



Test Report

Report No	EF0429-1 Issue 2
Client	Loea Corporation 164 West Street West Hatfield, MA 01088
Phone	1-413-247-9440
FRN	0013420088
Emission Designator	K1D4G23
Model	L-2500
FCC ID	S2N-L2500-2
Equipment Type Equipment Code	Licensed Non-Broadcast Station Transmitter TNB
Results	As detailed within this report
Prepared by	 Evan Gould – Test Engineer
Authorized by	 Michael Buchholz – EMC Manager
Issue Date	8/1/05
Conditions of issue	This Test Report is issued subject to the conditions stated in ‘terms and conditions’ section of this report.

Curtis-Straus LLC is accredited by the American Association for Laboratory Accreditation for the specific scope of accreditation under Certificate Number 1627-01. This report may contain data which is not covered by the A2LA accreditation.

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Summary

This test report supports an application for a licensed transmitter operating pursuant to 47 CFR 101. The product is the Loea Corporation L-2500 Millimeter Wave Radio. It is a transmitter that operates at either 73.5GHz or 83.5GHz depending on whether it is the Lo or Hi version.

Test Methodology

Radiated emissions testing is performed according to the procedures specified in TIA-603. Since the device is always installed in one orientation, emissions were maximized by rotating the device around it's vertical axis as well as varying the test antenna's height and polarity.

Frequency range investigated: 150kHz – 200GHz

Measurement distance:	150kHz – 30MHz	Conducted
	30 – 1000MHz	3m
	1 – 18GHz	3m or 1m
	18 – 26.5GHz	1m
	26.5 – 200GHz	0.1m

EUT Configuration

EUT Configuration				
Work Order: F0429 Company: Loea Corporation Company Address: 164 West Street West Hatfield, MA 01088 Contact: John Hutchings Person Present: John Hutchings				
MN		SN		
EUT: L-2500		000117M (83.5GHz radio)		
L-2500		000117F (73.5GHz radio)		
CyberPower UPS/Surge Protector	CPS625AVR	B1A3T1B06372		
EUT Description: Millimeter Wave Radio				
EUT Max Frequency: 83.5GHz				
Support Equipment:		MN		
SN				
<u>OC12 Generator</u>				
Surise Telecom	SunSet OCx	SSOCX12C0346122385		
<u>Gigabit Ethernet Generator</u>				
Tektronix	GTS1250	B010207		
EUT Cables:	Qty	Shielded?	Length	Ferrites
AC Power	1	No	6ft	No
Fiber pair	1	N/A	N/A	N/A
Unpopulated EUT Ports:	Qty	Reason		
DB9 Serial	1	Setup/Diag		
BNC AGC	1	Setup/Diag		
Ethernet	1	Not Used		
Software / Operating Mode Description:				
EUT was operating in TX and RX modes simultaneously. Both OC12 and Gig-E modulations were tested using pseudorandom data sequences. CW mode was used when needed as well. EUT has only one power level setting available.				

Fundamental Measurement**LIMIT**

55dBW (EIRP) [47 CFR 101.113]

MEASUREMENTS

Output Power (Conducted)					Curtis-Straus LLC		
Date: 3-Jun-05		Engineer: Evan Gould			Work Order: F0429		
Company: Loea Corp		EUT: L-2500			Fundamental Frequency: 73.5 or 83.5GHz		
Test Site: A		Cable: N/A			Power Meter: HP 437B		
Attenuator: N/A		Sensor Head: HP W8486A					
Notes: CW mode							
Radio	Frequency (GHz)	Reading (dBm)	Antenna Gain (dBi)	Adjusted Reading (dBW)	47 CFR 101.113		
					EIRP Limit (dBW)	Margin (dB)	Result (Pass/Fail)
73.5GHz	73.500	12.7	50.6	33.3	55.0	-21.7	Pass
83.5GHz	83.500	11.7	50.9	32.6	55.0	-22.4	Pass

Spectral Density

LIMITS

150mW/100MHz [47 CFR 101.113]

MEASUREMENTS

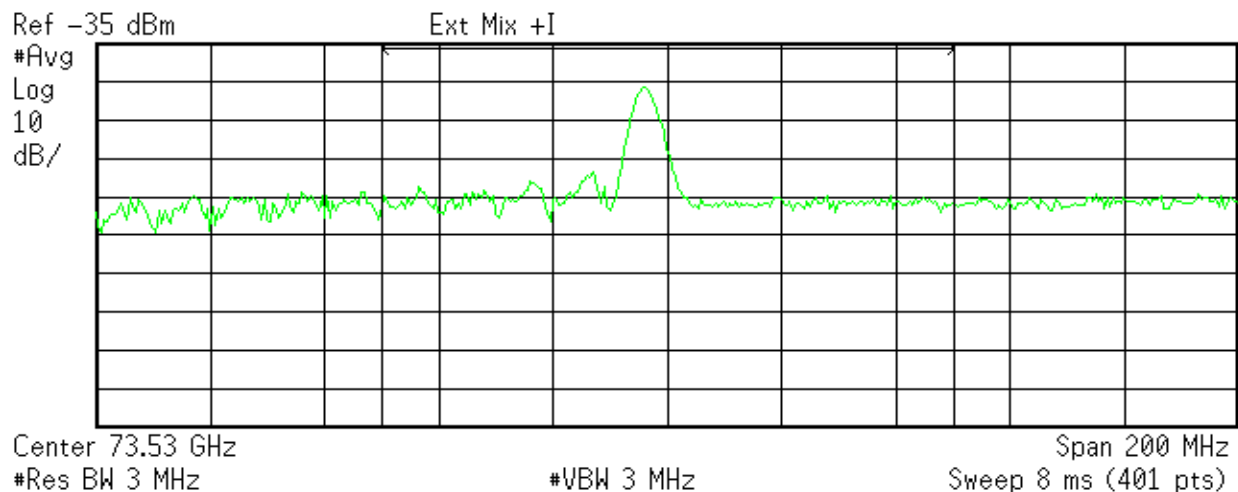
Power Spectral Density (Conducted)						Curtis-Straus LLC		
Date: 7-Jun-05		Engineer: Evan Gould				Work Order: F0429		
Company: Loea Corp		EUT: L-2500				Fundamental Frequency: 73.5 or 83.5GHz		
Test Site: A		Cable: Semflex				Analyzer: Orange		
Attenuator: QAF-E10000		Mixer: OML WR12 60-90GHz Mixer						
Measurement Type: Peak				Resolution BW: 3MHz				
				Video BW: 3MHz				
Notes:								
Radio / Modulation	Frequency (GHz)	Reading (dBm/100MHz)	Attenuator Factor (dB)	Conversion Loss (dB)	Adjusted Reading (dBm/100MHz)	47 CFR 101.113		
						150mW Limit (dBm/100MHz)	Margin (dB)	Result (Pass/Fail)
73.5GHz / Gig-E	73.5	-46.7	10.0	42.2	5.5	21.7	-16.2	Pass
73.5GHz / OC12	73.5	-47.2	10.0	42.2	5.0	21.7	-16.7	Pass
83.5GHz / Gig-E	83.5	-56.7	10.0	42.2	-4.5	21.7	-26.2	Pass
83.5GHz / OC12	83.5	-54.2	10.0	42.2	-2.0	21.7	-23.7	Pass

ANALYZER PLOT

73.5GHz Radio; Gig-E Modulation

* Agilent 14:16:13 Jun 7, 2005

R L



Channel Power

-46.74 dBm /100.0000 MHz

Power Spectral Density

-126.74 dBm/Hz

Occupied Bandwidth

LIMIT

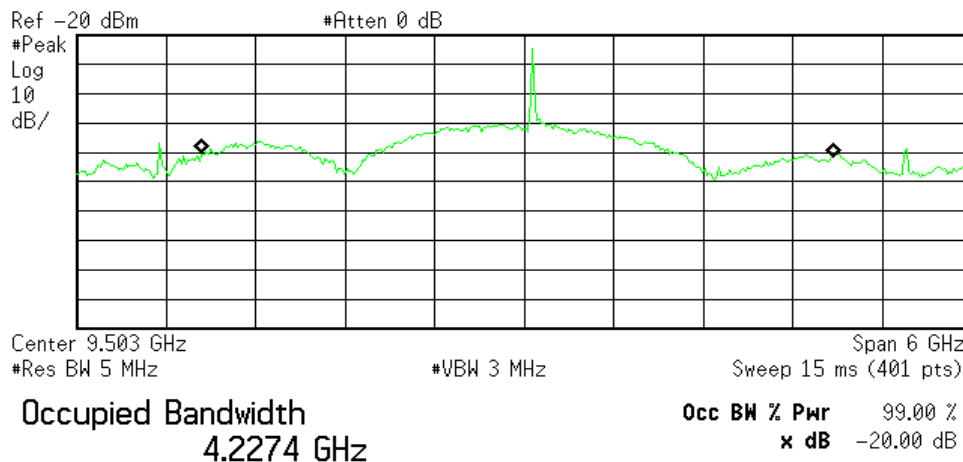
5000MHz [47 CFR 101.109]

ANALYZER PLOTS

73.5GHz Radio; Gig-E Modulation

Agilent 12:25:32 Jun 7, 2005

R L

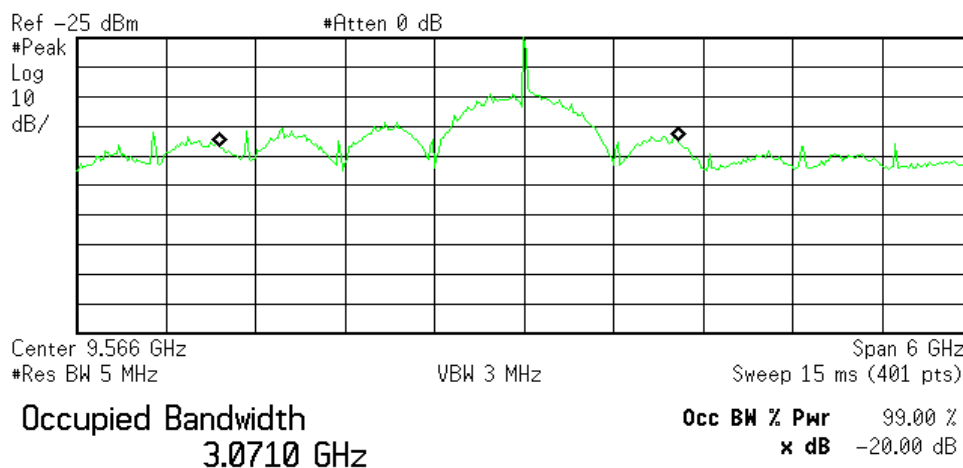


Transmit Freq Error -39.567 MHz
x dB Bandwidth 40.140 MHz

73.5GHz Radio; OC-12 Modulation

Agilent 12:41:07 Jun 7, 2005

R L

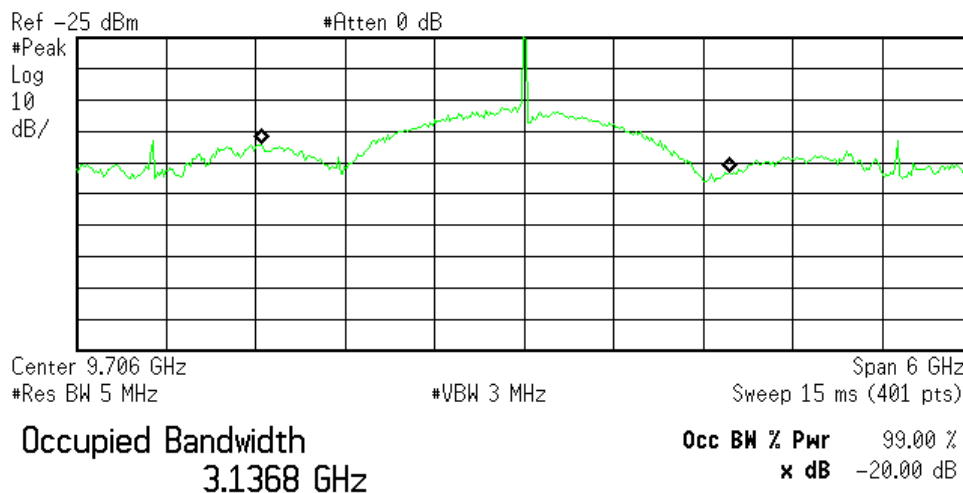


Transmit Freq Error -506.865 MHz
x dB Bandwidth 300.536 MHz

83.5GHz Radio; Gig-E Modulation

* Agilent 13:06:25 Jun 7, 2005

R L

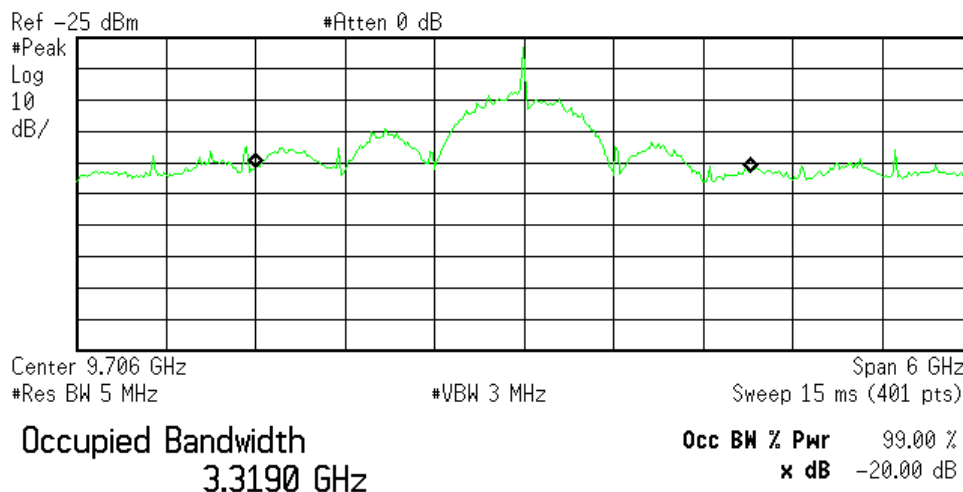


Transmit Freq Error -192.704 MHz
x dB Bandwidth 44.848 MHz

83.5GHz Radio; OC-12 Modulation

* Agilent 13:12:31 Jun 7, 2005

R L



Transmit Freq Error -147.038 MHz
x dB Bandwidth 647.408 MHz

Note: The method used to accurately reflect the shape of the emissions was to use a block down-converter which is why the frequency range shown in the plots is around 10GHz.

Emission Mask

Emissions Mask (Conducted)				Curtis-Straus LLC
Date: 7-Jun-05		Engineer: Evan Gould	Work Order: F0429	
Company: Loea Corp		EUT: L-2500	Fundamental Frequency: 73.5 or 83.5GHz	
Test Site: A		Cable: Semflex	Analyzer: Orange	
Mixer: OML WR08 90-140GHz		Mixer: OML WR12 60-90GHz	Diplexer: DPL.26	
Measurement Type: Peak		Resolution BW: 1MHz		
		Video BW: 3MHz		
Notes: Frequency Ranges are the 50% - 250% of the authorized bandwidth removed from the center frequency as specified in 47 CFR 101.111(a)(2)(ii). The authorized bandwidth used for the calculation is 5000MHz.				
Radio	Frequency Range (MHz)		Measurement (dBm)	Worst Case Limit (dBm)
73.5GHz	60995	70995	No emissions found of amplitude greater than -13dBm	-13
73.5GHz	75995	85995	No emissions found of amplitude greater than -13dBm	-13
83.5GHz	70940	80940	No emissions found of amplitude greater than -13dBm	-13
83.5GHz	85940	95940	No emissions found of amplitude greater than -13dBm	-13

Radiated Spurious Emissions

LIMIT

Must be attenuated by $43 + 10 \log(\text{output power in Watts})$ dB below the output power:
 $62.6\text{dBm (output power)} = 157.8\text{uV/m @ 3m (output power)}$

Attenuation required: $43 + 32.6\text{dBW} = 75.6\text{dB}$

Limit: $157.8\text{dBuV/m} - 75.6\text{dB} = 82.2\text{dBuV/m}$ [47 CFR 101.111]

The limits used in the following are the 15.209 limits which are worst case.

MEASUREMENTS

Radiated Emissions Table							Curtis-Straus LLC		
Date: 07-Jun-05			Company: Loea Corp			Work Order: F0429			
Engineer: Evan Gould			EUT Desc: L-2500						
Frequency Range: 30-1000MHz					Measurement Distance: 3 m				
Notes: 83.5GHz; OC-12					EUT Max Freq: 83.5GHz				
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBμV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBμV/m)	FCC Class B		
							Limit (dBμV/m)	Margin (dB)	Result (Pass/Fail)
V	105.0	35.0	24.7	11.7	2.4	24.4	43.5	-19.1	Pass
V	120.6	34.4	24.6	12.9	2.7	25.4	43.5	-18.1	Pass
V	169.5	31.4	24.5	10.4	3.2	20.5	43.5	-23.0	Pass
V	335.5	39.2	24.0	14.8	4.7	34.7	46.0	-11.3	Pass
H	460.8	39.1	23.9	17.3	5.7	38.2	46.0	-7.8	Pass
H	468.2	37.6	23.9	17.4	5.7	36.8	46.0	-9.2	Pass
Table Result:		Pass	by		-7.8 dB		Worst Freq:		460.8 MHz
Test Site: "A"		Pre-Amp: Orange		Cable: 100 ft.		Analyzer: White		Antenna: Green	

Radiated Emissions Table							Curtis-Straus LLC		
Date: 06-Jun-05			Company: Loea Corp				Work Order: F0429		
Engineer: Evan Gould			EUT Desc: L-2500						
Frequency Range: 1-18GHz					Measurement Distance: 3 m				
Notes: 73.5GHz; Gig E RBW=1MHz; VBW=3MHz					EUT Max Freq: 73.5GHz				
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBμV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBμV/m)	FCC Class B		
							Limit (dBμV/m)	Margin (dB)	Result (Pass/Fail)
Vav	1644.0	29.3	18.7	29.5	1.6	41.7	54.0	-12.3	Pass
Hav	1250.0	36.5	17.8	28.3	1.4	48.4	54.0	-5.6	Pass
Table Result:		Pass	by	-5.6 dB		Worst Freq:		1250.0 MHz	
Test Site: "A"		Pre-Amp: Yel-Blk		Cable: 6 RG142LL		Analyzer: Orange		Antenna: Yellow Horn	

Radiated Emissions Table							Curtis-Straus LLC		
Date: 06-Jun-05			Company: Loea Corp				Work Order: F0429		
Engineer: Evan Gould			EUT Desc: L-2500						
Frequency Range: 18-26.5GHz						Measurement Distance: 1 m			
Notes: 73.5GHz radio; Gig-E modulation RBW=1MHz; VBW=3MHz						EUT Max Freq: 73.5GHz Antenna: 18-26.5GHz Horn			
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBμV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBμV/m)	FCC Class B		
							Limit (dBμV/m)	Margin (dB)	Result (Pass/Fail)
Hav	20492.0	28.0	21.0	40.2	4.2	51.4	63.5	-12.1	Pass
Table Result:		Pass	by	-12.1 dB		Worst Freq:		20492.0 MHz	
Test Site: "A"		Pre-Amp: 18-26.5GHz		Cable: 7 Microflex		Analyzer: Orange			

Radiated Emissions Table							Curtis-Straus LLC		
Date: 06-Jun-05			Company: Loea Corp			Work Order: F0429			
Engineer: Evan Gould			EUT Desc: L-2500						
Frequency Range: 1-18GHz					Measurement Distance: 3 m				
Notes: 83.5GHz; OC12 RBW=1MHz; VBW=3MHz					EUT Max Freq: 83.5GHz				
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBμV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBμV/m)	FCC Class B		
							Limit (dBμV/m)	Margin (dB)	Result (Pass/Fail)
V	1244.0	30.0	17.8	28.3	1.4	41.9	54.0	-12.1	Pass
Table Result:		Pass	by	-12.1 dB		Worst Freq:		1244.0 MHz	
Test Site: "A"		Pre-Amp: Yel-Blk		Cable: 6 RG142LL		Analyzer: Orange		Antenna: Yellow Horn	

Radiated Emissions Table							Curtis-Straus LLC		
Date: 06-Jun-05			Company: Loea Corp				Work Order: F0429		
Engineer: Evan Gould			EUT Desc: L-2500						
Frequency Range: 1-18GHz					Measurement Distance: 1 m				
Notes: 83.5GHz; OC12 RBW=1MHz; VBW=3MHz					EUT Max Freq: 83.5GHz				
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBμV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBμV/m)	FCC Class B		
							Limit (dBμV/m)	Margin (dB)	Result (Pass/Fail)
Vpk	5186.0	33.8	20.4	34.5	2.9	50.8	63.5	-12.7	Pass
Table Result:		Pass	by	-12.7 dB		Worst Freq:		5186.0 MHz	
Test Site: "A"		Pre-Amp: Yel-Blk		Cable: 6 RG142LL		Analyzer: Orange		Antenna: Yellow Horn	

No other spurious emissions were found up to 200GHz.

AC Line Conducted Emissions**LIMITS**

Frequency of emission (MHz)	Quasi-peak limit (dBμV)	Average limit (dBμV)
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

[47 CFR 15.207(a)]

MEASUREMENTS

AC Mains Conducted Emissions							Curtis-Straus LLC				
Date: 06-Jun-05			Company: Loea Corp			Work Order: F0429					
Engineer: Evan Gould			EUT Desc: L-2500			Test Site: EMI 2					
Notes: 83.5GHz; OC-12											
LISN(s): Red Brown											
Range: 0.15-30Mhz			Other Equipment:				Spectrum Analyzer: Red				
Frequency (MHz)	Q.P. Readings		Ave. Readings		Impedance Factor	FCC/CISPR B		FCC/CISPR B		Overall Result (Pass/Fail)	
	QP1 (dBµV)	QP2 (dBµV)	AV1 (dBµV)	AV2 (dBµV)		qp Limit (dBµV)	qp Margin dB	AVE Limit (dBµV)	AVE Margin dB		
0.15	18.0	16.3			20.0	66.0	-28.0	56.0	-18.0	Pass	
6.37	1.9	3.5			20.0	60.0	-36.5	50.0	-26.5	Pass	
12.90	0.6	4.3			20.0	60.0	-35.7	50.0	-25.7	Pass	
14.30	11.5	10.6			20.0	60.0	-28.5	50.0	-18.5	Pass	
16.10	8.7	7.6			20.0	60.0	-31.3	50.0	-21.3	Pass	
24.10	0.6	9.6			20.0	60.0	-30.4	50.0	-20.4	Pass	
Table Result: Pass by -18.00 dB Worst Freq: 0.15 MHz											

Frequency Stability

MEASUREMENTS

Frequency Stability		Curtis-Straus LLC
Engineer: Evan Gould		Company: Loea Corp.
Date: 6/8/2005		EUT: L-2500
Analyzer: Orange		Work Order: F0429
Cable: 142LL#6		
Note: UPS/Surge Protector input voltage range: 92-140V (from manual). However, the limits at which it would supply the EUT properly was 95-141V, which was used for testing.		
Temperature	Supply Voltage	Center Frequency
(°C)	(VAC)	(GHz)
-30	120	83.497405
-20	120	83.492355
-10	120	83.482950
0	120	83.483525
10	120	83.492575
20	95	83.510650
20	120	83.515850
20	141	83.512850
30	120	83.464300
40	120	83.495100
50	120	83.553000
Largest frequency deviation = 88.7MHz		

Note: There is no requirement. But the measurements were taken to satisfy 47 CFR 2.1055.

Test Equipment Used

REV. 06-JUN-2005

REV: 06-JUN-2005							
SPECTRUM ANALYZERS		RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
WHITE		9kHz-22GHz	8593E	HP	3547U01252	00022	08-MAR-2006
ORANGE		9kHz-26.5GHz	E4407B	HP	US39440975	00394	05-NOV-2005
LISNs/MEASUREMENT PROBES		RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
RED		10kHz-30MHz	8012-50-R-24-BNC	SOLAR	956348	00753	15-APR-2006
BROWN		10kHz-30MHz	8012-50-R-24-BNC	SOLAR	0411656	00986	04-MAY-2006
OPEN AREA TEST SITE (OATS)			FCC CODE	IC CODE	VCCI CODE	CALIBRATION DUE	
SITE A			93448	IC 2762-A	R-903	20-MAR-2007	
LINE CONDUCTED TEST SITES			FCC CODE	IC CODE	VCCI CODE	CALIBRATION DUE	
EMI 2			93448	N/A	C-1802	01-MAY-2006	
MIXERS/DIPLEXERS		RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
MIXER / HORN	26.5-40 GHz	11970A/28-442-6	HP/ATM	2332A01695/A046903-01		1087	23-AUG-2005
MIXER / HORN	26.5-40 GHz	11970A/28-442-6	HP/ATM	3003A07825/A046903-01		1086	23-AUG-2005
MIXER / HORN	40-60 GHz	M19HW/A	OML	U30110-1		00821	02-MAR-2007
MIXER / HORN	60-90 GHz	M12HW/A	OML	E30110-1		00822	03-MAR-2007
MIXER / HORN	90-140 GHz	MO8HW/A	OML	F21206-1		00811	03-MAR-2007
MIXER / HORN	140-220 GHz	MO5HW/A	OML	G21206-1		00812	05-JAN-2005
DIPLEXER		DPL.26	OML	N/A		00813	03-MAR-2007
PREAMPS / ATTENUATORS / FILTERS		RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
ORANGE		0.01-2000MHz	ZFL-1000-LN	C-S	N/A	00765	10-FEB-2006
YELLOW-BLACK		1-20GHz	SMC-12A	C-S	535055	00801	21-JUL-2005
HF (YELLOW)		18-26.5GHz	AFS4-18002650-60-8P-4	C-S	467559	00758	20-JUL-2005
ANTENNAS		RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
GREEN BILOG		30-2000MHz	CBL6112B	CHASE	2742	00620	06-APR-2006
YELLOW HORN		1-18GHz	3115	EMCO	9608-4898	00037	27-MAY-2007(EMI) / 05-JUN-2006 (RFI)
HF (WHITE) HORN		18-26.5GHz	801-WLM	WAVELINE	00758	00758	15-JUL-2005
SMALL LOOP (RENTAL)		10kHz-30MHz	PLA-130/A	ARA	1009	TELOGY	11-FEB-2006
CHAMBERS		MN	MFR	SN	ASSET	CALIBRATION DUE	
ENVIRONMENTAL (SAFETY)		ECL5	B-M-A INC.	2041	00029	12-JAN-2006	
POWER/NOISE METERS			MN	MFR	SN	ASSET	CALIBRATION DUE
POWER METER			435B	HP	2445A11012	00773	06-APR-2006
POWER METER			437B	HP	2912A01367	01099	27-OCT-2005
POWER SENSOR			8481A	HP	2702A61351	00774	05-APR-2006
POWER SENSOR			W8486A	HP	3318A00321		28-JUL-2006

All equipment is calibrated using standards traceable to NIST or other nationally recognized calibration standard.

Terms And Conditions

Paragraph 1. SERVICES. LABORATORY will:

- 1.1 Use the degree of care and skill ordinarily exercised by and consistent with the standards of the profession.
- 1.2 Perform all technical services in substantial accordance with the generally accepted laboratory principles and practices.
- 1.3 Retain all pertinent records relating to the services performed for a period of three (3) years following submission of the report describing such services, during which period the records will be made available to CLIENT upon reasonable request.

Paragraph 2. CLIENT'S RESPONSIBILITIES. CLIENT or his authorized representative will:

- 2.1 Provide LABORATORY with all plans, schematics, specifications, addenda, change orders, drawings and other information for the proper performance of technical services.
- 2.2 Designate a person to act as CLIENT's representative with respect to LABORATORY's services to be performed on behalf of the CLIENT; such person or firm to have complete authority to transmit instructions, receive information and data, interpret and define CLIENT's policies and decisions with respect to the LABORATORY's work on behalf of the CLIENT and to order, at CLIENT's expense, such technical services as may be required.
- 2.3 Designate a person who is authorized to receive copies of LABORATORY's reports.
- 2.4 Undertake the following:
 - (a) Secure and deliver to LABORATORY, without cost to LABORATORY, preliminary representative samples of the equipment proposed to require technical services, together with any relevant data.
 - (b) Furnish such labor and equipment needed by LABORATORY to handle samples at the LABORATORY and to facilitate the specified technical services.

Paragraph 3. GENERAL CONDITIONS:

- 3.1 LABORATORY, by the performance of services covered hereunder, does not in any way assume any of those duties or responsibilities customarily vested in the CLIENT, its employees, or any other party, agency or authority.
- 3.2 LABORATORY shall not be responsible for acts of omissions of any other party or parties involved in the design, manufacture or maintenance of the equipment or the failure of any employee, contractor or subcontractor to undertake any aspect of equipment's design, manufacture or maintenance.
- 3.3 LABORATORY is not authorized to revoke, alter, release, enlarge or release any requirement of the equipment's design, manufacture or maintenance unless specifically authorized by CLIENT or his authorized representative.
- 3.4 THE ONLY WARRANTY MADE BY LABORATORY IN CONNECTION WITH ITS SERVICE PERFORMED HEREUNDER IS THAT IT WILL USE THAT DEGREE OF CARE AND SKILL AS SET FORTH IN PARAGRAPH 1 ABOVE. NO OTHER WARRANTY, EXPRESS OR IMPLIED, IS MADE OR INTENDED FOR SERVICES PROVIDED HEREUNDER.
- 3.5 Where the LABORATORY indicates that additional testing is advisable to obtain more valid or useful data, and where such testing has not been authorized, CLIENT agrees to view such test reports as inconclusive and preliminary.
- 3.6 The LABORATORY will supply technical service and prepare a report based solely on the sample submitted to the LABORATORY by the CLIENT. The CLIENT understands that application of the data to other devices is highly speculative and should be applied with extreme caution.
- 3.7 The LABORATORY agrees to exercise ordinary care in receiving, preserving and shipping (F.O.B. Littleton, MA) any sample to be tested, but assumes no responsibility for damages, either direct or consequential, which arise from loss, damage or destruction of the samples due to the act of examination, modification or testing, or technical services or circumstances beyond LABORATORY's control.
- 3.8 The LABORATORY will hold samples for thirty (30) days after tests are completed, or until the CLIENT's outstanding debts to the LABORATORY are satisfied, whichever is later.
- 3.9 The CLIENT recognizes that generally accepted error variances apply and agrees to consider such error variances in its use of test data.
- 3.10 It is agreed between LABORATORY and CLIENT that no distribution of any tests, reports or analysis other than that described below shall be made to any third party without the prior written consent of both parties unless such distribution is mandated by operation of law. It is agreed that tests, reports, or analysis results may be disclosed to third party auditors of the laboratory at the laboratory facility in the course of accreditation maintenance audits. No reference to reports or technical services of the LABORATORY shall be made in any advertising or promotional literature without the express written permission of the LABORATORY.
- 3.11 The CLIENT acknowledges that all employees of LABORATORY operate under employment contracts with the LABORATORY and CLIENT agrees not to solicit employment of such employees or to solicit information related to other clients from said employees.
- 3.12 In recognition of the relative risks and benefits of the project to both CLIENT and LABORATORY, the risks have been allocated such that the CLIENT agrees, to the fullest extent permitted by law, to limit the liability of the LABORATORY to the CLIENT for any and all claims, losses, costs, damages of any nature whatsoever or claims expenses from any cause or causes, including attorneys' fees and costs and expert witness fees and costs, so that the total aggregate liability of the LABORATORY to the CLIENT shall not exceed \$100,000, or the LABORATORY'S total fee for services rendered on this project, whichever is greater. It is intended that this limitation apply to any and all liability or cause of action however alleged or arising, unless otherwise prohibited by law.

Paragraph 4. INSURANCE:

- 4.1 LABORATORY shall secure and maintain throughout the full period of the services provided to the CLIENT adequate insurance to protect it from claims under applicable Workmen's Compensation Acts and also shall maintain one million dollars of general liability coverage to cover claims for bodily injury, death or property damage as may arise from the performance of its services.
- 4.2 The CLIENT hereby warrants that it has sufficient insurance to protect its employees adequately under applicable Workmen's Compensation Acts and for bodily injury, death, or property damage.
- 4.3 No insurance of whatever kind or type, which may be carried by either party is to be considered as in any way limiting any other party's responsibility for damages resulting from their operations or for furnishing work and materials.

Paragraph 5. PAYMENT:

- 5.1 CLIENT shall pay to LABORATORY such fees for services as previously agreed, orally or in writing, within 30 days of presentment of a bill for such services performed. In the event CLIENT ordered, orally or in writing, services but such services were not assigned a rate for billing, such services shall be billed at the LABORATORY's reasonable and customary rate.

- 5.2 CLIENT shall be responsible for all shipping, customs and other expenses related to services provided by LABORATORY to the CLIENT, and shall fully insure any test sample or other equipment provided to LABORATORY by the CLIENT.
- 5.3 Amounts overdue from CLIENT to LABORATORY shall be charged interest at a rate of 1½% per month.

Paragraph 6. ISO/IEC GUIDE 17025 ADDITIONS:

- 6.1 CLIENT agrees that this test report will not be reproduced except in full, without written approval from the LABORATORY.
- 6.2 CLIENT agrees that this test report shall not be used to claim product endorsement by A2LA or ANSI or any agency of the U.S. Government.
- 6.3 CLIENT agrees that test results presented herein relate only to the sample tested by the LABORATORY.

ETS EN 300 386-2 1997, 1998, ETS EN 300 386 2000 v1.2.1, 2001 v1.3.1 ETS 300 132-1 1996 ETS 300 132-2 1996 ETR 283 1997 <i>EU radio standards</i> (ETS) EN 300 385 v1.2.1: 1998, 1999 EN 300 330 v1.2.1: 1998, 1999 ETS 300 328 1996 ETS EN 300 440 v1.2.1 1999 EN 301 893:2002 v1.2.1 ETS 300 836-1:1998 EN301 489-17:2002 v1.2.1 (A2LA Cert. No. 1627-01) 10/31/03	Electromagnetic compatibility and radio spectrum matters (ERM); Telecommunication network equipment; Electromagnetic compatibility (EMC) requirements; Part 2: Product family standard. Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 1: Operated by alternating current (ac) derived from direct current (dc) sources Equipment Engineering (EE); Power supply interface at the input to telecommunications equipment; Part 2: Operated by direct current (dc) Equipment Engineering (EE): Transient voltages at Interface A on telecommunications direct current (DC) power distributions. Electromagnetic compatibility and Radio spectrum matters (ERM); Electromagnetic Compatibility (EMC) standard for fixed radio links and ancillary equipment (ETS) Electromagnetic compatibility and Radio spectrum matters (ERM); Short range devices (SRD); Technical characteristics and test methods for radio equipment in the range 9 kHz to 25 MHz and inductive loop systems in the frequency range 9 kHz to 30 MHz Radio Equipment and Systems (RES); Wideband transmission systems; Technical characteristics and test conditions for data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques Electromagnetic compatibility and Radio spectrum matters (ERM); Short range devices; Technical characteristics and test methods for radio equipment to be used in the 1 GHz to 40 GHz frequency range Broadband Radio Access Networks (BRAN); 5 GHz (draft) high performance RLAN; Harmonized EN covering Essential requirements of article 3.2 of the R&TTE Directive Broadband Radio Access Networks (BRAN); High Performance Radio Local Area Network (HIPERLAN) Type 1; Conformance testing specification; Part 1: Radio Type approval and Radio Frequency (RF) conformance test specification Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 17: Specific conditions for 2.4 GHz wideband transmission systems and 5 GHz high performance RLAN equipment Page 5 of 11	EN 300 328-2:2001 v1.2.1 EN 301 489-1:2002 EN 60669-2-1:2002 <i>Canada Radio Standards</i> Canadian GL-36 1995 Canadian RSS-119 1999, 2000 Issue 6 Canadian RSS-134 1996 & 2000, Issue 1 Rev 1 Canadian RSS-210 2000 Issue 3, RFS29 1998 Specification for Restricted Radiation Radio Apparatus (New Zealand) <i>FCC Standards</i> 47 CFR FCC low power transmitters operating on frequencies below 1 GHz, emergency alert systems, unintentional radiators and ISM devices. 47 CFR FCC low power transmitters operating on frequencies above 1 GHz, with the exception of spread spectrum devices. 47 CFR FCC Unlicensed Personal Scope Communications System (PCS) devices 47 CFR FCC Unlicensed National Scope Information Infrastructure devices and low power transmitters using spread spectrum techniques. 47 CFR FCC Personal mobile Scope Radio Services in the following FCC Rule Parts 22, 24, 25, 27. 47 CFR FCC General Mobile Radio Scope Services in the following FCC Rule Parts 22, 74, 90, 95, 97. 47 CFR FCC Maritime and Aviation Scope Radio Services in 47 CFR Parts 80 and 87 47 CFR FCC Microwave Radio Services Scope in 47 CFR Parts 21, 74 and 101. Scope A1 Scope A2 A3 A4 B1 B2 B3 B4 (A2LA Cert. No. 1627-01) 10/31/03	Electromagnetic compatibility and Radio spectrum Matters (ERM); Wideband Transmission systems; Data transmission equipment operating in the 2.4 GHz ISM band and using spread spectrum modulation techniques; Part 2: Harmonized EN covering essential requirements under article 3.2 of the R&TTE Directive Electromagnetic compatibility and Radio spectrum Matters (ERM); Electromagnetic Compatibility (EMC) standard for radio equipment and services; Part 1: Common technical requirements Switches for household and similar fixed electrical installations -- Part 2-1: Particular requirements -- Electronic switches Industry Canada -- technical requirements for low power Devices in the 2400 -- 2483.5 MHz band. Industry Canada -- Land mobile and fixed radio Transmitters and receivers, 27.41 to 960.0 MHz Industry Canada -- 900 MHz narrowband personal communications services Industry Canada -- Low power license-exempt radio 2001 Issue 5 communication devices
FCC/OST MP-5 1986 GR-1089-CORE: 1997, 1999 issue 2/ 2002 Issue 3 <i>ANSI EMC Standards</i> ANSI C63.4: 1992, 1999, 2001 ANSI C63.5 1988 <i>IEEE EMC Standards</i> IEEE C62.41: 1980, 1991 <i>Swedish EMC Standards</i> BAKOM 3336.3 1995 <i>South African EMC standards other than CISPR equivalents</i> SABS 1718-1: 1996 <i>Japanese VCCI Standards</i> VCCI V-3/99.05 1999 VCCI V-4/99.05 1999 Telecommunications Telecommunications Registration; General test methods; Lightning surge; Drop testing; Balance testing; Signal power (metallic and longitudinal); Frequency measurements; Pulse templates; Leakage testing; Impedance testing; Hearing Aid Compatibility testing (<i>excluding volume control</i>); Protocol analysis and Jitter testing. <u>Telecom Standards</u> FCC 47 CFR Part 68 Telephone CS-03 Issue 8 1996 through amendment 5 TIA/EIA TSB31-B 1998 (A2LA Cert. No. 1627-01) 10/31/03	FCC (Federal Communications Commission) methods Of measurement of radio noise emissions from industrial, scientific and medical equipment. Bellcore electromagnetic compatibility and electrical safety -- Generic criteria for network telecommunications equipment. American National Standard for methods of measurement of radio-noise emissions for low-voltage electrical and electronic equipment in the range of 9 kHz to 40GHz. American National Standard for electromagnetic compatibility -- radiated emissions measurements in electromagnetic interference (EMI) control -- calibration of antennas. IEEE recommended practice on surge voltages in low-voltage AC power circuits Electromagnetic compatibility and electrical safety (EMC & S) for wired terminal equipment. Harmonization document information over the OFCOM requirements. South African Bureau of Standards: Specification for Gaming equipment. Part 1: Casino equipment. Technical Requirements Instruction for Test Conditions for Requirement under Test Page 7 of 11	TIA/EIA-IS-968 TIA/EIA-IS-883 TIA-968-A T1.TRQ 6-2001 Canada VDSL Issue 1 January 2003 AS/ACIF S002-2001 AS/ACIF S016-2001 AS/ACIF S031-2001 AS/ACIF S038-2001 AS/ACIF S043-2001 ITU-T G.703 HKTA 2028 HKTA 2029 TBR 1 : 1995 TBR 2 : 1997 Telecommunications Telephone Terminal Equipment Technical Requirements for Connection of Terminal Equipment to the Telephone Network Telecommunications Telephone Terminal Equipment Supplemental Technical Requirements for Connection of Stutter Dial Tone Detection Devices and ADSL Modems to the Telephone Network Telecommunications Telephone Terminal Equipment Technical Requirements for Connection of Terminal Equipment to the Telephone Network Technical Requirements for SHDSL, HDSL2, HDSL4 Digital Subscriber Line Terminal Equipment to Prevent Harm to the Telephone Network Industry Terminal Attachment Program Requirements and Test Methods for Very-High-Bit-Rate Digital Subscriber Line (VDSL) Terminal Equipment Analogue interworking and non-interference requirements for Customer Equipment for connection to the Public Switched Telephone Network Requirements for Customer Equipment for connection to hierarchical digital interfaces Requirements for ISDN Basic Access Interface Requirements for ISDN Primary Rate Access Interface Requirements for Customer Equipment for Connection to a Metallic Local Loop Interface of a Telecommunications Network -- Part 1: General Part 2: Broadband Part 3: DC, Low Frequency AC and Voiceband Physical/electrical characteristics of hierarchical Digital interfaces Network connection specification for connection of CPE to the PTNs in Hong Kong using digital leased circuits at data rate of 1544 kbit/s Network connection specification for connection of CPE to the PTNs in Hong Kong using digital leased circuits at data rate of 2048 kbit/s Attachment requirements for terminal equipment to be connected to circuit switched data networks and leased circuits using a CCITT Recommendation X.21 interface, or at an interface physically, functionally and electrically compatible with CCITT Recommendation X.21 but operating at any data signaling rate up to, and including, 1 984 kbit/s Attachment requirements for Data Terminal Equipment (DTE) to connect to Packet Switched Public Data Networks (PSPDNs) for CCITT Recommendation X.25 interfaces at data signaling rates up to 1 920 kbit/s utilizing interfaces derived from CCITT Recommendations X.21 and X.21 bit (A2LA Cert. No. 1627-01)	Telecommunications Telephone Terminal Equipment Technical Requirements for Connection of Terminal Equipment to the Telephone Network Telecommunications Telephone Terminal Equipment Supplemental Technical Requirements for Connection of Stutter Dial Tone Detection Devices and ADSL Modems to the Telephone Network Telecommunications Telephone Terminal Equipment Technical Requirements for Connection of Terminal Equipment to the Telephone Network Technical Requirements for SHDSL, HDSL2, HDSL4 Digital Subscriber Line Terminal Equipment to Prevent Harm to the Telephone Network Industry Terminal Attachment Program Requirements and Test Methods for Very-High-Bit-Rate Digital Subscriber Line (VDSL) Terminal Equipment Analogue interworking and non-interference requirements for Customer Equipment for connection to the Public Switched Telephone Network Requirements for Customer Equipment for connection to hierarchical digital interfaces Requirements for ISDN Basic Access Interface Requirements for ISDN Primary Rate Access Interface Requirements for Customer Equipment for Connection to a Metallic Local Loop Interface of a Telecommunications Network -- Part 1: General Part 2: Broadband Part 3: DC, Low Frequency AC and Voiceband Physical/electrical characteristics of hierarchical Digital interfaces Network connection specification for connection of CPE to the PTNs in Hong Kong using digital leased circuits at data rate of 1544 kbit/s Network connection specification for connection of CPE to the PTNs in Hong Kong using digital leased circuits at data rate of 2048 kbit/s Attachment requirements for terminal equipment to be connected to circuit switched data networks and leased circuits using a CCITT Recommendation X.21 interface, or at an interface physically, functionally and electrically compatible with CCITT Recommendation X.21 but operating at any data signaling rate up to, and including, 1 984 kbit/s Attachment requirements for Data Terminal Equipment (DTE) to connect to Packet Switched Public Data Networks (PSPDNs) for CCITT Recommendation X.25 interfaces at data signaling rates up to 1 920 kbit/s utilizing interfaces derived from CCITT Recommendations X.21 and X.21 bit 10/31/03 Page 8 of 11

TBR 3 : 1995 + Amdt : 1997 TBR 4 : 1995 + Amdt : 1997 TBR 012 : 1993 + Amdt : 1996 TBR 013 : 1996 TBR 21 : 1998 TBR 24 : 1997 <i>Australia</i> TS 002 : 1997 TS 016 : 1997 TS 031 : 1997 TS 038 : 1997 AS/ACIF S043.2:2001 Product Safety General test methods; Input tests; Electric strength tests; Impulse tests; Permanency of marking tests; Accessibility tests; Energy Hazard measurements; Capacitor discharge tests; Humidity conditioning; Earthing tests; Limited power source measurements; Stability tests; Steel ball tests; Lithium Battery Reverse Current measurements; Leakage current tests; Transformer abnormal tests; Telecom leakage tests; Over voltage/power cross tests (<i>excluding x-ray tests</i>). <u>Product Safety Standards</u> Specific Product Safety Standards IEC 950 1991 UL 1950 1998 CSA C22.2 No.950-95 UL 60950 2000 (A2LA Cert. No. 1627-01) 10/31/03	Integrated Services Digital Network (ISDN); Attachment requirements for terminal equipment to connect to an ISDN using ISDN basic access Integrated Services Digital Network (ISDN); Attachment requirements for terminal equipment to connect to an ISDN using ISDN primary rate access Business Telecommunications (BT); Open Network Provision (ONP) technical requirements; 2 048 kbit/s digital unstructured leased line (D2048U) Attachment requirements for terminal equipment Business Telecommunications (BTC); 2 048 kbit/s digital structured leased lines (D2048S); Attachment requirements for terminal equipment interface Terminal Equipment (TE); Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE (excluding TE supporting the voice telephony service) in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signaling Business Telecommunications (BTC); 34 Mbit/s digital Unstructured and structured leased lines (D34U and D34S); Attachment requirements for terminal equipment interface Analogue Interworking and Non interference Requirements for Customer Equipment Connected to the Public Switched Telephone Network General Requirements for Customer Equipment Connected to Hierarchical Digital Interfaces Requirements for ISDN Basic Access Interface Requirements for ISDN Primary Rate Access Interface Requirements for Customer Equipment for connection to a metallic loop interface of a Telecommunications Network – Part 2 Broadband Title Safety of information technology equipment including Amendments 1, 2, 3, and 4 electrical business equipment. Safety of information technology equipment, including electrical business equipment. Safety of Information Technology Equipment (UL 1950) Safety of information technology equipment	IEC 60950 2000 EN 60950 1997, 1998, 2000 IEC 60950-1 2001 UL 60950-1 2003 CSA C22.2 No. 60950-00 CSA C22.2 No. 60950-1 03 AS/NZS 3260 1993 AS/NZS 3260 Supp 1 1996 ACA TS 001 1997 UL 1459 1995 IEC 1010-1 1990 IEC 61010-1 1993 EN 61010-1 1993, 2001 IEC 61010-1 2001 UL 61010B-1 2003 UL 3101-1 1993 CAN/CSA 1010-1 1999 (<i>Including AM 2</i>) UL 3111-1 1996 UL 3121-1 1995 IEC 60601-1 1995 EN 60601-1 1995 (<i>Including AM 2</i>) UL 2601-1 1997 IEC 60065 1998, 2000 ANSI/UL 6500: 1998 CAN/CSA 60065-00 AS/NZS 3250 1995 AS/NZS 60065 2000 Canadian C22.2 No. 1-94 (1-98) 1998 EN 60065 1994 IEC 60825 1990 EN 60825-1 1994 IEC 60825-1 2001 IEC 60825-2 2000-5 systems IEC 60825-4 1997-11 IEC 60335-1 1995 (<i>Including AM2 – 1997 & AM 12 – 1997</i>) EN 60335-1 2001 UL 60335-1 1998 CAN/CSA E335-1 1994	Safety of information technology equipment Safety of information technology equipment, including Electrical business equipment. Approval and test specification – Safety of information technology equipment including electrical business Equipment. Approval and test specification – Safety of information technology equipment including electrical business equipment – Alphabetical reference index to IEC 950 (Supplement to AS/NZS 3260:1993) Australian Communications Authority – Safety requirements for customer equipment. Telephone Equipment Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements. Safety requirements for electrical equipment for measurement, control and laboratory use, Part 1: General requirements. Electrical equipment for laboratory use Part 1: General requirements. Electrical measuring and test equipment. Part 1: General requirements. Medical electrical equipment. Part 1: General requirements for safety. Medical electrical equipment Medical electrical equipment. Part 1: General Requirements for safety. Audio, video and similar electronic apparatus – Safety requirements Audio/video and musical instrument apparatus for Household, commercial and similar general use Australian/New Zealand Standard – Approval and test Specification – Mains operated electronic and related Equipment for household and similar general use Audio, video and similar electronic equipment. Consumer and 1994, commercial products Safety requirements for main operated electronic and related apparatus for household and similar general use. Radiation safety of laser products, equipment Classification, requirements and user's guide Safety of laser products Part 1: equipment Classification, requirements and user's guide. Safety of laser products – Part 2: Safety of optical communication Safety of laser products – Part 4: Laser guards Safety of household and similar electrical appliances Part 1: General requirements
UL 61010A-1 : 2002 EN 61010-1 : 2001 AS/NZS 60950 : 2000 Environmental² <u>Environmental Standards</u> GR-63-CORE ETS 300 019 (vibration up to 1000Hz)	Electrical equipment for laboratory use; part 1: General requirements Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements Safety information technology equipment Title NEBS Requirements: Physical Protection Environmental conditions and environmental tests For telecommunications equipment		(A2LA Cert. No. 1627-01) 10/31/03
² Environmental testing is performed at the satellite facility located at 168 Ayer Rd, Littleton, MA 01460 (A2LA Cert. No. 1627-01) 10/31/03	Page 11 of 11		Page 10 of 11