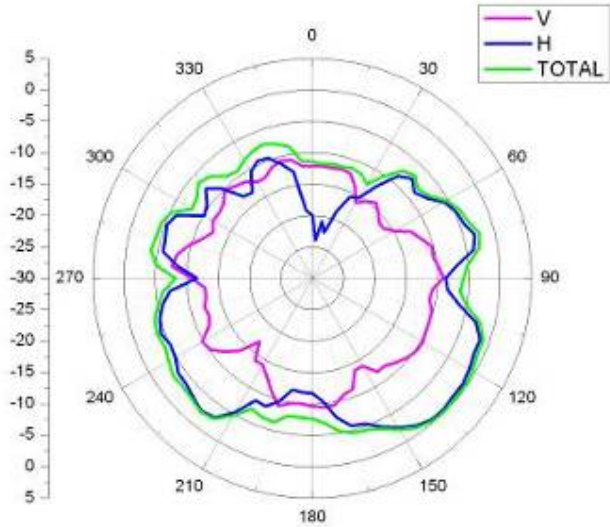
Center Frequency	5350 MHz
Horizontal (dBi) peak	-0.50
Vertical (dBi) peak	-5.89
H+V (dBi) peak	-0.24

MAIN antenna: 5470 MHz



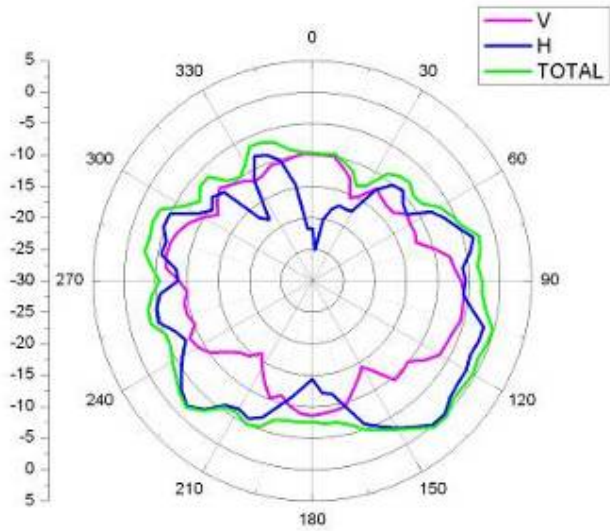
Center Frequency	5470 MHz
Horizontal (dBi) peak	0.65
Vertical (dBi) peak	-3.52
H+V (dBi) peak	0.71





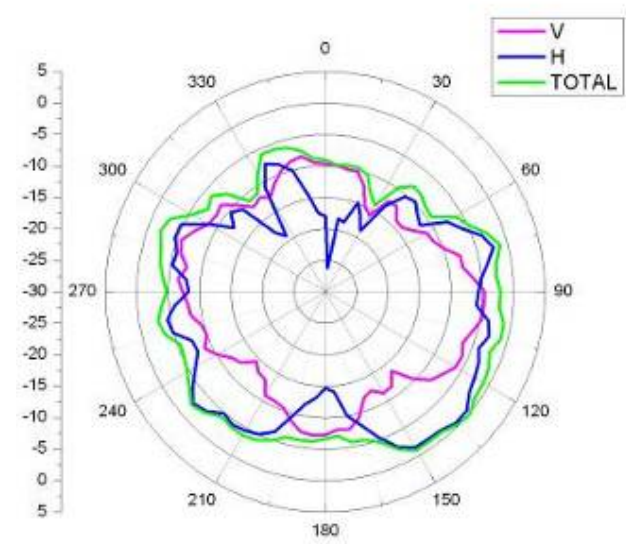
Center Frequency	5150 MHz
Horizontal (dBi) peak	-0.47
Vertical (dBi) peak	-7.58
H+V (dBi) peak	-0.10

AUX antenna: 5350 MHz



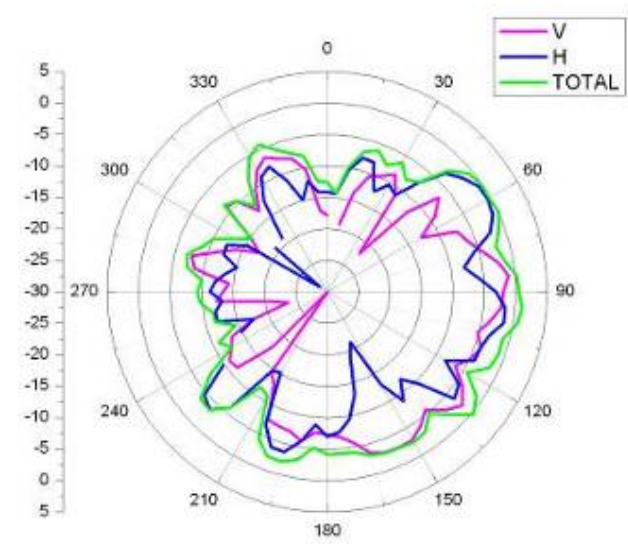
Center Frequency	5350 MHz
Horizontal (dBi) peak	-0.07
Vertical (dBi) peak	-5.49
H+V (dBi) peak	0.36

AUX antenna: 5470 MHz



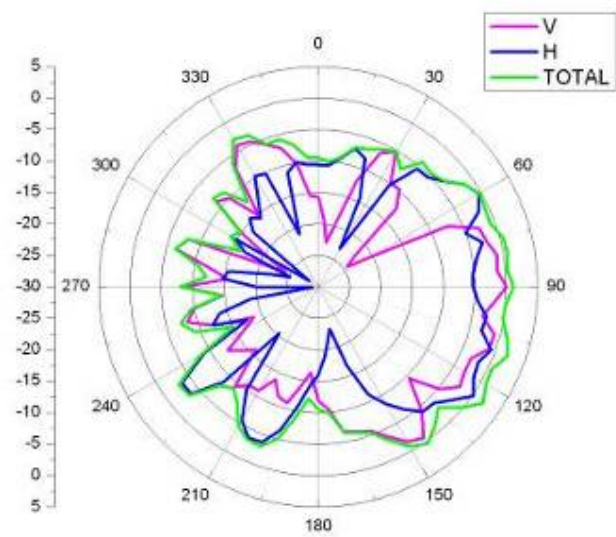
Center Frequency	5470 MHz
Horizontal (dBi) peak	-0.57
Vertical (dBi) peak	-4.65
H+V (dBi) peak	0.11

MIMO antenna: 5150 MHz



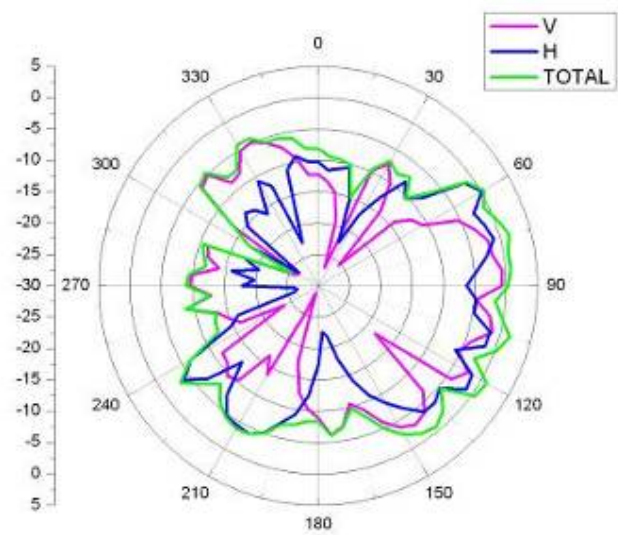
Center Frequency	5150 MHz
Horizontal (dBi) peak	-0.47
Vertical (dBi) peak	-1.02
H+V (dBi) peak	1.12

MIMO antenna: 5350 MHz



Center Frequency	5350 MHz
Horizontal (dBi) peak	0.19
Vertical (dBi) peak	0.02
H+V (dBi) peak	2.15

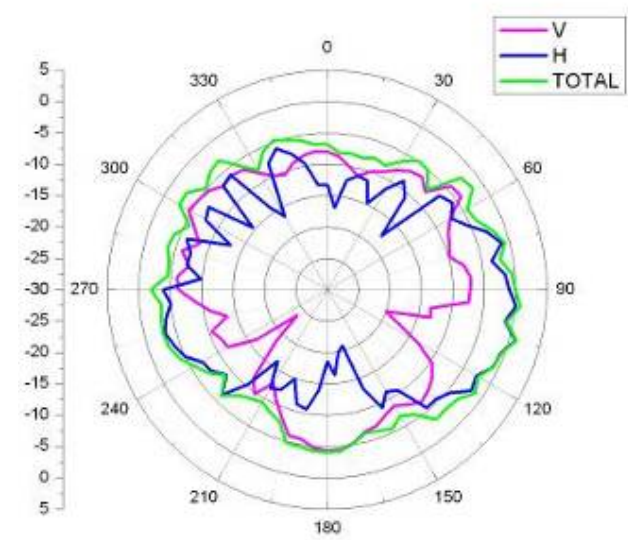
MIMO antenna: 5470 MHz



Center Frequency	5470 MHz
Horizontal (dBi) peak	0.10
Vertical (dBi) peak	-0.57
H+V (dBi) peak	1.56

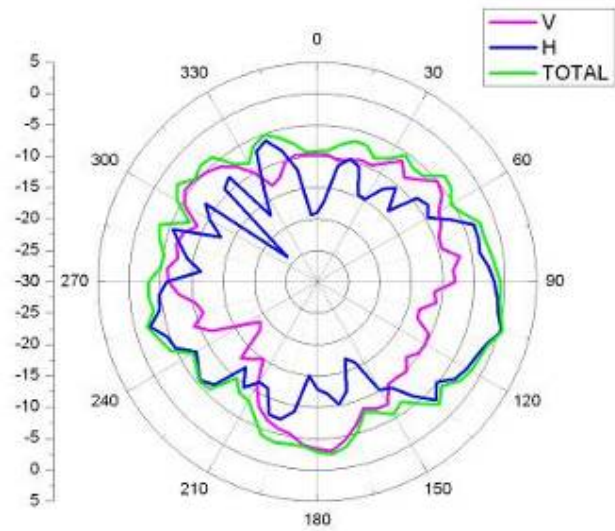
5725-5875 MHz radiation characteristic

MAIN antenna : 5725 MHz



Center Frequency	5725 MHz
Horizontal (dBi) peak	1.04
Vertical (dBi) peak	-3.99
H+V (dBi) peak	1.21

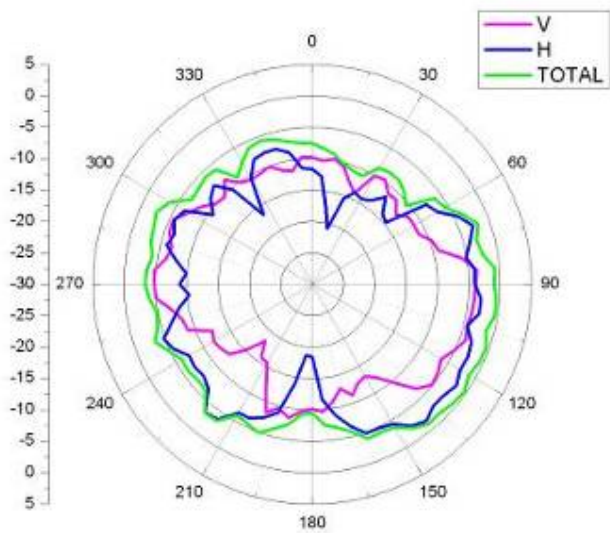
MAIN antenna: 5875 MHz



Center Frequency	5875 MHz
Horizontal (dBi) peak	0.39
Vertical (dBi) peak	-2.91
H+V (dBi) peak	0.58

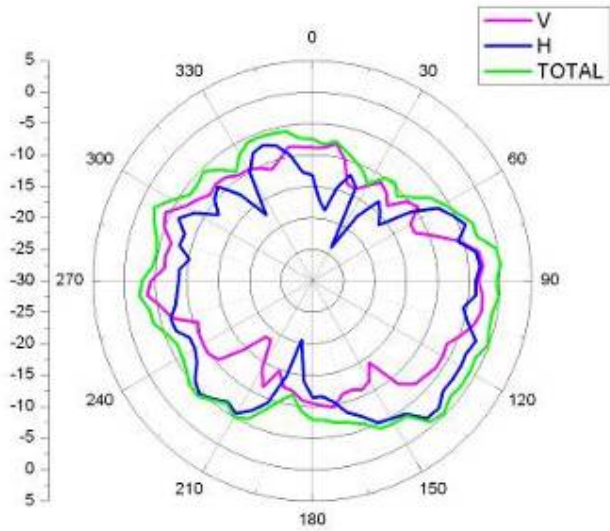


AUX antenna : 5725 MHz



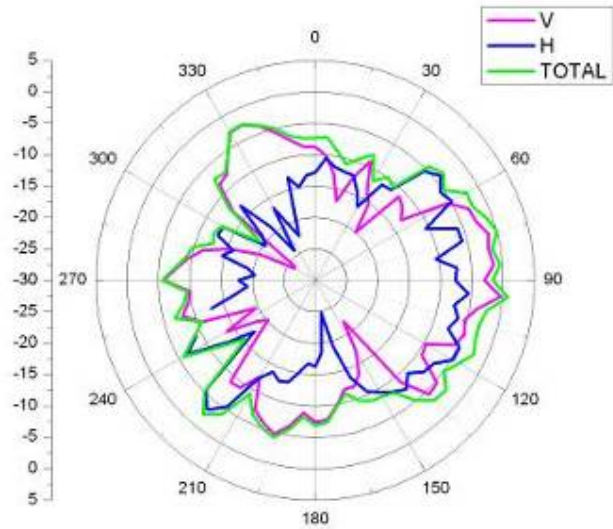
Center Frequency	5725 MHz
Horizontal (dBi) peak	-1.65
Vertical (dBi) peak	-3.60
H+V (dBi) peak	-0.35

AUX antenna : 5875 MHz



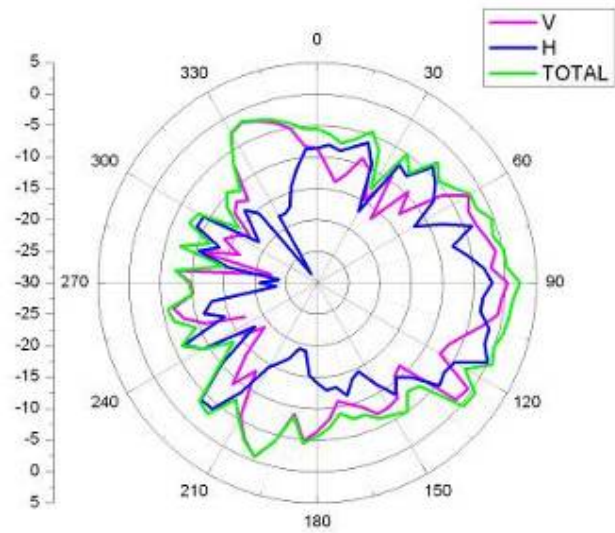
Center Frequency	5875 MHz
Horizontal (dBi) peak	-1.42
Vertical (dBi) peak	-2.55
H+V (dBi) peak	0.11

MIMO antenna : 5725 MHz



Center Frequency	<b>5725 MHz</b>
Horizontal (dBi) peak	<b>-3.16</b>
Vertical (dBi) peak	<b>-0.34</b>
H+V (dBi) peak	<b>0.83</b>

MIMO antenna : 5875 MHz



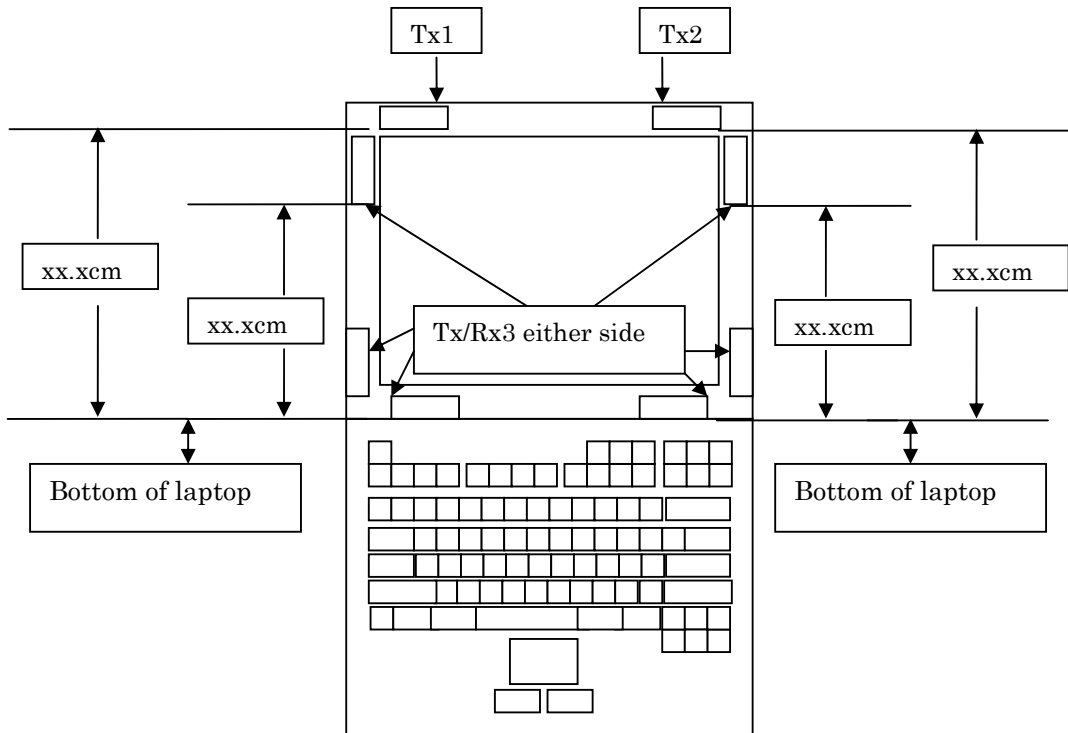
Center Frequency	5875 MHz
Horizontal (dBi) peak	-0.03
Vertical (dBi) peak	0.33
H+V (dBi) peak	2.29

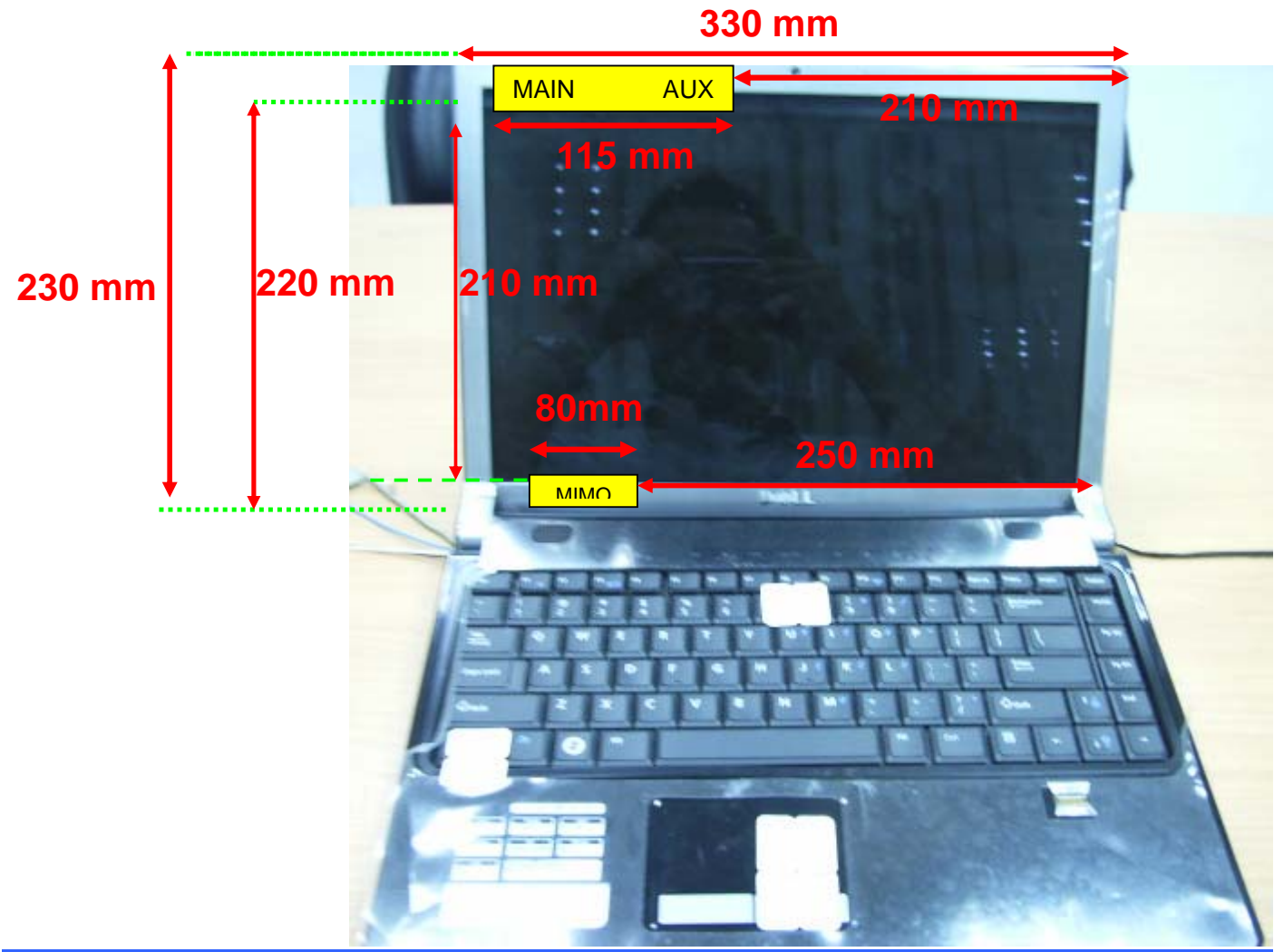
**Section 4. Host Platform Information**

OEM / ODM Host platform: (XXXXXXX) platform correlated to antenna data  
**Rating Label Photo:**

## Section 5. Antenna Host Platform Location Information

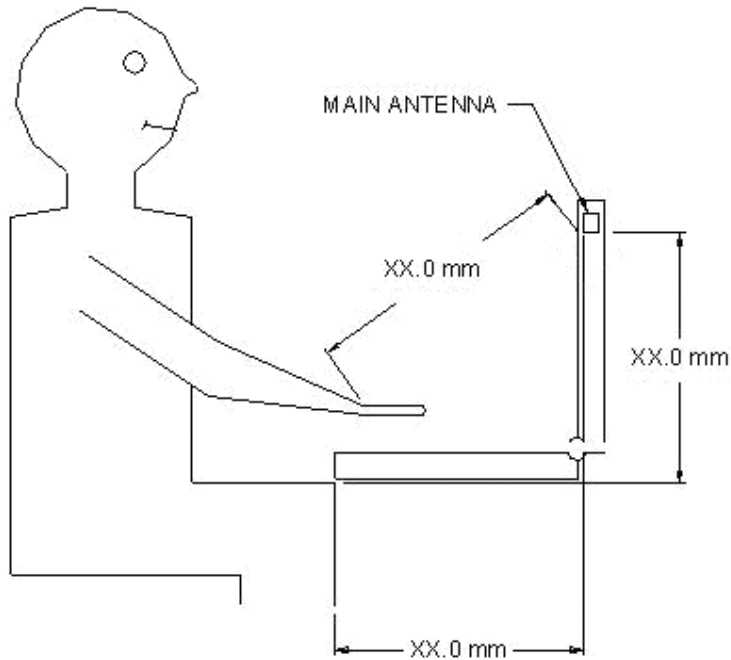
Include a **dimensioned photo or dimensioned drawing** of Tx1, Tx2 and Tx3 antenna placements (measurements are not required for receive-only antenna). Any antenna that transmits must show dimensions to bottom of laptop.





## Section 6. Antenna dimensional information for SAR evaluation

Include a **dimensioned photo or dimensioned drawing** showing the distance (mm) between the transmit antennas and the user (excluding hands, wrist, feet, lap/ thigh, and ankle)



**Antenna distance to Keyboard <7&8>**

**L main =275mm**

**Laux=270 mm**

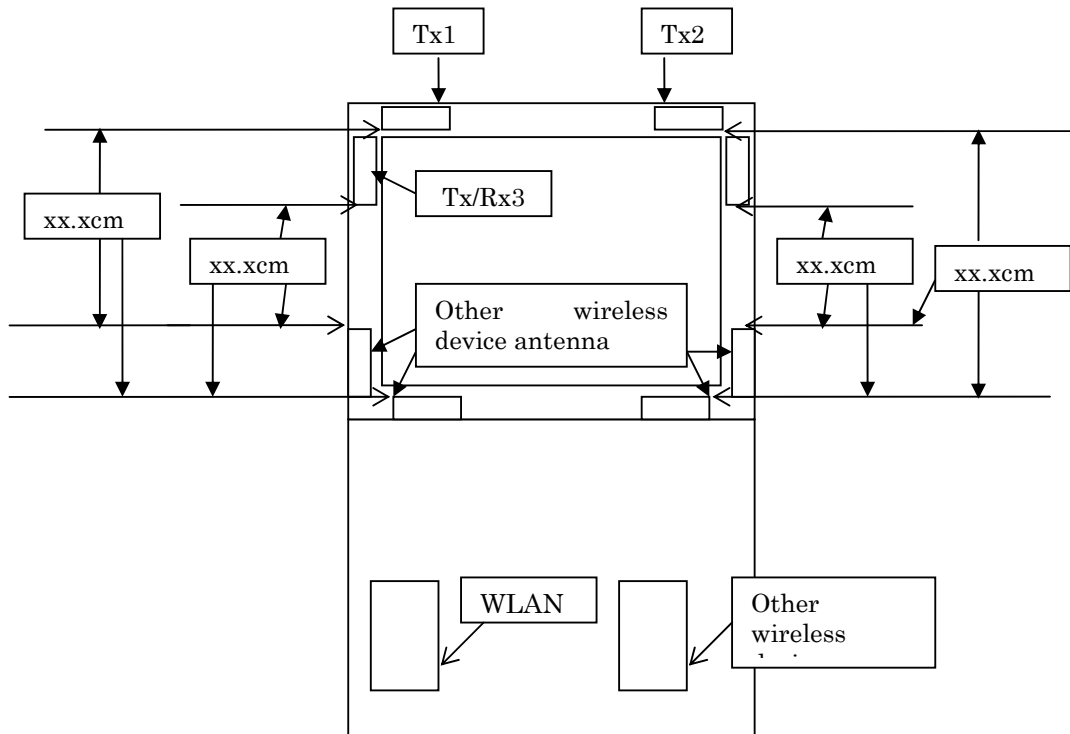
**Lmimo=150mm**

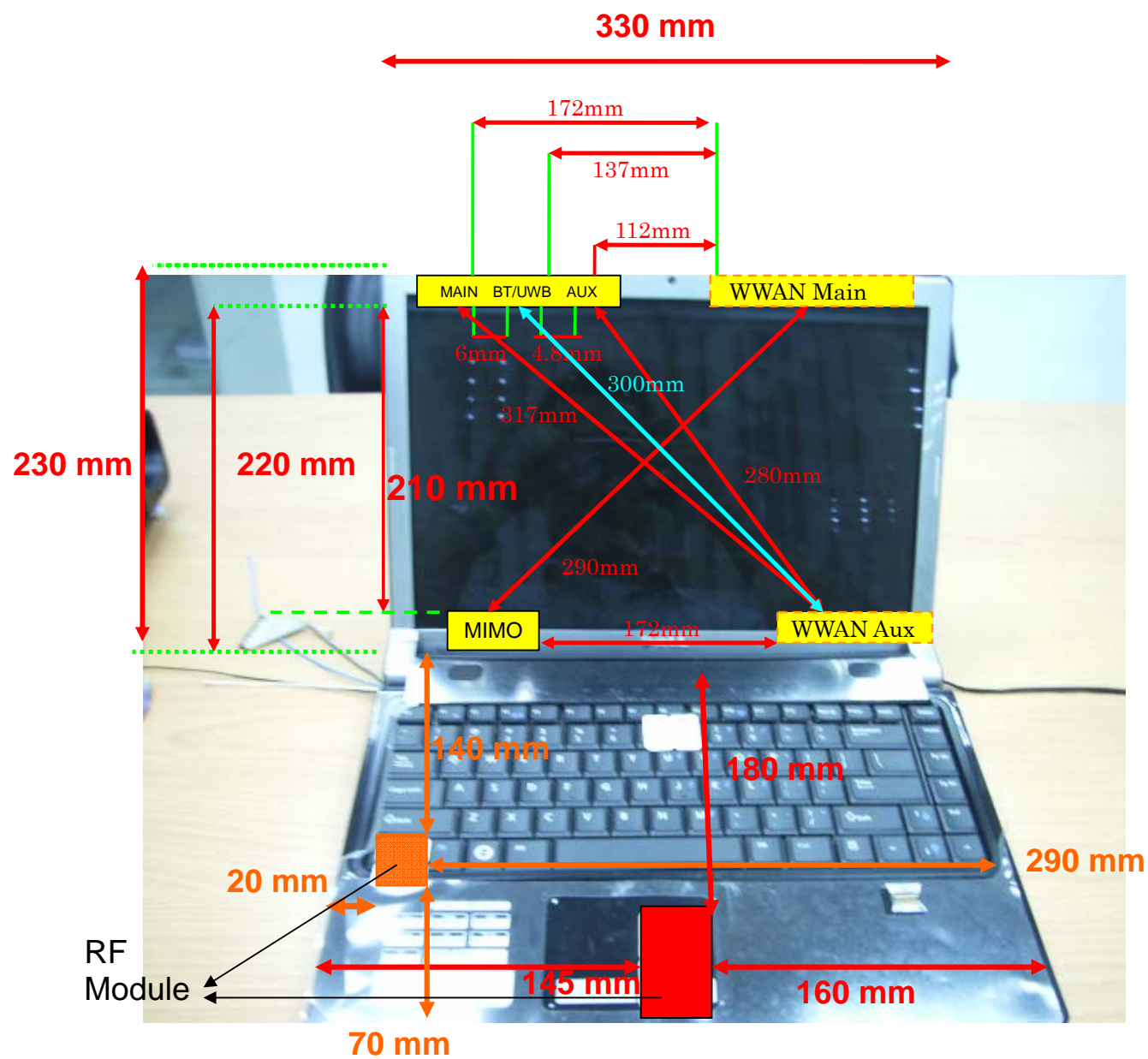


## Section 7. Diagram Example of Co-Location Antenna Separation

Include a **dimensioned photo or dimensioned drawing** showing the distance (mm) between all WLAN transmit antennas and other co-located radiator transmit antenna such as Bluetooth, WWAN,..

(Note: Due to the evolving rules regarding co-location, each platform will need to be reviewed on a case by case basis)





## **Section 8. Local representative contact information**

[Joseph\\_hoo@asus.com.tw](mailto:Joseph_hoo@asus.com.tw)

**Local representative contact information is required for regulatory support for target countries below.**