

Report No	EC0959-1 Issue 2
Client	Terabeam Corporation 1755 Osgood Street North Andover, MA 01845
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FRN	0007-5882-54
Model	6451e
FCC ID	O2700001-30-30
Equipment Type Equipment Code	DXX Low Power Communication Device Transmitter
Results	As detailed within this report
Prepared by	 Evan Gould – Test Engineer
Authorized by	 Michael Buchholz – EMC Manager
Issue Date	<u>1/8/03</u>
Conditions of issue	This Test Report is issued subject to the conditions stated in ‘terms and conditions’ section of this report.

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Summary

This report is an application for Certification of a Transmitter operating pursuant to 47 CFR 15.255 (October 2002). The product covered by this report is the Gigalink - Gigabit Ethernet Radio Transceiver (Model 6451e). This report is designed to demonstrate the compliance of this device with the requirements outlined in 47 CFR Part 15 using the methods outlined in 47 CFR Part 2 with guidance from FCC's "Millimeter Wave Test Procedures".

Two Gigalink units were tested: S/N: 572 was set to the Low frequency (58.6GHz), and S/N: 573 was set to the High frequency (61.9GHz).

Test Methodology

Radiated emissions testing is performed according to the procedures specified in ANSI C63.4 (2000).

Frequency range investigated: 30MHz – 200GHz

Measurement distance:	30 - 1000MHz	3 Meters
	1 - 18GHz	1 Meter*
	18 - ~60GHz	0.3 Meters*
	~60GHz (fundamental)	3 Meters
	~60 – 200GHz	0.3 Meters*

Maximization:

- EUT was rotated around vertical axis.
- Receiving antenna height and polarization was varied.
- Fundamental emission was maximized by hand. (as per FCC's Millimeter Wave Test Procedure)

***Note:** The horn antennas were held close to the EUT in searching for spurious emissions. None were found above 1GHz.

Statement of Conformity

The Terabeam Gigalink has been found to conform with the following parts of the 47 CFR as detailed below:

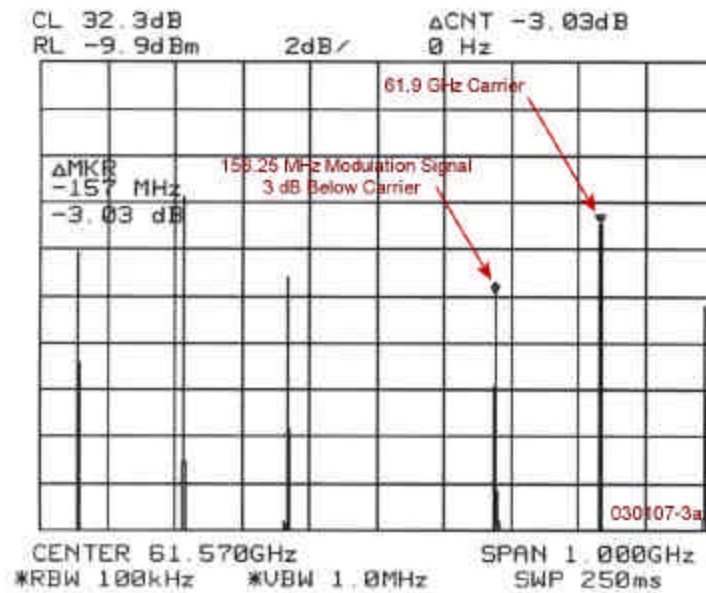
Part 2	Part 15	Comments
	15.15(b)	The product contains no user accessible controls that increase transmission power above allowable levels.
2.925	15.19	The label is shown in the label exhibit.
	15.21	Information to the user is shown in the instruction manual exhibit.
	15.27	No special accessories are required for compliance.
	15.31(e)	Measurements of the fundamental emissions were taken with the input voltage varied $\pm 15\%$ of the nominal rated supply voltage.
	15.203	This antenna is not removable.
	15.205 15.209 15.255(c)(2)	The fundamental is not in a Restricted band and the spurious emissions in the Restricted bands comply with the general emission limits of 15.209.
	15.255(b)	The unit complies with the power density limits of 15.255.
	15.255(c)(3)	No spurious emissions were detected above 40GHz.
	15.255(d)	No emissions appear in the range 57-57.05GHz.
	15.255(f)	The fundamental emission was found to stay within the specified band as temperature was varied from -20° to 50°C , and the supply voltage was varied $\pm 15\%$.
	15.255(g)	Refer to the attached document "FCC Human Exposure Calculation"
	15.255(h)	The EUT will not be equipped with external phase-locking inputs.
	15.255(i)	EUT is for outdoor use only.

Total Output Power

LIMIT

Peak: 500mW [15.255(e)]

The peak output power limit is 500mW for devices which have a 6dB power spectral density bandwidth of 100MHz or more. As is indicated in the plot below, and detailed in the attachment "Theory of Operation", the 6dB bandwidth for typical data rates is in excess of 100MHz.



In the above plot, the lower sideband is shown 3dB down from the carrier and 156.25MHz away.

MEASUREMENTS

Peak Output Power						Curtis-Straus LLC		
Date: 18-Dec-02			Engineer: Evan Gould			Work Order: C0959		
Company: Terabeam			EUT: Gigalink			Fundamental Frequency: 58/62GHz		
Test Site: "T"			Sensor Adaptor: MA4002B			TC Mount: MP716A		
Antenna: V-band 25dB Std Gain			Filter/Attenuator: N/A			Meter: ML4803A		
Measurement Distance: 3m								
Notes: Operating CW; Unmodulated This product supports operation on only two channels: Low and High								
Transmit Band (low/high)	Transmit Frequency (MHz)	Power Reading (dBm)	Voltage (dBμV)	Antenna Factor (dB/m)	Field Strength (dBμV/m)	Peak Power (W)	Peak Power Limit (W)	Result (Pass/Fail)
Low	58618	-14.7	92.3	40.6	132.9	0.0582	0.5	Pass
High	61894	-15	92	41.1	133.1	0.061	0.5	Pass

Power Density

LIMITS

Average: $9\mu\text{W}/\text{cm}^2$ @ 3m [15.255(b)(1)]

Peak: $18\mu\text{W}/\text{cm}^2$ @ 3m [15.255(b)(1)]

Note: If Peak measurements meet Average limits, then calculated Average values are not required.

MEASUREMENTS

Power Density Measurements										Curtis-Straus LLC	
Date: 18-Dec-02			Engineer: Evan Gould				Work Order: C0959				
Company: Terabeam			EUT: Gigalink				Fundamental Frequency: 58/62GHz				
Test Site: "T"			Sensor Adaptor: MA4002B				TC Mount: MP716A				
Antenna: V-band 25dB Std Gain			Filter/Attenuator: N/A				Meter: ML4803A				
Measurement Distance: 3m											
Notes: Operating CW; Unmodulated This product supports operation on only two channels: Low and High											
Transmit Band (low/high)	Transmit Frequency (MHz)	Power Reading (dBm)	Voltage (dBμV)	Antenna Factor (dB/m)	Field Strength (dBμV/m)	Peak EIRP (W)	Peak Pd (uW/cm²)	Ave Pd Limit (uW/cm²)	Peak Pd Limit (uW/cm²)	Result (Pass/Fail)	
Low	58618	-14.7	92.3	40.6	132.9	5.82	5.15	9	18	Pass	
High	61894	-15	92	41.1	133.1	6.1	5.36	9	18	Pass	

Band Edges								Curtis-Straus LLC		
Date: 17-Dec-02			Engineer: Evan Gould			Work Order: C0959				
Company: Terabeam			EUT: Gigalink			Fundamental Frequency: 58/62GHz				
Test Site: "T"			Cable: RG142LL			Pre-amp: Black				
Antenna: V-band 25dB Std Gain			Mixer: 11970V			Analyzer: Orange				
Measurement Distance: 3m										
Notes: Operating CW; Unmodulated This product supports operation on only two channels: Low and High										
Band	Frequency (GHz)	Reading	Voltage (dBμV)	Antenna Factor (dB/m)	Field Strength (dBμV/m)	Peak EIRP (W)	Peak Pd (uW/cm^2)	Ave Pd Limit (uW/cm^2)	Limit (pW/cm^2)	Result (Pass/Fail)
Low Band Edge	57	no emissions detected at 1cm from EUT							90	Pass
Coordination Band	57-57.05	no emissions detected at 1cm from EUT							90	Pass
High Band Edge	64	no emissions detected at 1cm from EUT							90	Pass

Sample Power Calculations

Sample Calculations (as per FCC millimeter wave test procedure)

Peak Power Output of EUT

$$P = (E * d)^2 / 30G$$

Power Measured at 3m = -15dBm

For 50 Ohm system, dBm => dBuV = +107dB

$$V \text{ [dBuV]} = -15\text{dBm} + 107\text{dB} = 92\text{dBuV}$$

$$E \text{ [V/m]} = 92\text{dBuV} + 41.1\text{dB/m (ant fact)} = 133.1 \text{ dBuV/m} = 4.5\text{V/m}$$

$$P = (4.5\text{V/m} * 3 \text{ m})^2 / (30 * 100 \text{ (numeric gain of EUT ant) })$$

$$P = 0.061\text{W} = \mathbf{61\text{mW}}$$

For EIRP G = 1

Therefore,

$$P_{\text{EIRP}} = 6.1 \text{ W} = P_t$$

Peak Power Density

$$P_d = P_t / (4 * \pi * d^2) = E^2 / 377$$

$$P_d = 6.1 \text{ W} / (4 * \pi * 3 \text{ m}^2) = 0.054 \text{ W/m}^2 = \mathbf{5.4 \text{ uW/cm}^2}$$

Spurious Emissions

REQUIREMENTS

"Radiated emissions below 40 GHz shall not exceed the general limits in Sec. 15.209." [15.255(c)(2)]

"Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90pW/cm² at a distance of 3 meters." [15.255(c)(3)]

LIMITS

Frequency (MHz)	Limit (μV/m)	Measurement Distance (meters)
0.009-0.49	2400/F(kHz)	300
0.49-1.705	24000/F(kHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

[47 CFR 15.209]

MEASUREMENTS

Spurious Emissions Table							Curtis-Straus LLC		
Date: 16-Dec-02			Company: Terabeam				Table: 3		
Engineer: Evan Gould			EUT Desc: Gigalink Model 6451e (high)				Work Order: C0959		
Frequency Range: 30-1000MHz					Measurement Distance: 3 m				
Notes:					EUT Max Freq: 60GHz				
Antenna Polarization (H / V)	Frequency (MHz)	Reading (dBµV)	Preamp Factor (dB)	Antenna Factor (dB/m)	Cable Factor (dB)	Adjusted Reading (dBµV/m)	47 CFR 15.209		
							Limit (dBµV/m)	Margin (dB)	Result (Pass/Fail)
H	180.0	44.9	21.7	9.8	1.4	34.4	43.5	-9.1	Pass
H	200.0	42.7	21.6	10.5	1.5	33.1	43.5	-10.4	Pass
H	220.0	51.4	21.6	11.6	1.6	43.0	46.0	-3.0	Pass
H	240.0	45.4	21.7	12.6	1.7	38.0	46.0	-8.0	Pass
H	260.0	40.4	21.7	13.3	1.8	33.8	46.0	-12.2	Pass
H	300.0	45.8	21.8	14.0	2.0	40.0	46.0	-6.0	Pass
H	400.0	35.3	21.8	16.6	2.4	32.5	46.0	-13.5	Pass
Table Result:			Pass	by	-3.0 dB		Worst Freq:		220.0 MHz
Test Site: "T"		Pre-Amp: Black		Cable: 65 ft RG8A/U		Analyzer: Blue		Antenna: Grn-Wht	

Note: No spurious emissions were detected above 1GHz.

Frequency Vs. Temperature/Voltage Variations

REQUIREMENT

"Fundamental emissions must be contained within the frequency bands specified in this section...over the temperature range -20 to +50 degrees celsius with an input voltage variation of 85% to 115% of rated input voltage..." [15.255(f)]

MEASUREMENTS

Frequency Stability			
Date: 12/19/02		Company: Terabeam	
Engineer: Evan Gould		EUT: Model 6451e	
Test Site: Environmental Chamber			
Analyzer: Orange		RBW: 10kHz	
Antenna: 50-75GHz horn		VBW: 10kHz	
Nominal (25°C @ 48V): 61894.26MHz			
Temperature (°C)	Center Frequency (MHz)	Drift (kHz)	Pass/Fail
50	61894.99	+730	Pass
40	61895.18	+920	Pass
30	61894.89	+630	Pass
25 (55.2V)	61894.27	+10	Pass
25 (41.8V)	61894.28	+20	Pass
20	61894.56	+300	Pass
10	61894.58	+320	Pass
0	61894.52	+260	Pass
-10	61894.39	+130	Pass
-20	61894.25	-10	Pass

The frequency was allowed to stabilize at each temperature and voltage.

RESULTS

The frequency stability of the EUT is within ± 1 MHz over the entire temperature and voltage range. This ensures that the fundamental emission will stay within the specified frequency band.

Amplitude Vs. Voltage Variation**REQUIREMENT**

"For intentional radiators, measurements of the variation of the...radiated signal level of the fundamental frequency component of the emission...shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage." [15.31(e)]

MEASUREMENTS

Voltage Variation		
Date: 18-Dec-02		Work Order: C0959
Company: Terabeam		Engineer: Evan Gould
EUT: Gigalink Model 6451e		
Antenna: 50-75GHz horn		
Analyzer: Orange		
Supply Voltage	Frequency (GHz)	Reading (dBμV)
(85%) 41.8V	61.89	59.1
(nominal) 48V	61.89	59.9
(115%) 55.2V	61.89	59.7

Test Equipment Used

REV. 12/13/02

<i>SPECTRUM ANALYZERS</i>	RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
BLUE	9kHz-1.8GHz	8591E	HP	3223A00227	00070	04-SEP-2003
ORANGE	9kHz-26.5GHz	E4407B	HP	US39440975	00394	07-JUN-2003
<i>OPEN AREA TEST SITE (OATS)</i>		FCC CODE	IC CODE	VCCI CODE	CALIBRATION DUE	
SITE T		93448	IC 2762-T	R-905	04-FEB-2004	
<i>ANTENNAS</i>	RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
GREEN-WHITE BILOG	30MHz-2GHz	CBL6112B	CHASE	2574	00319	11-JUL-2004
ORANGE HORN	1-18GHz	3115	EMCO	0004-6123	00390	27-MAY-2003
WHITE HORN	18-26.5GHz	3160-09	EMCO	9610-1068	00758	26-JUN-2003
<i>MIXERS/DIPLEXERS</i>	RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
MIXER / HORN	26.5-40 GHz	11970A/28-442-6	HP/ATM	2332A00900/A046903-01	00369	EACH USE
MIXER / HORN	90-140 GHz	MO8HW/A	OML	F21206-1	00811	EACH USE
MIXER / HORN	140-220 GHz	MO5HW/A	OML	G21206-1	00812	EACH USE
MIXER / HORN	40-60GHz	11970U/0689A	HP/MICOLAB FXR	3003AD1397/BLANK		EACH USE
MIXER / HORN	50-75GHz	11970V/15-7025	HP/AEROWAVE			EACH USE
MIXER / HORN	75-90GHz	11970W/861W/387	HP/AI MMW DIV	2521A00483/327		EACH USE
DIPLEXER		DPL.26	OML	N/A	00813	EACH USE
<i>PREAMPS</i>	RANGE	MN	MFR	SN	ASSET	CALIBRATION DUE
BLACK	0.01-2000MHz	ZFL-1000-LN	C-S	N/A	00799	22-MAR-2003
ORANGE-BLACK	1-20GHz	SMC-12A	C-S	690639	00761	27-AUG-2003
YELLOW	18-26.5GHz	AFS4-18002650-60-8P-4	C-S	467559	00758	27-AUG-2003
<i>CHAMBERS AND STRIPLINE</i>	MN	MFR	SN	ASSET	CALIBRATION DUE	
ENVIRONMENTAL (SAFETY)	SGTH-31S	B-M-A INC.	2245	00321	07-JUN-2003	
<i>POWER METERS</i>	MN	MFR	SN	CALIBRATION DUE		
POWER METER	ML4803A	ANRITSU	6100011821	JUNE-2003		
TC MOUNT	MP716A	ANRITSU	6100032396	JUNE-2003		
SENSOR ADAPTER	MA4002B	ANRITSU	6100032347			

Unless otherwise noted the calibration interval is one year. 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.