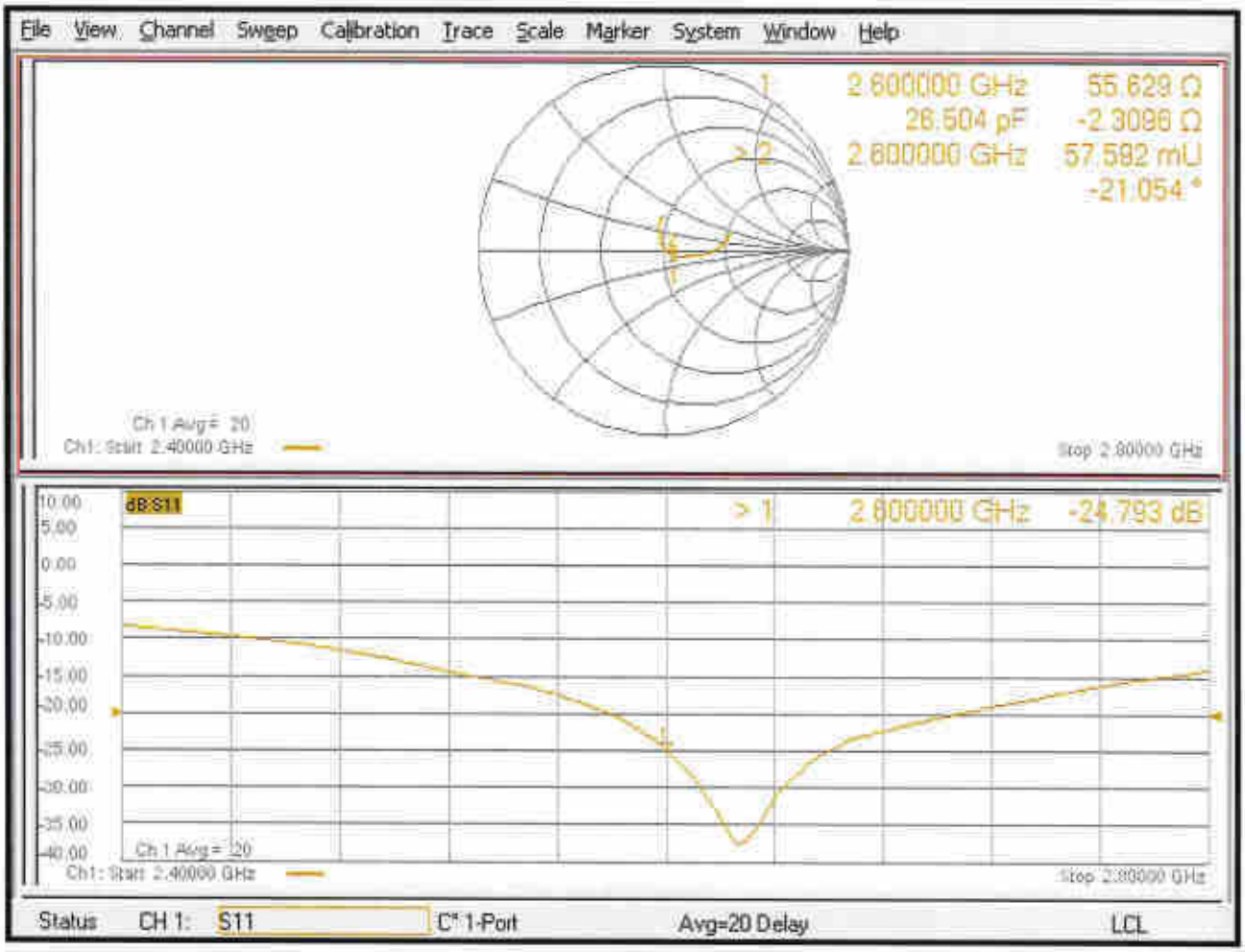
Impedance Measurement Plot for Head TSL



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Accreditation No.: SCS 0108

Client **Sporton**

Certificate No: DAE4-1303_Jul20

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BO - SN: 1303
Calibration procedure(s)	QA CAL-06.v30 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	July 07, 2020

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Sep-19 (No:25949)	Sep-20
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	09-Jan-20 (in house check)	In house check: Jan-21
Calibrator Box V2.1	SE UMS 006 AA 1002	09-Jan-20 (in house check)	In house check: Jan-21

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	

Issued: July 7, 2020

Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle*: The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement*: Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range:	1LSB =	6.1μV ,	full range =	-100...+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	405.621 ± 0.02% (k=2)	405.288 ± 0.02% (k=2)	405.521 ± 0.02% (k=2)
Low Range	3.95970 ± 1.50% (k=2)	4.00177 ± 1.50% (k=2)	4.00559 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	36.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200028.13	-4.41	-0.00
Channel X	+ Input	20005.33	0.15	0.00
Channel X	- Input	-20003.94	1.66	-0.01
Channel Y	+ Input	200034.95	3.01	0.00
Channel Y	+ Input	20004.62	-0.42	-0.00
Channel Y	- Input	-20006.63	-0.88	0.00
Channel Z	+ Input	200029.72	-2.88	-0.00
Channel Z	+ Input	20001.10	-3.93	-0.02
Channel Z	- Input	-20007.10	-1.35	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2000.83	-0.06	-0.00
Channel X	+ Input	201.48	0.52	0.26
Channel X	- Input	-198.72	0.43	-0.22
Channel Y	+ Input	2000.87	0.12	0.01
Channel Y	+ Input	199.93	-0.88	-0.44
Channel Y	- Input	-199.89	-0.62	0.31
Channel Z	+ Input	2000.93	0.20	0.01
Channel Z	+ Input	200.16	-0.59	-0.30
Channel Z	- Input	-199.91	-0.57	0.28

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-2.91	-4.53
	- 200	5.99	4.24
Channel Y	200	1.24	1.13
	- 200	-2.94	-3.20
Channel Z	200	-1.62	-1.40
	- 200	-0.52	-0.26

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (μV)	Channel Y (μV)	Channel Z (μV)
Channel X	200	-	0.82	-4.08
Channel Y	200	7.63	-	2.53
Channel Z	200	10.14	5.17	-

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	16198	15926
Channel Y	15904	15641
Channel Z	16229	15177

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.70	-0.97	2.67	0.58
Channel Y	-0.62	-1.86	0.89	0.42
Channel Z	-0.13	-1.67	0.85	0.41

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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Accreditation No.: SCS 0108

Client Sporton

Certificate No: ES3-3293_Sep20

CALIBRATION CERTIFICATE

Object: ES3DV3 - SN:3293

Calibration procedure(s): QA CAL-01.v9, QA CAL-23.v5, QA CAL-25.v7
Calibration procedure for dosimetric E-field probes

Calibration date: September 23, 2020

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	01-Apr-20 (No. 217-03100/03101)	Apr-21
Power sensor NRP-Z91	SN: 103244	01-Apr-20 (No. 217-03100)	Apr-21
Power sensor NRP-Z91	SN: 103245	01-Apr-20 (No. 217-03101)	Apr-21
Reference 20 dB Attenuator	SN: CC2552 (20x)	31-Mar-20 (No. 217-03106)	Apr-21
DAE4	SN: 660	27-Dec-19 (No. DAE4-660_Dec19)	Dec-20
Reference Probe ES3DV2	SN: 3013	31-Dec-19 (No. ES3-3013_Dec19)	Dec-20
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-20)	In house check: Jun-22
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-20)	In house check: Jun-22
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-19)	In house check: Oct-20

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 29, 2020

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Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
b) IEC 62209-1, ", "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3293

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	1.10	0.90	0.73	± 10.1 %
DCP (mV)[B]	102.3	109.5	106.9	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	199.2	± 3.5 %	± 4.7 %
		Y	0.0	0.0	1.0		179.4		
		Z	0.0	0.0	1.0		183.6		

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of Norm X,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 5).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3293

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-5.0
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

Note: Measurement distance from surface can be increased to 3-4 mm for an *Area Scan* job.

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3293

Calibration Parameter Determined in Head Tissue Simulating Media

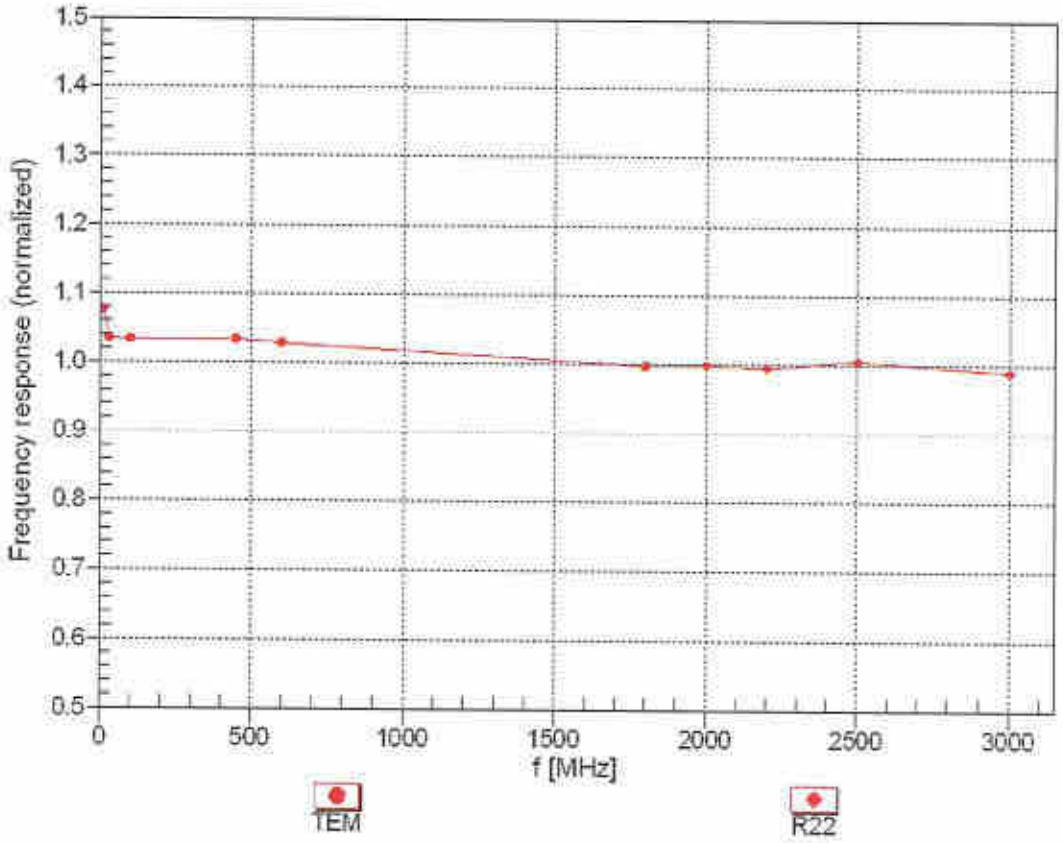
f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha [G]	Depth [G] (mm)	Unc (k=2)
750	41.9	0.89	6.51	6.51	6.51	0.80	1.18	± 12.0 %
835	41.5	0.90	6.43	6.43	6.43	0.78	1.16	± 12.0 %
900	41.5	0.97	6.24	6.24	6.24	0.80	1.18	± 12.0 %
1750	40.1	1.37	5.37	5.37	5.37	0.63	1.28	± 12.0 %
1900	40.0	1.40	5.14	5.14	5.14	0.50	1.44	± 12.0 %
2000	40.0	1.40	5.11	5.11	5.11	0.72	1.25	± 12.0 %
2300	39.5	1.67	4.81	4.81	4.81	0.65	1.34	± 12.0 %
2450	39.2	1.80	4.51	4.51	4.51	0.57	1.50	± 12.0 %
2600	39.0	1.96	4.38	4.38	4.38	0.80	1.23	± 12.0 %

[C] Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.

[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

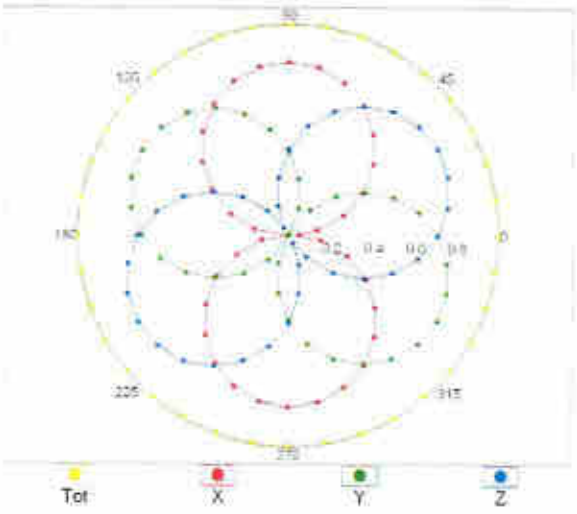
Frequency Response of E-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)



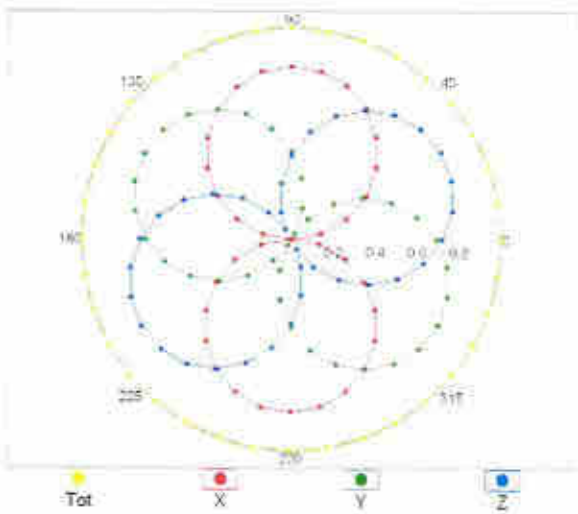
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

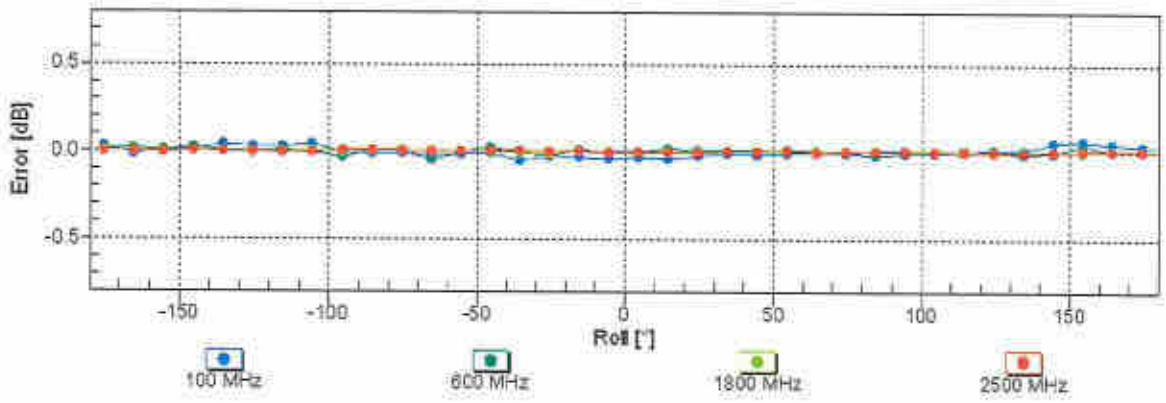
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



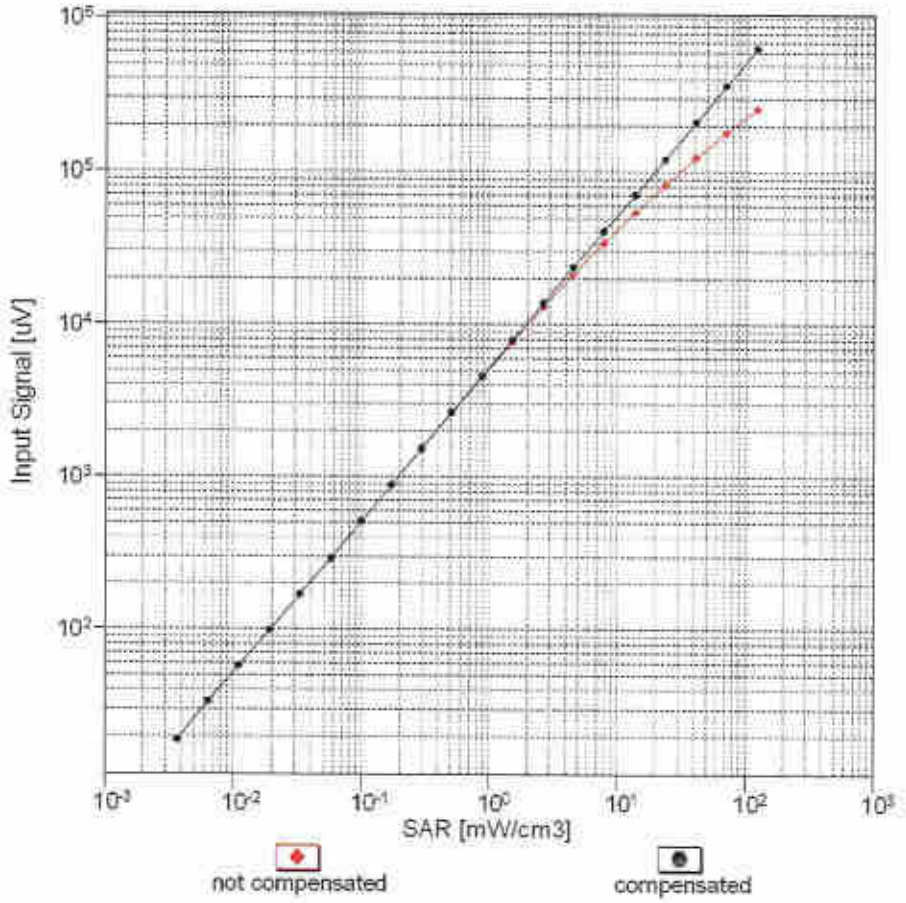
f=1800 MHz,R22

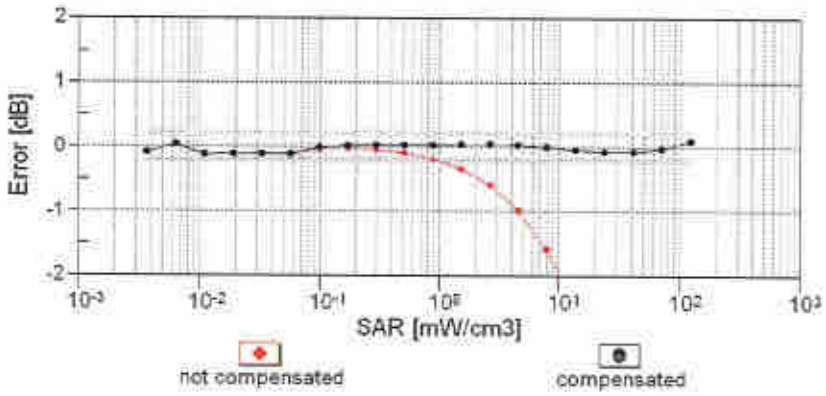




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR$_{head}$)
(TEM cell , f_{eval}= 1900 MHz)

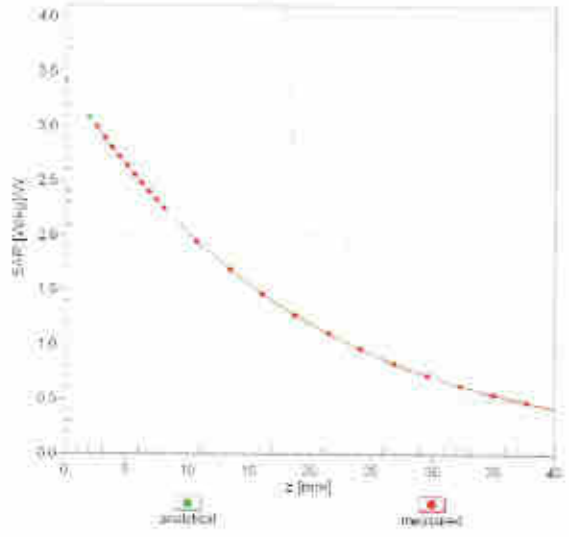




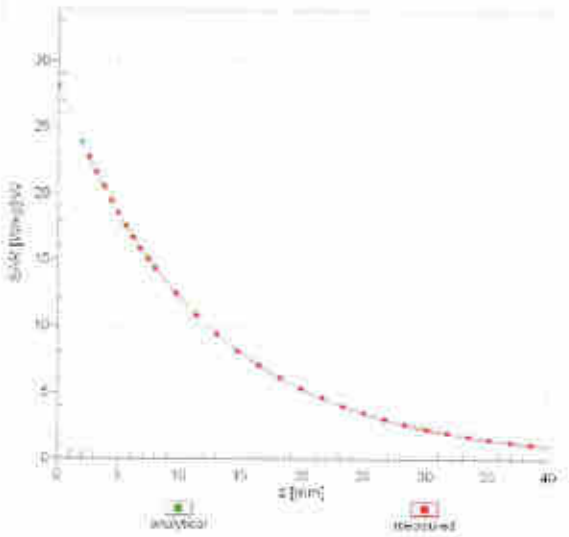
Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment

f = 835 MHz.WGLS R9 (H_convF)

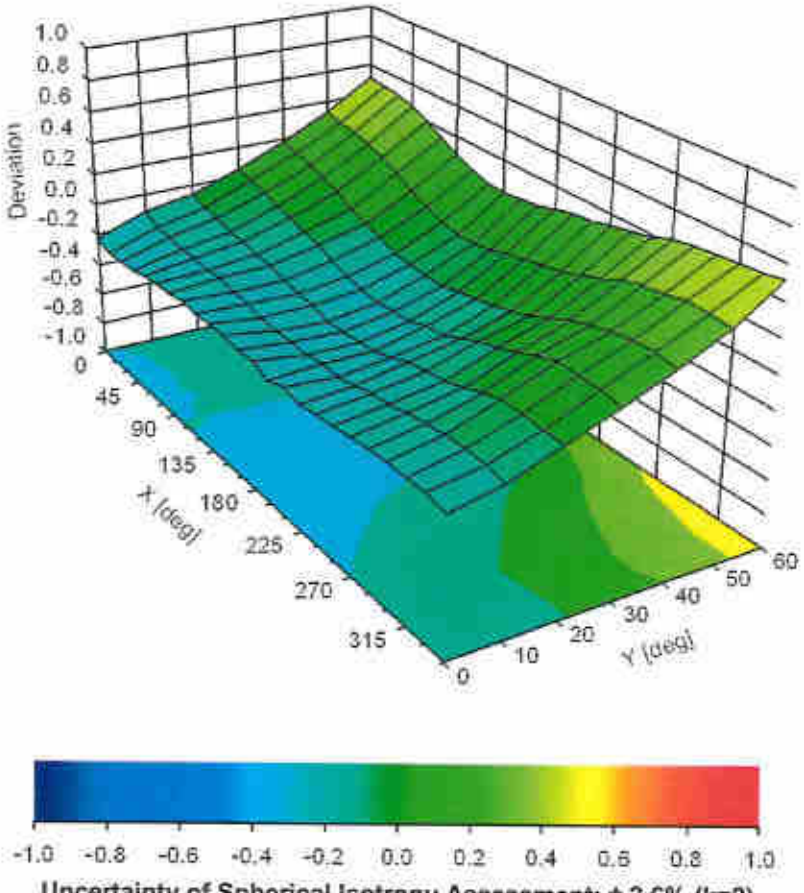


f = 1900 MHz.WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)

Appendix E. Conducted RF Output Power Table

The detailed power table are shown as follows.

GSM850	Burst Average Power (dBm)			Tune-up Limit (dBm)	Frame-Average Power (dBm)			Tune-up Limit (dBm)
TX Channel	128	189	251		128	189	251	
Frequency (MHz)	824.2	836.4	848.8		824.2	836.4	848.8	
GSM 1 Tx slot	32.35	32.29	32.33	33.00	23.35	23.29	23.33	24.00
GPRS 1 Tx slot	32.34	32.27	32.31	33.00	23.34	23.27	23.31	24.00
GPRS 2 Tx slots	29.95	29.97	29.94	30.00	23.95	23.97	23.94	24.00
GPRS 3 Tx slots	28.16	28.09	28.14	28.20	23.90	23.83	23.88	23.94
GPRS 4 Tx slots	26.02	26.10	26.03	27.00	23.02	23.10	23.03	24.00

GSM1900	Burst Average Power (dBm)			Tune-up Limit (dBm)	Frame-Average Power (dBm)			Tune-up Limit (dBm)
TX Channel	512	661	810		512	661	810	
Frequency (MHz)	1850.2	1880	1909.8		1850.2	1880	1909.8	
GSM 1 Tx slot	29.29	29.33	29.19	31.00	20.29	20.33	20.19	22.00
GPRS 1 Tx slot	29.28	29.31	29.18	31.00	20.28	20.31	20.18	22.00
GPRS 2 Tx slots	26.75	26.83	26.71	28.00	20.75	20.83	20.71	22.00
GPRS 3 Tx slots	25.13	25.21	25.06	26.20	20.87	20.95	20.80	21.94
GPRS 4 Tx slots	23.07	23.09	23.08	25.00	20.07	20.09	20.08	22.00

Band		WCDMA II			Tune-up Limit (dBm)	WCDMA IV			Tune-up Limit (dBm)	WCDMA V			Tune-up Limit (dBm)
TX Channel		9262	9400	9538		1312	1413	1513		4132	4182	4233	
Rx Channel		9662	9800	9938		1537	1638	1738		4357	4407	4458	
Frequency (MHz)		1852.4	1880	1907.6		1712.4	1732.6	1752.6		826.4	836.4	846.6	
3GPP Rel 99	AMR 12.2Kbps	23.90	23.99	23.98	25.00	23.88	23.94	23.81	25.00	23.98	24.07	24.03	25.00
3GPP Rel 99	RMC 12.2Kbps	23.91	24.01	24.00	25.00	23.90	23.95	23.82	25.00	24.00	24.09	24.04	25.00
3GPP Rel 6	HSDPA Subtest-1	23.78	23.88	23.76	24.00	22.81	23.12	22.84	24.00	23.88	23.92	23.96	24.00
3GPP Rel 6	HSDPA Subtest-2	23.58	23.69	23.66	24.00	22.68	22.92	22.78	24.00	22.69	22.59	22.48	24.00
3GPP Rel 6	HSDPA Subtest-3	22.86	22.97	22.83	23.50	22.59	22.85	22.63	23.50	22.70	22.41	22.42	23.50
3GPP Rel 6	HSDPA Subtest-4	22.58	22.68	22.55	23.50	22.61	22.83	22.66	23.50	22.06	22.06	22.11	23.50
3GPP Rel 6	HSUPA Subtest-1	19.92	20.04	19.71	24.00	22.14	22.57	22.17	24.00	20.28	20.30	20.38	24.00
3GPP Rel 6	HSUPA Subtest-2	20.86	20.97	20.62	22.00	22.57	22.79	22.55	24.00	21.06	20.87	21.05	22.00
3GPP Rel 6	HSUPA Subtest-3	20.80	20.92	20.56	23.00	22.48	22.94	22.49	24.00	20.99	21.26	20.99	23.00
3GPP Rel 6	HSUPA Subtest-4	20.95	21.02	20.93	22.00	22.87	22.88	22.60	24.00	20.82	20.88	20.56	22.00
3GPP Rel 6	HSUPA Subtest-5	22.90	23.10	22.90	24.00	22.90	23.40	23.00	24.00	23.95	23.91	24.00	24.00

Band 2 (1900MHz Band)
Part 24E

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.	Tune-up limit (dBm)	MPR (dB)
Channel				18700	18900	19100		
Frequency (MHz)				1860	1880	1900		
20	QPSK	1	0	22.90	22.98	22.79		
20	QPSK	1	49	22.82	22.87	22.83	24.5	0
20	QPSK	1	99	22.54	22.77	22.67		
20	QPSK	50	0	21.83	21.93	21.78		
20	QPSK	50	24	21.86	21.92	21.84	23.5	1
20	QPSK	50	50	21.89	21.80	21.89		
20	QPSK	100	0	21.80	21.93	21.84		
20	16QAM	1	0	21.90	21.76	22.09		
20	16QAM	1	49	22.02	21.63	22.09	23.5	1
20	16QAM	1	99	21.64	21.62	22.00		
20	16QAM	12	0	21.46	21.39	21.41		
20	16QAM	12	43	21.43	21.43	21.54	22.5	2
20	16QAM	12	86	21.56	21.30	21.57		
20	16QAM	27	0	20.64	20.40	20.62		
Channel				18675	18900	19125	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1857.5	1880	1902.5		
15	QPSK	1	0	22.74	22.79	22.67		
15	QPSK	1	37	22.78	22.96	22.81	24.5	0
15	QPSK	1	74	22.69	22.74	22.74		
15	QPSK	36	0	21.75	21.64	21.72		
15	QPSK	36	20	21.77	21.77	21.64	23.5	1
15	QPSK	36	39	21.74	21.68	21.75		
15	QPSK	75	0	21.70	21.87	21.73		
15	16QAM	1	0	21.84	21.68	22.01		
15	16QAM	1	37	21.90	21.52	21.90	23.5	1
15	16QAM	1	74	21.55	21.57	21.75		
15	16QAM	12	0	21.55	21.46	21.53		
15	16QAM	12	31	21.45	21.60	21.60	22.5	2
15	16QAM	12	61	21.44	21.37	21.56		
15	16QAM	27	0	20.47	20.56	20.51		
Channel				18650	18900	19150	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1855	1880	1905		
10	QPSK	1	0	22.76	22.69	22.68		
10	QPSK	1	25	22.83	22.85	22.85	24.5	0
10	QPSK	1	49	22.74	22.83	22.77		
10	QPSK	25	0	21.61	21.75	21.67		
10	QPSK	25	12	21.68	21.74	21.71	23.5	1
10	QPSK	25	25	21.64	21.55	21.74		
10	QPSK	50	0	21.66	21.80	21.66		
10	16QAM	1	0	21.76	21.65	21.95		
10	16QAM	1	25	21.77	21.51	21.89	23.5	1
10	16QAM	1	49	21.50	21.58	21.76		
10	16QAM	25	0	20.96	20.87	20.91		
10	16QAM	25	12	20.95	20.98	21.03	22.5	2
10	16QAM	25	25	20.92	20.99	20.95		
10	16QAM	27	0	20.50	20.48	20.39		
Channel				18625	18900	19175	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1852.5	1880	1907.5		
5	QPSK	1	0	22.63	22.58	22.57		
5	QPSK	1	12	22.73	22.85	22.83	24.5	0
5	QPSK	1	24	22.56	22.76	22.53		
5	QPSK	12	0	21.54	21.64	21.63		
5	QPSK	12	7	21.58	21.69	21.66	23.5	1
5	QPSK	12	13	21.68	21.61	21.68		
5	QPSK	25	0	21.51	21.62	21.68		
5	16QAM	1	0	21.56	21.68	21.75		
5	16QAM	1	12	21.57	21.53	21.78	23.5	1
5	16QAM	1	24	21.59	21.57	21.65		
5	16QAM	12	0	20.87	20.81	20.79		
5	16QAM	12	7	20.82	20.85	20.85	22.5	2
5	16QAM	12	13	20.85	20.86	20.78		
5	16QAM	25	0	20.94	20.87	20.96		
Channel				18615	18900	19185	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1851.5	1880	1908.5		
3	QPSK	1	0	22.72	22.67	22.61		
3	QPSK	1	8	22.56	22.64	22.73	24.5	0
3	QPSK	1	14	22.57	22.63	22.66		
3	QPSK	8	0	21.76	21.82	21.63		
3	QPSK	8	4	21.71	21.85	21.58	23.5	1
3	QPSK	8	7	21.61	21.65	21.64		
3	QPSK	15	0	21.74	21.84	21.52		
3	16QAM	1	0	21.74	21.64	21.98		
3	16QAM	1	8	21.64	21.60	21.87	23.5	1
3	16QAM	1	14	21.56	21.50	21.89		
3	16QAM	8	0	20.61	20.58	20.70		
3	16QAM	8	4	20.60	20.80	20.65	22.5	2
3	16QAM	8	7	20.66	20.67	20.65		
3	16QAM	15	0	20.81	20.78	20.80		
Channel				18607	18900	19193	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1850.7	1880	1909.3		
1.4	QPSK	1	0	22.54	22.50	22.57		
1.4	QPSK	1	3	22.78	22.87	22.82		
1.4	QPSK	1	5	22.68	22.78	22.70	24.5	0
1.4	QPSK	3	0	22.62	22.68	22.66		
1.4	QPSK	3	1	22.57	22.90	22.67		
1.4	QPSK	3	3	22.66	22.62	22.68		
1.4	QPSK	6	0	21.57	21.77	21.69	23.5	1
1.4	16QAM	1	0	21.63	21.52	21.87		
1.4	16QAM	1	3	21.58	21.65	21.76		
1.4	16QAM	1	5	21.67	21.66	21.67	23.5	1
1.4	16QAM	3	0	21.52	21.69	21.60		
1.4	16QAM	3	1	21.75	21.79	21.68		
1.4	16QAM	3	3	21.55	21.54	21.52		
1.4	16QAM	6	0	20.64	20.53	20.56	22.5	2

Band 4 (AWS Band)
Part 27L (only on channel required)

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.	Tune-up limit (dBm)	MPR (dB)
Channel				20050	20175	20300		
Frequency (MHz)				1720	1732.5	1745		
20	QPSK	1	0	22.94	23.00	22.84		
20	QPSK	1	49	22.84	22.92	22.95	24.5	0
20	QPSK	1	99	22.72	22.67	22.63		
20	QPSK	50	0	21.86	21.96	21.95		
20	QPSK	50	24	21.93	21.94	21.78	23.5	1
20	QPSK	50	50	21.92	21.92	21.84		
20	QPSK	100	0	21.89	21.91	21.72		
20	16QAM	1	0	22.04	22.09	22.06		
20	16QAM	1	49	22.06	21.81	21.98	23.5	1
20	16QAM	1	99	21.65	21.77	21.92		
20	16QAM	12	0	21.87	21.73	21.65		
20	16QAM	12	43	21.77	21.72	21.55	22.5	2
20	16QAM	12	86	21.63	21.63	21.49		
20	16QAM	27	0	20.75	20.66	20.61		
Channel				20025	20175	20325	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1717.5	1732.5	1747.5		
15	QPSK	1	0	22.84	22.86	22.76		
15	QPSK	1	37	22.77	22.72	22.76	24.5	0
15	QPSK	1	74	22.60	22.59	22.54		
15	QPSK	36	0	21.75	21.79	21.90		
15	QPSK	36	20	21.77	21.83	21.65	23.5	1
15	QPSK	36	39	21.75	21.75	21.64		
15	QPSK	75	0	21.80	21.68	21.67		
15	16QAM	1	0	21.95	21.87	21.87		
15	16QAM	1	37	21.95	21.73	21.79	23.5	1
15	16QAM	1	74	21.56	21.57	21.76		
15	16QAM	12	0	21.90	21.66	21.69		
15	16QAM	12	31	21.85	21.79	21.66	22.5	2
15	16QAM	12	61	21.77	21.66	21.49		
15	16QAM	27	0	20.92	20.65	20.75		
Channel				20000	20175	20350	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1715	1732.5	1750		
10	QPSK	1	0	22.84	22.92	22.69		
10	QPSK	1	25	22.77	22.79	22.83	24.5	0
10	QPSK	1	49	22.60	22.58	22.57		
10	QPSK	25	0	21.63	21.68	21.76		
10	QPSK	25	12	21.71	21.87	21.59	23.5	1
10	QPSK	25	25	21.70	21.77	21.63		
10	QPSK	50	0	21.80	21.82	21.54		
10	16QAM	1	0	21.90	21.94	21.91		
10	16QAM	1	25	21.98	21.72	21.91	23.5	1
10	16QAM	1	49	21.56	21.71	21.87		
10	16QAM	25	0	20.89	21.01	20.86		
10	16QAM	25	12	20.97	20.98	20.93	22.5	2
10	16QAM	25	25	21.00	20.83	20.82		
10	16QAM	27	0	20.81	20.68	20.60		
Channel				19975	20175	20375	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1712.5	1732.5	1752.5		
5	QPSK	1	0	22.79	22.84	22.68		
5	QPSK	1	12	22.68	22.72	22.60	24.5	0
5	QPSK	1	24	22.60	22.50	22.65		
5	QPSK	12	0	21.66	21.58	21.63		
5	QPSK	12	7	21.64	21.73	21.62	23.5	1
5	QPSK	12	13	21.56	21.68	21.67		
5	QPSK	25	0	21.61	21.71	21.64		
5	16QAM	1	0	21.75	21.72	21.73		
5	16QAM	1	12	21.91	21.63	21.80	23.5	1
5	16QAM	1	24	21.61	21.54	21.64		
5	16QAM	12	0	20.82	20.82	20.67		
5	16QAM	12	7	20.76	20.79	20.75	22.5	2
5	16QAM	12	13	20.90	20.74	20.72		
5	16QAM	25	0	20.97	20.93	20.92		
Channel				19965	20175	20385	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1711.5	1732.5	1753.5		
3	QPSK	1	0	22.69	22.78	22.66		
3	QPSK	1	8	22.51	22.56	22.78	24.5	0
3	QPSK	1	14	22.58	22.62	22.56		
3	QPSK	8	0	21.55	21.69	21.72		
3	QPSK	8	4	21.67	21.60	21.53	23.5	1
3	QPSK	8	7	21.60	21.53	21.52		
3	QPSK	15	0	21.52	21.61	21.62		
3	16QAM	1	0	21.56	21.58	21.65		
3	16QAM	1	8	21.69	21.61	21.63	23.5	1
3	16QAM	1	14	21.69	21.78	21.80		
3	16QAM	8	0	20.70	20.68	20.54		
3	16QAM	8	4	20.55	20.68	20.55	22.5	2
3	16QAM	8	7	20.76	20.54	20.51		
3	16QAM	15	0	20.89	20.79	20.76		
Channel				19957	20175	20393	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				1710.7	1732.5	1754.3		
1.4	QPSK	1	0	22.57	22.61	22.67		
1.4	QPSK	1	3	22.50	22.57	22.65		
1.4	QPSK	1	5	22.59	22.60	22.50	24.5	0
1.4	QPSK	3	0	22.69	22.68	22.65		
1.4	QPSK	3	1	22.52	22.59	22.67		
1.4	QPSK	3	3	22.50	22.61	22.64		
1.4	QPSK	6	0	21.64	21.54	21.57	23.5	1
1.4	16QAM	1	0	21.65	21.63	21.62		
1.4	16QAM	1	3	21.68	21.51	21.62		
1.4	16QAM	1	5	21.60	21.63	21.51	23.5	1
1.4	16QAM	3	0	21.70	21.65	21.50		
1.4	16QAM	3	1	21.70	21.58	21.61		
1.4	16QAM	3	3	21.81	21.54	21.69		
1.4	16QAM	6	0	20.74	20.88	20.84	22.5	2

Band 5 (Celluar Band)
Part 22H(only on channel required)

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.	Tune-up limit (dBm)	MPR (dB)
Channel				20450	20525	20600		
Frequency (MHz)				829	836.5	844		
10	QPSK	1	0	22.93	23.04	22.86		
10	QPSK	1	25	23.03	22.98	22.94	24.5	0
10	QPSK	1	49	22.81	22.82	22.79		
10	QPSK	25	0	22.12	22.20	22.14		
10	QPSK	25	12	22.19	22.16	21.98	23.5	1
10	QPSK	25	25	22.15	22.14	22.04		
10	QPSK	50	0	22.09	22.10	22.01		
10	16QAM	1	0	22.01	22.43	22.31		
10	16QAM	1	25	22.39	22.25	22.40	23.5	1
10	16QAM	1	49	22.04	22.07	22.42		
10	16QAM	25	0	20.98	21.15	21.19		
10	16QAM	25	12	21.41	21.43	21.22	22.5	2
10	16QAM	25	25	21.30	21.42	21.43		
10	16QAM	27	0	20.66	20.68	20.76		
Channel				20425	20525	20625	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				826.5	836.5	846.5		
5	QPSK	1	0	22.75	22.85	22.73		
5	QPSK	1	12	22.83	22.86	22.88	24.5	0
5	QPSK	1	24	22.60	22.64	22.63		
5	QPSK	12	0	22.04	22.06	22.08		
5	QPSK	12	7	22.07	21.97	21.84	23.5	1
5	QPSK	12	13	21.95	22.09	21.85		
5	QPSK	25	0	21.90	21.91	21.94		
5	16QAM	1	0	21.84	22.20	22.15		
5	16QAM	1	12	22.27	22.19	22.28	23.5	1
5	16QAM	1	24	21.97	21.97	22.23		
5	16QAM	12	0	20.87	20.96	21.08		
5	16QAM	12	7	21.29	21.26	20.99	22.5	2
5	16QAM	12	13	21.10	21.26	21.32		
5	16QAM	25	0	21.16	21.40	21.43		
Channel				20415	20525	20635	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				825.5	836.5	847.5		
3	QPSK	1	0	22.57	22.71	22.55		
3	QPSK	1	8	22.64	22.71	22.71	24.5	0
3	QPSK	1	14	22.57	22.56	22.68		
3	QPSK	8	0	21.92	21.91	21.89		
3	QPSK	8	4	21.92	21.80	21.79	23.5	1
3	QPSK	8	7	21.82	21.88	21.71		
3	QPSK	15	0	21.80	21.86	21.87		
3	16QAM	1	0	21.74	22.13	21.93		
3	16QAM	1	8	22.05	21.98	22.19	23.5	1
3	16QAM	1	14	21.80	21.85	22.09		
3	16QAM	8	0	20.70	20.81	21.00		
3	16QAM	8	4	21.13	21.11	20.88	22.5	2
3	16QAM	8	7	20.90	21.04	21.11		
3	16QAM	15	0	21.02	21.32	21.31		
Channel				20407	20525	20643	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				824.7	836.5	848.3		
1.4	QPSK	1	0	22.69	22.69	22.67		
1.4	QPSK	1	3	22.73	22.70	22.74		
1.4	QPSK	1	5	22.64	22.53	22.67	24.5	0
1.4	QPSK	3	0	22.74	22.65	22.71		
1.4	QPSK	3	1	22.67	22.56	22.64		
1.4	QPSK	3	3	22.60	22.76	22.67		
1.4	QPSK	6	0	21.76	21.80	21.79	23.5	1
1.4	16QAM	1	0	21.77	22.15	22.03		
1.4	16QAM	1	3	22.08	21.98	22.20		
1.4	16QAM	1	5	21.84	21.76	22.14	23.5	1
1.4	16QAM	3	0	21.55	21.52	21.61		
1.4	16QAM	3	1	21.84	21.87	21.63		
1.4	16QAM	3	3	21.79	21.82	21.87		
1.4	16QAM	6	0	21.02	21.26	21.21	22.5	2

Band 7 (2600MHz Band)
Part 27

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.	Tune-up limit (dBm)	MPR (dB)
Channel				20850	21100	21350		
Frequency (MHz)				2510	2535	2560		
20	QPSK	1	0	22.78	22.97	22.61	24	0
20	QPSK	1	49	22.89	22.82	22.76		
20	QPSK	1	99	22.67	22.60	22.52		
20	QPSK	50	0	20.90	20.91	20.72	22	2
20	QPSK	50	24	20.79	20.74	20.78		
20	QPSK	50	50	20.84	20.70	20.80		
20	QPSK	100	0	20.80	20.83	20.64		
20	16QAM	1	0	20.94	20.89	20.97	22	2
20	16QAM	1	49	20.97	20.81	20.87		
20	16QAM	1	99	20.78	20.88	21.00		
20	16QAM	12	0	20.60	20.89	20.72	21	3
20	16QAM	12	43	20.58	20.68	20.59		
20	16QAM	12	86	20.57	20.66	20.64		
20	16QAM	27	0	19.80	20.20	19.72		
Channel				20825	21100	21375	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				2507.5	2535	2562.5		
15	QPSK	1	0	22.58	22.92	22.75	24	0
15	QPSK	1	37	22.70	22.71	22.65		
15	QPSK	1	74	22.79	22.56	22.67		
15	QPSK	36	0	20.80	20.70	20.65	22	2
15	QPSK	36	20	20.68	20.66	20.68		
15	QPSK	36	39	20.72	20.53	20.65		
15	QPSK	75	0	20.58	20.61	20.54		
15	16QAM	1	0	20.82	20.94	20.93	22	2
15	16QAM	1	37	20.76	20.64	20.78		
15	16QAM	1	74	20.72	20.72	20.88		
15	16QAM	12	0	20.52	20.64	20.57	21	3
15	16QAM	12	31	20.59	20.62	20.53		
15	16QAM	12	61	20.56	20.61	20.51		
15	16QAM	27	0	19.58	20.07	19.63		
Channel				20800	21100	21400	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				2505	2535	2565		
10	QPSK	1	0	22.64	22.91	22.51	24	0
10	QPSK	1	25	22.73	22.66	22.67		
10	QPSK	1	49	22.60	22.68	22.73		
10	QPSK	25	0	20.71	20.72	20.64	22	2
10	QPSK	25	12	20.60	20.52	20.72		
10	QPSK	25	25	20.72	20.62	20.61		
10	QPSK	50	0	20.64	20.63	20.48		
10	16QAM	1	0	20.85	20.95	20.94	22	2
10	16QAM	1	25	20.91	20.62	20.78		
10	16QAM	1	49	20.63	20.79	20.83		
10	16QAM	25	0	20.48	20.36	20.06	21	3
10	16QAM	25	12	20.36	20.29	20.23		
10	16QAM	25	25	20.35	20.28	20.26		
10	16QAM	27	0	19.57	19.83	19.52		
Channel				20775	21100	21425	Tune-up limit (dBm)	MPR (dB)
Frequency (MHz)				2502.5	2535	2567.5		
5	QPSK	1	0	22.64	22.73	22.67	24	0
5	QPSK	1	12	22.64	22.54	22.62		
5	QPSK	1	24	22.77	22.63	22.61		
5	QPSK	12	0	20.57	20.50	20.47	22	2
5	QPSK	12	7	20.40	20.32	20.56		
5	QPSK	12	13	20.57	20.45	20.48		
5	QPSK	25	0	20.53	20.43	20.28		
5	16QAM	1	0	20.78	20.80	20.75	22	2
5	16QAM	1	12	20.81	20.52	20.96		
5	16QAM	1	24	20.55	20.68	20.66		
5	16QAM	12	0	20.28	20.22	20.01	21	3
5	16QAM	12	7	20.22	20.12	20.01		
5	16QAM	12	13	20.22	20.14	20.18		
5	16QAM	25	0	19.93	20.01	20.00		