# Measurement of RF Interference from a Model PPCTX02A 433.9MHz Transmitter

For : Kell Laboratories
Burlington, WI

P.O. No. : 3110
Date Received : December 31, 2003
Date Tested : December 31, 2003
Test Personnel : Mark E. Longinotti, NARTE® Certified EMC Test Engineer, ATL-0154-E
Specification : FCC "Code of Federal Regulations" Title 47 Part 15, Subpart C

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**Measurement of RF Emissions from an PPCTX02A 433.9MHz Transmitter**

## 1.0 INTRODUCTION:

**1.1 Description of Test Item -** This document represents the results of the series of radio interference measurements performed on a model PPCTX02A transmitter, serial number: none assigned, (hereinafter referred to as the test item). The test item was designed to transmit at approximately 433.9MHz using an internal antenna. The test item was manufactured and submitted for testing by Kell Laboratories located in Burlington, WI.

**1.2 Purpose -** The test series was performed to determine if the test item meets the conducted and radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.231 for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-2001.

**1.3 Deviations, Additions and Exclusions -** There were no deviations, additions to, or exclusions from the test specification during this test series.

**1.4 Applicable Documents -** The following documents of the exact issue designated form part of this document to the extent specified herein:

- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 15, Subpart C, dated 1 October 2002
- ANSI C63.4-2001, "American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz"

**1.5 Subcontractor Identification -** This series of tests was performed by Elite Electronic Engineering Incorporated of Downers Grove, Illinois. The laboratory is accredited by the National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP). NVLAP Lab Code: 100278-0.

**1.6 Laboratory Conditions** The temperature at the time of the test was 22° C and the relative humidity was 21%.

## 2.0 TEST ITEM SETUP AND OPERATION:

The test item is a model PPCTX02A 433.9MHz transmitter. A block diagram of the test item setup is shown as Figure 1.

**2.1 Power Input** - The test item obtained 12VDC power from 2 each 6V batteries tied in series. The batteries were connected to the test item via 2 each, 16-inch long, unshielded leads. The 16-inch long leads were used because that will be the standard length used in manufacturing.

**2.2 Grounding** - Since it is normally not grounded, the test item was ungrounded during the tests.

**2.3 Peripheral Equipment** - The test item was submitted for testing with no peripheral equipment.

**2.4 Interconnect Cables** - The test item was submitted for testing with no interconnect cables.

**2.5 Operational Mode** - For all tests the test item was placed on an 80cm high non-conductive stand. The test item was energized. The test item was programmed to continuously transmit for testing purposes.

**2.6 Test Item Modifications** - The following modifications were performed to the test item: the value of R5 was changed to 270 ohms and the value of R6 was changed to 100 kohms.

## 3.0 TEST EQUIPMENT:

**3.1 Test Equipment List** - A list of the test equipment used can be found on Table I. All equipment was calibrated per the instruction manuals supplied by the manufacturer.

The fundamental, harmonics and spurious emissions were measured with a spectrum analyzer. The spectrum analyzer peak detected readings were converted to average readings using a duty cycle factor. All measurements were taken with the resolution and video bandwidth of the measuring instrument adjusted to 100kHz below 1GHz and 1MHz above 1GHz.

**3.2 Calibration Traceability** Test equipment is maintained and calibrated on a regular basis. All calibrations are traceable to the National Institute of Standards and Technology (NIST).

**3.3 Measurement Uncertainty** - All measurements are an estimate of their true value. The measurement uncertainty characterizes, with a specified confidence level, the spread of values which may be possible for a given measurement system.

The measurement uncertainty budgets were based on guidelines in "ISO Guide to the Expression of Uncertainty in Measurements" and NAMAS NIS81 "The Treatment of Uncertainty in EMC Measurements".

The measurement uncertainty for these tests is presented below:

| Conducted Emission Measurements | | |
|---|---|---|
| Combined Standard Uncertainty | 1.07 | -1.07 |
| Expanded Uncertainty (95% confidence) | 2.1 | -2.1 |

| Radiated Emission Measurements | | |
|---|---|---|
| Combined Standard Uncertainty | 2.26 | -2.18 |
| Expanded Uncertainty (95% confidence) | 4.5 | -4.4 |

## 4.0 REQUIREMENTS, PROCEDURES AND RESULTS:

### 4.1 Powerline Conducted Emissions

**4.1.1 Requirements** – Since the test item was powered by external batteries, no conducted emissions tests were performed.

### 4.2 Duty Cycle Factor Measurements:

**4.2.1 Procedures** - The duty cycle factor is used to convert peak detected readings to average readings. This factor is computed from the time domain trace of the pulse modulation signal.

With the transmitter set up to transmit for maximum pulse density, the time domain trace is displayed on the spectrum analyzer. This trace is obtained by tuning center frequency to the transmitter frequency and then setting a zero span width with 10msec/div. The amplitude setting are adjusted so that the on/off transitions clear the 4th division from the bottom of the display. The markers are set at beginning and end of a word period. If the word period exceeds 100 msec the word period is set to 100 msec. The on-time and off-time are then measured. The on-time is total time signal level exceeds the 4th division. Off-time is time under for the word period. The duty cycle is then computed as the (On-time/ word period) where the word period = (On-time + Off-time).

**4.2.2 Results** - A representative plot of the duty cycle is shown on data page 12. Since the transmitter uses a rolling code, the duty cycle used was calculated based on the worst case. The worst case information was supplied by Kell Laboratories. With the test item transmitting at 433.91MHz, the worst case duty cycle would be -11.2dB.

### 4.3 Radiated Measurements

**4.3.1 Requirements** - The test item must comply with the requirements of FCC "Code of Federal Regulations Title 47", Part 15, Subpart C, Section 15.205 et seq.

Paragraph 15.231(b) has the following radiated emission limits:

| Fundamental Frequency MHz | Field Intensity uV/m @ 3 meters | Field Strength Harmonics and Spurious @ 3 meters |
|---|---|---|
| 260 to 470 | 3,750 to 12,500* | 375 to 1,250* |

* - Linear Interpolation

*Example For 433.91MHz, the limit at the fundamental is 10996.3uV/m @ 3m and the limit on the harmonics is 1099.6uV/m @ 3m.

In addition, emissions appearing in the Restricted Bands of Operation listed in paragraph 15.205(a) shall not exceed the general requirements shown in paragraph 15.209.

**4.3.2 Procedures** - Preliminary measurements were performed in a 32ft.x20ft.x14ft. high shielded enclosure. The shielded enclosure prevents emissions from other sources, such as radio and TV stations from interfering with the measurements. All powerlines and signal lines entering the enclosure pass through filters on the enclosure wall. The powerline filters prevent extraneous signals from entering the enclosure on these leads.

The broadband measuring antenna was positioned at a 3 meter distance from the test item. The entire frequency range from 30MHz to 5.0GHz was investigated using a peak detector function. The data was then processed by the computer to equivalent field intensity at 3 meters.

The final emission tests were performed at a test distance of 3 meters using a peak detector. The peak detected levels were converted to average levels using a duty cycle factor which was computed from the pulse train. The frequency range from 433.91MHz to 4339.1MHz was investigated. Between 300MHz and 1000MHz, a tuned dipole antenna was used as the pick-up device. A broadband double ridged waveguide antenna was used above 1GHz.

To ensure that maximum emission levels were measured, the following steps were taken:

(1) The test item was rotated so that all of its sides were exposed to the receiving antenna.
(2) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.
(3) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.
(4) For hand-held or body-worn devices, the test item was rotated through three

orthogonal axes to determine which orientation produces the highest emission relative to the limit

**4.3.3 Results** - The preliminary plots, with the test item transmitting at 433.91MHz, are presented on data pages 13 and 14. The plots are presented for a reference only, and are not used to determine compliance.

The final radiated levels, with the test item transmitting at 433.91MHz, are presented on data page 15. As can be seen from the data, all emissions measured from the test item were within the specification limits. The emissions level closet to the limit (worst case) occurred at 433.91MHz. The emissions level at this frequency was 2.2dB within the limit. See data page 15 for details. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figure 2.

**4.4 Occupied Bandwidth Measurements**

**4.4.1 Requirement** - In accordance with paragraph 15.231(c), all emissions within 20dB of the peak amplitude level of the center frequency are required to be within a band less than 0.25% of the center frequency wide.

**4.4.2 Procedures** - The test item was placed on an 80cm high non-conductive stand. The unit was set to transmit continuously. With an antenna positioned nearby, occupied bandwidth emissions were displayed on the spectrum analyzer. The resolution bandwidth was set to 100kHz and span was set to 5 MHz. The frequency spectrum near the fundamental was plotted

**4.4.3 Results** - The plot of the emissions near the fundamental frequency are presented on data page 16. As can be seen from this data page, the transmitter met the occupied bandwidth requirements.

## 5.0 CONCLUSIONS:

With the value of R5 changed to 270 ohms and the value of R6 changed to 100 kohms, the Kell Laboratories, Part No. PPCTX02A, Serial No. None assigned, did fully meet the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.205 et seq. for Intentional Radiators, when tested per ANSI C63.4-2001.

## 6.0 CERTIFICATION:

Elite Electronic Engineering Incorporated certifies that the information contained in this report was obtained under conditions which meet or exceed those specified in the test specifications.

The data presented in this test report pertains to the test item at the test date as operated by Kell

Laboratories personnel. Any electrical or mechanical modification made to the test item subsequent to the specified test date will serve to invalidate the data and void this certification.

**7.0 ENDORSEMENT DISCLAIMER:**

This report must not be used to claim product endorsement by NVLAP or any agency of the US Government.

TABLE I: TEST EQUIPMENT LIST

ELITE ELECTRONIC ENG. INC. Page: 1

| Eq ID | Equipment Description | Manufacturer | Model No. | Serial No. | Frequency Range | Cal Date | Cal Inv | Due Date |
|---|---|---|---|---|---|---|---|---|
| Equipment Type: ACCESSORIES, MISCELLANEOUS | | | | | | | | |
| XZG0 | ATTENUATOR/SWITCH DRIVER | HEWLETT PACKARD | 11713A | 3439A02724 | --- | | N/A | |
| Equipment Type: AMPLIFIERS | | | | | | | | |
| APK0 | PRE-AMPLIFIER | HEWLETT PACKARD | 8449B | 3008A00662 | 1-26.5GHZ | 02/19/03 | 12 | 02/19/04 |
| Equipment Type: ANTENNAS | | | | | | | | |
| NDQ1 | TUNED DIPOLE ANTENNA | EMCO | 3121C-DB4 | 313 | 400-1000MHZ | 01/27/03 | 12 | 01/27/04 |
| NTA0 | BILOG ANTENNA | CHASE EMC LTD. | BILOG CBL611 | 2057 | 0.03-2GHZ | 07/03/03 | 12 | 07/03/04 |
| NWF0 | RIDGED WAVE GUIDE | EMCO | 3105 | 2035 | 1-12.4GHZ | 11/03/02 | 14 | 01/03/04 |
| Equipment Type: RECEIVERS | | | | | | | | |
| RAC1 | SPECTRUM ANALYZER | HEWLETT PACKARD | 85660B | 3407A08369 | 100HZ-22GHZ | 01/29/03 | 12 | 01/29/04 |
| RACB | RF PRESELECTOR | HEWLETT PACKARD | 85685A | 3506A01491 | 20HZ-2GHZ | 01/29/03 | 12 | 01/29/04 |
| RAF3 | QUASIPEAK ADAPTER | HEWLETT PACKARD | 85650A | 3303A01775 | 0.01-1000MHZ | 01/29/03 | 12 | 01/29/04 |

Cal. Interval: Listed in Months I/O: Initial Only N/A: Not Applicable
Note 1: For the purpose of this test, the equipment was calibrated over the specified frequency range, pulse rate, or modulation prior to the test or monitored by a calibrated instrument.

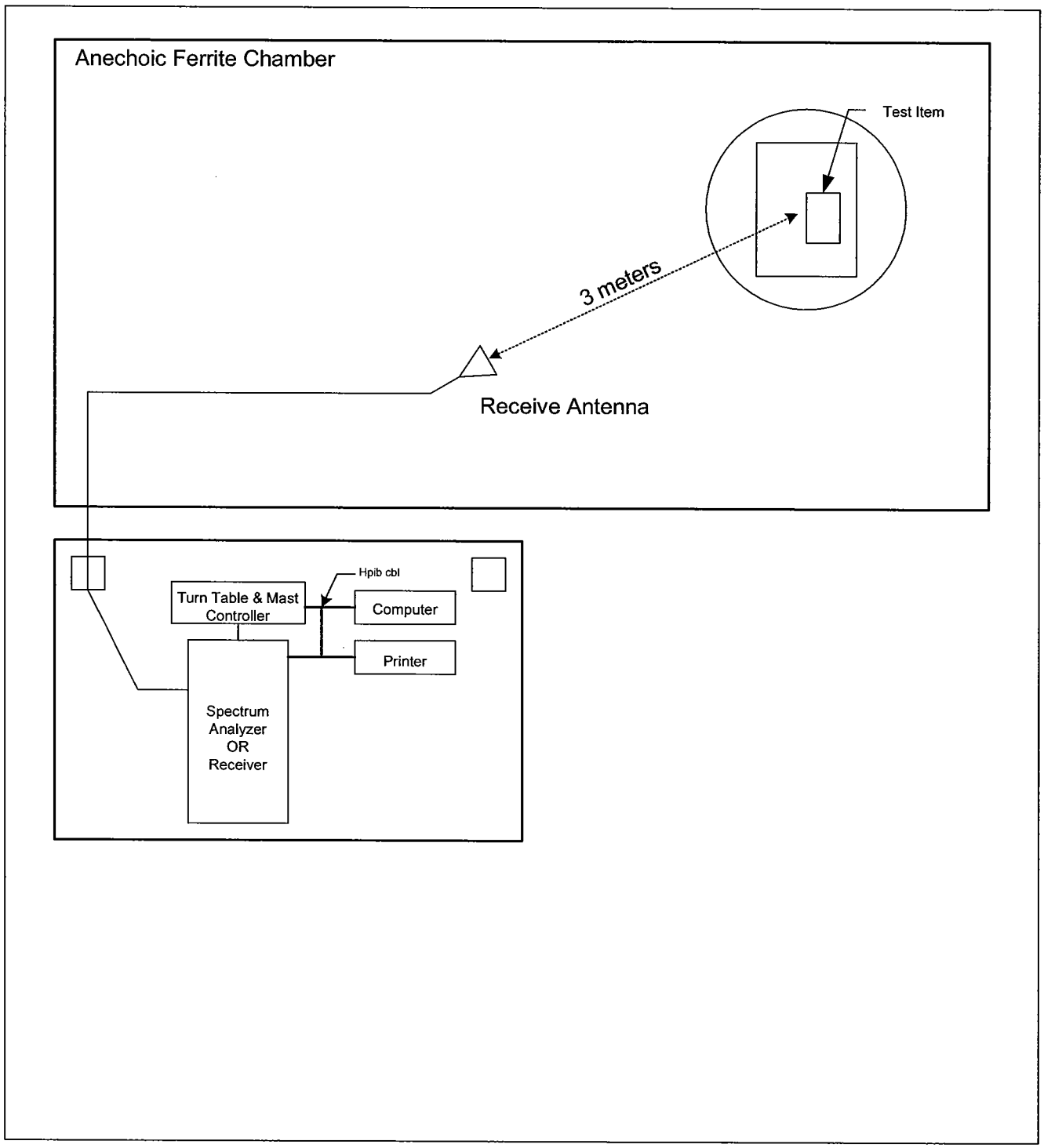
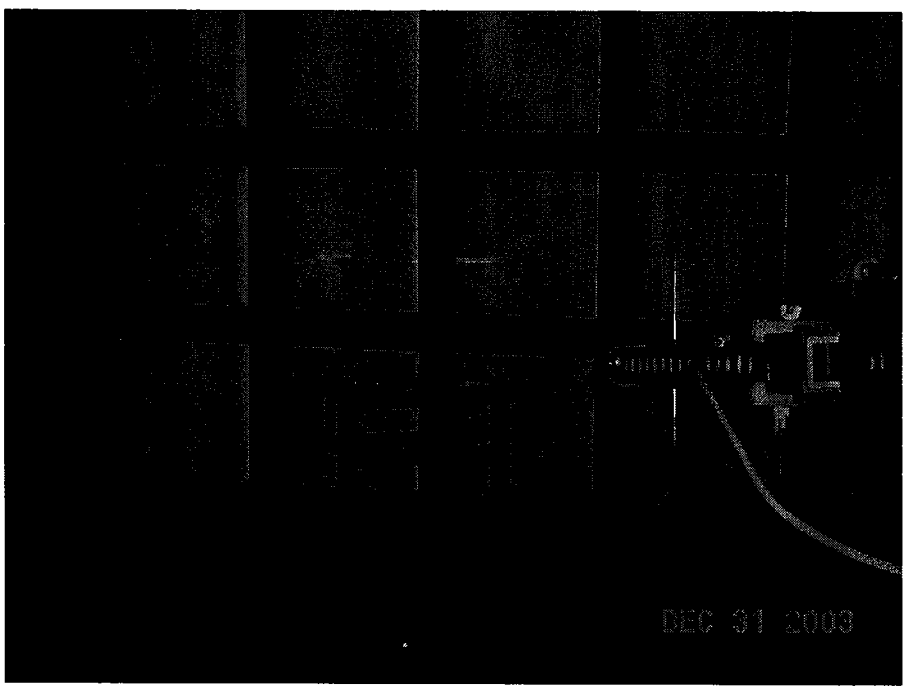


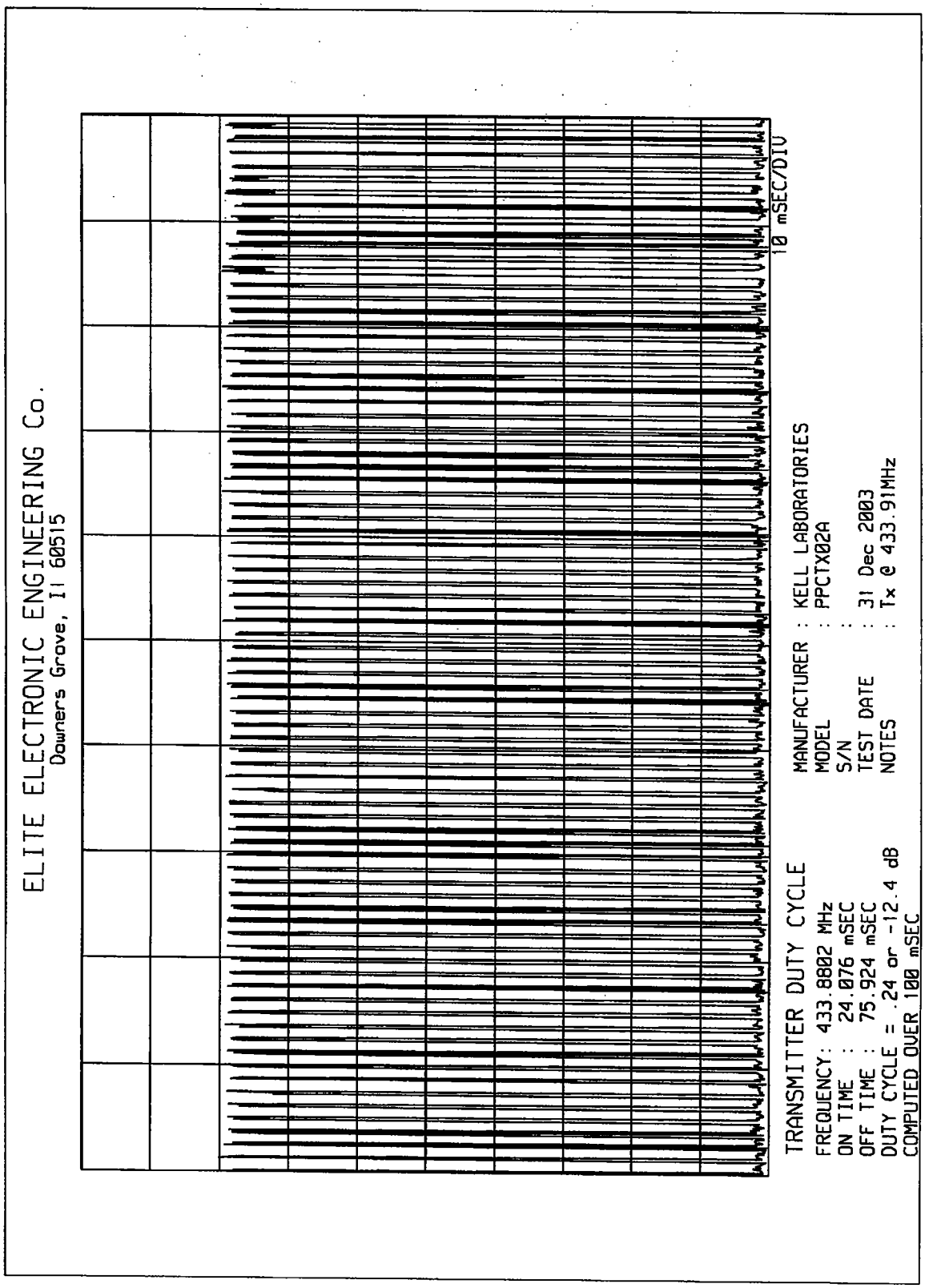

Figure 1 - Test Setup for Radiated Emissions

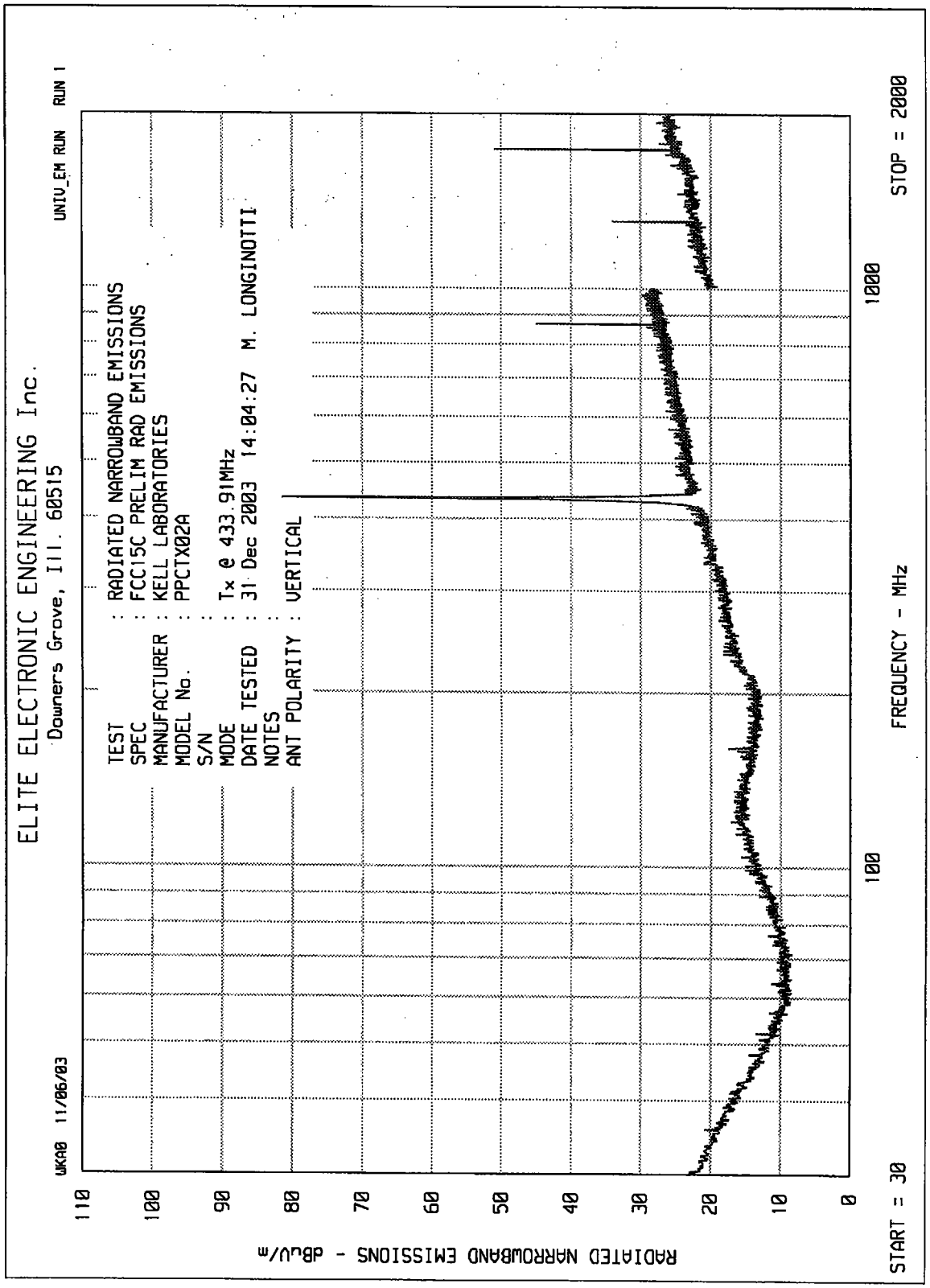
Figure 2

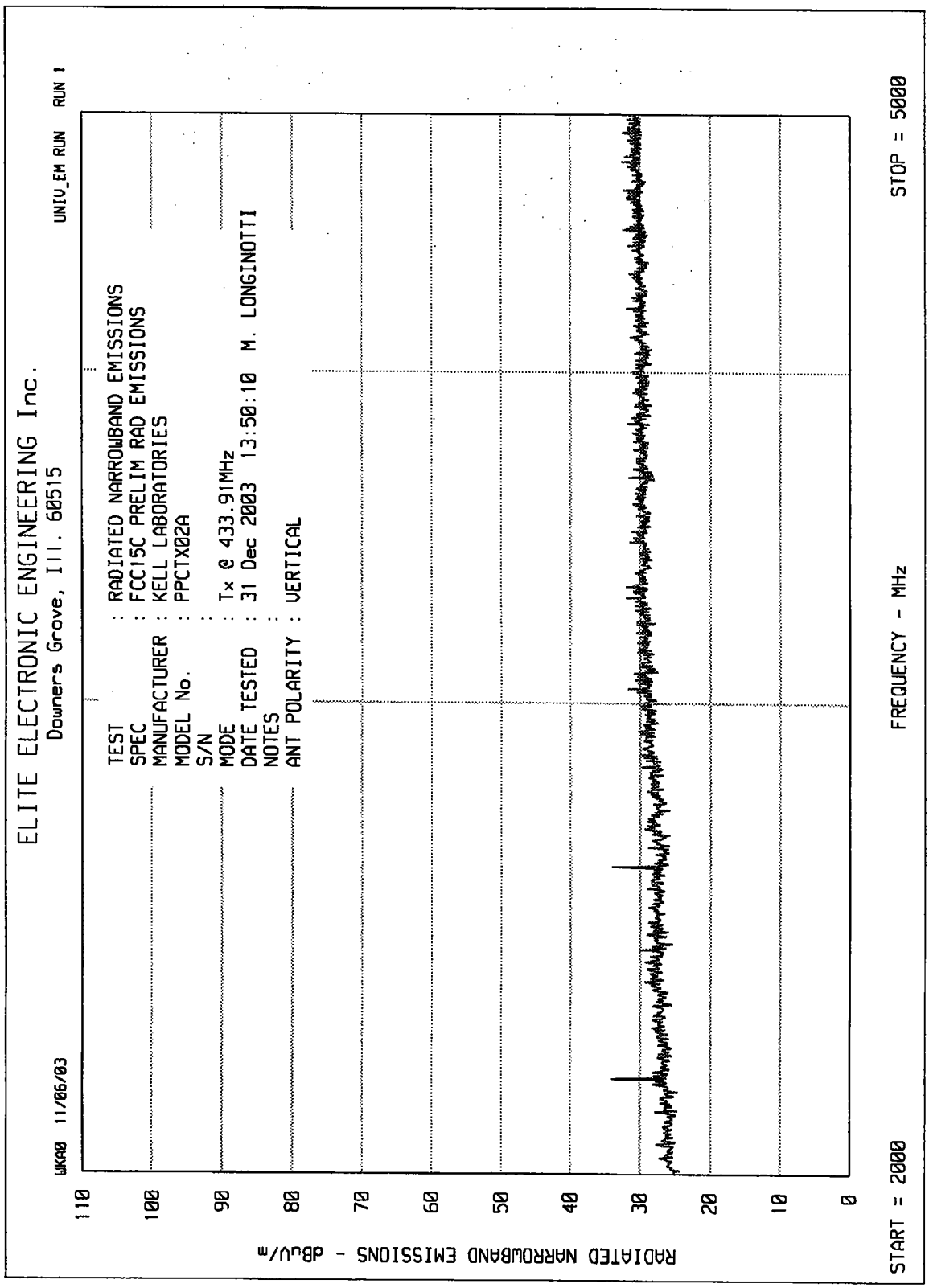

Test Setup for Radiated Emissions - Horizontal Polarization




Test Setup for Radiated Emissions - Vertical Polarization


ELITE ELECTRONIC ENGINEERING Co.
Downers Grove, Il 60515
10 mSEC/DIV
TRANSMITTER DUTY CYCLE
FREQUENCY: 433.8802 MHz
ON TIME : 24.076 mSEC
OFF TIME : 75.924 mSEC
DUTY CYCLE = .24 or -12.4 dB
COMPUTED OVER 100 mSEC
MANUFACTURER : KELL LABORATORIES
MODEL : PPCTX02A
S/N :
TEST DATE : 31 Dec 2003
NOTES : Tx @ 433.91MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
UKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC15C PRELIM RAD EMISSIONS
MANUFACTURER : KELL LABORATORIES
MODEL No. : PPCTX02A
S/N :
MODE : Tx @ 433.91MHz
DATE TESTED : 31 Dec 2003 14:04:27 M. LONGINOTTI
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
1000
STOP = 2000
FREQUENCY - MHz


ELITE ELECTRONIC ENGINEERING Inc.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 11/06/03
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC15C PRELIM RAD EMISSIONS
MANUFACTURER : KELL LABORATORIES
MODEL No. : PPCTX02A
S/N :
MODE : Tx @ 433.91MHz
DATE TESTED : 31 Dec 2003 13:50:10 M. LONGINOTTI
NOTES :
ANT POLARITY : VERTICAL
RADIATED NARROWBAND EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 2000
FREQUENCY - MHz
STOP = 5000

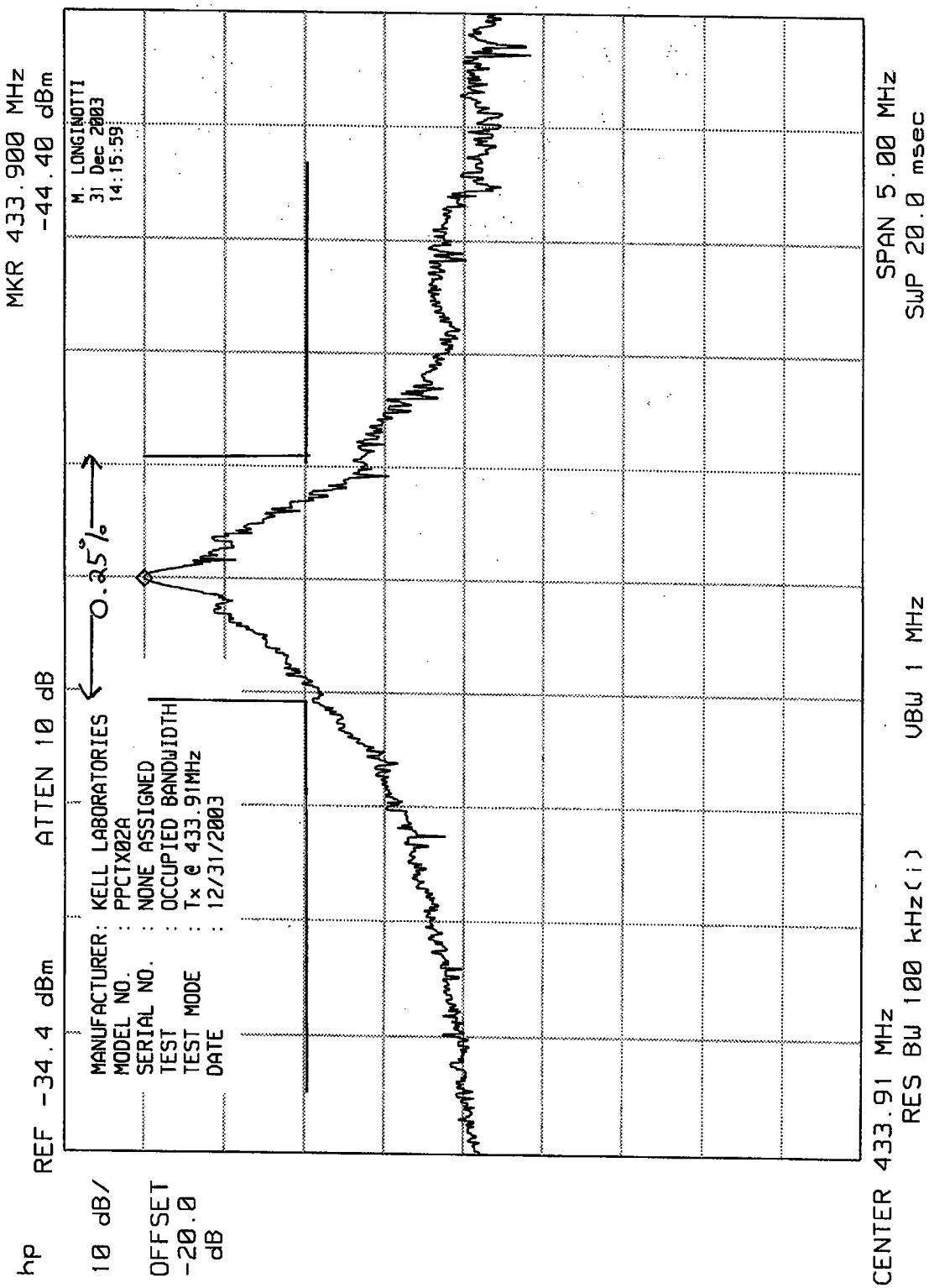
ETR No.
DATA PAGE

SPECIFICATION : FCC PART 15C(REV OCT 1, 94) TRANSMITTER OPEN FIELD DATA
MANUFACTURER : KELL LABORATORIES
MODEL : PPCTX02A
S/N :
TEST DATE : 31 Dec 2003
NOTES : Tx @ 433.91MHz
TEST ANTENNA : ROBERTS DIPOLE & DRWG ANTENNAS

| FREQUENCY MHz | ANT POL | MTR RDG dBuV | CBL FAC dB | ANT FAC dB | DUTY CYCLE dB | TOTAL dBuV/m @3m | TOTAL uV/m @3m | LIMIT uV/m @3m | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| 433.91 | H | 67.1 | 1.5 | 21.2 | -11.2 | 78.6 | 8552.8 | 10996.3 | |
| 433.91 | V | 63.8 | 1.5 | 21.2 | -11.2 | 75.3 | 5849.4 | 10996.3 | |
| 867.80 | H | 17.9 | 1.9 | 27.3 | -11.2 | 35.9 | 62.2 | 1099.6 | |
| 867.80 | V | 17.1 | 1.9 | 27.3 | -11.2 | 35.1 | 56.7 | 1099.6 | |
| 1301.80 | H | 16.6 | 2.4 | 26.5 | -11.2 | 34.3 | 51.8 | 500.0 | * |
| 1301.80 | V | 10.5 | 2.4 | 26.5 | -11.2 | 28.2 | 25.6 | 500.0 | * |
| 1735.60 | H | 31.7 | 2.8 | 27.8 | -11.2 | 51.1 | 358.5 | 1099.6 | |
| 1735.60 | V | 19.8 | 2.8 | 27.8 | -11.2 | 39.2 | 91.1 | 1099.6 | |
| 2169.50 | H | 18.7 | 3.2 | 29.5 | -11.2 | 40.2 | 102.4 | 1099.6 | |
| 2169.50 | V | 12.7 | 3.2 | 29.5 | -11.2 | 34.2 | 51.3 | 1099.6 | |
| 2603.50 | H | 11.7 | 3.7 | 31.1 | -11.2 | 35.2 | 57.8 | 1099.6 | |
| 2603.50 | V | 12.4 | 3.7 | 31.1 | -11.2 | 35.9 | 62.7 | 1099.6 | |
| 3037.40 | H | 8.9AMB | 4.0 | 32.2 | 0.0 | 45.1 | 180.9 | 1099.6 | |
| 3037.40 | V | 8.4AMB | 4.0 | 32.2 | 0.0 | 44.6 | 170.8 | 1099.6 | |
| 3471.30 | H | 7.6AMB | 4.3 | 32.5 | 0.0 | 44.4 | 165.4 | 1099.6 | |
| 3471.30 | V | 8.1AMB | 4.3 | 32.5 | 0.0 | 44.9 | 175.2 | 1099.6 | |
| 3905.20 | H | 7.1AMB | 4.5 | 32.8 | 0.0 | 44.4 | 166.8 | 500.0 | * |
| 3905.20 | V | 7.5AMB | 4.5 | 32.8 | 0.0 | 44.8 | 174.7 | 500.0 | * |
| 4339.10 | H | 7.4AMB | 4.7 | 32.8 | 0.0 | 45.0 | 176.9 | 500.0 | * |
| 4339.10 | V | 8.0AMB | 4.7 | 32.8 | 0.0 | 45.6 | 189.5 | 500.0 | * |

* DENOTES A FREQUENCY CONFLICT WITH RESTRICTED BANDS

checked by: Mark E. Longinotti
M. LONGINOTTI


ELITE ELECTRONIC ENGINEERING Inc.
hp
REF -34.4 dBm
ATTEN 10 dB
MKR 433.900 MHz
-44.40 dBm
10 dB/
OFFSET
-20.0
dB
MANUFACTURER: KELL LABORATORIES
MODEL NO. : PPCTX02A
SERIAL NO. : NONE ASSIGNED
TEST : OCCUPIED BANDWIDTH
TEST MODE : Tx @ 433.91MHz
DATE : 12/31/2003
M. LONGINOTTI
31 Dec 2003
14:15:59
0.35%
CENTER 433.91 MHz
RES BW 100 kHz(i)
VBW 1 MHz
SPAN 5.00 MHz
SWP 20.0 msec