Electromagnetic Emissions Test Report and Request for Class II Permissive Change pursuant to FCC Part 15, Subpart C Specifiactions for a Intentional Radiator on the Toolz Limited Model: RoboLaser Transmitter

PRESENT FCC ID:	MNWRR1
GRANT DATE:	December 5, 1997
GRANTEE:	Toolz Limited 555 Bryant Street, #355 Palo Alto,CA 94301
TEST SITE:	Elliott Laboratories, Inc. 684 W. Maude Avenue Sunnyvale, CA 94086
REPORT DATE:	September 3, 1998
FINAL TEST DATE:	August 21, 1998

AUTHORIZED SIGNATORY: _____

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TABLE OF CONTENTS

TABLE OF CONTENTS cont.

SCOPE

An electromagnetic emissions test has been performed on the Toolz Limited transmitter model RoboLaser Transmitter pursuant to Subpart C of Part 15 of FCC Rules for intentional radiators. Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in FCC Rules This test has been performed to confirm continued compliance of a new version of the RoboLaser Transmitter in accordance with Part 2, Section 2.1043 of the FCC Rules for permissive changes to Certified devices.

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant FCC performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The test results recorded herein are based on a single type test of the Toolz Limited model RoboLaser Transmitter and therefore apply only to the tested sample. The sample was selected and prepared by Andy Butler of Toolz Limited.

OBJECTIVE

The primary objective of the manufacturer is compliance with Subpart C of Part 15 of FCC Rules for the radiated and conducted emissions of intentional radiators. In this case, minor modifications to the design of the subject device require that additional testing be performed to demonstrate that the device continues to comply with the Rules. The original Grant of Equipment Authorization issued by the FCC for the Certification of the subject device will be valid for the new version once acceptance is received from the FCC.

Certification is a procedure where the manufacturer or a contracted laboratory makes measurements and submits the test data and technical information to the FCC. The FCC issues a Grant of Equipment Authorization upon successful completion of their review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units which are subsequently manufactured.

Maintenance of FCC compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

TEST SITE

GENERAL INFORMATION

Final test measurements were taken on August 21, 1998 at the Elliott Laboratories Open Area Test Site located at 684 West Maude Avenue, Sunnyvale, California. Pursuant to section 2.948 of the Rules, construction, calibration, and equipment data has been filed with the Commission.

The FCC recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement with the exception of predictable local TV, radio, and mobile communications traffic. The test site contains separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent FCC requirements.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.4. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment. The test site is maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

AN EMI receiver as specified in CISPER 16 is used for emissions measurements. The ESH3 receiver can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers, allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the particular detector used during measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz.

INSTRUMENT CONTROL COMPUTER

A Rohde and Schwarz EZM Spectrum Monitor/Controller is utilized to convert the receiver measurements to the field strength at the antenna, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate.

The EZM provides a visual display of the signal being measured. In addition, the EZM Spectrum Monitor runs the automated data collection programs which control both receivers. This provides added accuracy since all site correction factors, such as cable loss and antenna factors, are added automatically.

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The 50 uH LISNs used were manufactured by Fischer Custom Communications, model LISN-3 in combination with a 250 uH Fischer Custom Communications LISN-3 CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

POWER METER

A power meter and thermister mount are used for all output power measurements from transmitters as they provides a broadband indication of the power output. The power meter used was the Hewlett Packard model 432A, S/N 992-05509 and the thermister mount was the Hewlett Packard model 478A, S/N 46397.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A biconical antenna is used to cover the range from 30 MHz to 300 MHz and a log periodic antenna is utilized from 300 MHz to 1000 MHz. Narrowband tuned dipole antennas are used over the 30 to 1000 MHz range for precision measurements of field strength. Above 1000 MHz, a horn antenna is used.

The antenna calibration factors are included in site factors which are programmed into the test receivers

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

ANSI C63.4 specifies that the test height above ground for table mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An appendix of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The FCC requires that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.4, and the worst case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

RADIATED EMISSIONS

Radiated emissions measurements are performed in two phases as well. A preliminary scan of emissions is conducted in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed from 30 to 1000 MHz. One or more of these is with the antenna polarized vertically while the one or more of these is with the antenna polarized horizontally. During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit.

A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth which results in the highest emission is then maintained while varying the antenna height from one to four meters. The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain. Emissions which have values close to the specification limit may also be measured with a tuned dipole antenna to determine compliance.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS

Frequency Range (MHz)	Limit (uV)	Limit (dBuV)
0.450 to 30.000	250	48

RADIATED EMISSIONS SPECIFICATION LIMITS

Frequency Range (MHz)	Limit (uV/m @ 3m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100	40
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - B = C$$

and

$$C - S = M$$

where:

R_r = Receiver Reading in dBuV

B = Broadband Correction Factor*

C = Corrected Reading in dBuV

S = Specification Limit in dBuV

M = Margin to Specification in +/- dB

* Broadband Level - Per ANSI C63.4, 13 dB may be subtracted from the quasi-peak level if it is determined that the emission is broadband in nature. If the signal level in the average mode is six dB or more below the signal level in the peak mode, the emission is classified as broadband.

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements. A distance factor, when used for electric field measurements, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBuV/m

L_s = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Toolz Limited model RoboLaser Transmitter is a low-power transmitter which is designed to operate in the 49.82 - 49.90 MHz band at a fixed frequency of 49.860 MHz. The device is designed to control the RoboLaser Base Station using an FSK modulated signal. The RoboLaser system is a self-levelling LASER pointer system intended for use in the construction trades. The sample was received on August 21, 1998 and tested on August 21, 1998. The EUT consisted of the following component(s):

Manufacturer/Model/Description	Serial Number	FCC ID Number
Toolz RoboLaser Remote Transmitter	03	NMWRR1

ENCLOSURE

The EUT enclosure is primarily constructed of plastic. It measures approximately 7.5 cm wide by 13 cm long by 3.8 cm high.

INPUT POWER

The EUT input is rated at 120/240, 50/60 Hz. The EUT contained the following input power components during emissions testing:

Description	Manufacturer	Model
The EUT is battery powered from a 9V cell	-	-

EMI SUPPRESSION DEVICES

The EUT contained the following EMI suppression devices during emissions testing:

Description	Manufacturer	Part Number
None		

PRINTED WIRING BOARDS

The Toolz Limited model RoboLaser Transmitter contained the following printed wiring boards during emissions testing:

Manufacturer/Description	Assembly #	Rev.	Serial #	Crystals (MHz)
Toolz RoboLaser Remote	699-0004	04	03	16.62*

* The transmitter utilises a tripler circuit to obtain the fundamental transmit frequency . No digital circuitry operating above 9 KHz is utilized in the device.

SUBASSEMBLIES

The Toolz Limited model RoboLaser Transmitter contained the following subassembly modules during emissions testing:

Manufacturer/Description	Assembly #	Rev.	Serial Number
None			

SUPPORT EQUIPMENT

No support equipment was used during emissions testing.

EXTERNAL I/O CABLING

The I/O cabling configuration during emissions testing was as follows:

Cable Description	Length (m)	From Unit/Port	To Unit/Port
None			

ANTENNA SYSTEM

The EUT's antenna is internally mounted within the enclosure. As there is no external antenna port the device meets the requirements for an intentional radiator outlined in §15.203.

TEST MODES

During testing the EUT was hardwired to continuously transmit an FSK modulated signal. (In normal operation the device transmits when the operator presses one of the buttons). Scans of the emissions were made with the device orientated in all three axes during testing.

PROPOSED MODIFICATION DETAILS

GENERAL

This section details the modifications to the Toolz Limited model RoboLaser Transmitter being proposed. All performance and construction deviations from the characteristics originally reported to the FCC are addressed

PRINTED WIRING BOARD LAYOUT

The printing wiring board contained the following changes from the device origianlly submitted to the FCC:

C29 - tunable capacitor
R31 - 20K .

The purpose of these changes was to de-tune the antenna and provide for a more controlled output level.

These changes would only affect the output power and spurious radiated emissions.

TEST RESULTS

TEST DATA ANALYSIS - FUNDAMENTAL FREQUENCY

Frequency MHz	Level dBuV/m	Pol v/h	15.235 Limit	15.235 Margin	Detector	Azimuth degrees	Height meters	Comments
49.863	77.0	v	79.0	-2.0	Pk	0	1.0	RBW=120kHz, Pk Reading, Avg Limit
49.863	69.0	h	80.0	-11.0	Pk	95	3.0	RBW=120kHz, Pk Reading, Avg Limit

TEST DATA ANALYSIS - RADIATED

The following measurements were extracted from the data recorded during the radiated electric field emissions scan and represent the highest amplitude peaks relative to the specification limit. The actual test data and correction factors are contained in the appendices of this report.

Maximized Radiated Emissions,
Quasi-Peak Readings, Sorted by Margin
EUT on its side - worst case orientation

Frequency MHz	Level dBuV/m	Pol v/h	FCC 15.209 Limit	FCC 15.209 Margin	Detector Pk/QP/Avg	Azimuth degrees	Height meters	Comments
299.184	33.5	h	46.0	-12.5	QP	287	1.0	
249.320	28.5	h	46.0	-17.5	QP	90	1.3	
149.593	24.1	h	43.5	-19.4	QP	60	1.5	
498.640	26.6	h	46.0	-19.4	QP	190	1.8	
498.640	26.2	v	46.0	-19.8	QP	305	1.0	
448.777	26.0	h	46.0	-20.0	QP	0	2.3	
299.184	25.2	v	46.0	-20.8	QP	315	1.0	
349.049	24.1	h	46.0	-21.9	QP	80	1.0	
398.913	24.0	v	46.0	-22.0	QP	285	1.4	
448.777	23.7	v	46.0	-22.3	QP	0	1.0	
398.913	23.5	h	46.0	-22.5	QP	165	1.0	
149.593	20.3	v	43.5	-23.2	QP	165	1.0	
232.699	20.6	h	46.0	-25.4	QP	120	1.3	
249.320	20.2	v	46.0	-25.8	QP	295	1.0	

TEST DATA ANALYSIS - BANDWIDTH

This was not affected by the proposed changes - a graph has been attached to the test data in the appendices of this report showing that, at the band edges, the transmitted signal was still more than 26dB below the fundamental level.

EXHIBIT A

Test Equipment Calibration

Test Equipment List - SVOATS#2

	Manufacturer/Description		Model	Asset #	Interval	Last Cal	Cal Due
☐	Com-Power	Comb Generator, 1 / 5 MHz Step	CG-515	467	6	7/29/98	1/29/99
☐	Elliott Laboratories	FCC / CISPR LISN	LISN-4, OATS	362	12	6/30/98	6/30/99
☐	Elliott Laboratories	2 x (Solar 8028 LISN + 6512 Caps)	LISN-5,	379	12	6/26/98	6/26/99
☐	EMCO	Double Ridge Horn Antenna, 1-18	3115	487	12	6/18/98	6/18/99
☐	EMCO	Double Ridge Horn Antenna, 1-18	3115	286	12	11/13/97	5/13/99
☑	EMCO	Biconical Antenna	3110B	801		6/4/97	12/4/98
☑	EMCO	Antenna, Log Periodic	3146A	802	12	6/13/97	12/13/98
☐	Hewlett Packard	Power Meter	432A	259, (F304)	12	3/10/98	3/10/99
☐	Hewlett Packard	Spectrum Analyzer	8563E	284, (FI94)	24	1/14/98	1/14/2000
☐	Hewlett Packard	Microwave Preamplifier, 1-26.5	8449B	263, (F303)	12	6/8/98	6/8/99
☐	Hewlett Packard	Thermistor Mount	478A	652	12	3/10/98	3/10/99
☑	Hewlett Packard	EMC Receiver /Analyzer	8595EM	780	24	10/24/97	10/24/99
☐	Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	785	12	11/10/97	11/10/98
☐	Hewlett Packard	EMC Receiver /Analyzer	8595EM	787	12	10/27/97	10/27/98
☐	Narda-West	EMI Filter 5.6 GHz, High Pass	60583 HXF370	247	12	8/10/98	8/10/99
☐	Narda-West	EMI Filter 2.4 GHz, High Pass	60583 HPF-161	248	12	8/10/98	8/10/99
☑	Rohde & Schwarz	Test Receiver	ESN	775	12	6/22/98	6/22/99
☐	Rohde& Schwarz	Pulse Limiter	ESH3Z2	811	12	2/5/98	2/5/99

* used 8/24/98 for the bandwidth measurement

File Number: T27890

Date: 8-21-98

Engr: P.G.

EXHIBIT B

Test Measurement Data

The following data includes conducted emission measurements of the Toolz Limited model RoboLaser Transmitter and maximized radiated emissions measurements of the complete system.

Elliott

EMC Test Log

Client:	Toolz Limited	Date:	8/21/98	Test Engr:	Pamela Galvan
Product:	RoboLaser Transmitter	File:	D27890	Proj. Eng:	Mark Briggs
Objective:	Engineering Evaluation	Site:	SVOATS #2	Contact:	David Shafer
Spec:	FCC 15.209 and 15.235	Page:	1 of 3	Approved:	

Test Objective

The objective of this test session is to perform final qualification testing the EUT defined below relative to the specification(s) defined above in order to prepare an application for a Class 2 Permissive Change. The changes made to the device since the original submittal was made to the FCC are detailed in the appropriate sections of this test log.

Test Summary

Run #1 - Maximized Preliminary Radiated Emissions Scan, Field Strength Of Fundamental

Results: FCC 15.235 -2.0 dB Pk @ 49.863 MHz Vertical*

* The margin is the difference between the Peak reading and the average limit.

Run #2 - Maximized Radiated Emissions Spurious Emissions and Harmonics of The Fundamental

PASS Results: FCC 15.209 -12.5 dB QP @ 299.184 MHz Horizontal

Equipment Under Test (EUT) General Description

The EUT is a low-power transmitter which is designed to operate in the 49.82 - 49.90 MHz band at a fixed frequency of 49.860 MHz. The device is designed to control the RoboLaser Base Station using an FSK modulated signal. The RoboLaser system is a self-levelling LASER pointer system intended for use in the construction trades. Normally, the EUT would be hand-held during operation. The EUT was placed on a table-top during emissions testing to simulate the end user environment. Measurements of the fundamental transmit signal and spurious emissions were made with the device orientated in all three orthogonal axes (on its back, standing upright on its base and on its side).

Equipment Under Test (EUT)

Manufacturer/Model/Description	Serial Number	FCC ID Number
Toolz RoboLaser Remote Transmitter	03	NMWRR1

Client:	Toolz Limited	Date:	8/21/98	Test Engr:	Pamela Galvan
Product:	RoboLaser Transmitter	File:	D27890	Proj. Eng:	Mark Briggs
Objective:	Engineering Evaluation	Site:	SVOATS #2	Contact:	David Shafer
Spec:	FCC 15.209 and 15.235	Page:	2 of 3	Approved:	

Power Supply and Line Filters

Description	Manufacturer	Model
The EUT is battery powered from a 9V cell	-	-

Antenna

The EUT's antenna is internally mounted within the enclosure. As there is no external antenna port the device meets the requirements for an intentional radiator outlined in §15.203.

Printed Wiring Boards in EUT

Manufacturer/Description	Assembly #	Rev.	Serial Number	Crystals (MHz)
Toolz RoboLaser Remote	699-0004	04	03	16.62*

* The transmitter utilises a tripler circuit to obtain the fundamental transmit frequency . No digital circuitry operating above 9 KHz is utilized in the device.

Subassemblies in EUT

Manufacturer/Description	Assembly Number	Rev.	Serial Number
None	-	-	-

EUT Enclosure(s)

The EUT enclosure is primarily constructed of plastic. It measures approximately 7.5 cm wide by 13 cm long by 3.8 cm high.

EMI Suppression Devices

Description	Manufacturer	Part Number
None	-	-

Changes Made To The EUT

The following changes were incorporated into the EUT tested:

Added a tunable capacitor and 20K resistor to the antenna circuit to detune the antenna and provide for a more controlled output level. These components are identified as C29 and R31 on the schematics.

These changes would only affect the output power and the radiated spurious emissions. They would not affect the signal synthesis or modulation characteristics as reported to the FCC in the original submittal. Only the radiated emissions (fundamental and spurious) were re-measured.

Support Equipment

Manufacturer/Model/Description	Serial Number	FCC ID Number
None	-	-

Interface Cabling

Cable Description	Length (m)	From Unit/Port	To Unit/Port
None	-	-	-

Test Configuration

During testing the EUT was hardwired to continuously transmit an FSK modulated signal. (In normal operation the device transmits when the operator presses one of the buttons). Scans of the emissions were made with the device orientated in all three axes during testing.

General Test Conditions

During radiated testing, the EUT was powered form a new 9V cell.

Test Data Tables

See attached data

Elliott

Emissions Test Data

Client:	Toolz Limited	Date:	8/21/98	Test Engr:	Pamela Galvan
Product:	RoboLaser Transmitter	File:	D27890	Proj. Engr:	Mark Briggs
Objective	Engineering Evaluation	Site:	SVOATS #2	Contact:	David Shafer
Spec:	FCC 15.209 and 15.235	Distance:	3 m	Approved:	

Run #1: Fundamental frequency.
Orientation: EUT on its side

Frequency	Level	Pol	FCC 15.235	FCC 15.235	Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
49.863	77.0	v	79.0	-2.0	Pk	0	1.0	RBW=120kHz, Pk Reading, Avg Limit
49.863	69.0	h	80.0	-11.0	Pk	95	3.0	RBW=120kHz, Pk Reading, Avg Limit

Orientation: EUT on its back

49.863	68.1	h	80.0	-11.9	Pk	0	2.2	RBW=120kHz, Pk Reading, Avg Limit
49.863	49.9	v	80.0	-30.1	Pk	150	1.0	RBW=120kHz, Pk Reading, Avg Limit

Orientation: EUT on its bottom edge

49.863	75.7	v	80.0	-4.3	Pk	0	1.1	RBW=120kHz, Pk Reading, Avg Limit
49.863	70.3	h	80.0	-9.7	Pk	275	2.2	RBW=120kHz, Pk Reading, Avg Limit

Run #2: Maximized radiated scan, 30-500 MHz. Harmonics and other Spurious emissions
Orientation: EUT on its side

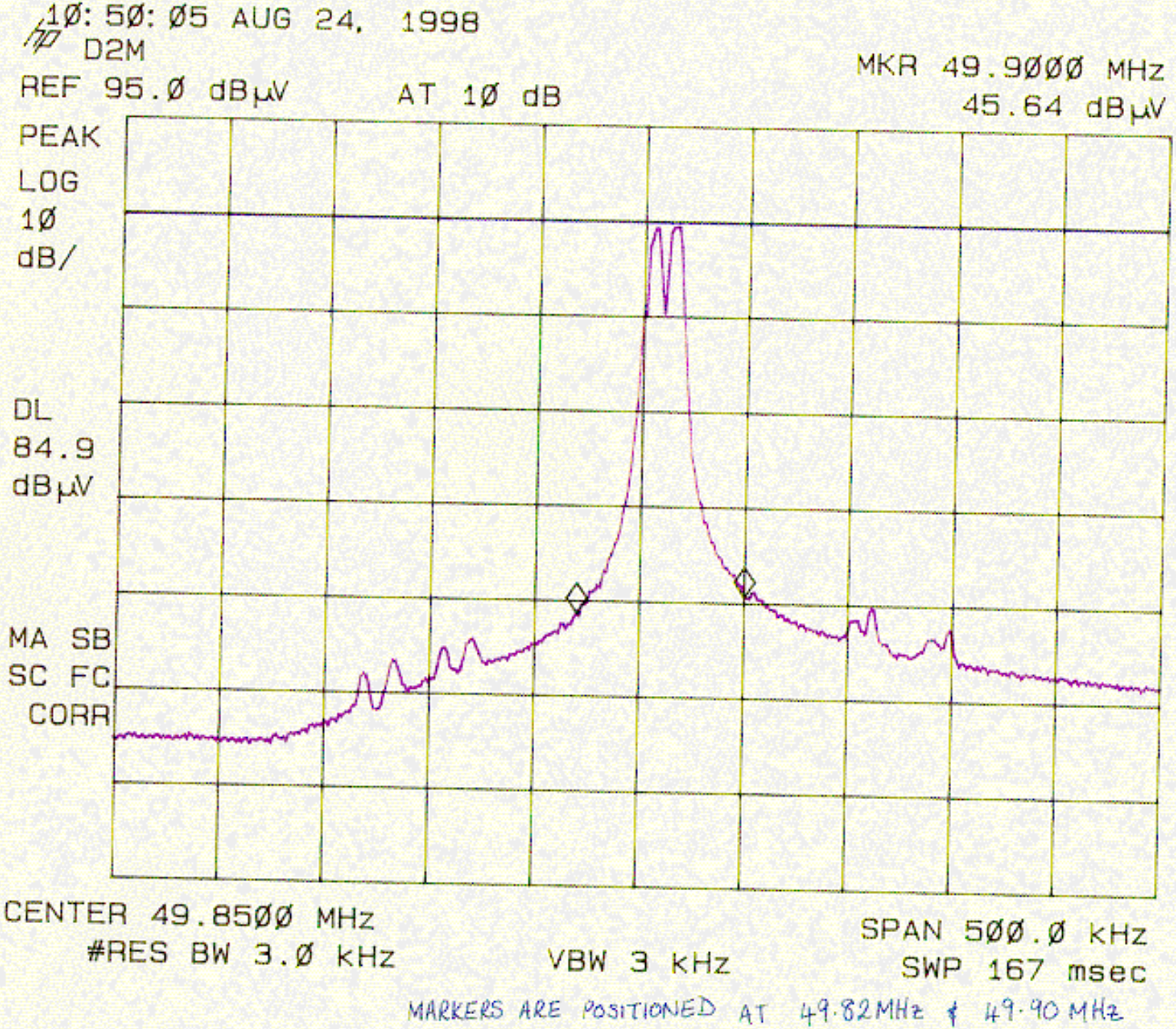
Frequency	Level	Pol	FCC 15.209	FCC 15.209	Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
299.184	33.5	h	46.0	-12.5	QP	287	1.0	
249.320	28.5	h	46.0	-17.5	QP	90	1.3	
149.593	24.1	h	43.5	-19.4	QP	60	1.5	
498.640	26.6	h	46.0	-19.4	QP	190	1.8	
498.640	26.2	v	46.0	-19.8	QP	305	1.0	
448.777	26.0	h	46.0	-20.0	QP	0	2.3	
299.184	25.2	v	46.0	-20.8	QP	315	1.0	
349.049	24.1	h	46.0	-21.9	QP	80	1.0	
398.913	24.0	v	46.0	-22.0	QP	285	1.4	
448.777	23.7	v	46.0	-22.3	QP	0	1.0	
398.913	23.5	h	46.0	-22.5	QP	165	1.0	
149.593	20.3	v	43.5	-23.2	QP	165	1.0	
232.699	20.6	h	46.0	-25.4	QP	120	1.3	
249.320	20.2	v	46.0	-25.8	QP	295	1.0	

Orientation: EUT on its bottom edge

Frequency	Level	Pol	FCC 15.209	FCC 15.209	Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
299.184	28.7	h	46.0	-17.3	QP	0	1.1	
498.640	26.2	h	46.0	-19.8	QP	55	1.6	
149.593	23.6	h	43.5	-19.9	QP	170	1.2	
249.320	26.0	h	46.0	-20.0	QP	100	1.0	
448.777	25.2	h	46.0	-20.8	QP	235	1.8	
498.640	24.6	v	46.0	-21.4	QP	305	1.0	

Orientation: EUT on its back

Frequency	Level	Pol	FCC 15.209	FCC 15.209	Detector	Azimuth	Height	Comments
MHz	dBuV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
299.184	31.6	h	46.0	-14.4	QP	100	1.6	
249.320	27.6	h	46.0	-18.4	QP	265	1.4	
149.593	24.3	h	43.5	-19.2	QP	80	1.2	
498.640	26.4	v	46.0	-19.6	QP	245	1.0	
448.777	22.6	h	46.0	-23.4	QP	0	2.3	
498.640	21.9	h	46.0	-24.1	QP	55	1.6	



MARKERS ARE POSITIONED AT 49·82 MHz & 49·90 MHz

EXHIBIT C

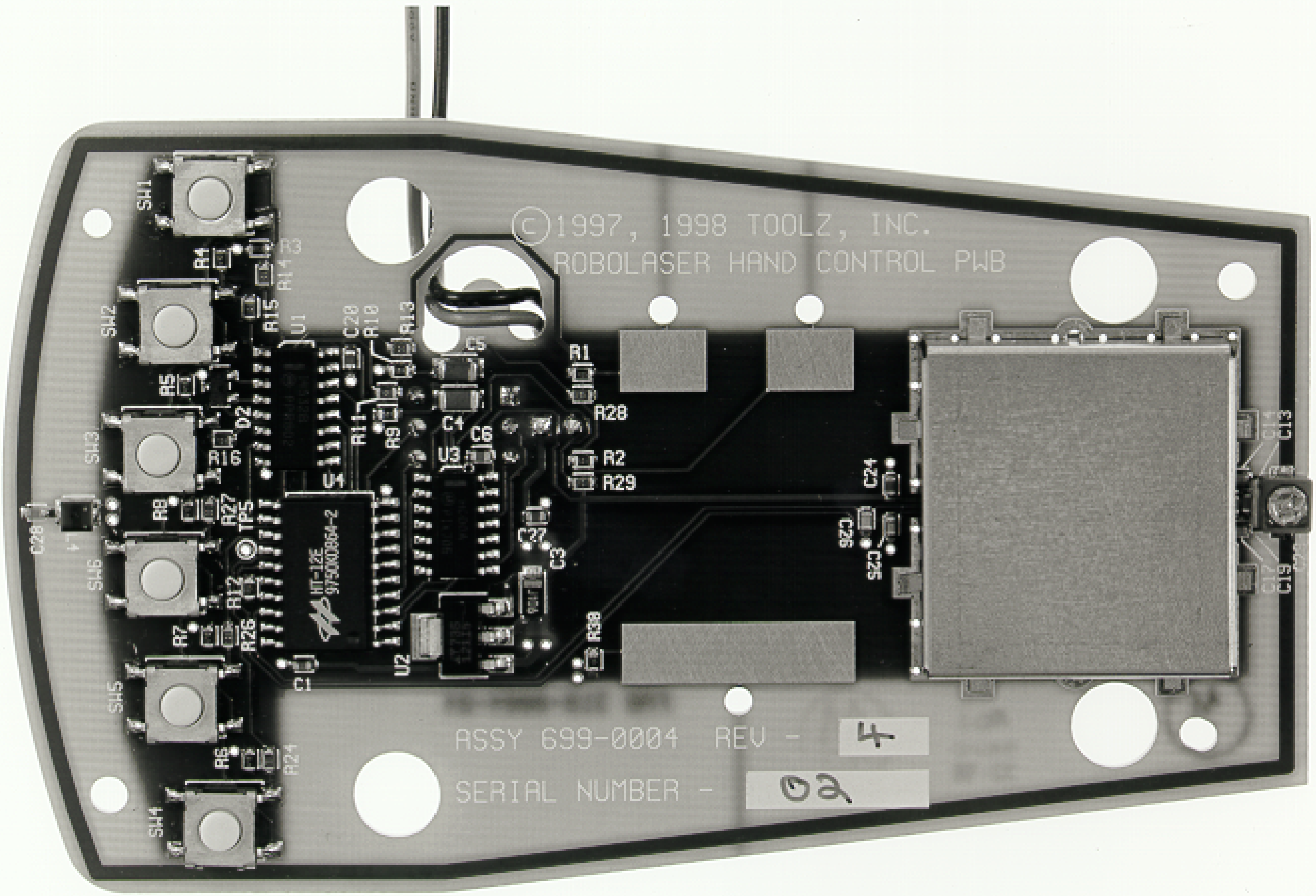
Photographs of Test Configurations

PHOTOGRAPH OF FINAL TEST CONFIGURATION

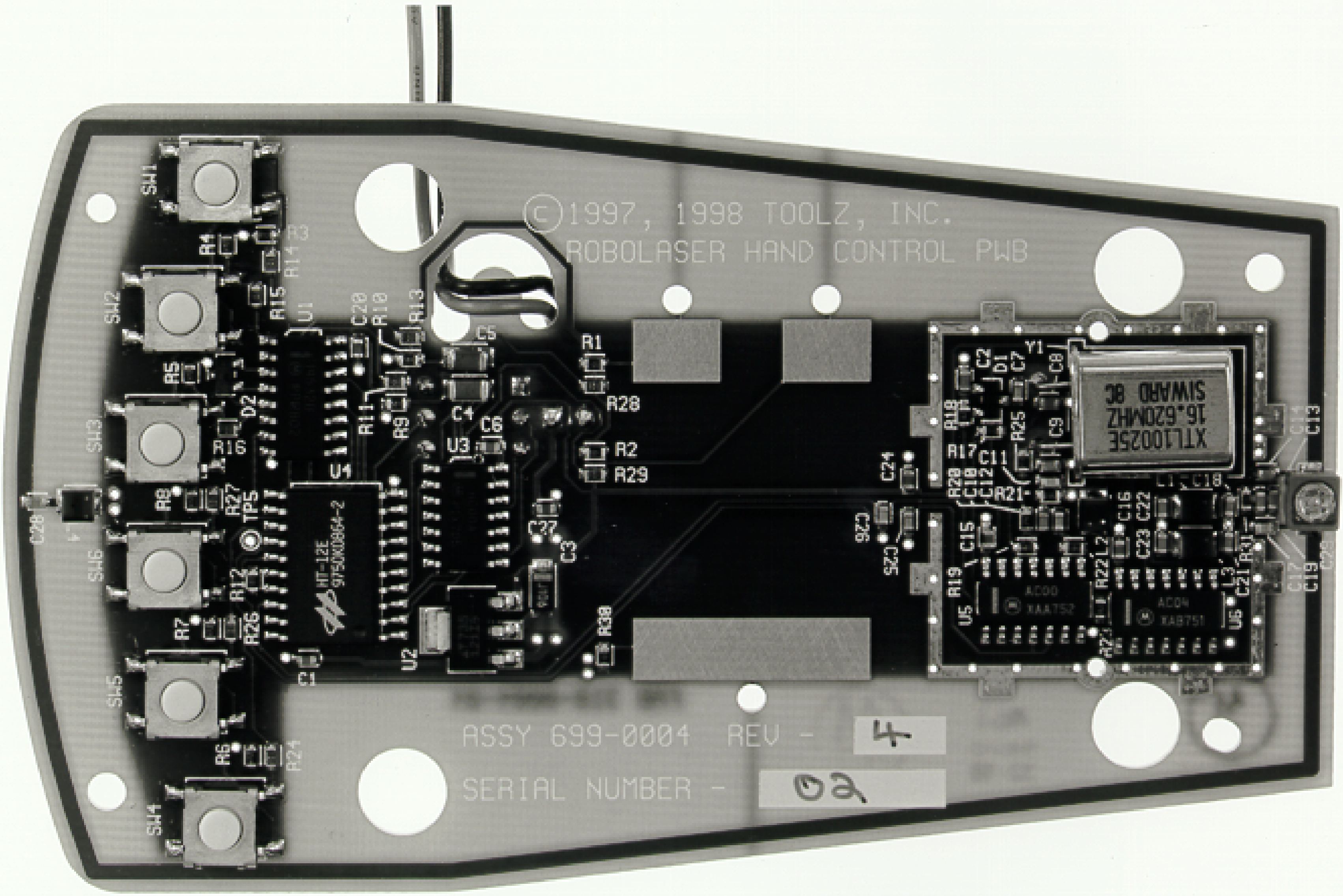
Radiated Emissions

EXHIBIT D

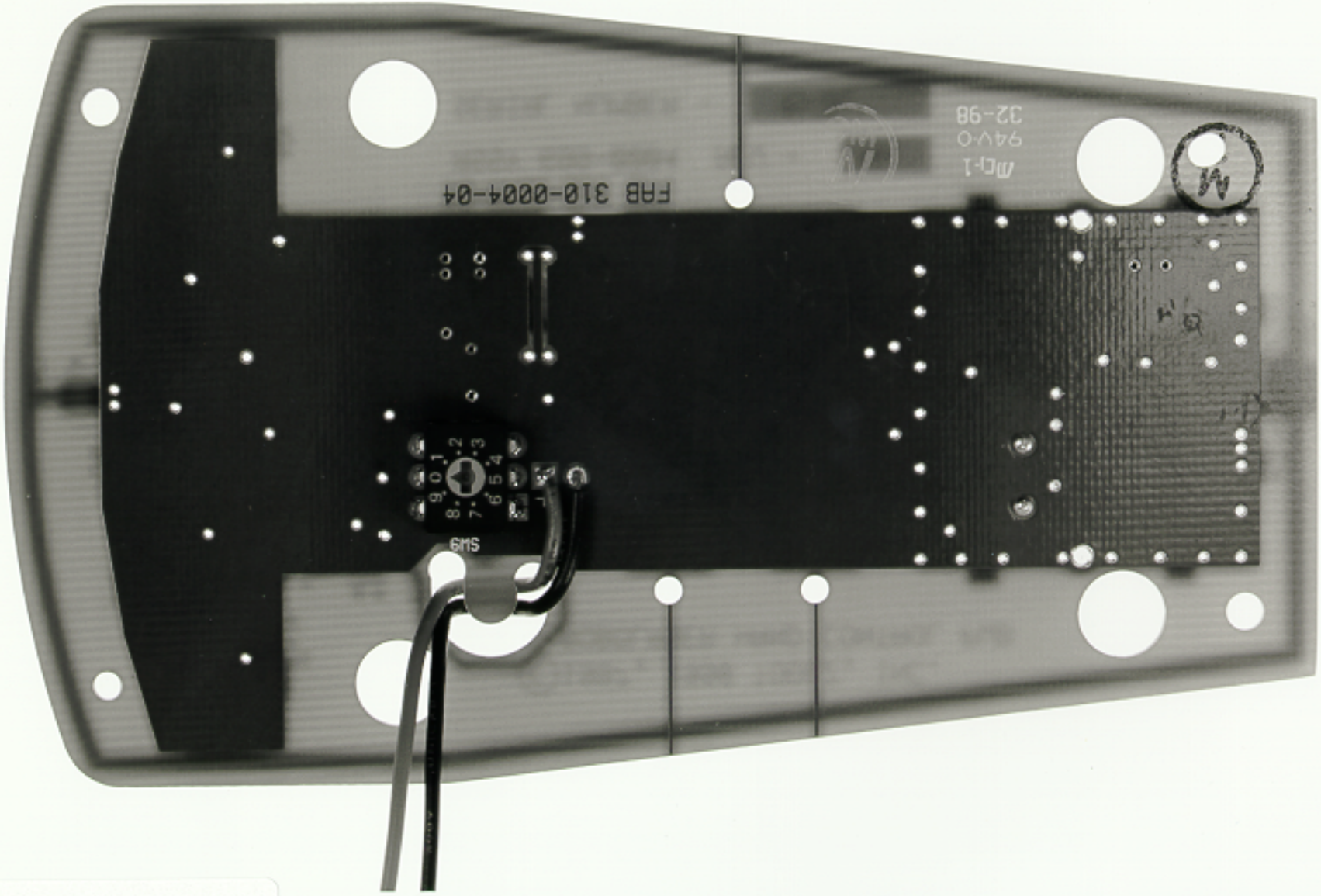
Detailed Photographs of Toolz Limited Model RoboLaser Transmitter Proposed Change of Construction



Toolz Limited
FCC ID: MNWRR1
Circuit Board
Component side w/shield



Toolz Limited
FCC ID: MNWRR1
Circuit Board
Component side w/o shield



Toolz Limited
FCC ID: MNWRR1
Circuit Board
Bottom side

EXHIBIT E

Block Diagram of Toolz Limited Model RoboLaser Transmitter

Not Required - this remains unchanged from the
block diagram included with the original submittal for the device.

EXHIBIT G

Theory of Operation for Toolz Limited Model RoboLaser Transmitter

Not Required - this remains unchanged from the
Theory of Operation included with the original submittal for the device.

EXHIBIT H

Operator's Manual for Toolz Limited Model RoboLaser Transmitter

Not Required - this remains unchanged from the
Operator's Manual included with the original submittal for the device.