
Project Number: 99-345

Prepared for:

LESTER ELECTRICAL, INC.
625 West A Street
Lincoln, Nebraska 68522-1794

By

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March 1999

TYPE CERTIFICATION
Electromagnetic Interference
Test Report

LESTER ELECTRICAL, INC.
Universal Transceiver Module
(Intentional Radiator Portion)

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THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL, WITHOUT THE WRITTEN APPROVAL OF PROFESSIONAL TESTING (EMI), INC.



Certificate of Compliance

Applicant: Lester Electrical, Inc.
Applicant's Address: 625 West A Street
Lincoln, Nebraska 68522
Model: Universal Transceiver Module
Serial Number: N/A
Project Number: 99-345
Test Dates: March 8, 1999

I, Jeffrey A. Lenk, for Professional Testing (EMI), Inc., being familiar with the FCC rules and test procedures have reviewed the test setup, measured data and this report. I believe them to be true and accurate.

The **Lester Electrical, Inc. Universal Transceiver Module** was tested to and found to be in compliance with FCC Part 15 Subpart C for an Intentional Radiator.

The highest emissions generated by the above equipment are listed below:

| | <u>Frequency (MHz)</u> | <u>Level (dBμV/m)</u> | <u>Limit (dBμV/m)</u> | <u>Margin (dB)</u> |
|-------------|------------------------|-----------------------|-----------------------|--------------------|
| Fundamental | 916.5 | 92.6 | 93.9 | -1.3 |
| Spurious | 1832.9 | 58.1 | 63.5 | -5.4 |

Occupied Bandwidth

Record Only Per 47 CFR 15 - Widest OCBW: 99.8 kHz

Jeffrey A. Lenk
President

This report has been reviewed and accepted by Lester Electrical, Inc. The undersigned is responsible for ensuring that the **Universal Transceiver Module** will continue to comply with the FCC rules.

1.0 EUT Description

The Equipment Under Test (EUT) is the **Lester Electrical, Inc., Universal Transceiver Module**. The Universal transceiver Module is designed to be a Base personal computer which is connected in turn to a standard telephone line through a modem. Radio frequency data is received from one or many Data Collector Modules. The EUT operates in the 902-928 MHz band and is designed for compliance with 47 CFR 15.249 of the FCC rules. Specific test requirements for this device include the following:

| | |
|--------------------------------|--|
| 47 CFR 15.249 | Fundamental Transmit Power |
| 47 CFR 15.249 & 15.205 | Spurious Radiated Power |
| 47 CFR 15.249 & 2.989 | Occupied Bandwidth (2.989 used as Procedural Reference) |
| 47 CFR 15.203 | Antenna Requirement |
| 47 CFR 15.207 | Conducted Powerline Emissions |
| 47 CFR 15.31(e) & 15.215(c) | Frequency and Amplitude Stability |

The system tested consisted of the following:

| <u>Manufacturer & Model</u> | <u>Serial #</u> | <u>FCC ID #</u> | <u>Description</u> |
|---|------------------------|------------------------|---------------------------|
| Lester Electrical, Inc. Universal Transceiver Module | N/A | OBH21810 | Data Collection System |
| ILH386V/9015 | N/A | N/A | Base Station PC |

1.1 EUT Operation

The **Universal Transceiver Module** was tested with the wireless link active and fully modulated. Radiated spurious emissions were tested with the EUT and Occupied Bandwidth was done also. Initial tests of the module emissions versus orientation were performed to find the worst case EUT orientation. Setup and operational modes cover worst case configuration and operational modes for the device. For all tests except those involving frequency stability, the EUT was powered from an RS-232 port on a typical PC. For frequency stability tests, the EUT was powered from a variable power supply.

2.0 Electromagnetic Emissions Testing

Professional Testing (EMI), Inc. (PTI), follows the guidelines of NIST for all uncertainty calculations, estimates and expressions thereof for EMC testing.

Radiated emission measurements were made of the Fundamental and Spurious Emission levels for the **Universal Transceiver Module**. Measurements of the occupied bandwidth were also made for the equation.

Measurements of the maximum emission levels for the fundamental and the spurious/harmonic emissions of the **Universal Transceiver Module** were made at the Professional Testing "Open Field" Site 3, located in Marble Falls, Texas to determine the radio noise radiated from the EUT. A "Description of Measurement Facilities" has been submitted to the FCC and approved pursuant to Section 2.948 of CFR 47 of the FCC rules.

Tests of the fundamental for the device were performed at the respective 'worst case' frequencies to determine the worst case polarization of the devices. The fundamental emissions of the device were measured with the antennas of the devices vertical and horizontal to the ground plane.

2.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a motorized turntable which allows 360 degree rotation. For measurements of the fundamental signal, a measurement antenna was positioned at a distance of 3 meters as measured from the closest point of the EUT. For spurious/harmonic measurements above 1GHz, the measurement antenna was placed 1 meter from the EUT. The radiated emissions were maximized by configuring the EUT, by rotating the EUT, and by raising and lowering the antenna from 1 to 4 meters.

A Spectrum Analyzer with peak detection was used to find the maximums of the radiated emissions during the variability testing. A drawing showing the test setup is given as Figure 1.

2.2 Test Criteria

The FCC Part 15.249 radiated limits are given below for an intentional radiator operating in the 902 to 928 MHz band. The reference distance for each limit is also shown in this table.

| Signal Type | Test Distance (Meters) | Field Strength | |
|--------------------|---------------------------|----------------|----------------|
| | | (μ V/m) | (dB μ V/m) |
| Fundamental | 3 | 50,000 | 93.9 |
| Spurious/Harmonics | 3 | 500 | 53.9 |
| Spurious/Harmonics | 1 | 1500 | 63.5 |

In addition to these requirements, the EUT must meet the restricted emission band requirements of §15.205. For this frequency range, the unintentional radiated emission limits of §15.249 for a 902 to 928 MHz radiator and the restricted band limits of §15.205 are identical. Measurements of the harmonic were performed to the 10th harmonic of the fundamental.

2.3 Test Results

The radiated test data is included as Appendix B. The emissions were maximized at each frequency and the highest emissions identified were measured using peak detection. The radiated emissions generated by the **Universal Transceiver Module** are below the FCC Part 15.249 maximum emission criteria.

3.0 Occupied Bandwidth Measurements

Measurements of the occupied bandwidth for the fundamental signals of **Universal Transceiver Module** were made at the Professional Testing's Round Rock, Texas laboratory. All measurements were made in a controlled indoor environment in a configuration which did not present measurement distortion or ambient interference.

3.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the floor. The table was rotated to an angle which presented the highest signal level. The occupied bandwidth was also measured on the device. Peak detection was used for all tests. The occupied bandwidth was based on a 26 dB criteria (26 dB down either side of the emission from the nominal center of the emission). For these tests, a 2.5 kHz audio tone was used to modulate the EUTs. All testing was done at a distance of 0.5 meter. A drawing showing the test setup is given as Figure 1.

3.2 Test Criteria

While the FCC rules do not state a specific limit of occupied bandwidth for the transceiver module, submission of the emission bandwidth is normally required during the Type Certification procedure. The only implication regarding an occupied bandwidth requirement is that the emission cannot exceed 80% of the band authorized under §15.249 (902 to 928 MHz for this device).

Measurement of the occupied bandwidth was performed to verify that the emission bandwidth did not change beyond what is typically seen for data transceiver module. The typical occupied bandwidth for the module is 100 kHz to 200 kHz.

Data from these tests was also used to verify compliance with the main frequency range requirement of §15.249. For this device, the lowest allowed center frequency of the intended emission is 902 MHz and the highest allowed center frequency of the intended emission is 928 MHz.

3.3 Test Results

The occupied bandwidth test data is included in Appendix C. The occupied bandwidth for the fundamental frequency (916.5 MHz) is 99.8 kHz. The figure is typical for the data collection module.

The intended center frequency for the EUT was centered at 916.5 MHz. The center frequency is within the allowed band. The fundamental signal generated by **Universal Transceiver Module** is within the band allowed under FCC Part 15.249 emission band criteria.

4.0 Conducted Emissions Measurements

Conducted emissions measurements were made to determine the line-to-ground radio noise from the **Universal Transceiver Module** external personal computer power supply power-input terminals which connect to the public utility lines.

4.1 Test Procedure

The tests were performed in a 12' X 16' RayProof modular shielded room. The measurements were taken using Schwarzbeck 8127 Line Impedance Stabilization Network (LISN). A Hewlett Packard Spectrum Analyzer in association with a Quasi-Peak Adapter were used to record the conducted emissions. The Quasi-Peak Adapter utilizes a measurement bandwidth of 9 kHz.

The power cord length in excess of the distance between the EUT and LISN was wrapped in a "figure eight" pattern using tie wraps to establish the correct power cable length.

4.2 Test Criteria

The §15.207 conducted emission limits are given below:

| Frequency (MHz) | Maximum RF Line Voltage | |
|--------------------|-------------------------|--------------|
| | (μ V) | (dB μ V) |
| 0.45 to 30.0 | 250 | 48 |

4.3 Test Results

The **Universal Transceiver Module** operates at 916.5 MHz. Conducted emission testing of the EUT was performed with the device in a constant transmit mode.

Conducted test data is contained in Appendix D of this report. The **Universal Transceiver Module** met the §15.207 conducted emission requirements.

5.0 Frequency and Amplitude Stability Measurements

Measurements were made on the **Universal Transceiver Module** to verify compliance with the frequency stability requirements of §15.31(e) and 15.215(c). Under these specifications, the EUT is tested to verify satisfactory frequency and amplitude stability versus changes in the amplitude of DC voltage.

5.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the floor. The distance between the table and antenna is 3 meters. The test is operated at the "worst case" measurement of fundamental frequency.

DC Power to the input terminals was varied from 4.25VDC to 5.75VDC. The normal DC mains power for this system is 5.0 VAC. The center frequency and center frequency power level was recorded at 0.25 volt intervals over this range.

5.2 Test Criteria

When combined, Sections 15.31(e) and 15.215(c) indicate that the output frequency of the transmitter shall remain within the central 80% appropriate channel band with DC mains power varied from 85% to 115% of the nominal value. For battery powered units, the EUT shall meet this criteria when tested with a fully charged battery supply. Based on this criteria, no significant drift of the frequency shall occur under these conditions. In addition, in accordance with Section 15.31(e), the amplitude of the transmit signal(s) should not vary significantly over this impact range. While 15.215(c) is a recommendation, for the purposes of this test it is viewed as a requirement.

5.3 Test Results

Data for this test is located in the Appendix E of this report. No significant movement of the center frequency and amplitude was detected over the DC input variation range. The **Universal Transceiver Module** meets the frequency and amplitude stability requirements for frequency stability versus DC mains input variation based on the criteria listed above.

6.0 Antenna Requirement

An analysis of the **Universal Transceiver Module** was performed to determine compliance with Section 15.203 of the Rules. This section requires specific handling and control of antennas used for devices subject to regulation under the Intentional Radiator portions of Part 15.

6.1 Evaluation Procedure

The structure and application of the **Universal Transceiver Module** were analyzed with respect to the rules. The antenna for this unit is a two inches rubber rod on top of the unit. The antenna is soldered onto the main board and is not accessible by the user and an auxiliary antenna port is not present.

6.2 Evaluation Criteria

Section 15.203 of the rules states that the subject device must meet at least one of the following criteria:

- (a) Antenna be permanently attached to the unit.
- (b) Antenna must use a unique type of connector to attach to the EUT.
- (c) Unit must be professional installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

6.3 Evaluation Results

The **Universal Transceiver Module** meets the criteria of this rule by virtue of having an external antenna permanently attached to the unit. The EUT is therefore compliant with §15.203.

7.0 Modifications to Equipment

There were no modifications made on the **Universal Transceiver Module** during the performance of the test program in order to meet the FCC criteria.

8.0 List of Test Equipment

A list of the test equipment utilized to perform the testing is given below. The date of calibration is given for each.

Electromagnetic Emissions Test Equipment

| <u>Device</u> | <u>Description</u> | <u>Date Last Calibrated</u> | <u>Calibration Due</u> |
|------------------------|--------------------|-----------------------------|------------------------|
| HP 8566B | Spectrum Analyzer | 09/22/97 | 09/22/98 |
| HP 85650A | Quasi Peak Adapter | 09/22/97 | 09/22/98 |
| HP 8447 | Preamp | 05/22/98 | 05/22/99 |
| EMCO 3108 | Biconical Antenna | 05/22/98 | 05/22/99 |
| EMCO 3106 | Log Antenna | 05/22/98 | 05/22/99 |
| EMCO 3115 | Microwave Antenna | 05/22/98 | 05/22/99 |
| Schwarzbeck 8127 | LISN | 05/22/98 | 05/22/99 |
| MITEQ | Preamp | 05/22/98 | 05/22/99 |
| AFS4-00101800-40-10P-N | | | |

FIGURE 1: Radiated Emissions Test Setup

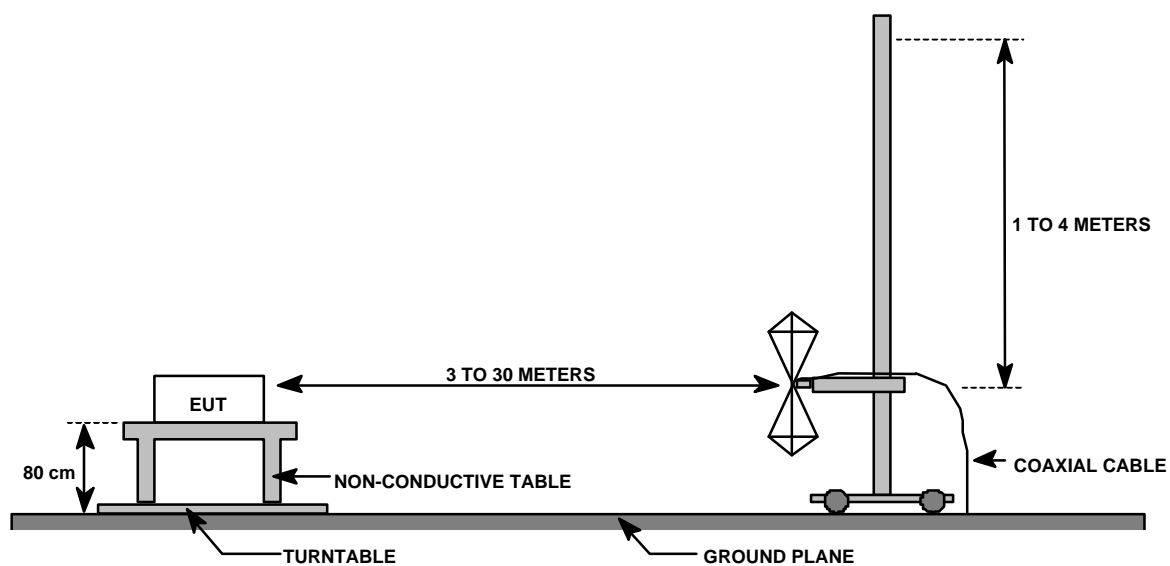
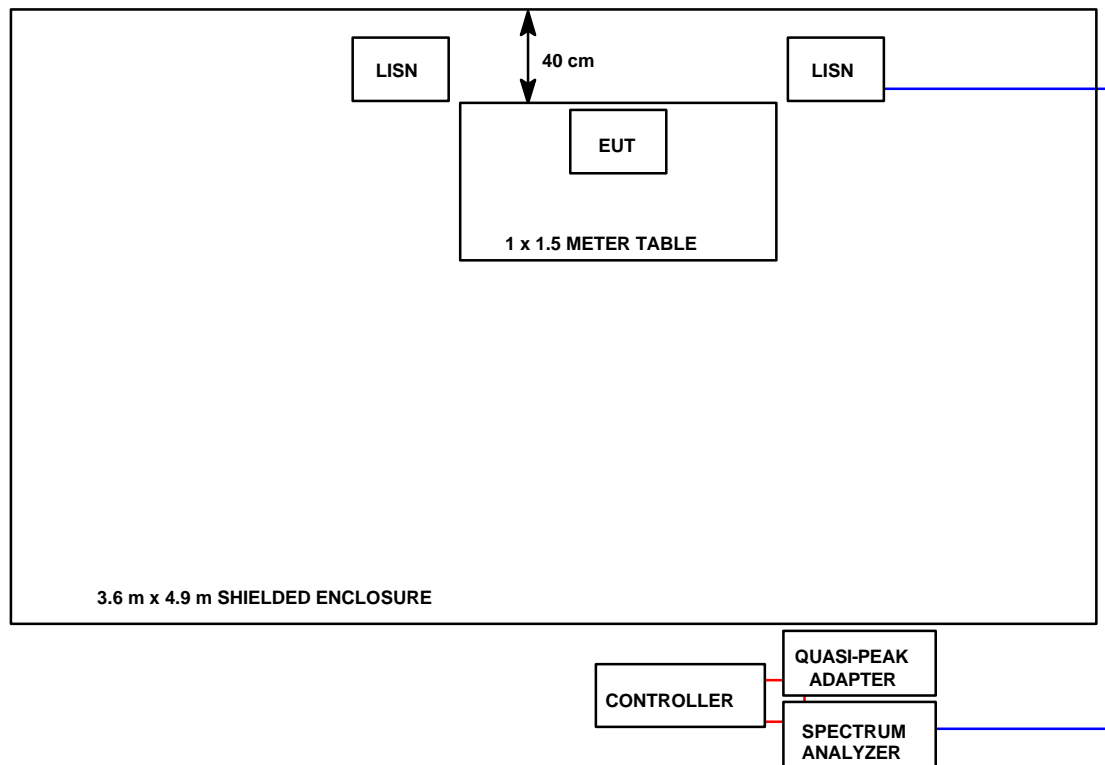


FIGURE 2: Conducted Emissions Test Setup



Fundamental Radiated Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A
DATE: 03/05/99
PROJECT #: 99-345

MEASUREMENT DISTANCE (m): 3
DETECTOR FUNCTION: Peak

EUT Vertical, Antenna Horizontal

| Freq. (MHz) | EUT Dir. (Deg.) | Antenna Height (Meter) | Recorded Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|----------------|-----------------------|------------------------------|-----------------------------|-----------------------------|-----------------------|--------------------------------|-------------------|----------------|
| 916.5 | 0.0 | 1.0 | 63.2 | 22.7 | 6.7 | 92.6 | 93.9 | -1.3 |

EUT Vertical, Antenna Vertical

| Freq. (MHz) | EUT Dir. (Deg.) | Antenna Height (Meter) | Recorded Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|----------------|-----------------------|------------------------------|-----------------------------|-----------------------------|-----------------------|--------------------------------|-------------------|----------------|
| 916.5 | 250.0 | 1.0 | 60.6 | 22.7 | 6.7 | 90.0 | 93.9 | -3.9 |

$$\text{Corrected Level} = \text{Recorded Level} + \text{Antenna Factor} + \text{Cable Loss}$$

COMMENT #1: EUT will only be installed with the antenna vertically polarized (as stated by the manufacturer).

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

Spurious Radiated Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A
DATE: 03/08/99
PROJECT #: 99-343

MEASUREMENT DISTANCE (m): 1
ANTENNA POLARIZATION: Horizontal
DETECTOR FUNCTION: Peak

| Freq. (MHz) | EUT Dir. (Deg.) | Recorded Level (dBuV) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|----------------|-----------------------|-----------------------------|-----------------------------|-----------------------|--------------------------------|-------------------|----------------|
| 1832.9 | 160.0 | 30.8 | 25.9 | 1.4 | 58.1 | 63.5 | -5.4 |
| 2749.4 | 160.0 | 21.1 | 26.7 | 1.6 | 49.4 | 63.5 | -14.1 |
| 3665.8 | 160.0 | 23.0 | 31.1 | 2.2 | 56.3 | 63.5 | -7.2 |
| 4582.3 | 160.0 | 18.3 | 32.4 | 3.4 | 54.1 | 63.5 | -9.4 |
| 5498.7 | 160.0 | 5.3 | 34.9 | 3.8 | 44.0 | 63.5 | -19.5 |
| 6415.2 | 160.0 | 16.7 | 34.3 | 3.6 | 54.6 | 63.5 | -8.9 |
| 7331.7 | 160.0 | 13.4 | 37.1 | 3.4 | 53.9 | 63.5 | -9.6 |
| 8248.1 | 160.0 | -0.6 | 36.5 | 4.0 | 39.9 | 63.5 | -23.6 |
| 9163.9 | 160.0 | -10.8 | 37.2 | 3.8 | 30.2 | 63.5 | -33.3 |

Corrected Level = Recorded Level + Antenna Factor + Cable Loss

COMMENT #1: EUT Vertical.

COMMENT #2: Antenna Elevation optimized at 1 meter.

COMMENT #3: All signals measured above the fundamental are ambients.

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

Spurious Radiated Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A
DATE: 03/04/99
PROJECT #: 99-343

MEASUREMENT DISTANCE (m): 1
ANTENNA POLARIZATION: Vertical
DETECTOR FUNCTION: Peak

| Freq. (MHz) | EUT Dir. (Deg.) | Recorded Level (dBUV) | Antenna Factor (dB/m) | Cable Loss (dB) | Corrected Level (dBUV/m) | Limit (dBUV/m) | Margin (dB) |
|----------------|-----------------------|-----------------------------|-----------------------------|-----------------------|--------------------------------|-------------------|----------------|
| 1832.9 | 160.0 | 28.9 | 25.9 | 1.4 | 56.2 | 63.5 | -7.3 |
| 2749.4 | 160.0 | 22.5 | 26.7 | 1.6 | 50.8 | 63.5 | -12.7 |
| 3665.8 | 160.0 | 21.6 | 31.1 | 2.2 | 54.9 | 63.5 | -8.6 |
| 4582.3 | 160.0 | 18.9 | 32.4 | 3.4 | 54.7 | 63.5 | -8.8 |
| 5498.7 | 160.0 | 12.3 | 34.9 | 3.8 | 51.0 | 63.5 | -12.5 |
| 6415.2 | 160.0 | 13.5 | 34.3 | 3.6 | 51.4 | 63.5 | -12.1 |
| 7331.7 | 160.0 | 16.7 | 37.1 | 3.4 | 57.2 | 63.5 | -6.3 |
| 8248.1 | 160.0 | 2.3 | 36.5 | 4.0 | 42.8 | 63.5 | -20.7 |
| 9163.9 | 160.0 | -5.9 | 37.2 | 3.8 | 35.1 | 63.5 | -28.4 |

Corrected Level = Recorded Level + Antenna Factor + Cable Loss

COMMENT #1: EUT Vertical.

COMMENT #2: Antenna Elevation optimized at 1 meter.

COMMENT #3: All signals measured above the fundamental are ambients.

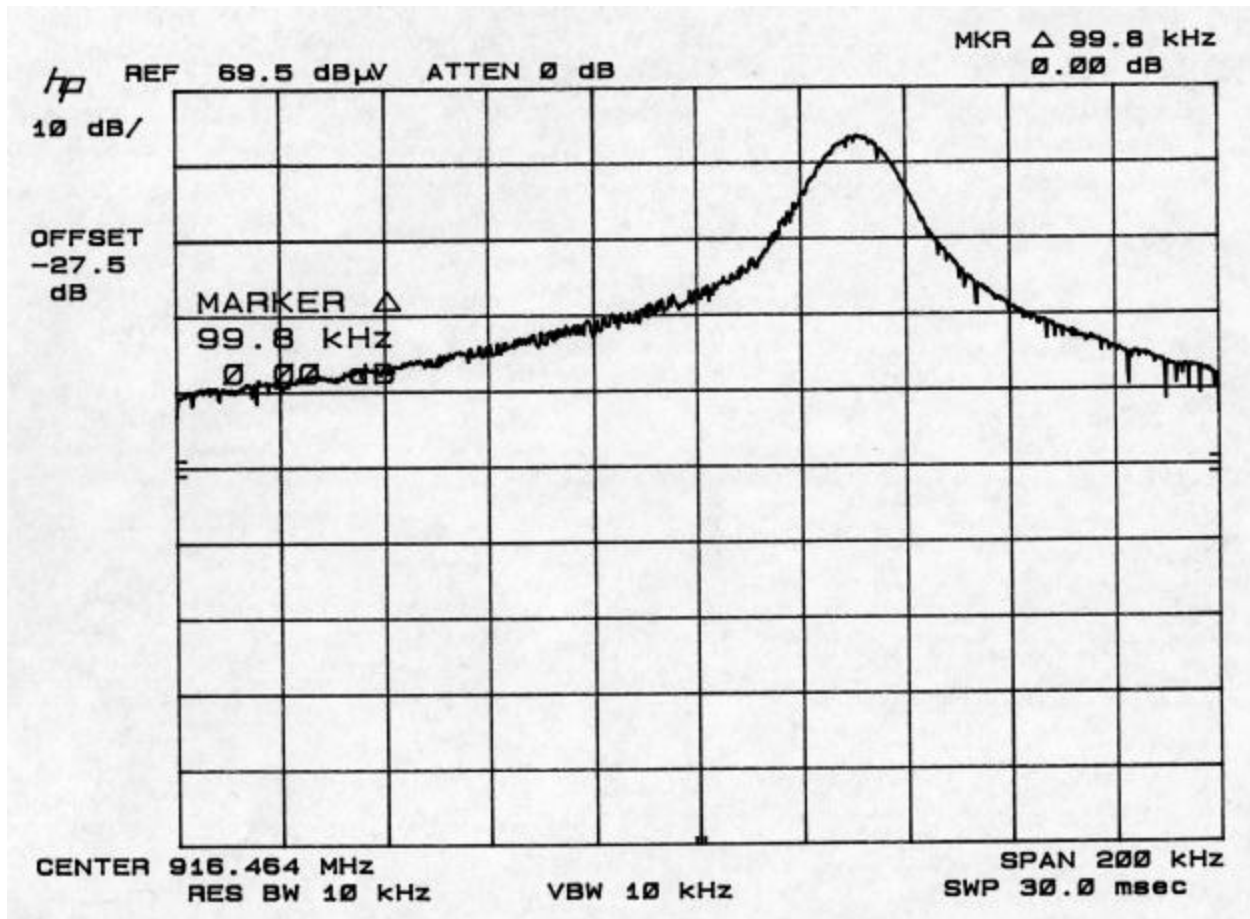
TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

Occupied Bandwidth Data sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A
DATE: 03/09/99
PROJECT #: 99-345

MEASUREMENT DISTANCE (m): 0.5
ANTENNA POLARIZATION: Vertical
DETECTOR FUNCTION: Peak



COMMENT #1: 26dB Bandwidth = 99.8 kHz

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

FCC Part 15.207 Conducted Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A

DATE: March 09, 1999

DETECTOR FUNCTION: Quasi-Peak

LINE MEASURED: Neutral

PROJECT #: 99-345

| Frequency Measured (MHz) | Recorded Level (dBuV) | Cable Loss (dB) | LISN Factor (dB) | Corrected Level (dBuV) | Limit Quasi-Peak (dBuV) | Margin (dB) |
|--------------------------------|-----------------------------|-----------------------|------------------------|------------------------------|-------------------------------|----------------|
| 0.46 | 40.5 | 0.1 | 1.1 | 41.7 | 48.0 | -6.3 |
| 0.53 | 35.8 | 0.1 | 1.1 | 37.0 | 48.0 | -11.0 |
| 0.59 | 33.1 | 0.1 | 1.1 | 34.3 | 48.0 | -13.7 |
| 1.33 | 25.1 | 0.2 | 1.1 | 26.4 | 48.0 | -21.6 |
| 24.10 | 30.2 | 0.9 | 2.5 | 33.6 | 48.0 | -14.4 |
| 19.00 | 28.7 | 0.9 | 2.1 | 31.7 | 48.0 | -16.3 |
| 26.30 | 31.0 | 1.0 | 2.8 | 34.8 | 48.0 | -13.2 |

COMMENT #1: 120VAC/60Hz; Transmit mode

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

FCC Part 15.207 Conducted Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

SERIAL #: N/A

DATE: March 09, 1999

DETECTOR FUNCTION: Quasi-Peak

LINE MEASURED: Phase

PROJECT #: 99-345

| Frequency Measured (MHz) | Recorded Level (dBuV) | Cable Loss (dB) | LISN Factor (dB) | Corrected Level (dBuV) | Limit Quasi-Peak (dBuV) | Margin (dB) |
|--------------------------------|-----------------------------|-----------------------|------------------------|------------------------------|-------------------------------|----------------|
| 0.46 | 42.3 | 0.1 | 1.1 | 43.5 | 48.0 | -4.5 |
| 0.53 | 35.6 | 0.1 | 1.1 | 36.8 | 48.0 | -11.2 |
| 3.54 | 25.5 | 0.3 | 1.3 | 27.1 | 48.0 | -20.9 |
| 12.37 | 28.6 | 0.7 | 1.7 | 31.0 | 48.0 | -17.0 |
| 19.04 | 29.0 | 0.8 | 2.6 | 32.4 | 48.0 | -15.6 |
| 20.05 | 28.4 | 0.9 | 2.7 | 32.0 | 48.0 | -16.0 |
| 30.00 | 25.9 | 1.0 | 4.4 | 31.3 | 48.0 | -16.7 |

COMMENT #1: 120VAC/60Hz; Transmit mode

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

Frequency Stability vs. DC Power Supply Voltage Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

PROJECT #: 99-345
DATE: March 9, 1999

SERIAL #: N/A

| DC Voltage | Center Frequency (MHz) | Frequency Deviation (kHz) |
|------------|------------------------|---------------------------|
| 4.25 | 916.415 | 0.0 |
| 4.50 | 916.410 | -5.0 |
| 4.75 | 916.410 | -5.0 |
| 5.00 | 916.415 | 0.0 |
| 5.25 | 916.410 | -5.0 |
| 5.50 | 916.405 | -10.0 |
| 5.75 | 916.415 | 0.0 |

COMMENT #1: Nomal DC voltage: 5.0 VDC per manufacturer

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk

Amplitude Stability vs. DC Power Supply Voltage Data Sheet

Lester Electrical, Inc. Universal Transceiver Module

PROJECT #: 99-345
DATE: March 9, 1999

SERIAL #: N/A

| DC Voltage | Maximum Amplitude (dBuV) | Amplitude Deviation (dB) |
|------------|-----------------------------|-----------------------------|
| 4.25 | 92.240 | -0.4 |
| 4.50 | 92.440 | -0.2 |
| 4.75 | 91.800 | -0.8 |
| 5.00 | 92.600 | 0.0 |
| 5.25 | 92.290 | -0.3 |
| 5.50 | 91.460 | -1.1 |
| 5.75 | 92.260 | -0.3 |

COMMENT #1: Normal DC voltage: 5.0 VDC per manufacturer

COMMENT #2:

TEST ENGINEER: _____ APPROVED BY: _____
Larry Zhou Jeffrey Lenk