



SAR & HAC Instruments for Wireless • Consulting • Research • Standards • Compliance • Training

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: 24th May 2008
Released on: 24th 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

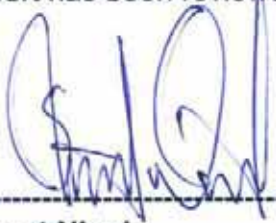
Conditions

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

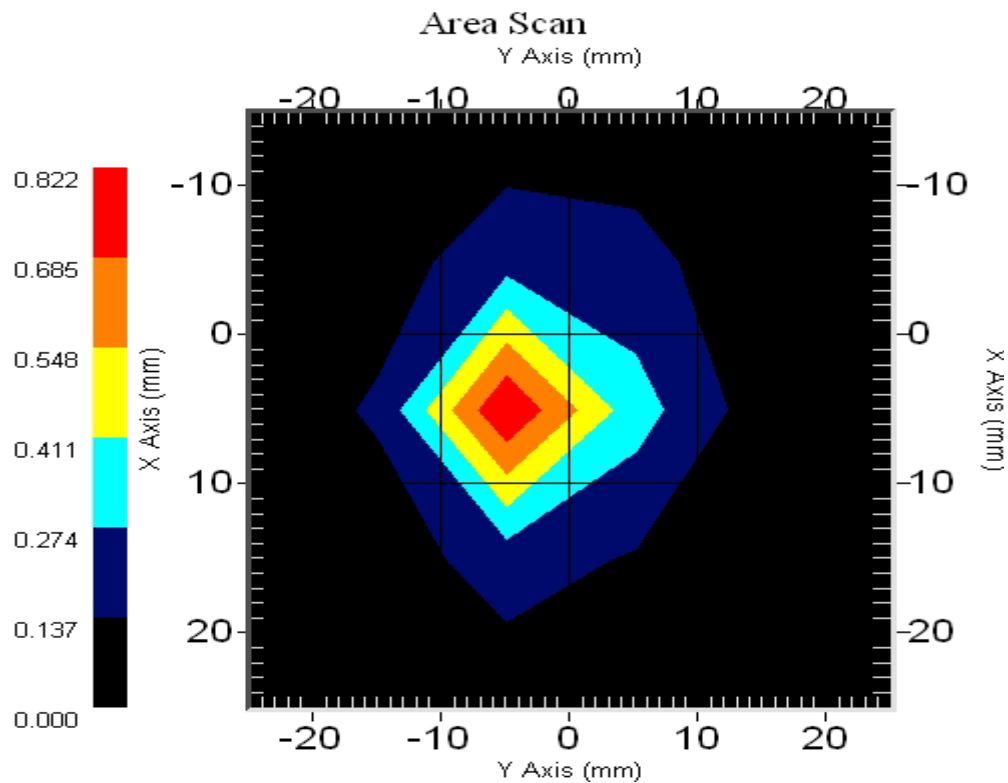
SWR: 1.22 U

Return Loss: -20.0 dB

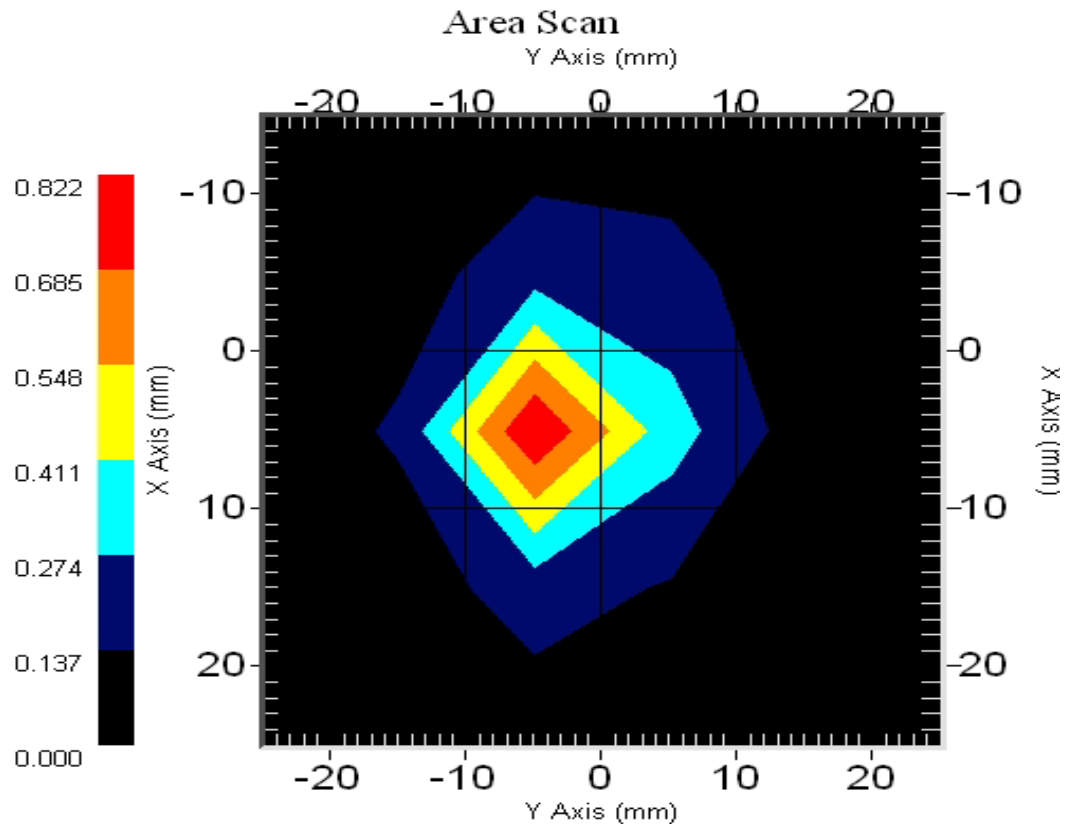
Impedance: 50.0 Ω

System Validation Results

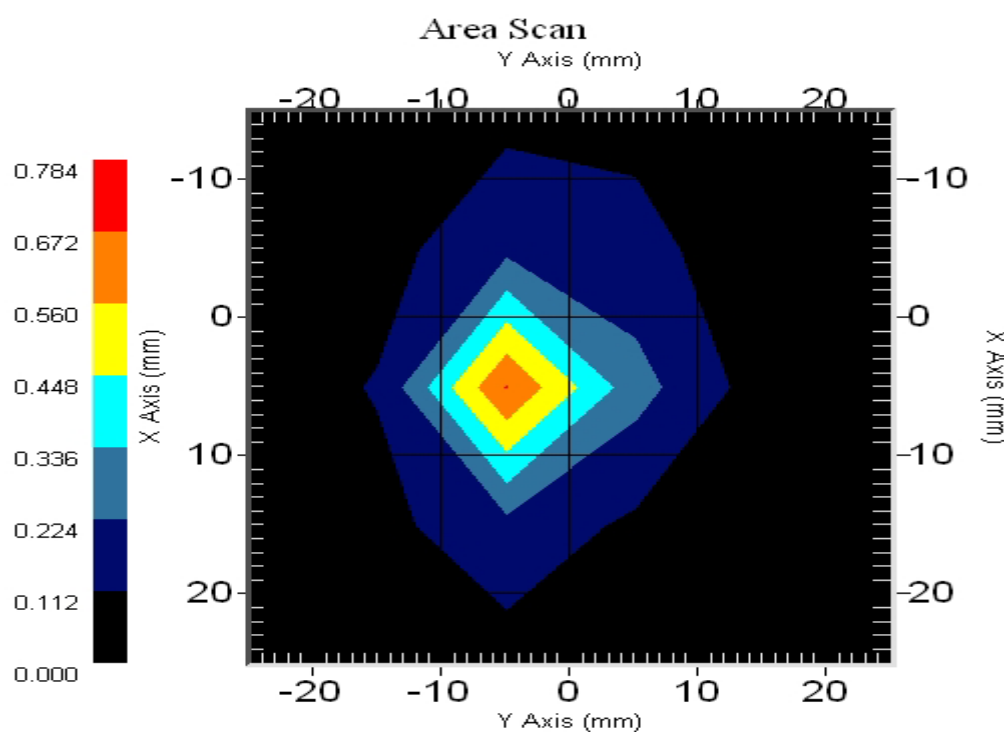
Frequency	1 Gram	10 Gram	Peak
5200 MHz	51.9	17.9	223.1



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, ϵ_r	47.0
Conductivity, σ [S/m]	5.30

Head Tissue 5600 MHz	Measured
Dielectric constant, ϵ_r	46.1
Conductivity, σ [S/m]	5.78

Head Tissue 5800 MHz	Measured
Dielectric constant, ϵ_r	46.7
Conductivity, σ [S/m]	6.22

Mechanical Verification

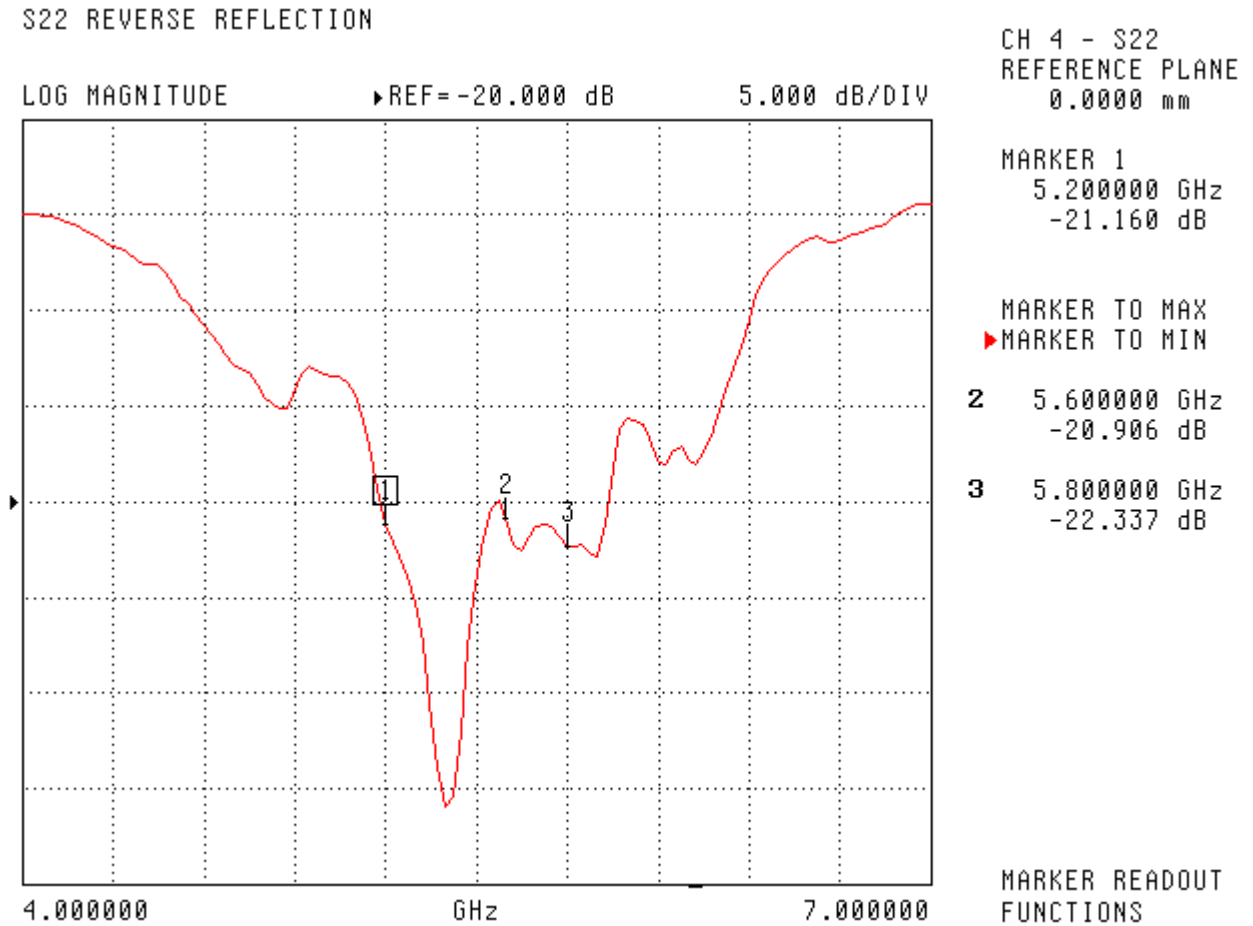
APREL Length	APREL Height	Measured Length	Measured Height
23.1 mm	20.7 mm	23.3 mm	20.3 mm

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.

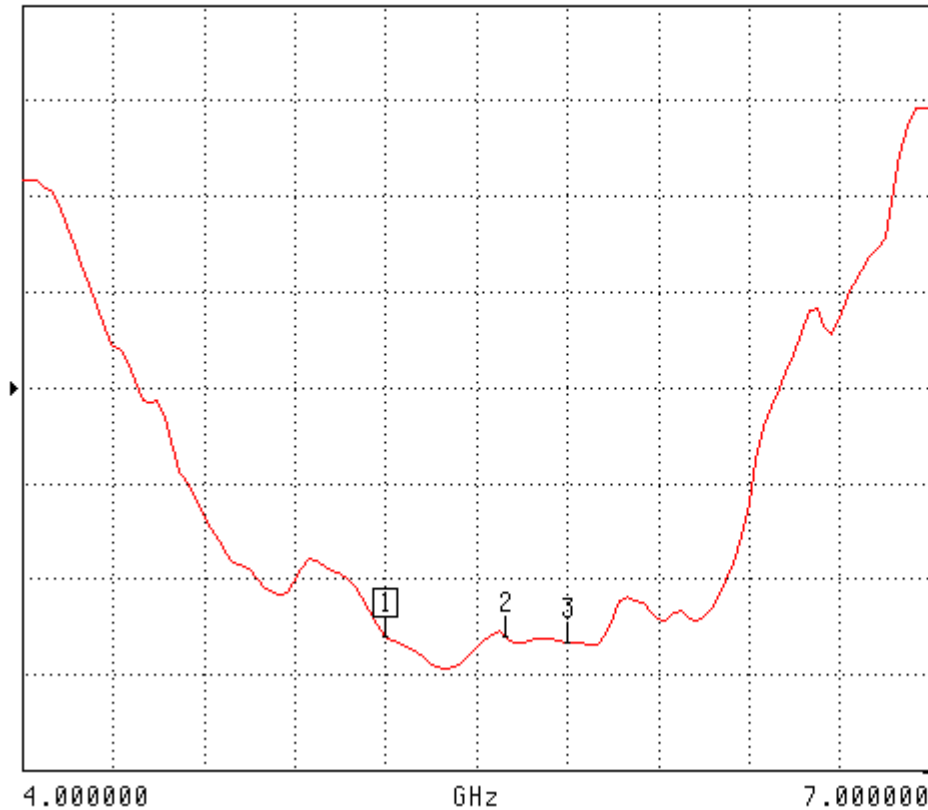
S11 Parameter Return Loss



SWR

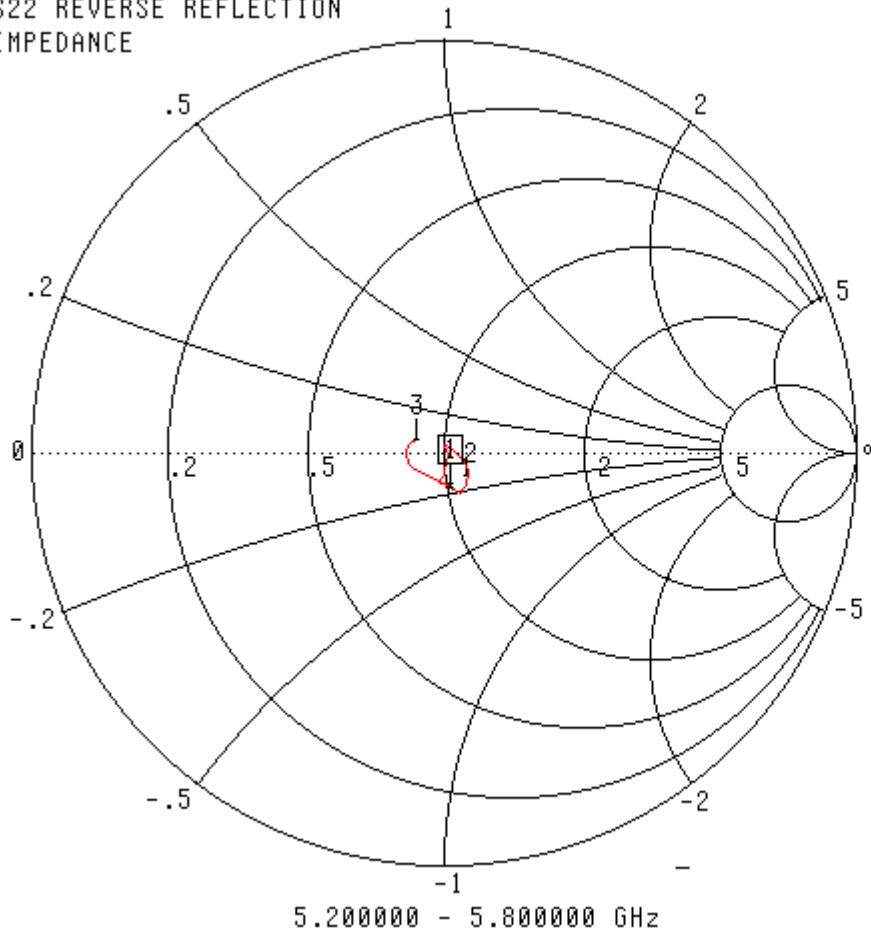
S22 REVERSE REFLECTION

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 Ω
-8.263 j Ω

MARKER TO MAX
▶ MARKER TO MIN

2 5.600000 GHz
51.084 Ω
-9.223 j Ω
3 5.800000 GHz
43.924 Ω
2.683 j Ω

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: 4th May 2008
Released on: 4th 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

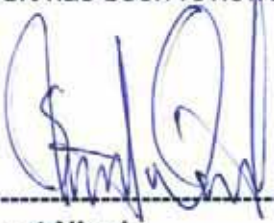
Conditions

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

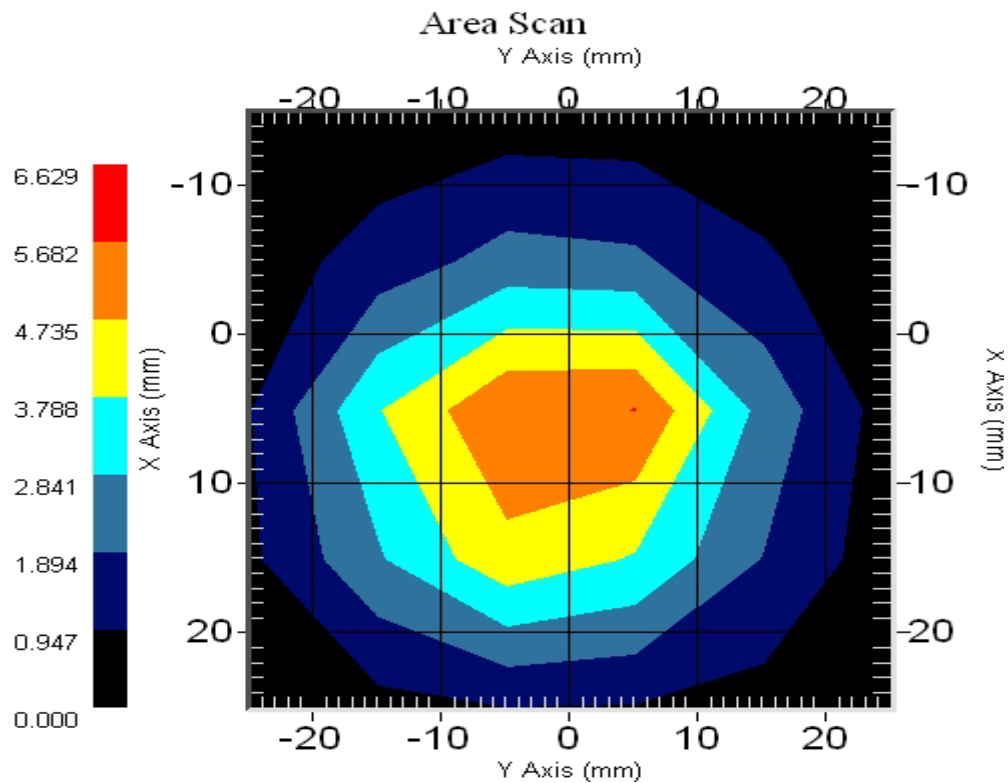
Length: 52.4 mm
Height: 30.3 mm

Electrical Specification

SWR: 1.056 U
Return Loss: -32.0 dB
Impedance: 50.2 Ω

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

APREL Length	APREL Height	Measured Length	Measured Height
51.5 mm	30.4 mm	52.4 mm	30.3 mm

Tissue Validation

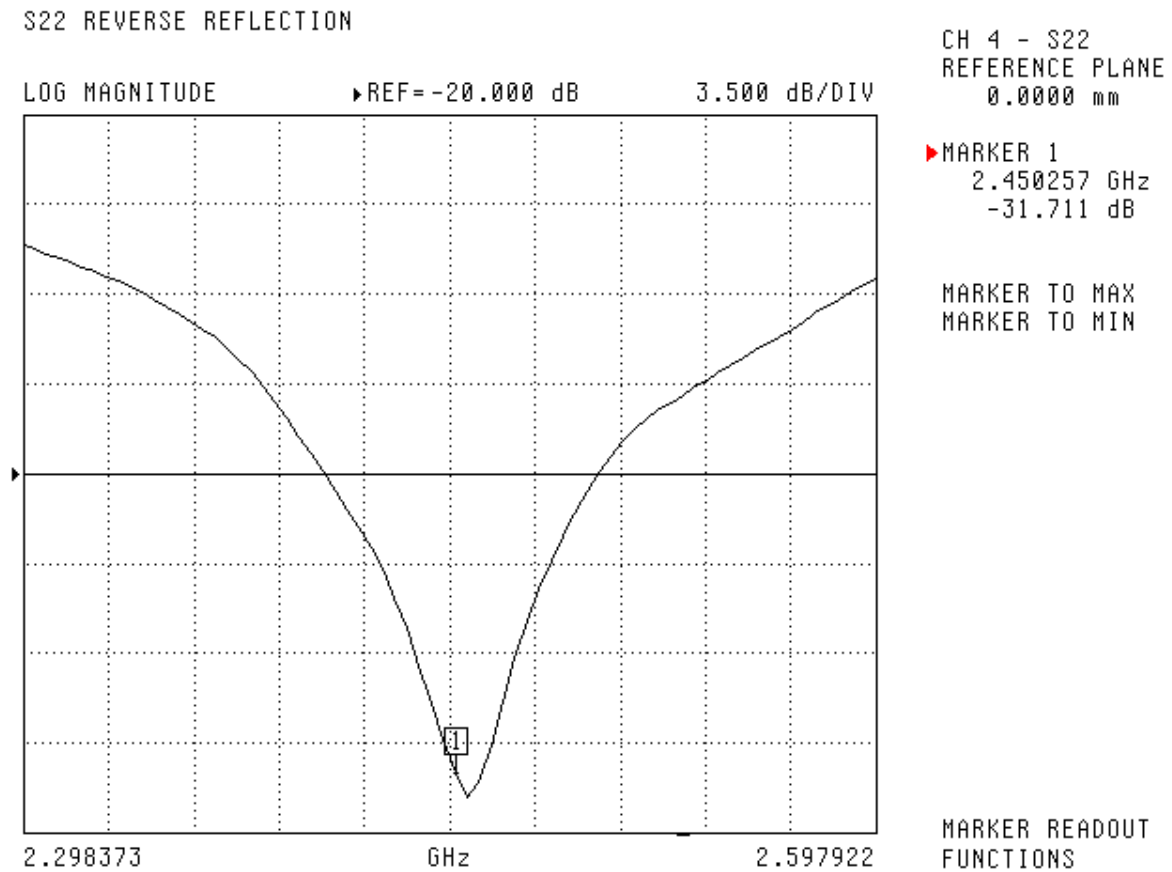
Head Tissue 2450 MHz	Measured
Dielectric constant, ϵ_r	39.2
Conductivity, σ [S/m]	1.80

Electrical Calibration

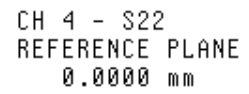
Test	Result
S11 R/L	-32.0 dB
SWR	1.05 U
Impedance	50.2 Ω

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

S11 Parameter Return Loss



S22 REVERSE REFLECTION



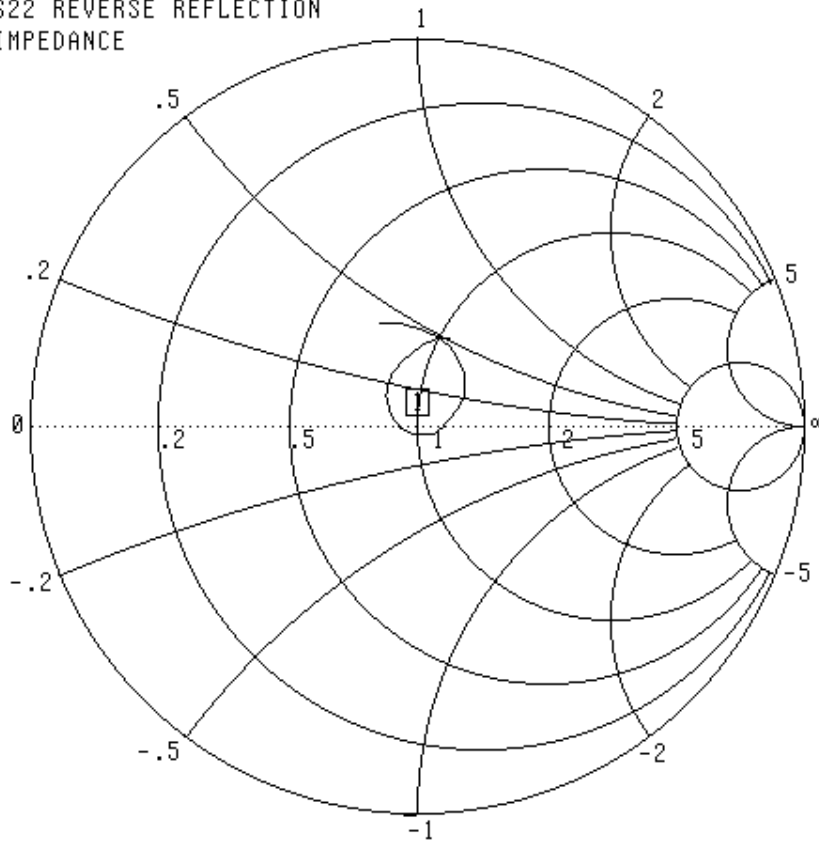
```
▶ MARKER 1
    2.450257 GHz
    1.051 U
```

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

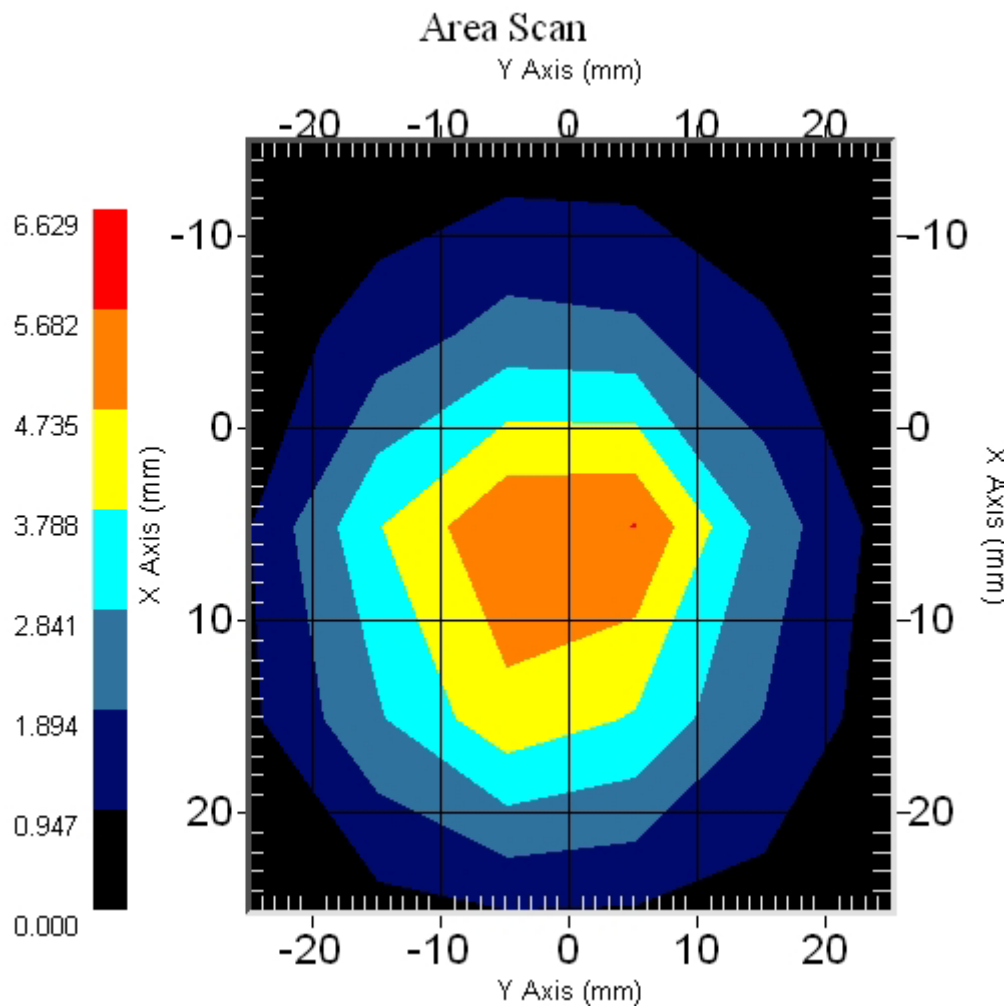
▶ MARKER 1
2.450257 GHz
50.225 Ω
-2.500 $j\Omega$

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: 3rd May 2008
Released on: 3rd 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

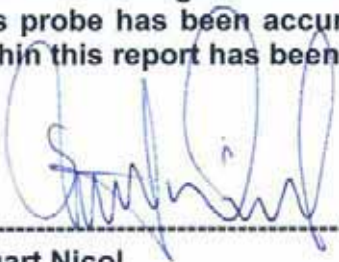
Conditions

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



Jesse Hones

Calibration Results Summary

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

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Y:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Z:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Diode Compression Point:	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.

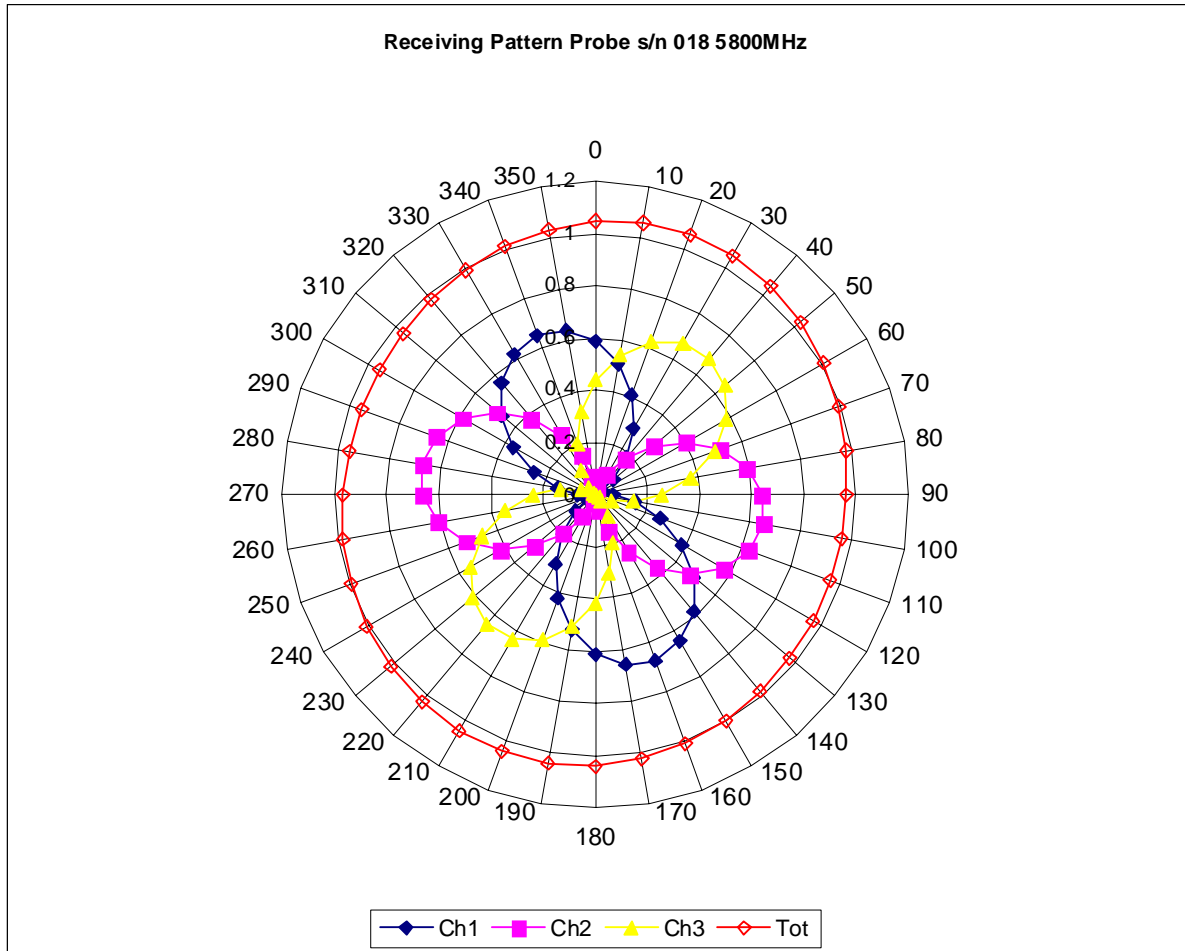
Broad Band Calibration:

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

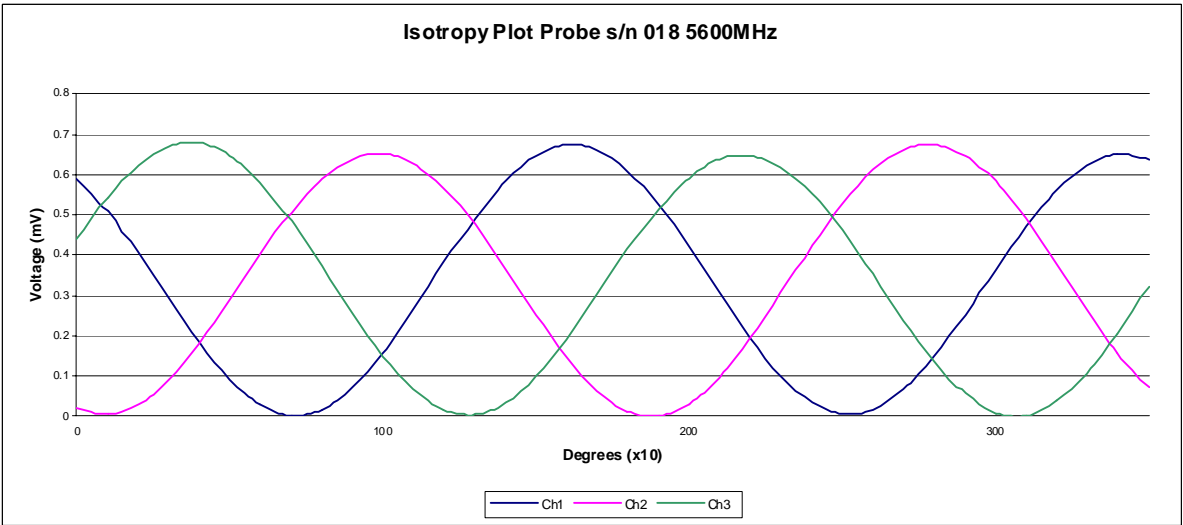
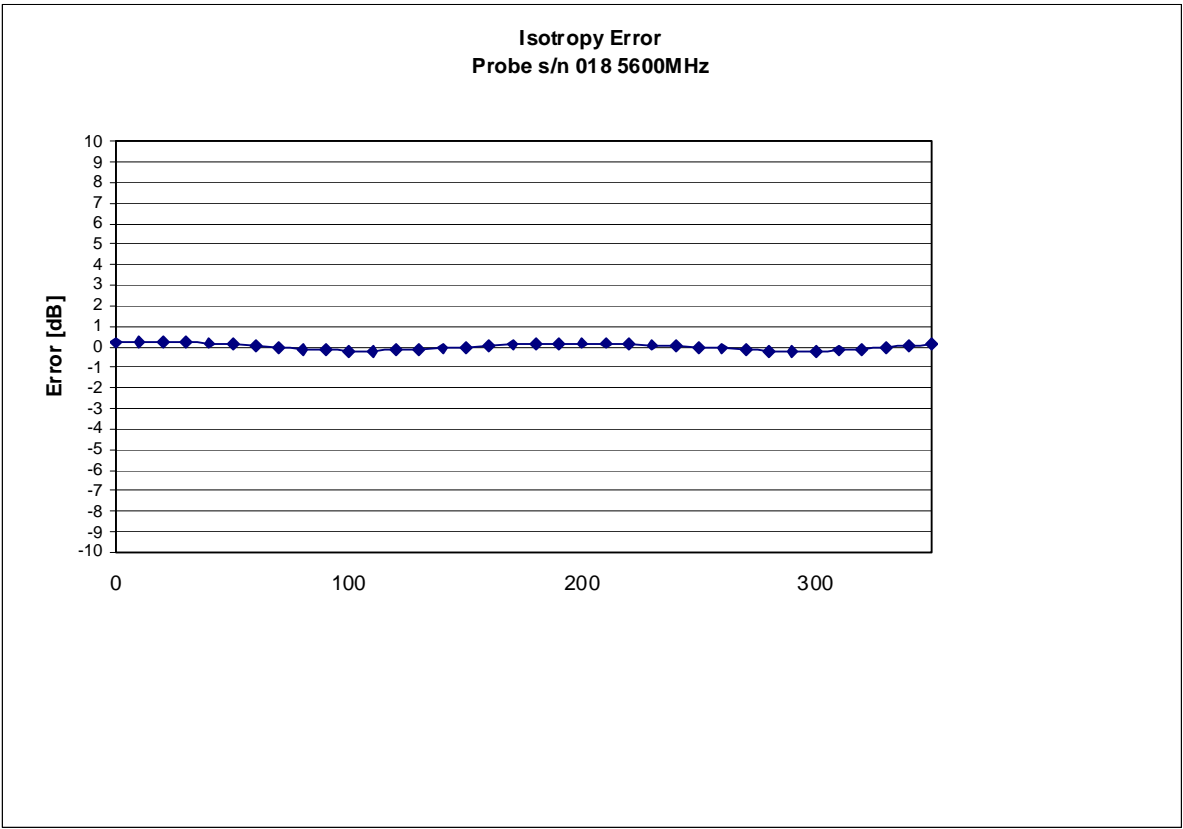
Deviation at -40MHz: -3.77%

Deviation at +40MHz: +4.28%

Receiving Pattern 5600 MHz (Air)



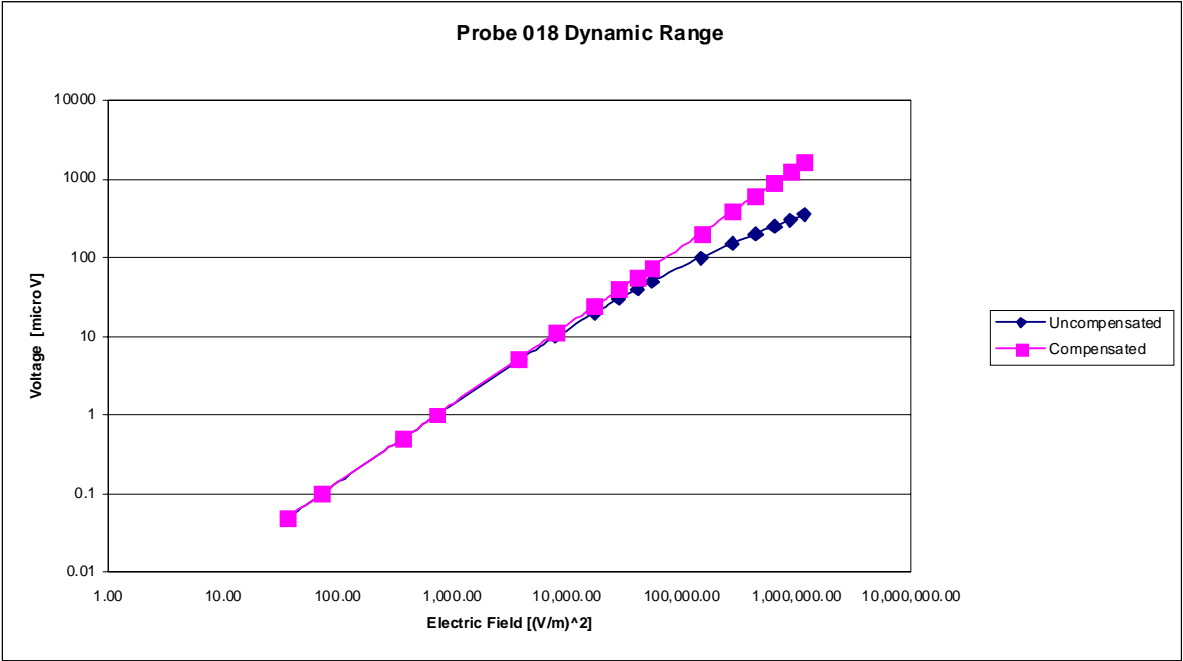
Isotropy Error 5600 MHz (Air)



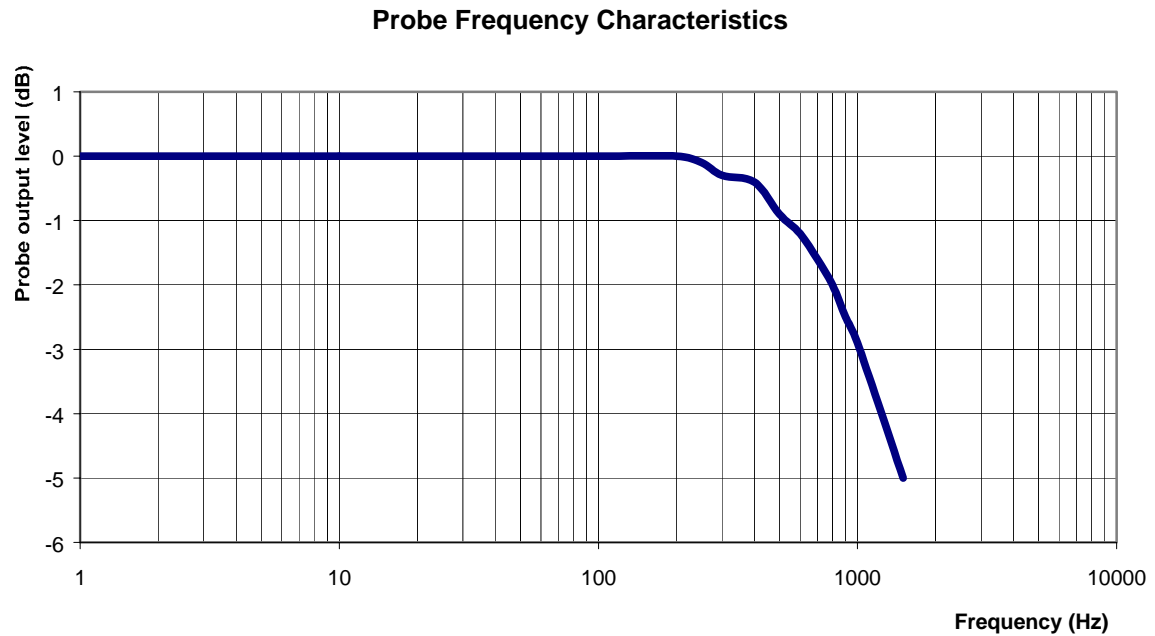
Isotropy in Tissue:

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

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 Ω .

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: 3rd May 2008
Released on: 3rd 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

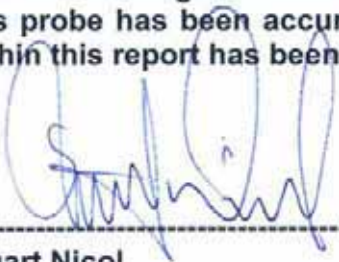
Conditions

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



Jesse Hones

Calibration Results Summary

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

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Y:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Z:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Diode Compression Point:	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.

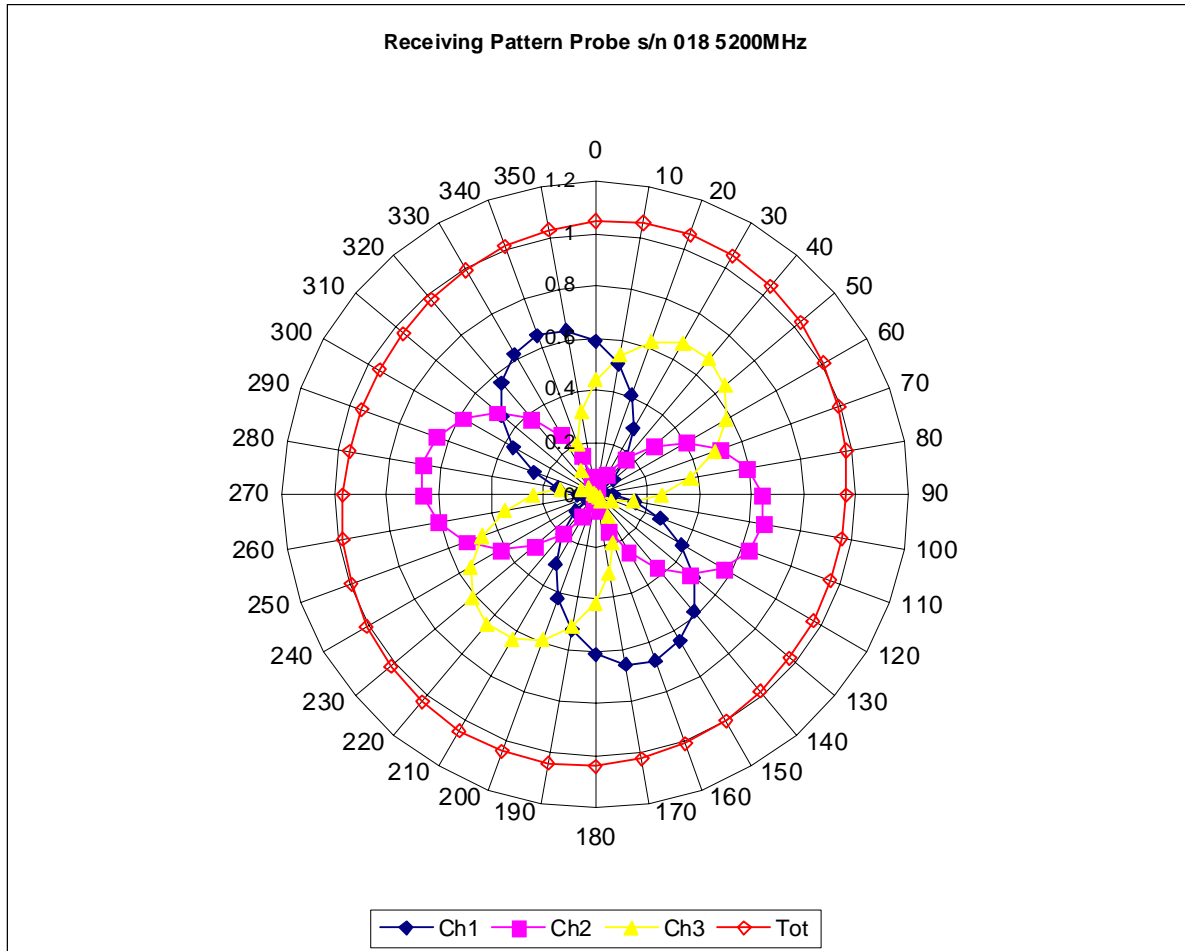
Broad Band Calibration:

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

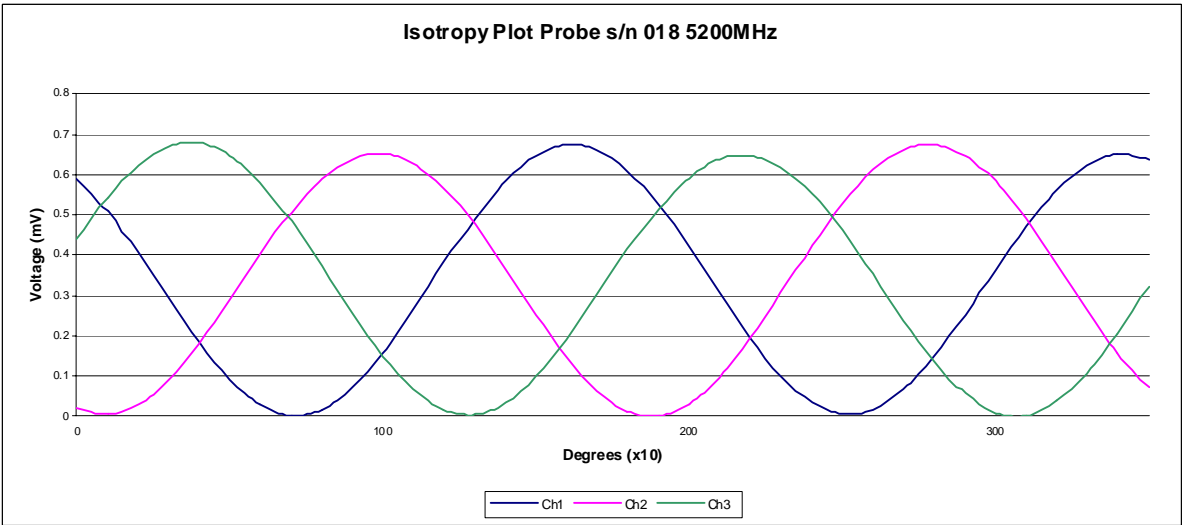
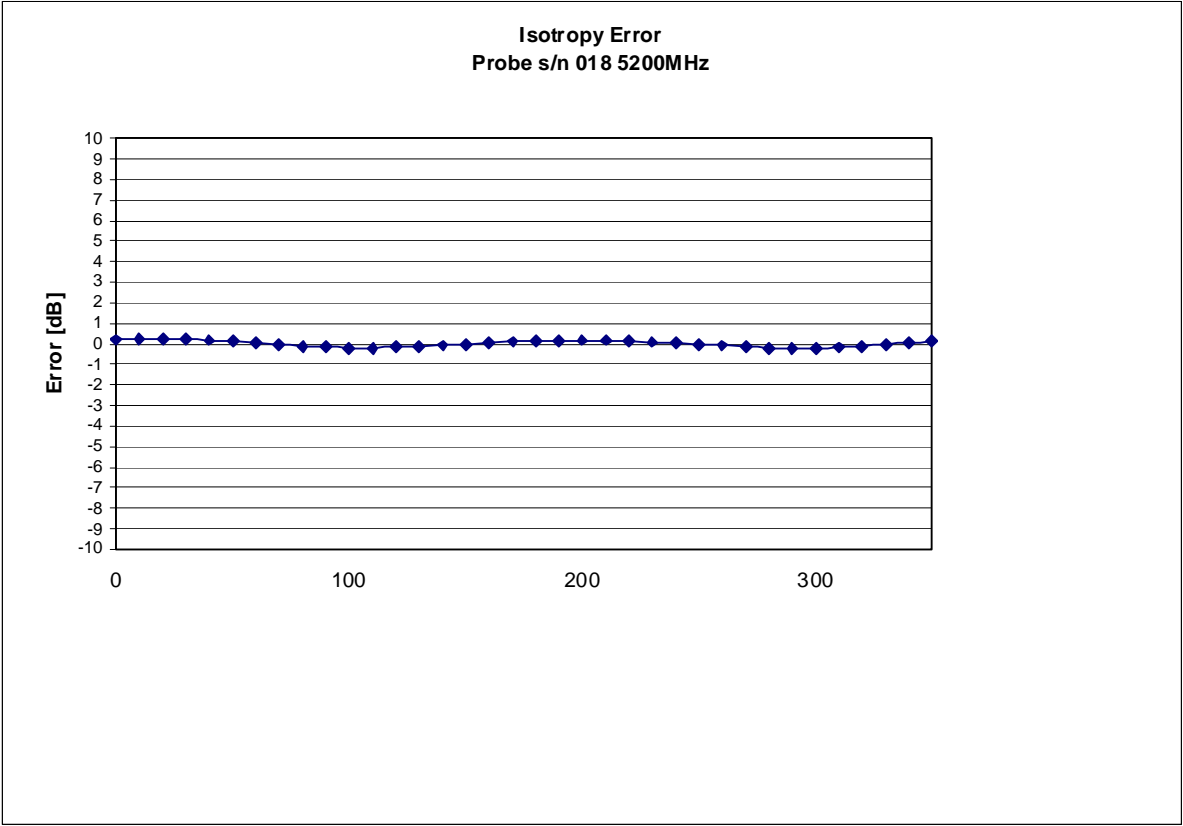
Deviation at -40MHz: -4.16%

Deviation at +40MHz: +2.78%

Receiving Pattern 5200 MHz (Air)



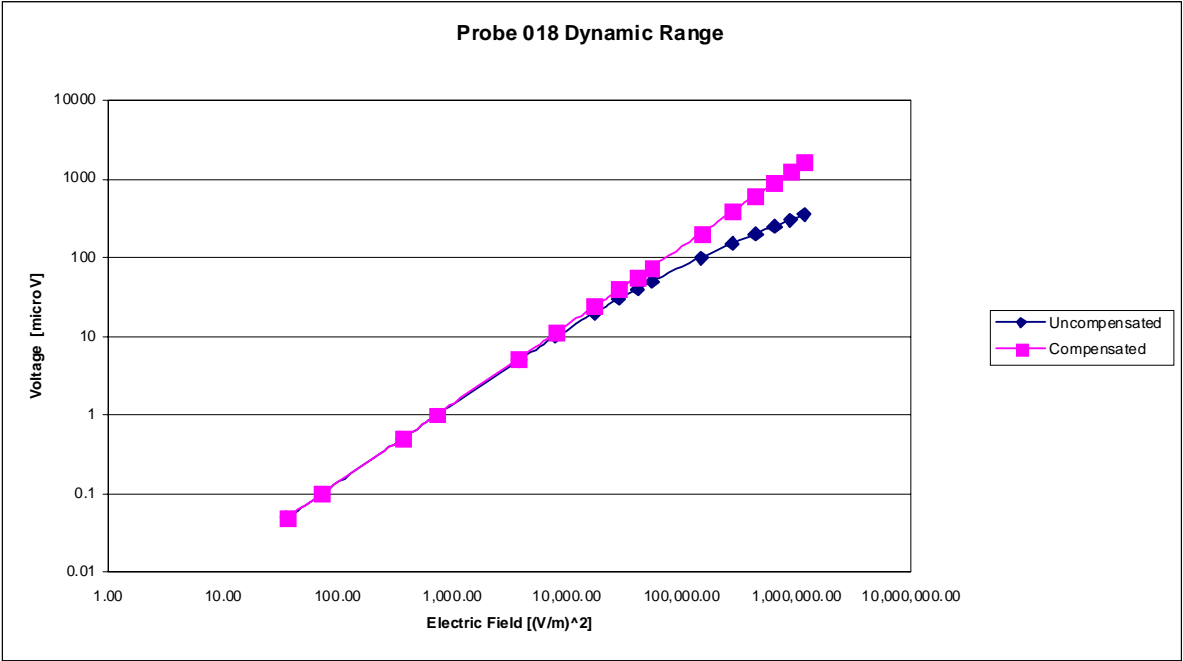
Isotropy Error 5200 MHz (Air)



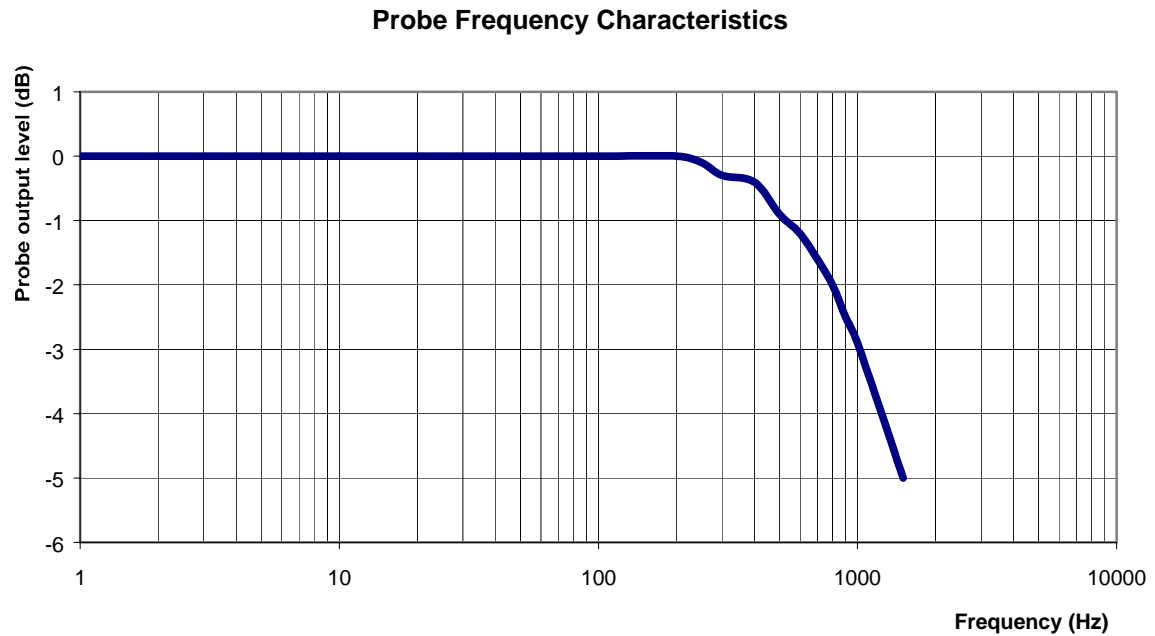
Isotropicity in Tissue:

0.10 dB

Dynamic Range



Video Bandwidth



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

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 Ω .

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: 3rd May 2008
Released on: 3rd 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

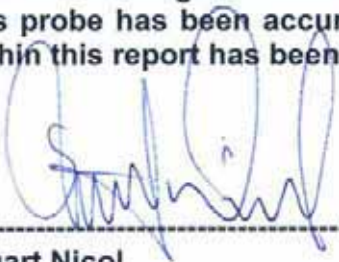
Conditions

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



Jesse Hones

Calibration Results Summary

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

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Y:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Z:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Diode Compression Point:	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.

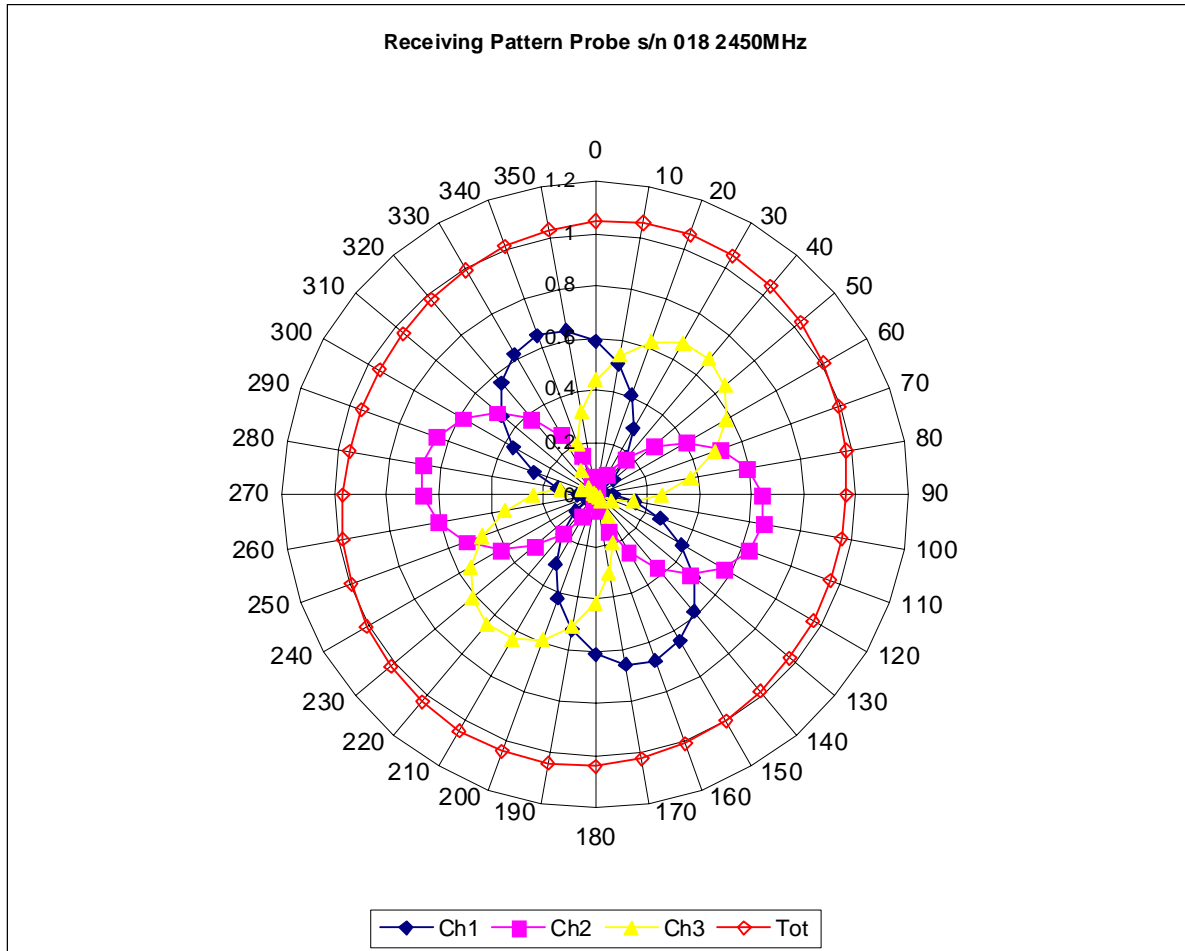
Broad Band Calibration:

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

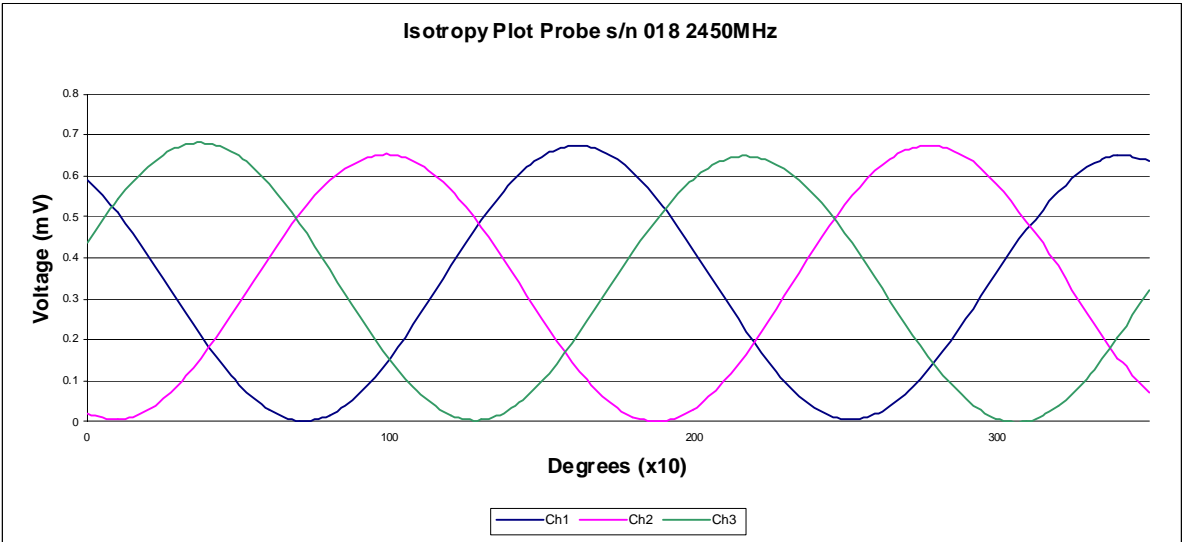
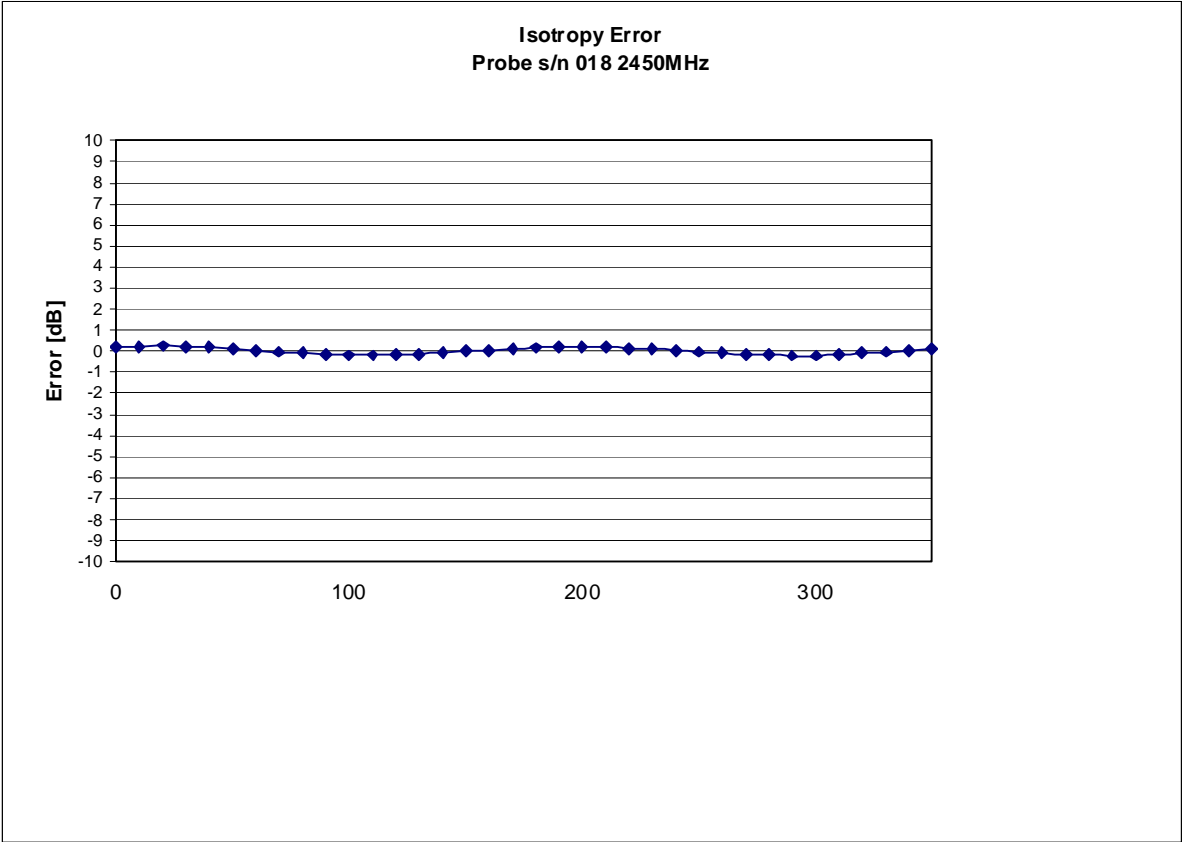
Deviation at -40MHz: -1.56%

Deviation at +40MHz: +1.3%

Receiving Pattern 2450 MHz (Air)



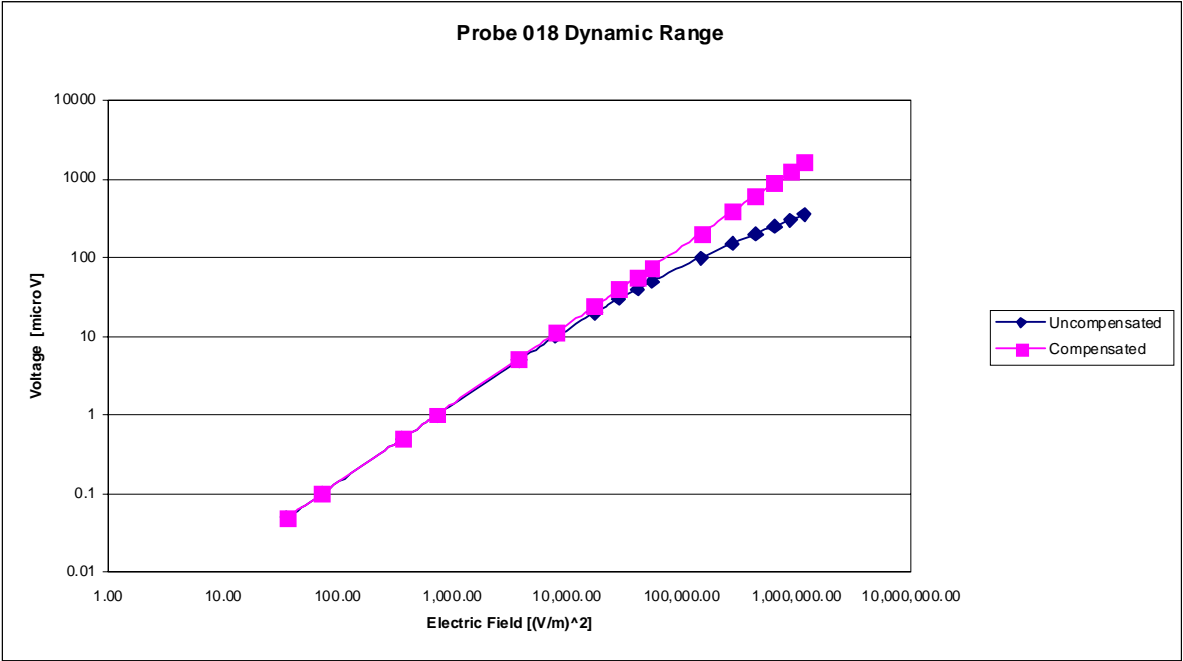
Isotropy Error 2450 MHz (Air)



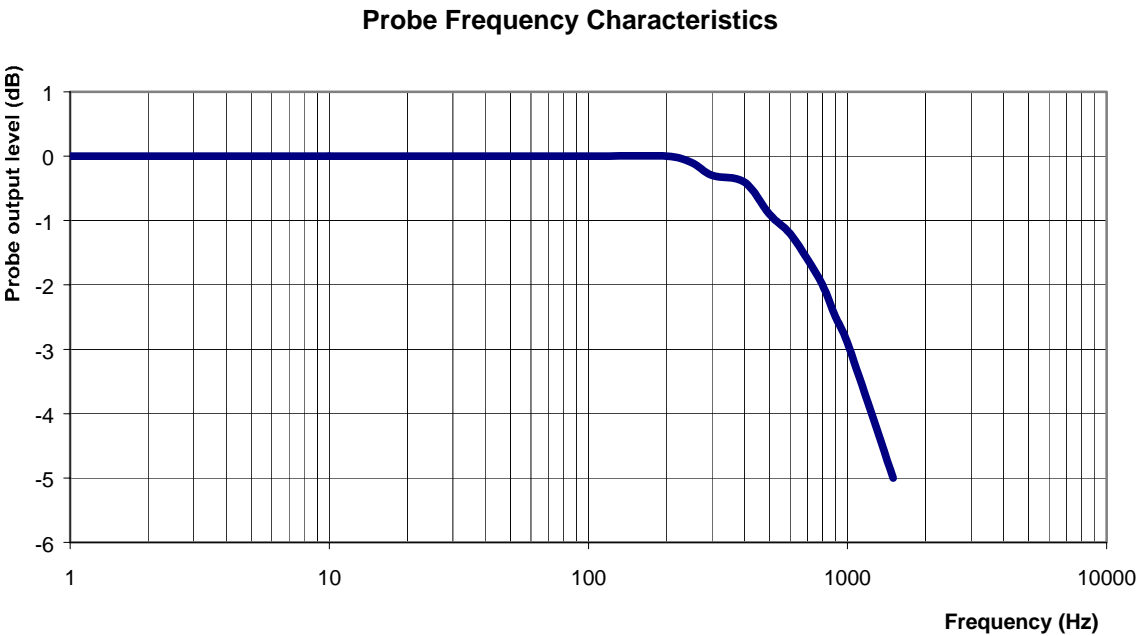
Isotropy in Tissue:

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

ConvF

Channel X: 4.01	7%(K=2)
Channel Y: 4.01	7%(K=2)
Channel Z: 4.01	7%(K=2)

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

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: 3rd May 2008
Released on: 3rd 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

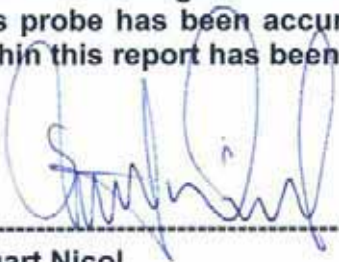
Conditions

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



Jesse Hones

Calibration Results Summary

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

*Resistive to recommended tissue recipes per IEEE-1528

Sensitivity in Air

Channel X:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Y:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Channel Z:	$1.2 \mu\text{V}/(\text{V}/\text{m})^2$
Diode Compression Point:	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.

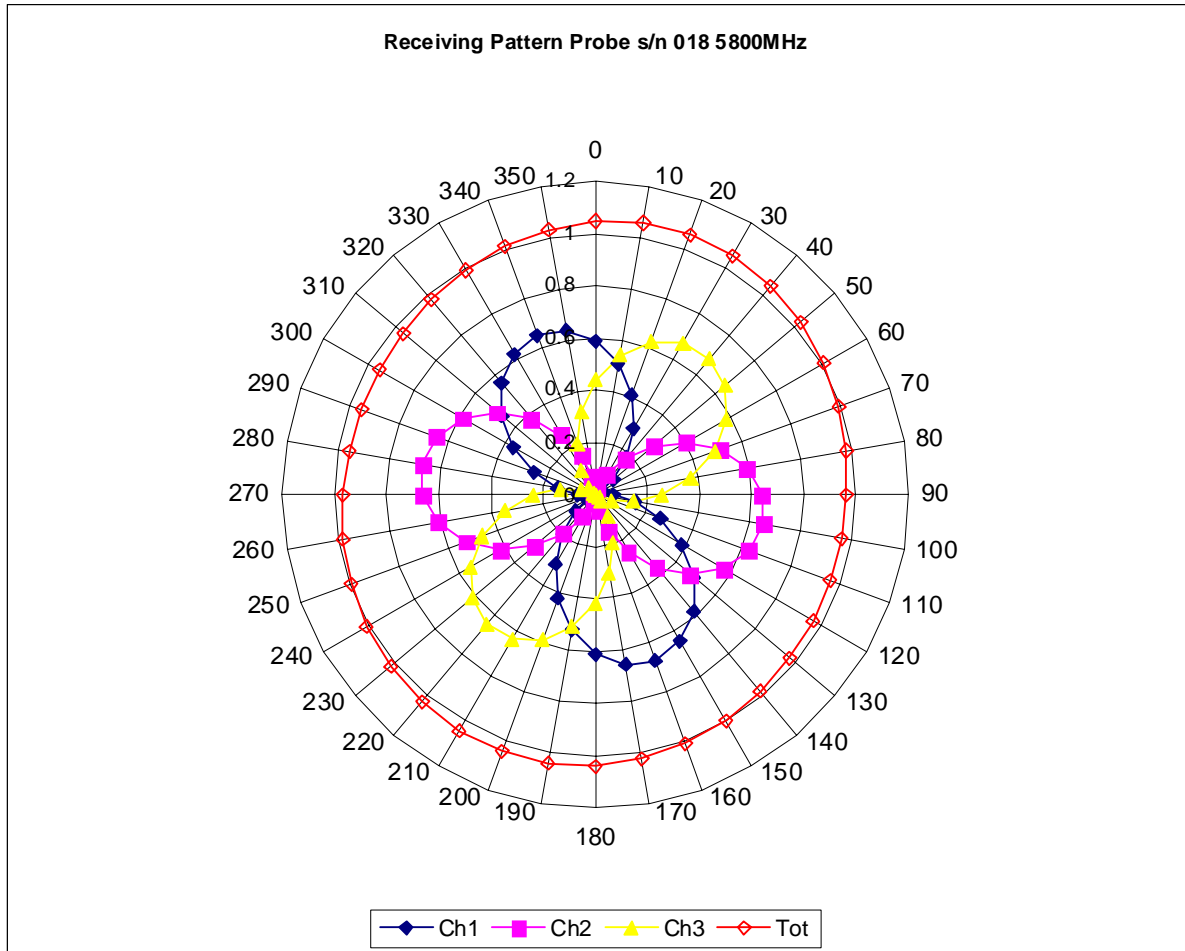
Broad Band Calibration:

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

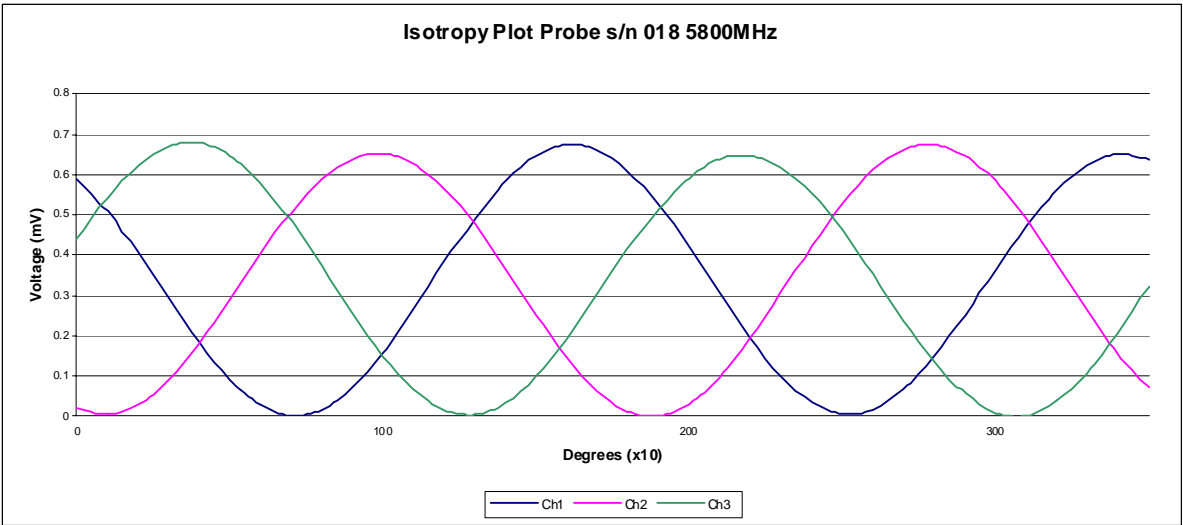
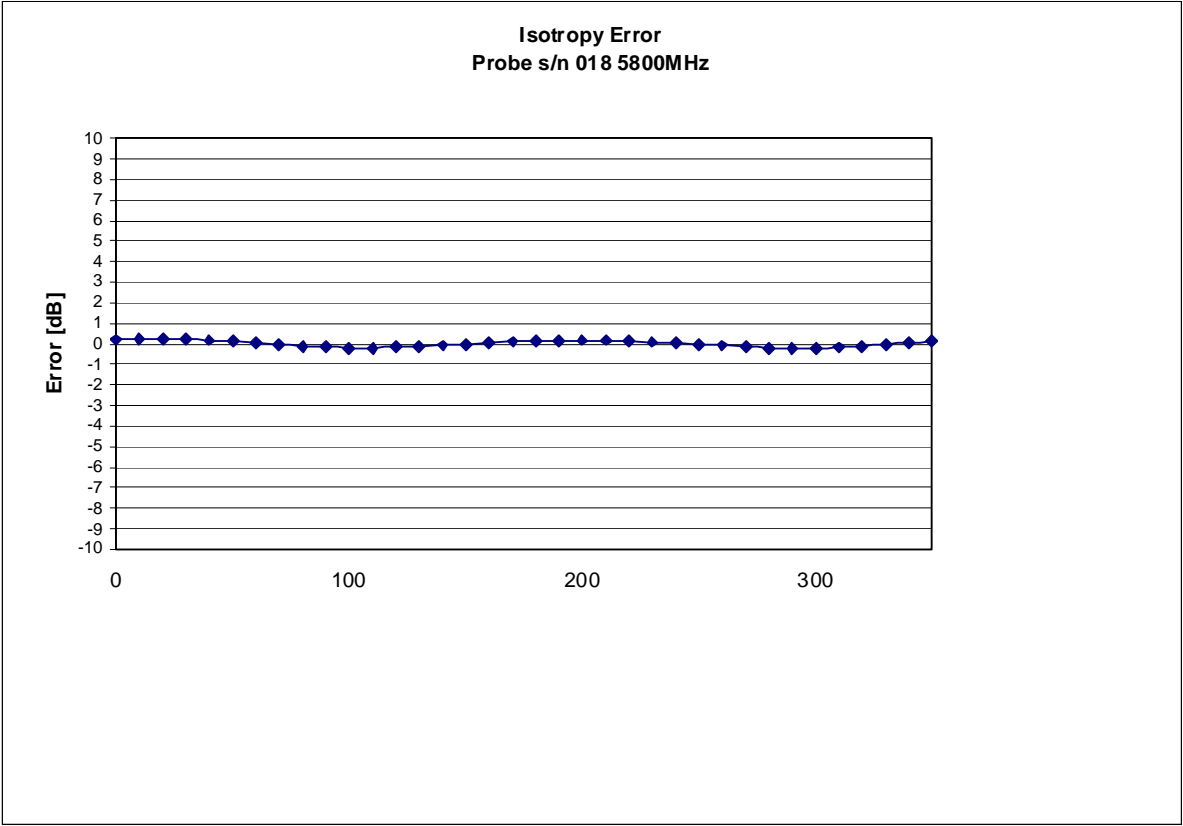
Deviation at -40MHz: -3.07%

Deviation at +40MHz: +3.22%

Receiving Pattern 5800 MHz (Air)



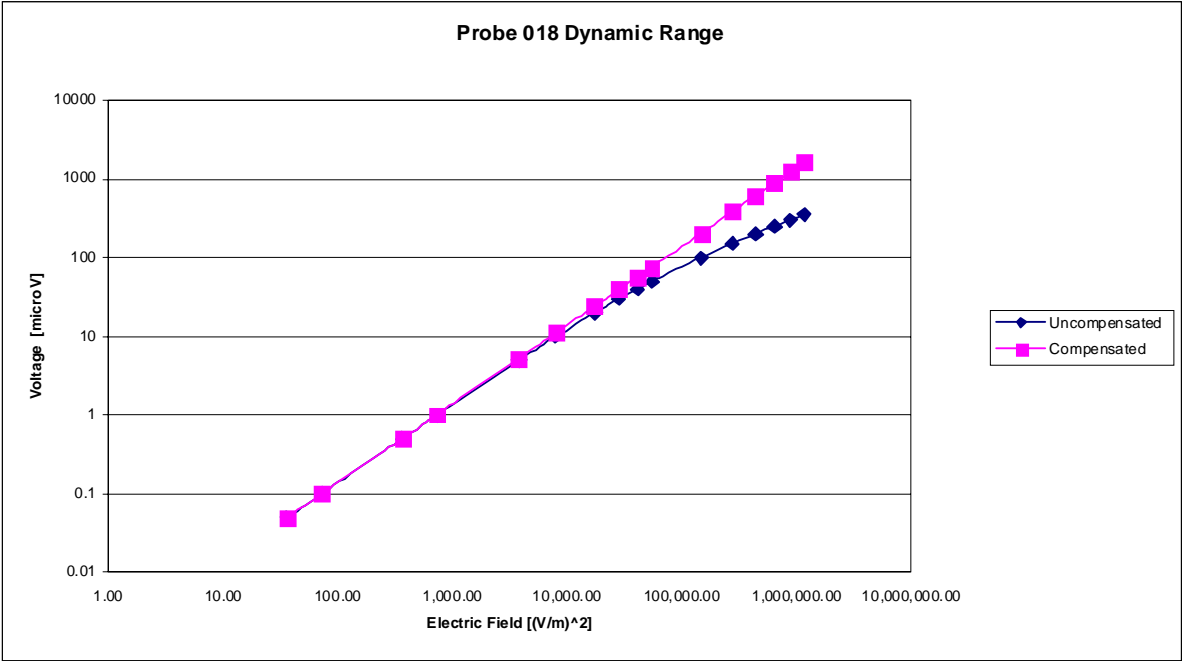
Isotropy Error 5800 MHz (Air)



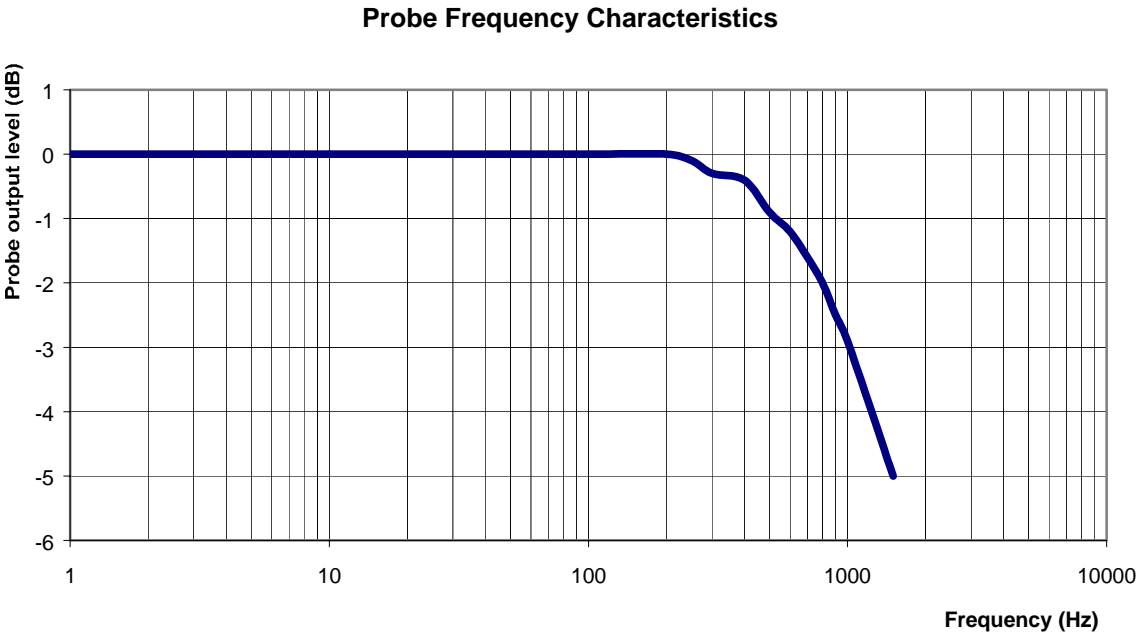
Isotropy in Tissue:

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 MΩ.

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

Platform	
Platform Owner	DELL
Brand Name	DELL
Model Name	Pacino
ODM	Quanta
Target Launch Date	
Antenna	
Brand Name	Amphenol Taiwan Corporation
Part Number	■ Tx1 Antenna: QT0932-11-001-R
	■ Tx2 Antenna: QT0932-11-001-R
	■ Tx3 (or Rx3) Antenna: QT0932-11-004-R
Module	
With WLAN Module	■ 512AN_HMW
(Check Box)	■ 533AN_HMW

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 3rd 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)
(P/N: QT0932-11-001 -R) Tx1 antenna	Amphenol Taiwan Corporation	PIFA/ Metal stamping, carrier, Foil	(P/N: GBE RF 113XL5)) 50 ohm Coaxial. length:66.8cm diameter:1.13mm Connector: IPEX	2400-2500MHz 1.98dBi (peak)	2400-2500MHz 3.69dBi (peak)	2400-2500MHz 1.63 max	2400-2500MHz 1.71dBi (peak)
				5150-5350MHz 0.52dBi (peak)	5150-5350MHz 3.33dBi (peak)	5150-5350MHz 1.81max	5150-5350MHz 2.81dBi (peak)
				5470-5725MHz 3.23dBi (peak)	5470-5725MHz 6.08dBi (peak)	5470-5725MHz 1.58 max	5470-5725MHz 2.85dBi (peak)
				5725-5850MHz 3.23dBi (peak)	5725-5850MHz 6.13dBi (peak)	5725-5850MHz 1.57max	5725-5850MHz 2.9dBi (peak)
(P/N: QT0932-11-001 -R) Tx2 antenna	Amphenol Taiwan Corporation	PIFA/ Metal stamping, carrier, Foil	(P/N: GBE RF 113XL5)) 50 ohm Coaxial. length: 67.4cm diameter:1.13mm Connector: IPEX	2400-2500MHz 3.06dBi (peak)	2400-2500MHz 4.84dBi (peak)	2400-2500MHz 2.08 max	2400-2500MHz 1.78dBi (peak)
				5150-5350MHz -0.27dBi (peak)	5150-5350MHz 2.54dBi (peak)	5150-5350MHz 1.53max	5150-5350MHz 2.81dBi (peak)
				5470-5725MHz 2.5dBi (peak)	5470-5725MHz 5.35dBi (peak)	5470-5725MHz 1.37max	5470-5725MHz 2.85dBi (peak)
				5725-5850MHz 2.5dBi (peak)	5725-5850MHz 5.4dBi (peak)	5725-5850MHz 1.73max	5725-5850MHz 2.9dBi (peak)
(P/N: QT0932-11-004 -R) Tx3 (or Rx3) antenna	Amphenol Taiwan Corporation	PIFA/ Metal stamping, carrier, Foil	(P/N: GBE RF 113XL5)) 50 ohm Coaxial. length:45.4cm diameter:1.13mm Connector: IPEX	2400-2500MHz -1.74dBi (peak) *	2400-2500MHz 0.6dBi (peak) *	2400-2500MHz 2.38max *	2400-2500MHz 1.14dBi (peak) *
				5150-5350MHz -0.94dBi (peak) *	5150-5350MHz 0.92dBi (peak) *	5150-5350MHz 1.67 max *	5150-5350MHz 1.86dBi (peak) *
				5470-5725MHz -0.87dBi (peak) *	5470-5725MHz 1.04dBi (peak) *	5470-5725MHz 2.46max *	5470-5725MHz 1.91dBi (peak) *
				5725-5850MHz -0.41dBi (peak) *	5725-5850MHz 1.54dBi (peak) *	5725-5850MHz 2.47 max *	5725-5850MHz 1.95dBi (peak) *

NOTE:

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

Antenna Peak Gain Table:

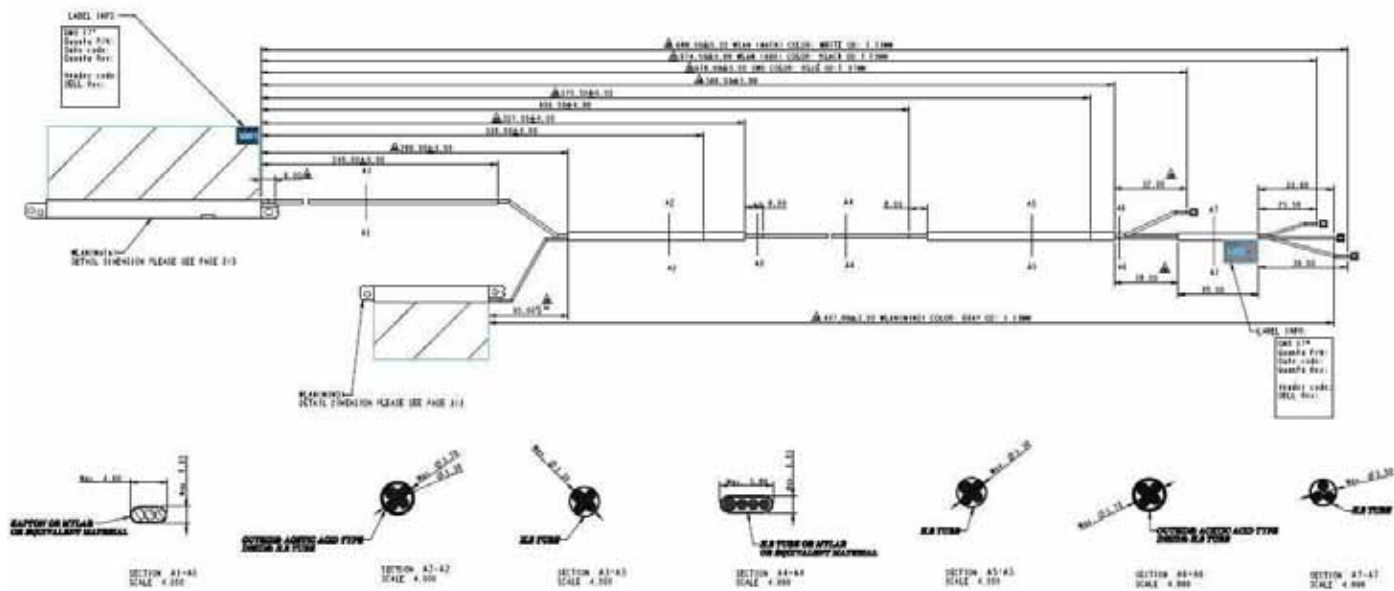
	Tx1 antenna		Tx2 Antenna		Tx3 (or Rx3) Antenna	
Frequency (MHz)	Horizontal (dBi)	Vertical (dBi)	Horizontal (dBi)	Vertical (dBi)	Horizontal (dBi)	Vertical (dBi)
2400	-0.77	-5.51	1.03	-0.38	-3.83	-3.78
2450	1.14	-2.77	1.21	-0.14	-4.46	-4.36
2500	-0.91	-2.95	1.85	0.31	-5.45	-4.54
5150	-1.43	-3.26	-2.71	-2.8	-5.71	-1.44
5250	-2.47	-3.48	-5.8	-3.43	-6.16	-2.44
5350	-0.06	-3.57	-2.18	-0.38	-4.02	-2.3
5470	-0.44	-1.93	-1.3	0.03	-3.47	-2.25
5600	-0.83	-0.92	-3.47	1.36	-2.87	-1.82
5725	2.61	-2.35	-2.44	2.17	-2.16	-1.34
5785	0.26	-1.76	-3.86	-0.83	-2.96	-2.16
5850	0.45	-1.79	-3.21	0.98	-3.33	-0.81

- Antenna Peak Gain required being test in system basis.
- 1E frame contend absolutely peak antenna gain include H/V
- If Rx3 only (3rd 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:

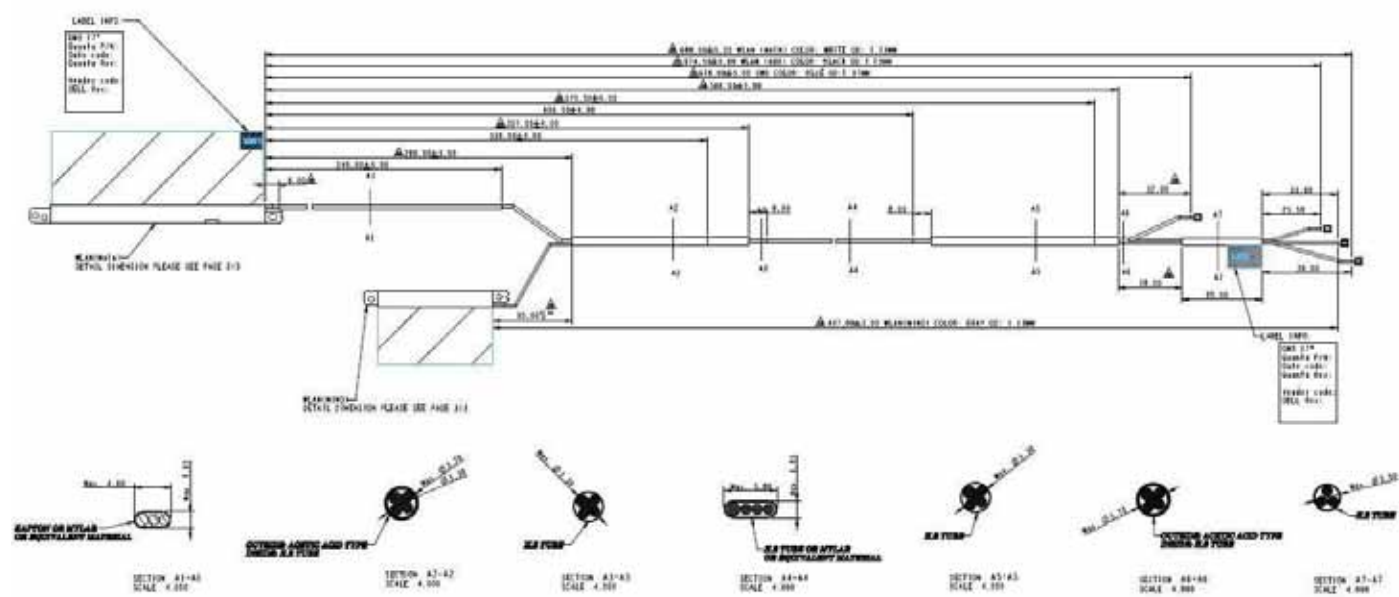


Tx1 Antenna Photo:



Include a dimensioned photo and dimensioned drawing of Tx2 antenna here.

Tx2 Antenna Dimensioned Drawing:

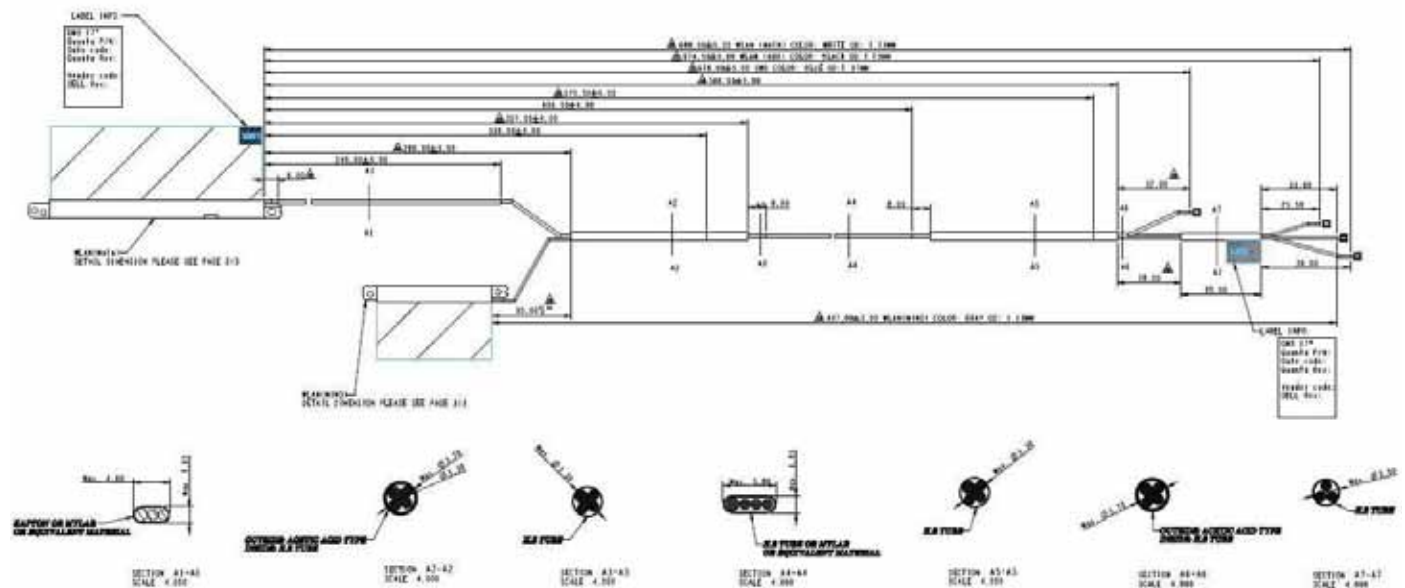


Tx2 Antenna Photo:



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

Tx3 (or Rx3) Antenna Dimensioned Drawing:



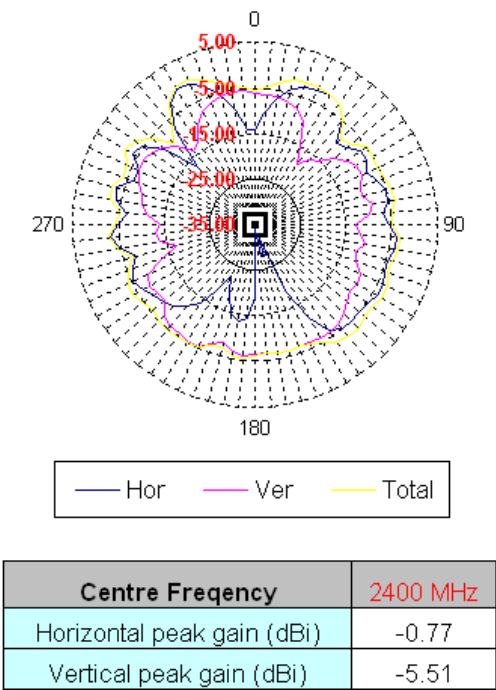
Tx3 (or Rx3) Antenna Photo:



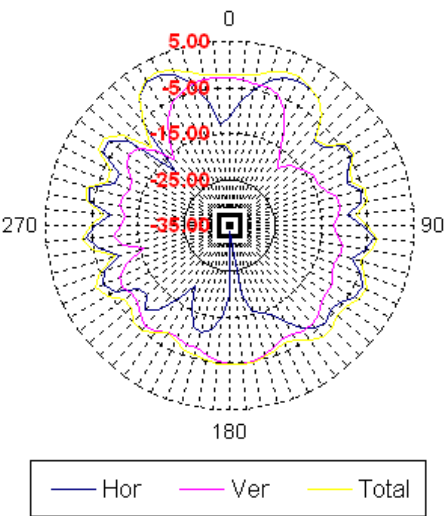
Section 3. Radiation characteristics of antennae Loaded in Host Platform

2400-2500MHz radiation characteristic

Tx1 antenna: 2400 MHz

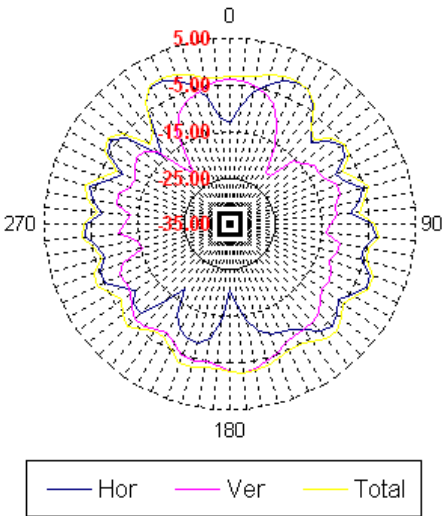


Tx1 antenna: 2450 MHz



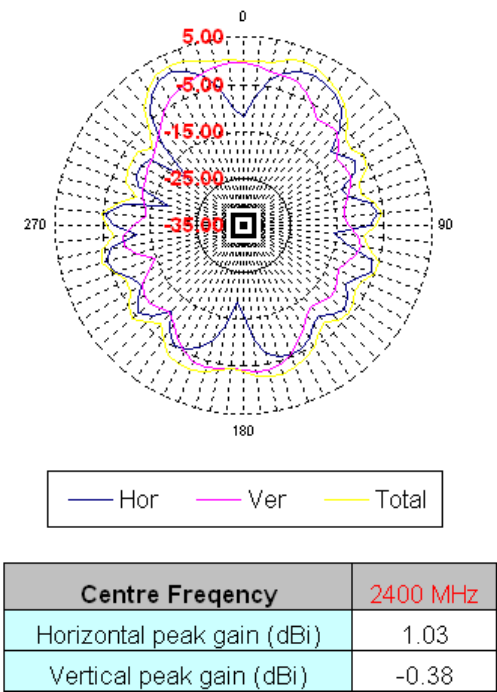
Centre Frequency	2450 MHz
Horizontal peak gain (dBi)	1.14
Vertical peak gain (dBi)	-2.77

Tx1 antenna: 2500 MHz

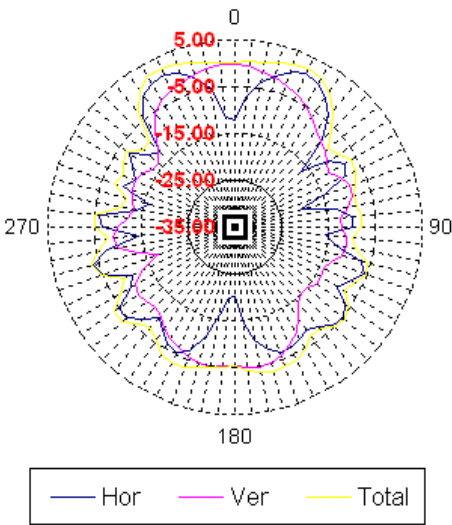


Centre Frequency	2500 MHz
Horizontal peak gain (dBi)	-0.91
Vertical peak gain (dBi)	-2.95

Tx2 antenna: 2400 MHz

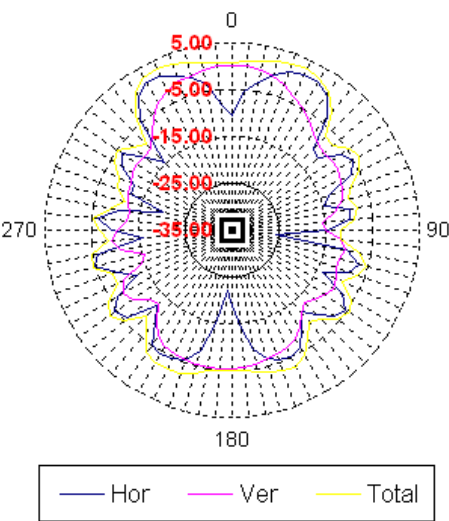


Tx2 antenna: 2450 MHz



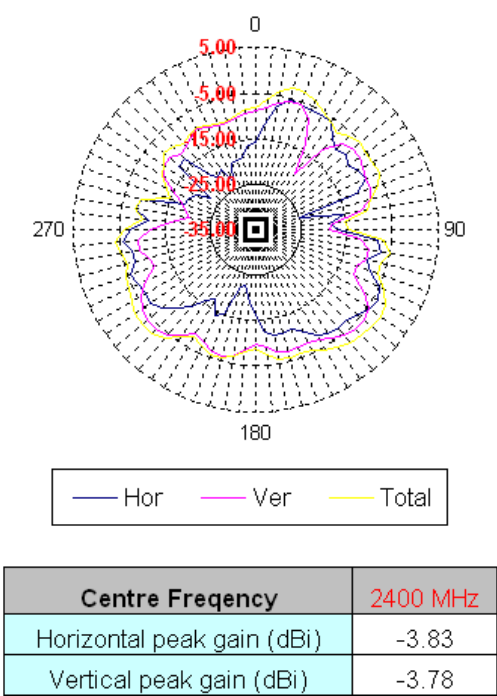
Centre Frequency	2450 MHz
Horizontal peak gain (dBi)	1.21
Vertical peak gain (dBi)	-0.14

Tx2 antenna: 2500 MHz

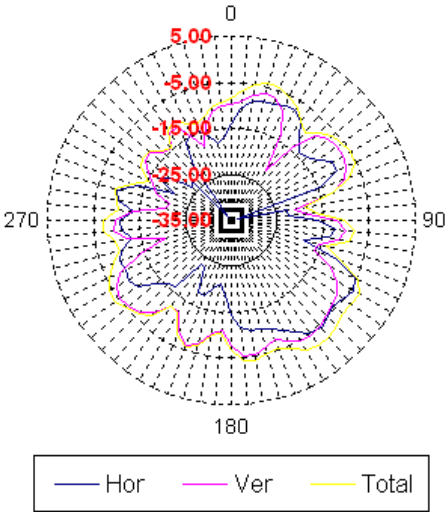


Centre Frequency	2500 MHz
Horizontal peak gain (dBi)	1.85
Vertical peak gain (dBi)	0.31

Tx3 (or Rx3) antenna: 2400 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)

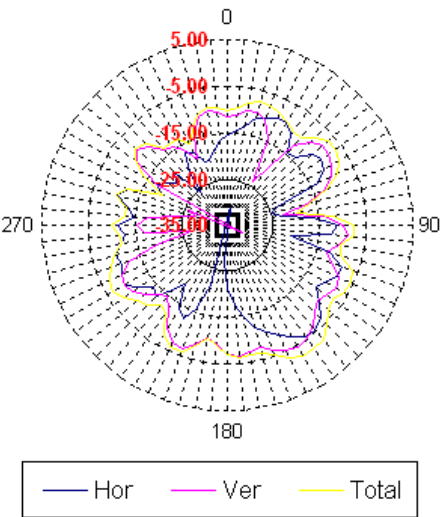


Tx3 (or Rx3) antenna: 2450 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



Centre Frequency	2450 MHz
Horizontal peak gain (dBi)	-4.46
Vertical peak gain (dBi)	-4.36

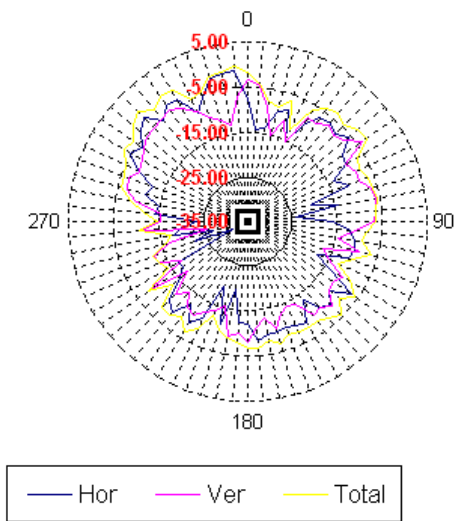
Tx3 (or Rx3) antenna: 2500 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



Centre Frequency	2500 MHz
Horizontal peak gain (dBi)	-5.45
Vertical peak gain (dBi)	-4.54

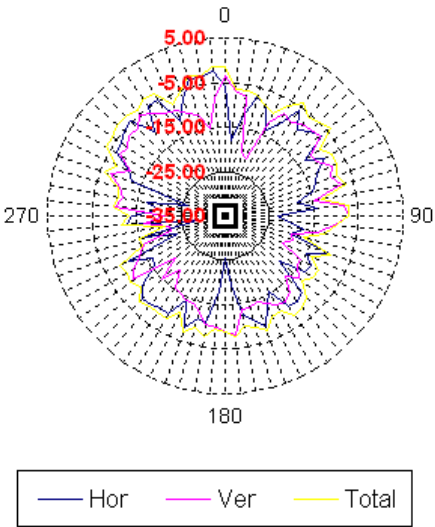
5150-5350 MHz radiation characteristic

Tx1 antenna: 5150 MHz



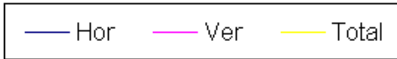
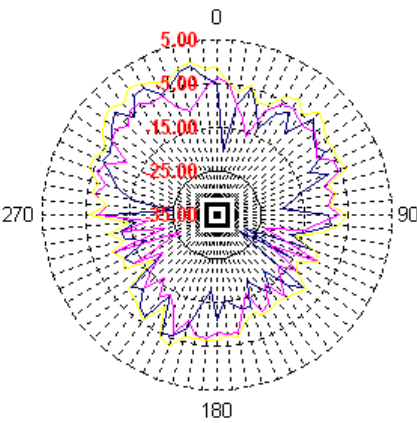
Centre Frequency	5150 MHz
Horizontal peak gain (dBi)	-1.43
Vertical peak gain (dBi)	-3.26

Tx1 antenna: 5250 MHz



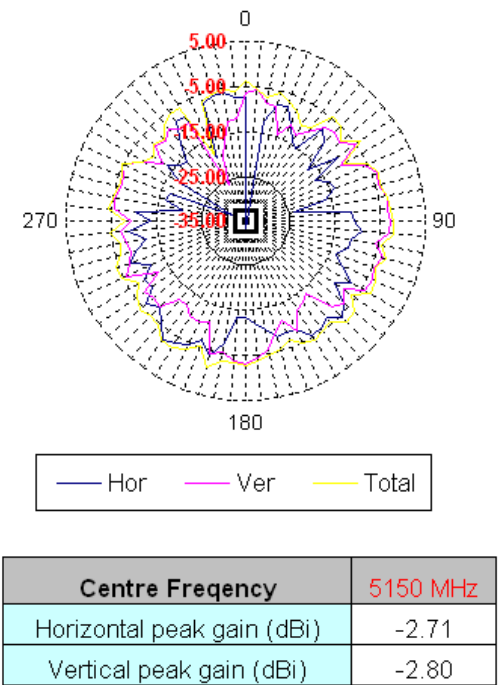
Centre Frequency	5250 MHz
Horizontal peak gain (dBi)	-2.47
Vertical peak gain (dBi)	-3.48

Tx1 antenna: 5350 MHz

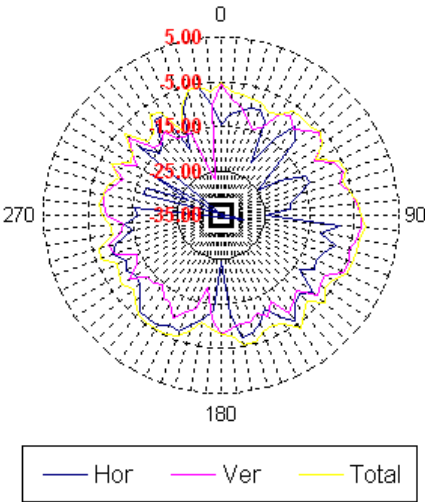


Centre Frequency	5350 MHz
Horizontal peak gain (dBi)	-0.06
Vertical peak gain (dBi)	-3.57

Tx2 antenna: 5150 MHz

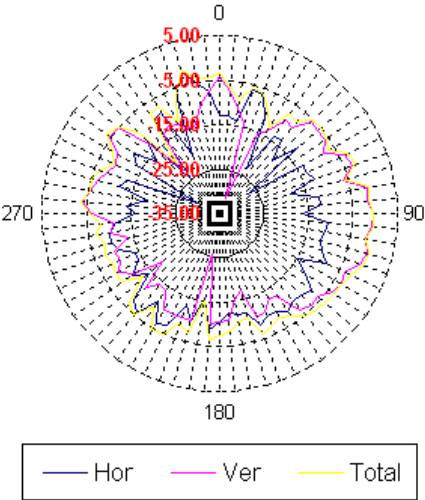


Tx2 antenna: 5250 MHz



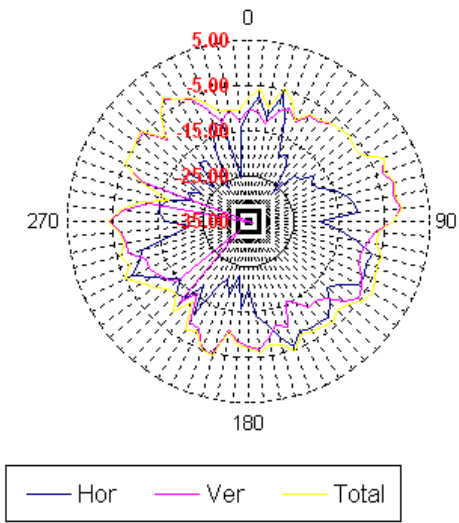
Centre Frequency	5250 MHz
Horizontal peak gain (dBi)	-5.80
Vertical peak gain (dBi)	-3.43

Tx2 antenna: 5350 MHz



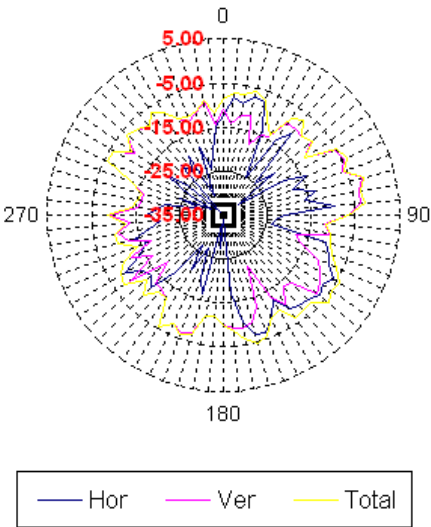
Centre Frequency	5350 MHz
Horizontal peak gain (dBi)	-2.18
Vertical peak gain (dBi)	-0.38

Tx3 (or Rx3) antenna: 5150 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



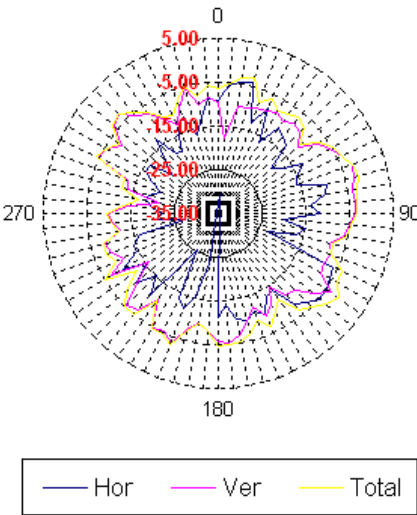
Centre Frequency	5150 MHz
Horizontal peak gain (dBi)	-5.71
Vertical peak gain (dBi)	-1.44

Tx3 (or Rx3) antenna: 5250 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



Centre Frequency	5250 MHz
Horizontal peak gain (dBi)	-6.16
Vertical peak gain (dBi)	-2.44

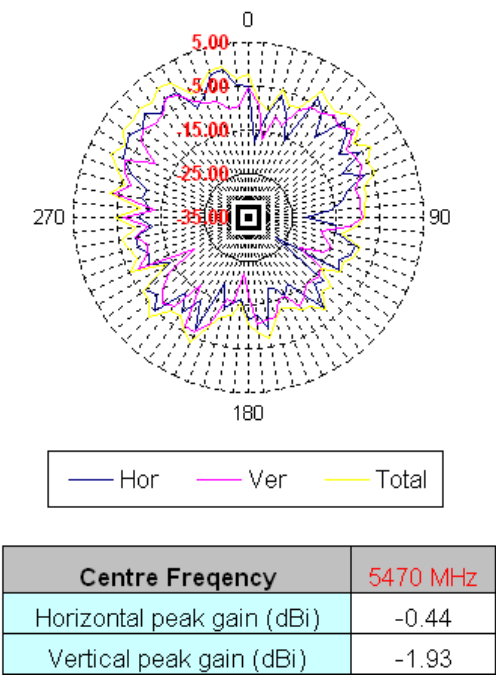
Tx3 (or Rx3) antenna: 5350 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



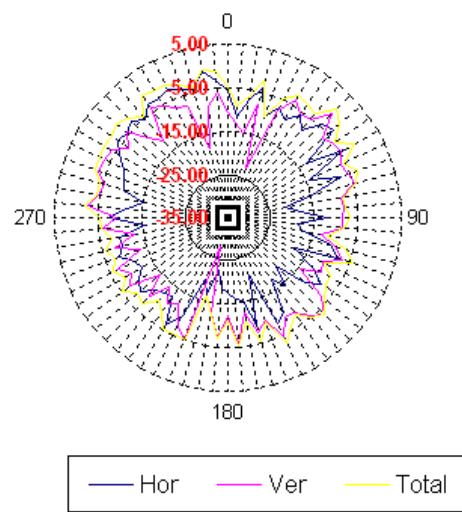
Centre Frequency	5350 MHz
Horizontal peak gain (dBi)	-4.02
Vertical peak gain (dBi)	-2.30

5470-5725MHz radiation characteristic

Tx1 antenna: 5470 MHz

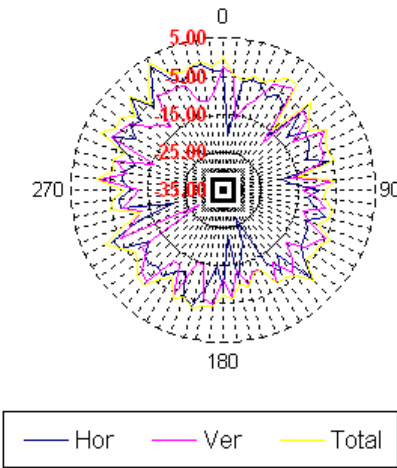


Tx1 antenna: 5597.5 MHz



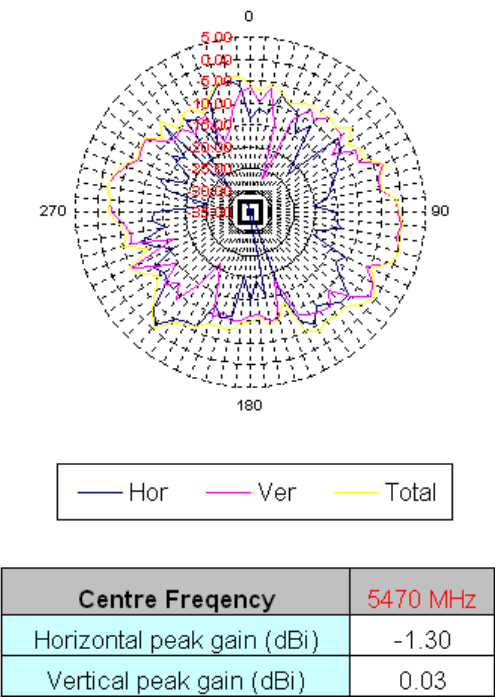
Centre Frequency	5600 MHz
Horizontal peak gain (dBi)	-0.83
Vertical peak gain (dBi)	-0.92

Tx1 antenna: 5725 MHz

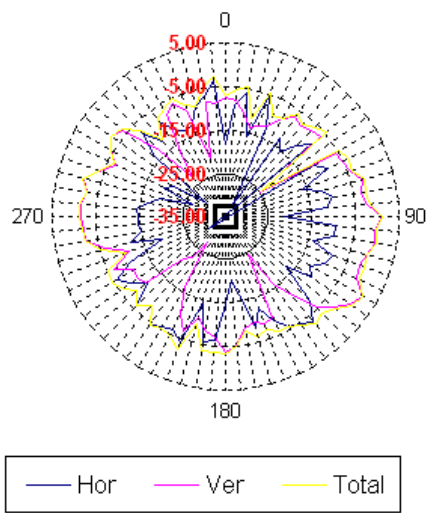


Centre Frequency	5725 MHz
Horizontal peak gain (dBi)	2.61
Vertical peak gain (dBi)	-2.35

Tx2 antenna: 5470 MHz

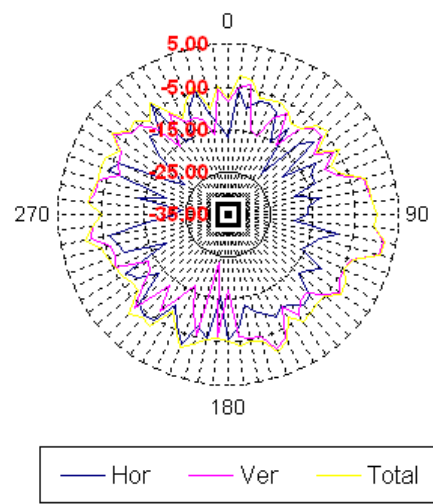


Tx2 antenna: 5597.5 MHz



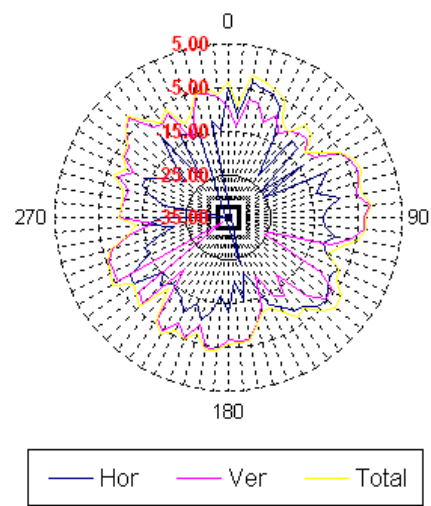
Centre Frequency	5600 MHz
Horizontal peak gain (dBi)	-3.47
Vertical peak gain (dBi)	1.36

Tx2 antenna: 5725 MHz



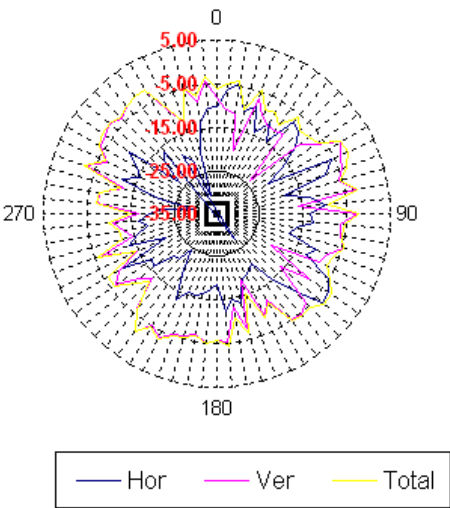
Centre Frequency	5725 MHz
Horizontal peak gain (dBi)	-2.44
Vertical peak gain (dBi)	2.17

Tx3 (or Rx3): 5470 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



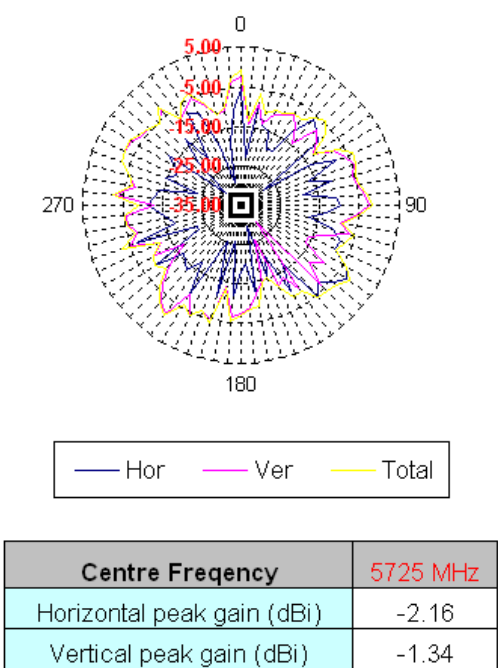
Centre Frequency	5470 MHz
Horizontal peak gain (dBi)	-3.47
Vertical peak gain (dBi)	-2.25

Tx3 (or Rx3) antenna: 5597.5 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



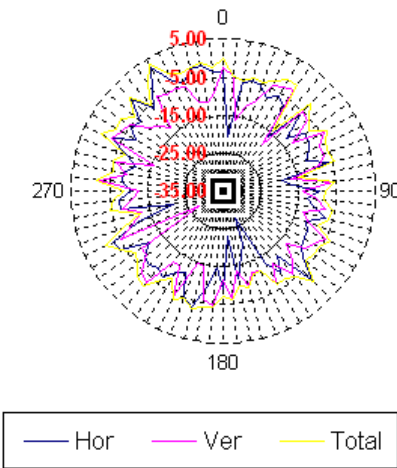
Centre Frequency	5600 MHz
Horizontal peak gain (dBi)	-2.87
Vertical peak gain (dBi)	-1.82

Tx3 (or Rx3) antenna: 5725 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



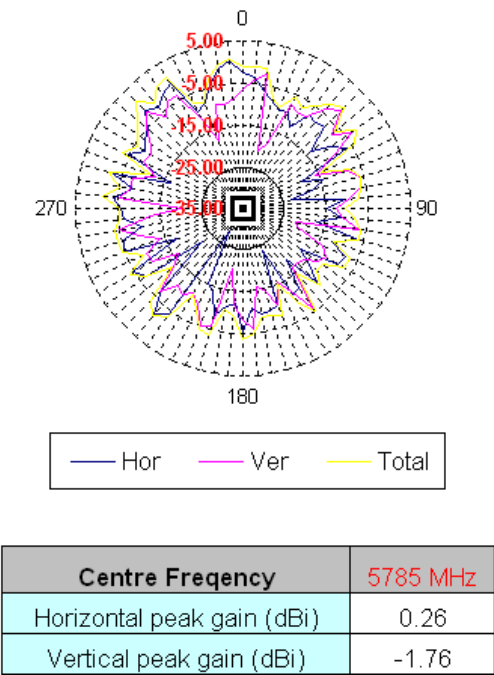
5725-5850 MHz radiation characteristic

Tx1 antenna: 5725 MHz

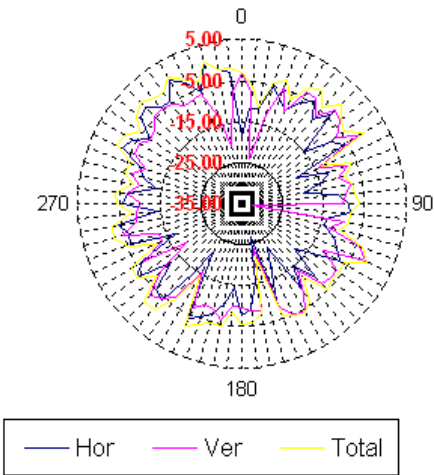


Centre Frequency	5725 MHz
Horizontal peak gain (dBi)	2.61
Vertical peak gain (dBi)	-2.35

Tx1 antenna: 5785 MHz

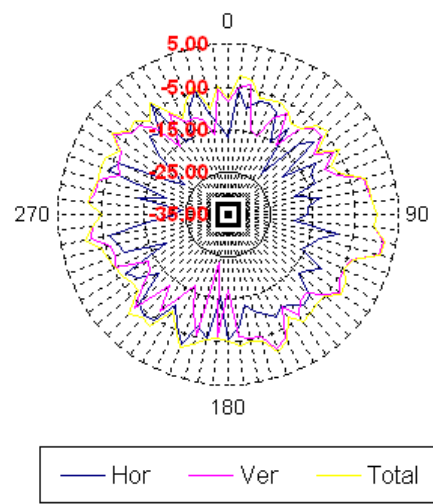


Tx1 antenna: 5850 MHz



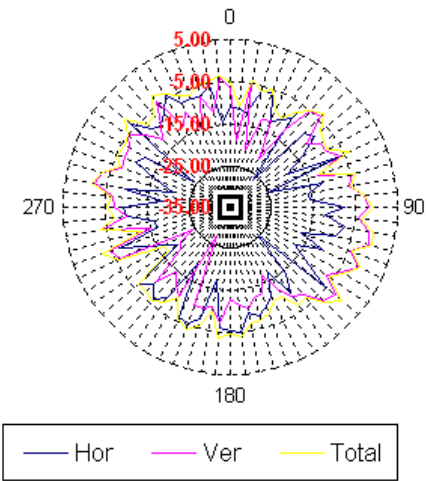
Centre Frequency	5850 MHz
Horizontal peak gain (dBi)	0.45
Vertical peak gain (dBi)	-1.79

Tx2 antenna: 5725 MHz



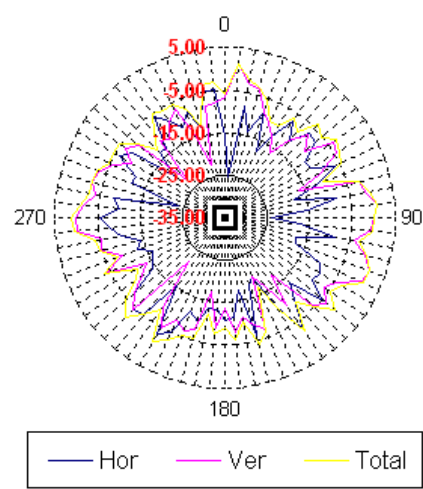
Centre Frequency	5725 MHz
Horizontal peak gain (dBi)	-2.44
Vertical peak gain (dBi)	2.17

Tx2 antenna: 5785 MHz



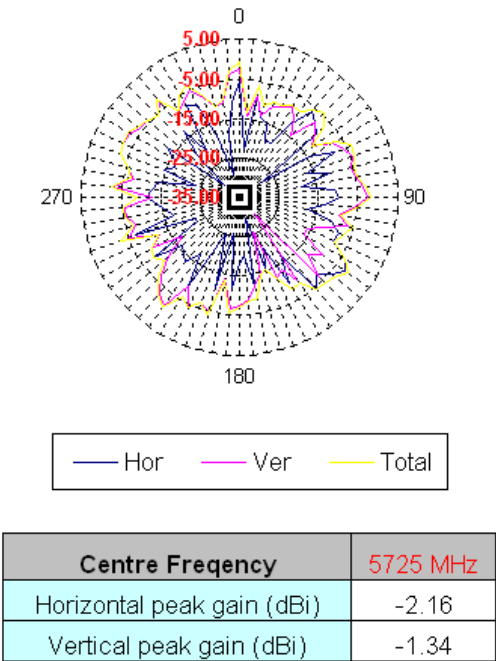
Centre Frequency	5785 MHz
Horizontal peak gain (dBi)	-3.86
Vertical peak gain (dBi)	-0.83

Tx2 antenna: 5850 MHz

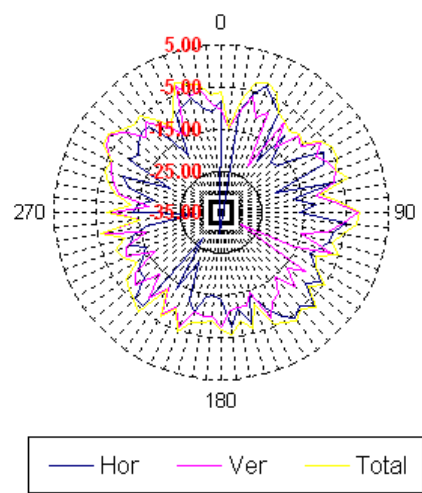


Centre Frequency	5850 MHz
Horizontal peak gain (dBi)	-3.21
Vertical peak gain (dBi)	0.98

Tx3 (or Rx3) antenna: 5725 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)

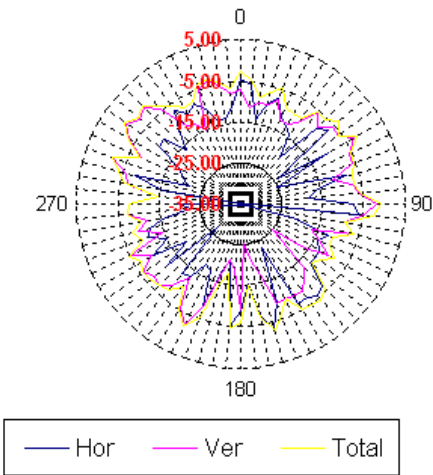


Tx3 (or Rx3) antenna: 5785 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx3 for 4965AGN)



Centre Frequency	5785 MHz
Horizontal peak gain (dBi)	-2.96
Vertical peak gain (dBi)	-2.16

Tx3 (or Rx3) antenna: 5850 MHz (Plot is not required if 3rd Antenna is receive only e.g. Rx 3 for 4965AGN)



Centre Frequency	5850 MHz
Horizontal peak gain (dBi)	-3.33
Vertical peak gain (dBi)	-0.81

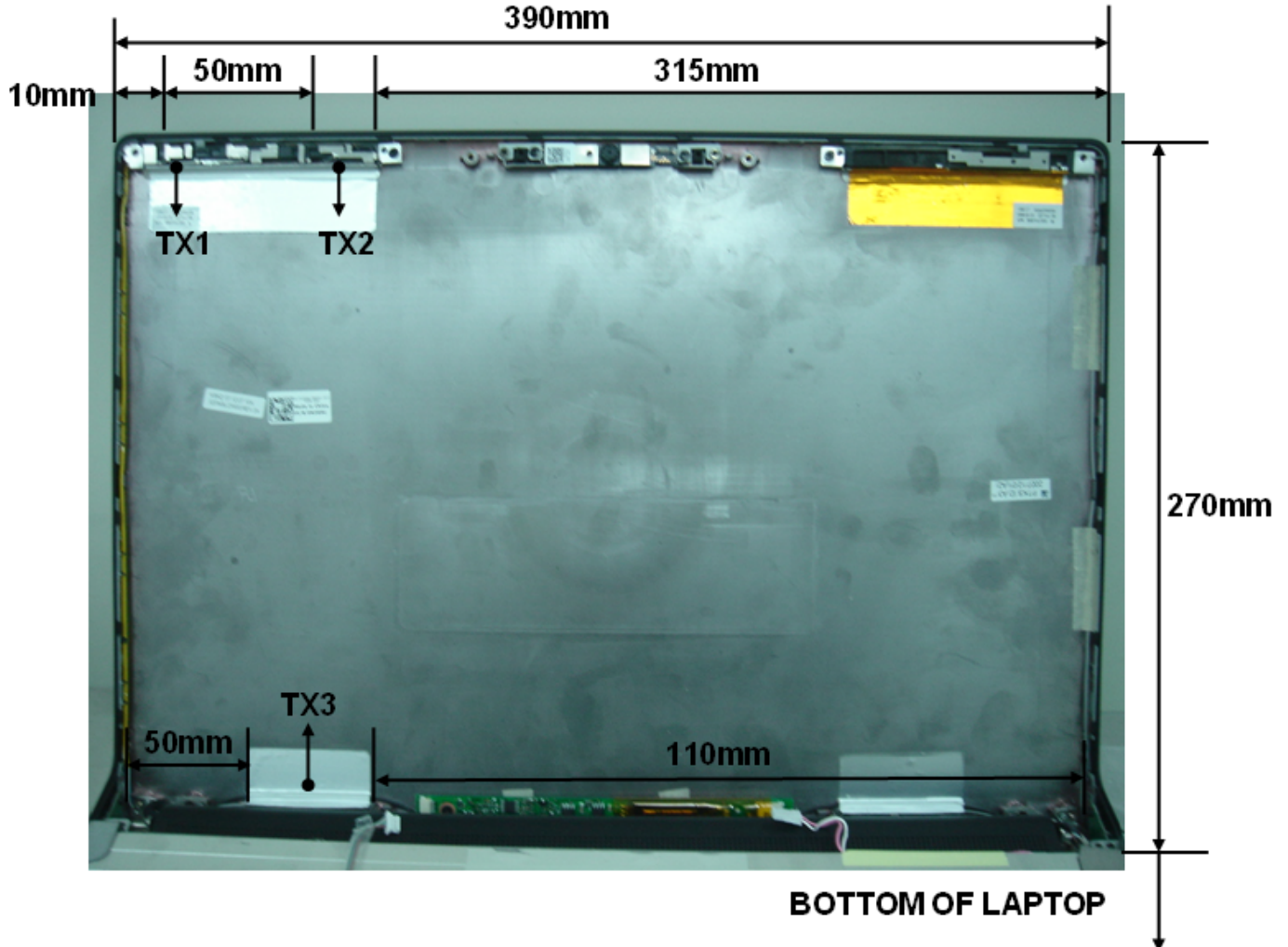
Section 4. Host Platform Information

OEM / ODM Host platform: (XXXXXXX) platform correlated to antenna data

Rating Label Photo:

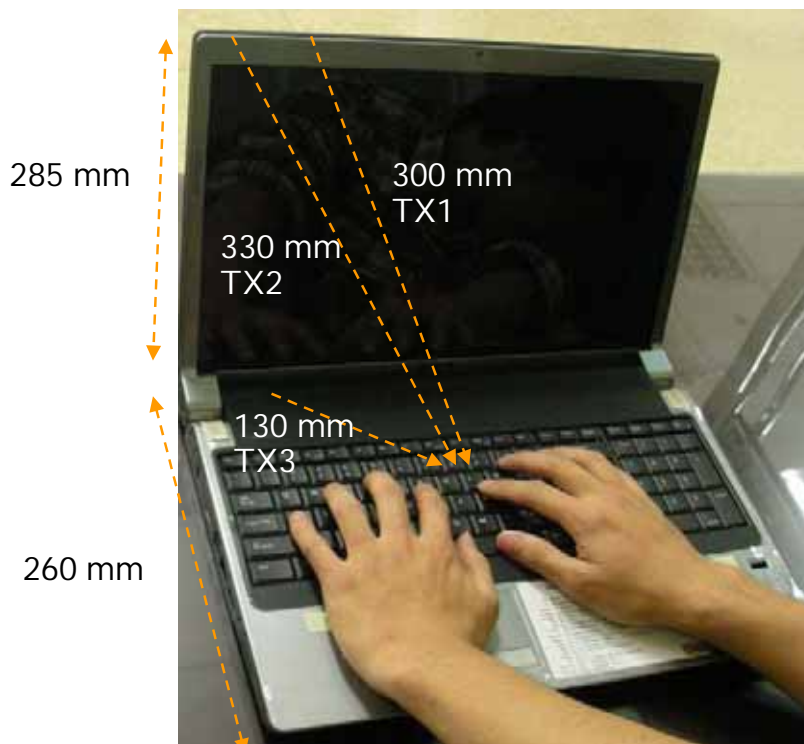
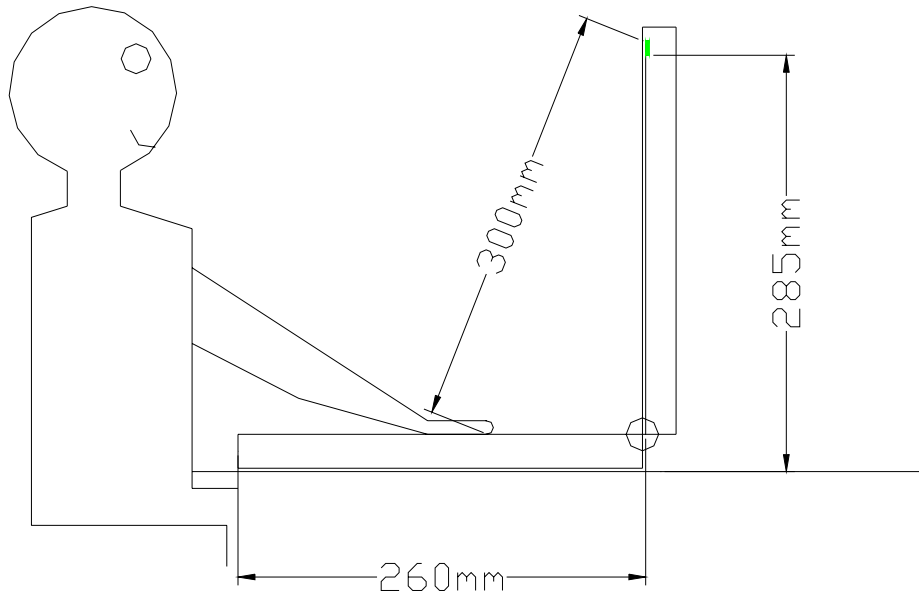
Section 5. Antenna Host Platform Location Information

Include a **dimensioned photo or dimensioned drawing** of Tx1, Tx2 and Tx3 antenna placements. (Not applicable for receive-only antenna e.g. Rx3 for 4965AGN)



Section 6. Antenna dimensional information for SAR evaluation

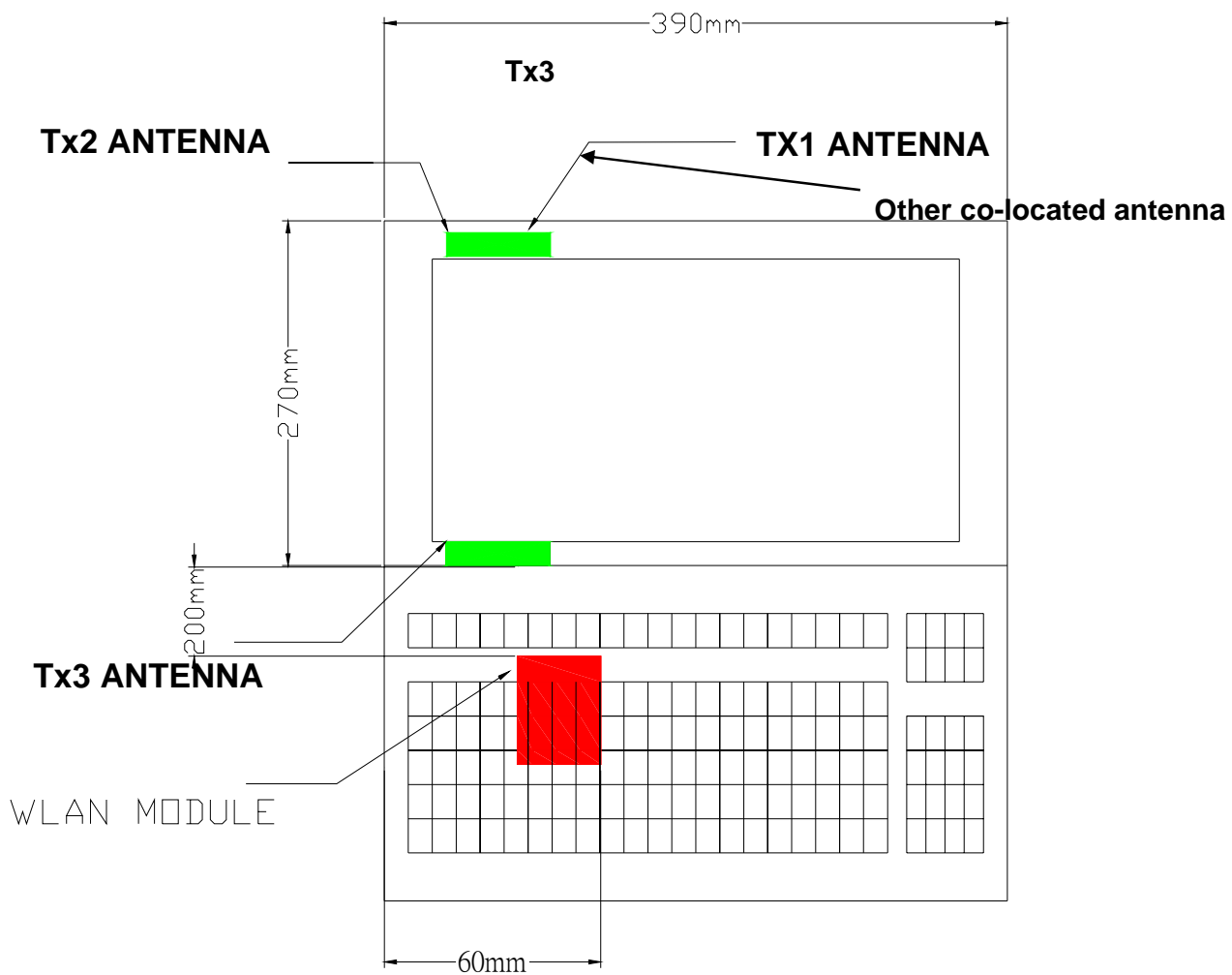
Include a **dimensioned photo or dimensioned drawing** showing the distance (mm) between the transmit antennas and the user (excluding hands, wrist, feet, lap/ thigh, and ankle)



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

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

	Local company name	Contact name	Phone number	FAX Number	e-Mail Address	Notes
Argentina						
Brazil						
Indonesia						
Israel						
Malaysia						
Mexico						
Singapore						Telecommunication Equipment Dealer License Required
South Africa						
USA, Canada						