ELITE ELECTRONIC ENGINEERING INCORPORATED
1516 CENTRE CIRCLE
DOWNERS GROVE, ILLINOIS 60515-1082

ELITE PROJECT: 28502 DATE TESTED: February 10 & 14, 2000

TEST PERSONNEL: Mark E. Longinotti, Robert Olajos

TEST SPECIFICATION: FCC "Code of Federal Regulations" Title 47
Part 15, Subpart C, Section 15.205

ENGINEERING TEST REPORT NO. 22431

MEASUREMENT OF RF INTERFERENCE FROM

A MODEL 984LM TRANSMITTER

FOR: Chamberlain Manufacturing
Elmhurst, IL

PURCHASE ORDER NO.: 30556

Report By:
Neil J. Hurley

Witnessed By:
Rob Keller
Chamberlain Manufacturing

Approved By:
Raymond J. Klouda
Registered Professional
Engineer of Illinois - 44894

ENGINEERING TEST REPORT NO. 22431

ADMINISTRATIVE DATA AND SUMMARY OF TESTS

DESCRIPTION OF TEST ITEM: Transmitter

MODEL NO: 984LM **SERIAL NO:** None Assigned

MANUFACTURER: Chamberlain Manufacturing

APPLICABLE SPECIFICATIONS: FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C

QUANTITY OF ITEMS TESTED: One (1)

TEST PERFORMED BY: ELITE ELECTRONIC ENGINEERING INCORPORATED
Radio Interference Consultants
Downers Grove, Illinois 60515

DATE RECEIVED: February 10, 2000

DATE TESTED: February 10 & 14, 2000

PERSONNEL (OPERATORS, OBSERVERS, AND CO-ORDINATORS):
CUSTOMER: Rob Keller of Chamberlain Manufacturing was present.
ELITE ELECTRONIC: Mark E. Longinotti, Robert Olajos

ELITE JOB NO.: 28502

ABSTRACT: The model 984LM transmitter, does meet the radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15 for Intentional Radiators, when tested per ANSI C63.4-1992.

The radiated emissions level closest to the limit (worst case) occurred at 390MHz. The emissions level at this frequency was 0.4dB within the limit. See data page 21 for more details.

ENGINEERING TEST REPORT NO. 22431

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ENGINEERING TEST REPORT NO. 22431

MEASUREMENT OF RF INTERFERENCE FROM

A MODEL 984LM TRANSMITTER

1.0 INTRODUCTION:

1.1 DESCRIPTION OF TEST ITEM: This document presents the results of a series of radio interference measurements performed on a model 984LM Transmitter, (hereinafter referred to as the test item). No serial number was assigned to the test item. The test item was designed to transmit at approximately 390 MHz using an internal antenna. The tests were performed for Chamberlain Manufacturing of Elmhurst, IL.

1.2 PURPOSE: The test series was performed to determine if the test item meets the radiated RF emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Sections for Intentional Radiators. Testing was performed in accordance with ANSI C63.4-1992.

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 1998
- ANSI C63.4-1992, "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:

A block diagram of the test item setup is included as Figure 3.

2.1 POWER INPUT: The test item was powered by two 3VDC internal batteries (6VDC).

2.2 GROUNDING: Since the test item was powered with two 3VDC batteries (6VDC), it was ungrounded during the tests.

2.3 PERIPHERAL EQUIPMENT: No peripheral equipment was submitted with the test item.

2.4 INTERCONNECT CABLES: No interconnect cables were submitted with the test item.

2.5 OPERATIONAL MODE: For all tests the test item was placed on a 80cm high non-conductive stand. The test item and all peripheral equipment was energized.

For all tests, the test item's transmit button was held down thereby setting the unit to transmit continuously. The unit was modified to allow continuous transmission. Transmission was verified by observation of an LED which was lit whenever the transmit button was enabled. The transmitting mechanism automatically deactivated when released. The battery voltage was periodically checked to ensure proper operation at maximum level. The tests were performed with the test item operating at 390 MHz.

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 detector 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 120kHz below 1GHz and 1MHz above 1GHz.

The duty cycle factor was calculated from the pulse train for the test item. A data plot was obtained to determine the duty cycle factor. The duty cycle factor was computed as the Word ON time divided by the Word period (ON time + OFF time). The duty cycle factor in dB = 20 log (Word ON/Word period). If the word period is more than 100 milliseconds, then the duty cycle would be computed on the maximum Word ON time during a 100 millisecond period.

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: All radio frequency voltages on the power lines of an intentional radiator shall be below 250uV (quasi-peak) over the frequency range from 0.45MHz to 30MHz. It is also to be noted that if emitted levels in the peak detector function do not exceed the above limits, the test item does meet the intent of these requirements.

Since the test item was powered by internal batteries, no conducted emissions tests were performed.

4.2 DUTY CYCLE FACTOR MEASUREMENTS:

4.2.2 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. The off-time is the total time the signal level is under the 4th division. The duty cycle is then computed as 20*log(On-time/word period) where the word period = (On-time + Off-time) or 100msec.

4.2.3 RESULTS: A representative plot of the duty cycle is shown on data page 16. The actual duty cycle factor used was supplied by Chamberlain Manufacturing. The factor was calculated based on the worst case duty cycle and was determined to be -10.0dB.

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.

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

For 390 MHz, the limit at the fundamental is 9166.7μV/m @ 3m and the limit on the harmonics is 916.7uV/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:

4.3.2.1 PRELIMINARY RADIATED MEASUREMENTS: All preliminary tests were performed in a 26ft. x 10ft. x 12ft. 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 1 meter distance from the test item. The entire frequency range from 30MHz to 4.0GHz was investigated using a peak detector function. The data was then processed by the computer to equivalent field intensity at 3 meters using linear extrapolation. A -9.5dB (-9.5dB = 20 * Log (1m/3m)) distance correction factor has automatically been applied to the plotted emissions data to allow a direct comparison of the data obtained at 1 meter with the emissions limit at the 3 meter specification distance.

4.3.2.2 FINAL RADIATED MEASUREMENTS: All final measurements were performed in a 32ft. x 20ft. x 18ft. hybrid ferrite-tile/anechoic absorber lined test chamber. The walls and ceiling of the shielded chamber are lined with ferrite tiles. Anechoic absorber material is installed over the ferrite tile. The floor of the chamber is used as the ground plane. The chamber complies with ANSI C63.4 1992 for site attenuation.

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 frequencies where significant emission levels were noted during the preliminary radiated emissions measurements were remeasured.

Final radiated emissions were performed on all significant broadband and narrowband emissions found in the preliminary sweeps using the following methods:

1) Measurements were made using a peak detector and a tuned dipole or double ridged waveguide antenna.

2) To ensure that maximum, or worst case, emission levels were measured, the following steps were taken:

   (a) The test item was rotated so that all of its sides were exposed to the receiving antenna.

   (b) Since the measuring antenna is linearly polarized, both horizontal and vertical field components were measured.

   (c) The measuring antenna was raised and lowered from 1 to 4 meters for each antenna polarization to maximize the readings.

   (d) The fundamental through the 10th harmonic of the transmit frequency were measured.

4.3.3 RESULTS: The preliminary plots, with the test item transmitting at 390 MHz, are presented on data pages 17 through 20. 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 390 MHz, are presented on data page 21. 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 390MHz. The emissions level at this frequency was 0.4dB within the limit. See data page 21 for details. Photographs of the test configuration which yielded the highest, or worst case, radiated emission levels are shown on Figures 1 and 2.

4.4 OCCUPIED BANDWIDTH MEASUREMENTS:

4.4.1 REQUIREMENTS: 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 30 kHz and span was set to 2 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 22. As can be seen from this data page, the transmitter met the occupied bandwidth requirements.

5.0 CONCLUSION:

It was found that the Chamberlain Manufacturing model 984LM Transmitter does meet the radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15 for Intentional Radiators, when tested per ANSI C63.4-1992.

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 specification.

The data presented in this test report pertains only to the test item at the test date. 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.

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	---	01/29/99	N/A	
XZG1	ATTENUATOR/SWITCH DRIVER	HEWLETT PACKARD	11713A	3439A02724	---		N/A	
Equipment Type: AMPLIFIERS								
APK0	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	3008A00662	1-26.5GHZ	01/31/00	12	01/31/01
APK1	PRE-AMPLIFIER	HEWLETT PACKARD	8449B	3008A01243	1-26.5GHZ	03/04/99	12	03/04/00
Equipment Type: ANTENNAS								
NBC0	BICONICAL ANTENNA	TENSOR	4104	2003	20-220MHZ	07/28/99	12	07/28/00
NDP0	TUNED DIPOLE ANTENNA	EMCO	3121C-DB3	311	140-400MHZ	11/19/99	12	11/19/00
NDQ0	TUNED DIPOLE ANTENNA	EMCO	3121C-DB4	311	400-1000MHZ	12/13/99	12	12/13/00
NSC1	LOG SPIRAL ANTENNA	EMCO	3101	2204	200-1000MHZ	12/08/99	12	12/08/00
NWH0	DOUBLE RIDGED WAVEGUIDE	TENSOR	4105	2081	1-12.4GHZ	08/27/99	12	08/27/00
Equipment Type: CONTROLLERS								
CDD2	COMPUTER	HEWLETT PACKARD	D4171A#ABA	US61654645	---		N/A	
CMA0	MULTI-DEVICE CONTROLLER	EMCO	2090	9701-1213	---		N/A	
Equipment Type: PRINTERS AND PLOTTERS								
HRE1	LASER JET 5P	HEWLETT PACKARD	C3150A	USHB061052	---		N/A	
Equipment Type: RECEIVERS								
RAC1	SPECTRUM ANALYZER	HEWLETT PACKARD	85660B	3407A08369	100HZ-22GHZ	01/19/00	12	01/19/01
RACC	RF PRESELECTOR	HEWLETT PACKARD	85685A	2648A00507	20HZ-2GHZ	01/10/00	12	01/10/01
RACD	RF PRESELECTOR	HEWLETT PACKARD	85685A	3010A01205	20HZ-2GHZ	01/29/99	13	02/29/00
RAE5	SPECTRUM ANALYZER	HEWLETT PACKARD	8566B	2532A02136	100HZ-22GHZ	05/27/99	12	05/27/00
RAF3	QUASIPEAK ADAPTER	HEWLETT PACKARD	85650A	3303A01775	0.01-1000MHZ	01/19/00	12	01/19/01
RAKG	RF SECTION	HEWLETT PACKARD	85462A	3549A00284	9KHZ-6.5GHZ	01/24/00	12	01/24/01
RAKH	RF FILTER SECTION	HEWLETT PACKARD	85460A	3448A00324	---	01/24/00	12	01/24/01

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.

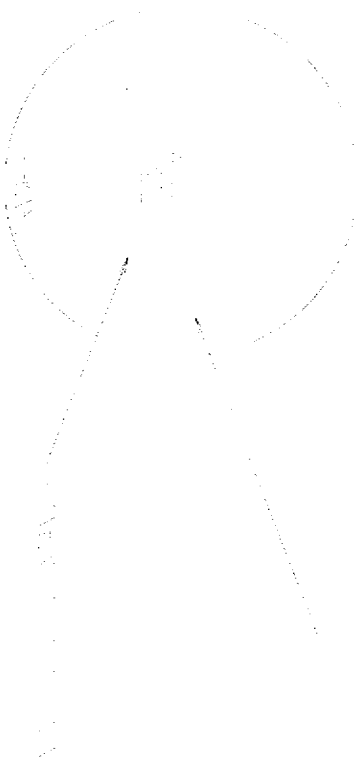
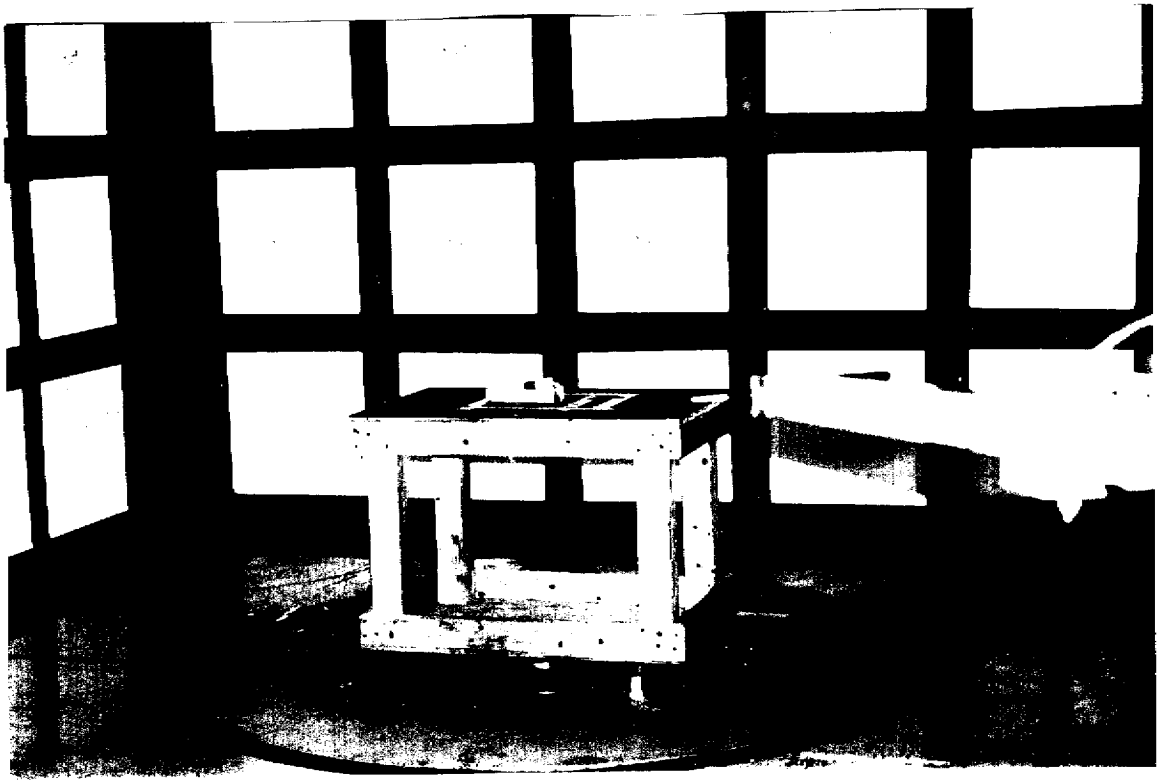
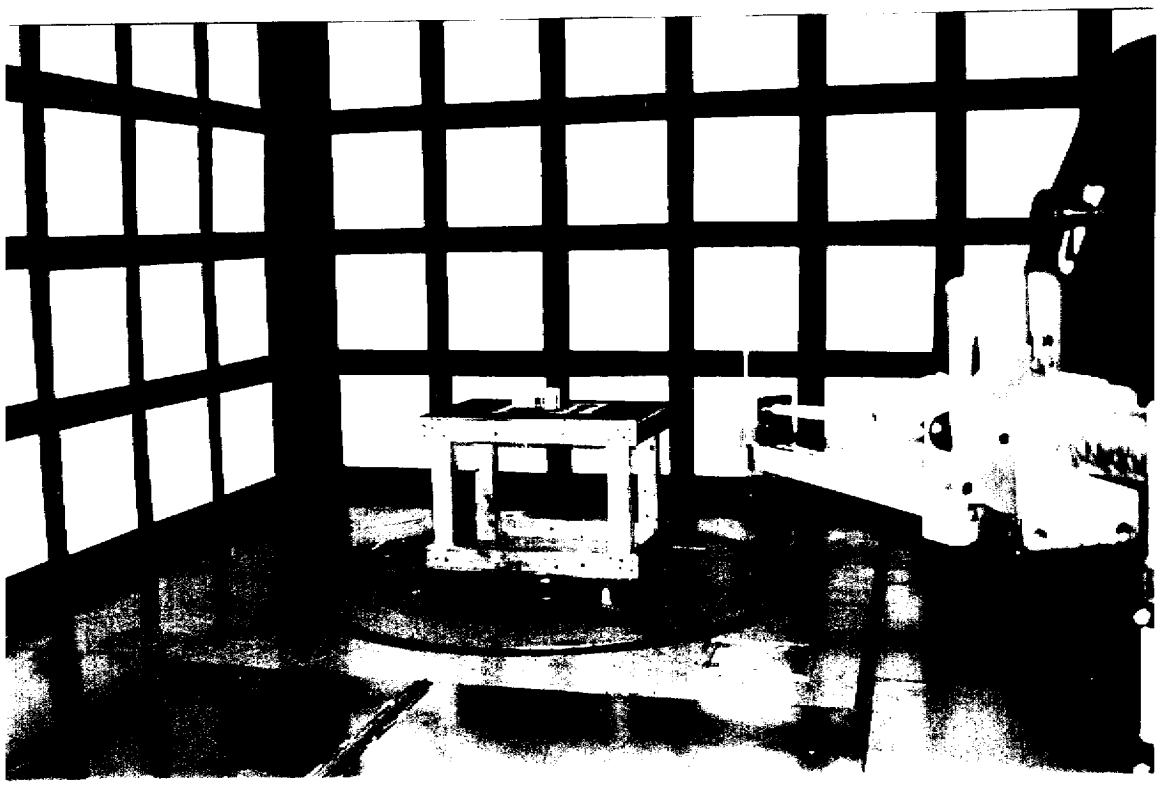


FIGURE 1

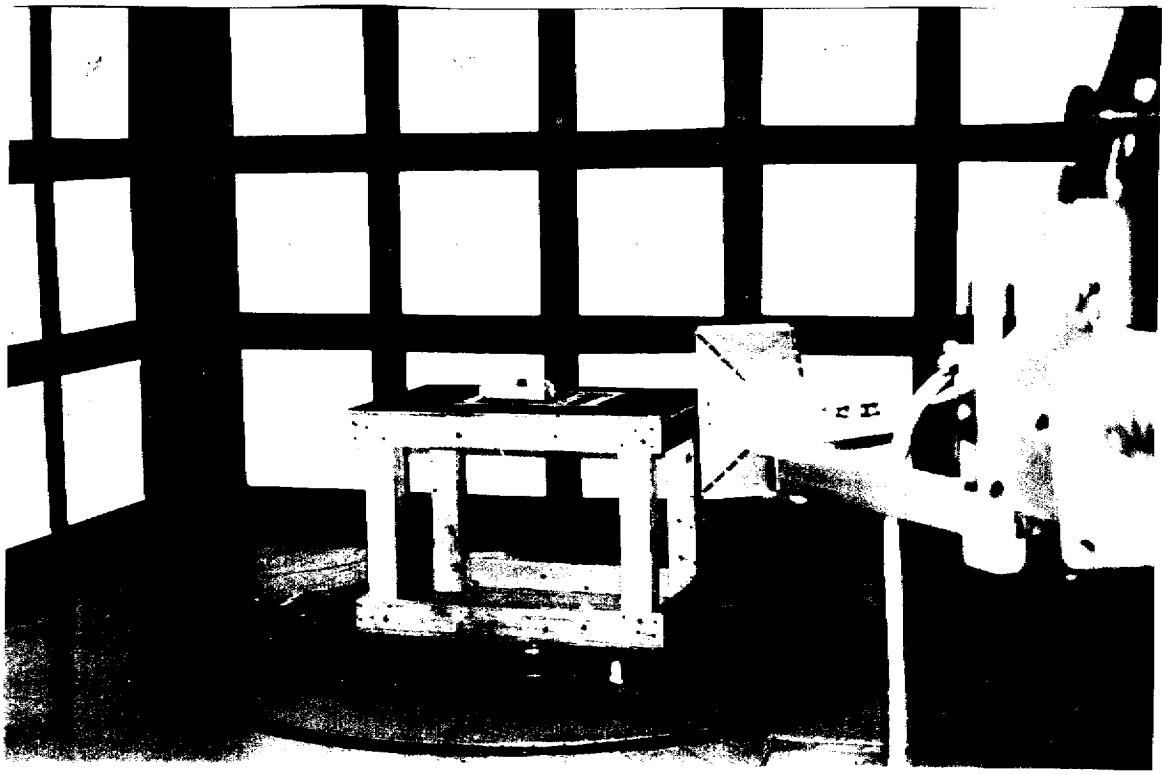


TEST SETUP FOR RADIATED EMISSIONS MEASUREMENTS
MAXIMIZED FOR MEASUREMENT OF WORST CASE EMISSIONS
HORIZONTAL POLARIZATION (30MHz TO 1GHz)

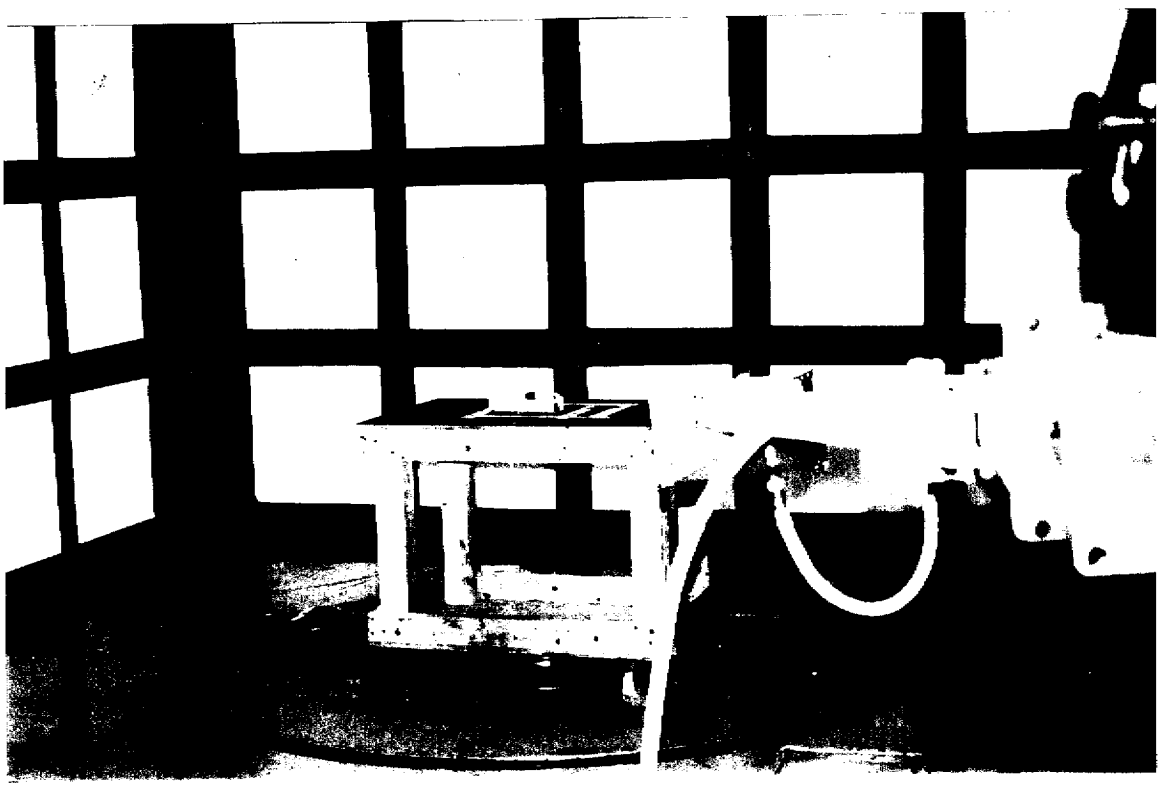


TEST SETUP FOR RADIATED EMISSIONS MEASUREMENTS
MAXIMIZED FOR MEASUREMENT OF WORST CASE EMISSIONS
VERTICAL POLARIZATION (30MHz TO 1GHz)

FIGURE 2



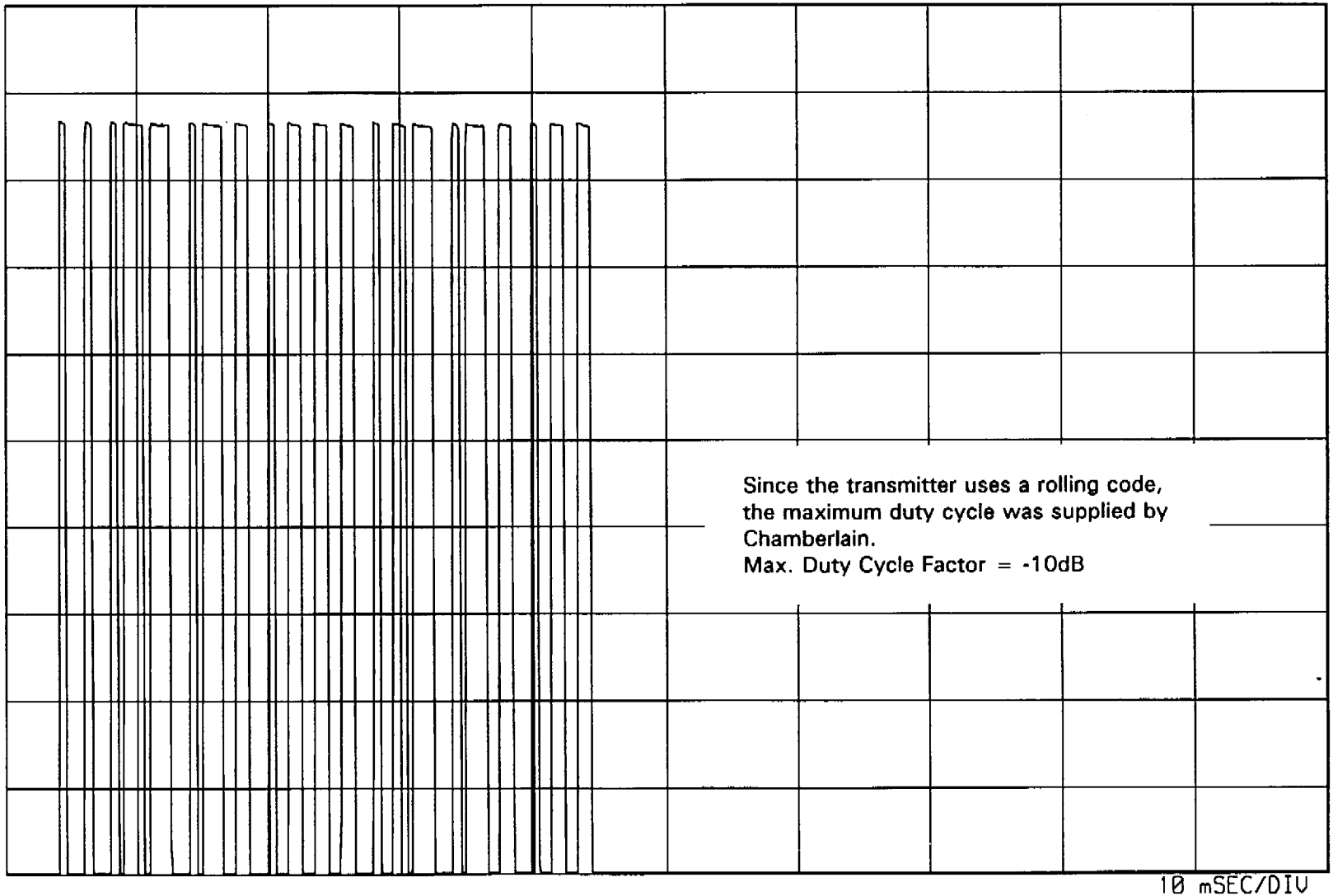
TEST SETUP FOR RADIATED EMISSIONS MEASUREMENTS
MAXIMIZED FOR MEASUREMENT OF WORST CASE EMISSIONS
HORIZONTAL POLARIZATION (1GHz TO 4GHz)



TEST SETUP FOR RADIATED EMISSIONS MEASUREMENTS
MAXIMIZED FOR MEASUREMENT OF WORST CASE EMISSIONS
VERTICAL POLARIZATION (1GHz TO 4GHz)

ELITE ELECTRONIC ENGINEERING Co.

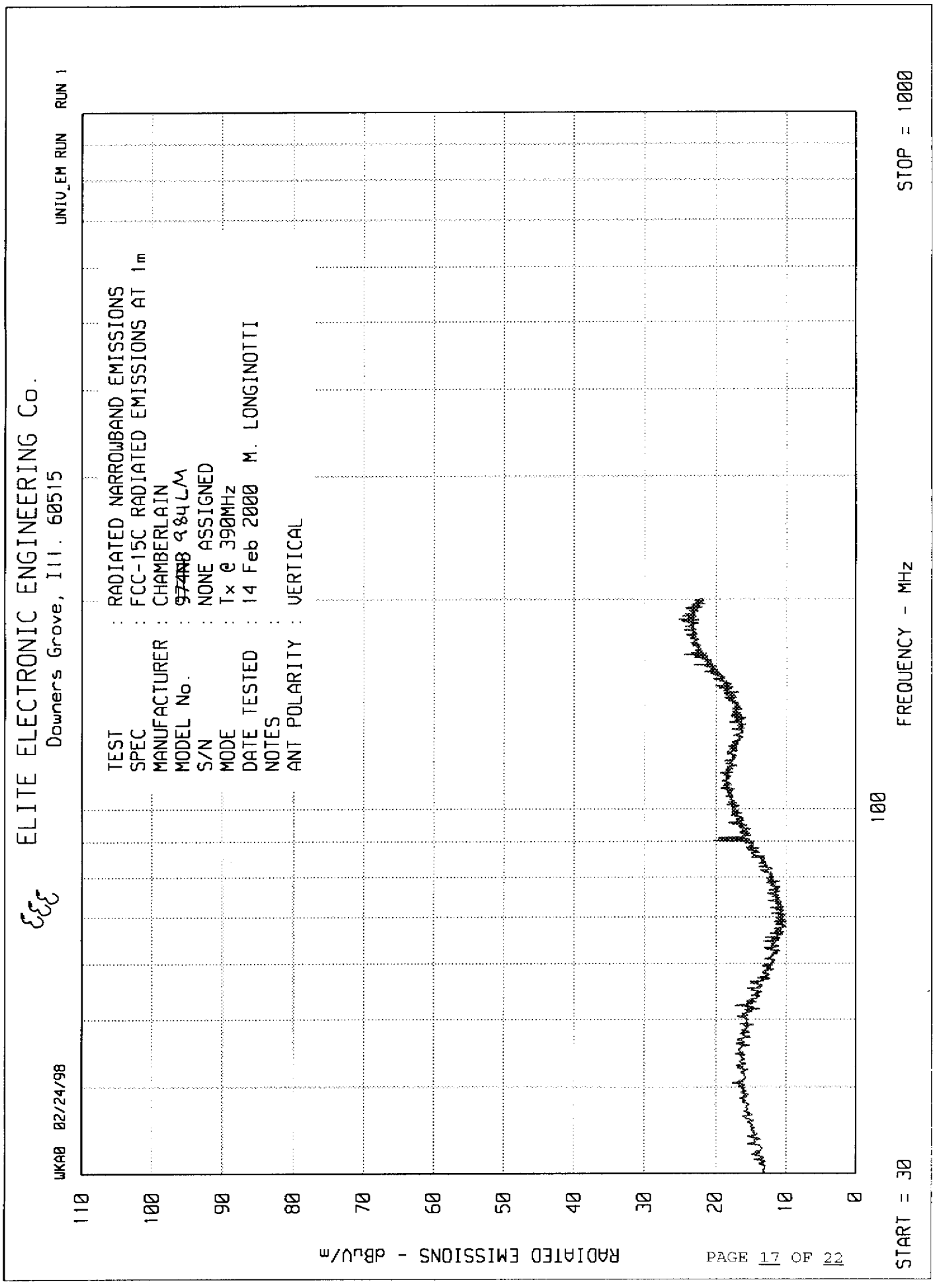
Downers Grove, Il 60515

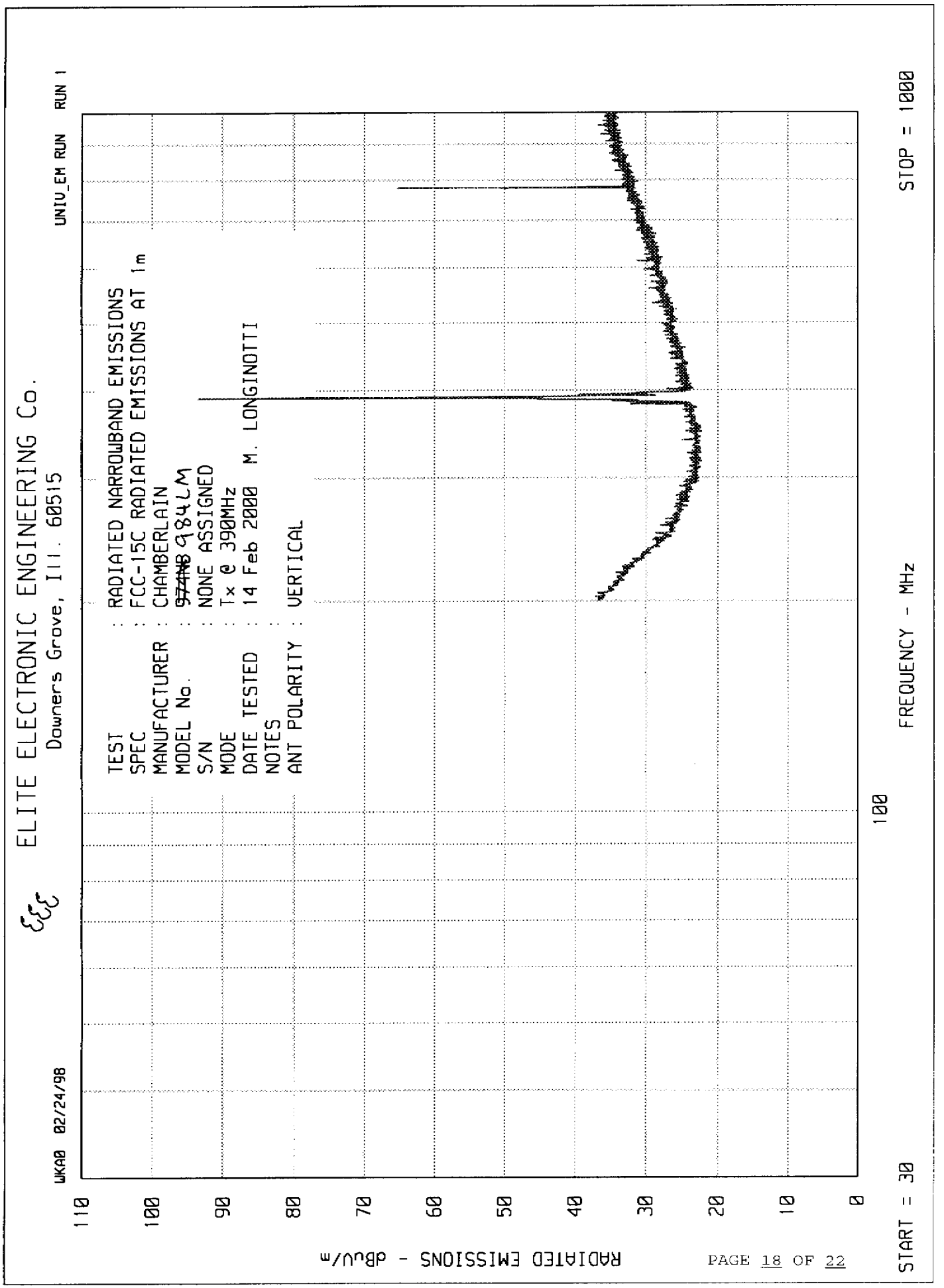


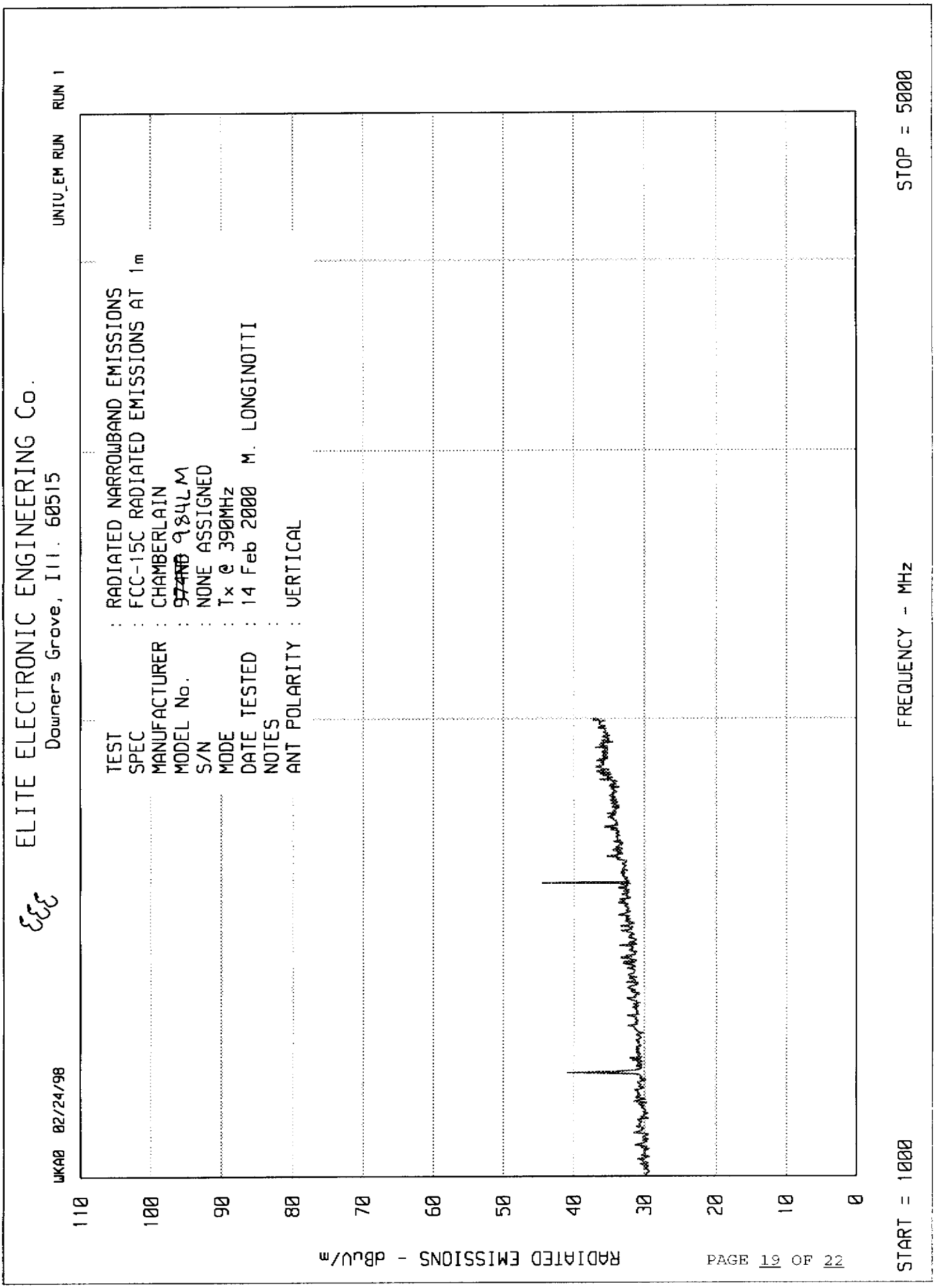
TRANSMITTER DUTY CYCLE

FREQUENCY: 389.9264 MHz
ON TIME : 19.78 mSEC
OFF TIME : 80.22 mSEC
DUTY CYCLE = .2 or -13.98 dB
COMPUTED OVER 100 mSEC

MANUFACTURER : CHAMBERLAIN
MODEL : 984LM
S/N : NONE ASSIGNED
TEST DATE : 14 Feb 2000
NOTES : Tx @ 390MHz


ELITE ELECTRONIC ENGINEERING Co.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 02/24/98
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15C RADIATED EMISSIONS AT 1m
MANUFACTURER : CHAMBERLAIN
MODEL No. : 9748 9846M
S/N : NONE ASSIGNED
MODE : Tx @ 390MHz
DATE TESTED : 14 Feb 2000 M. LONGINOTTI
NOTES :
ANT POLARITY : VERTICAL
RADIATED EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
FREQUENCY - MHz
STOP = 1000


ELITE ELECTRONIC ENGINEERING Co.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 02/24/98
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15C RADIATED EMISSIONS AT 1m
MANUFACTURER : CHAMBERLAIN
MODEL No. : 9748 984LM
S/N : NONE ASSIGNED
MODE : Tx @ 390MHz
DATE TESTED : 14 Feb 2000 M. LONGINOTTI
NOTES :
ANT POLARITY : VERTICAL
RADIATED EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 30
100
FREQUENCY - MHz
STOP = 1000

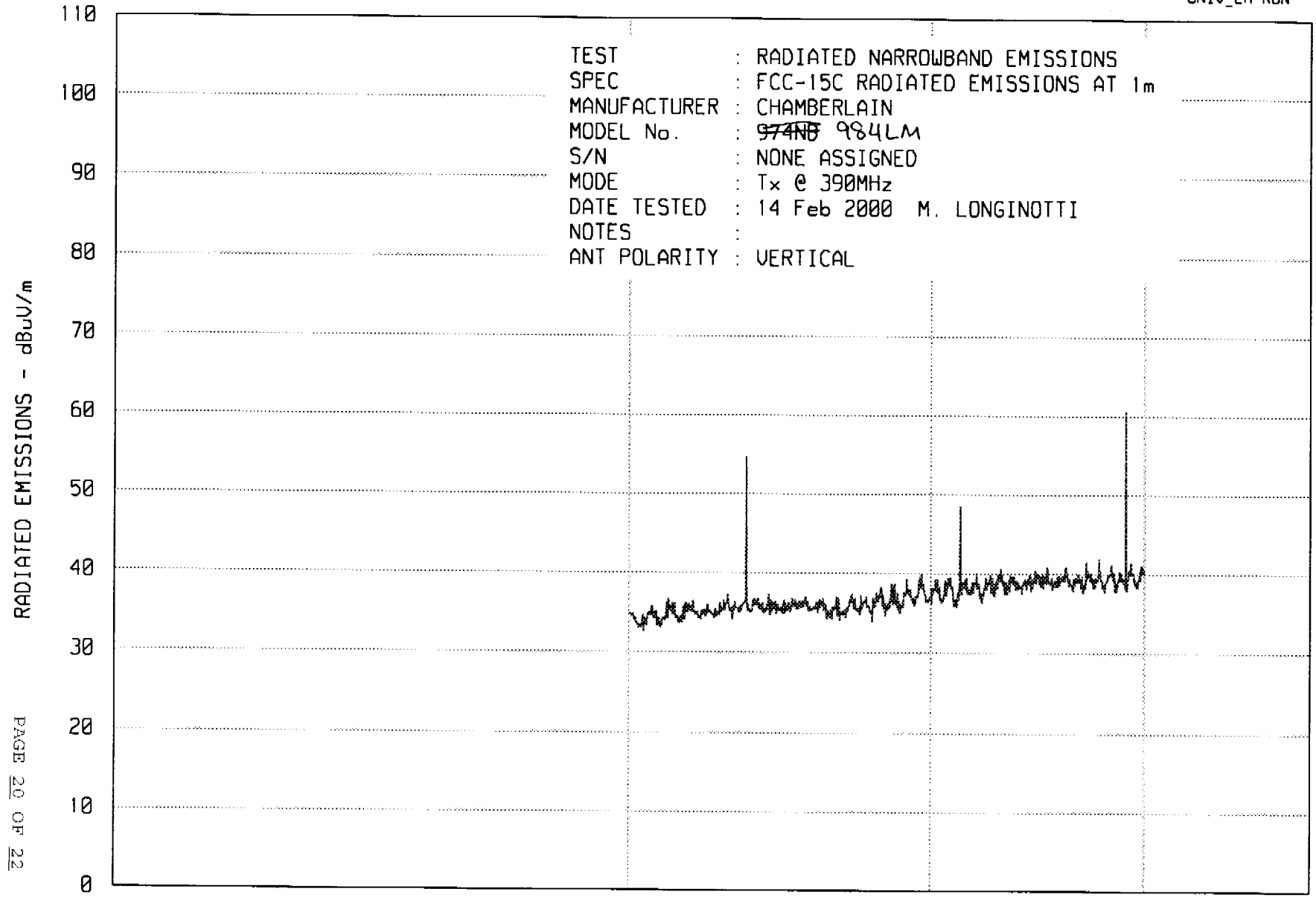

ELITE ELECTRONIC ENGINEERING Co.
Downers Grove, Ill. 60515
UNIV_EM RUN RUN 1
WKA0 02/24/98
TEST : RADIATED NARROWBAND EMISSIONS
SPEC : FCC-15C RADIATED EMISSIONS AT 1m
MANUFACTURER : CHAMBERLAIN
MODEL No. : 9746M
S/N : NONE ASSIGNED
MODE : Tx @ 390MHz
DATE TESTED : 14 Feb 2000 M. LONGINOTTI
NOTES :
ANT POLARITY : VERTICAL
RADIATED EMISSIONS - dBuV/m
110
100
90
80
70
60
50
40
30
20
10
0
START = 1000
FREQUENCY - MHz
STOP = 5000

ELITE ELECTRONIC ENGINEERING Co.

Downers Grove, Ill. 60515

WKA0 02/24/98

UNIV_EM RUN RUN 1



ENGINEERING TEST REPORT NO. 22431
ETR No.
DATA PAGE

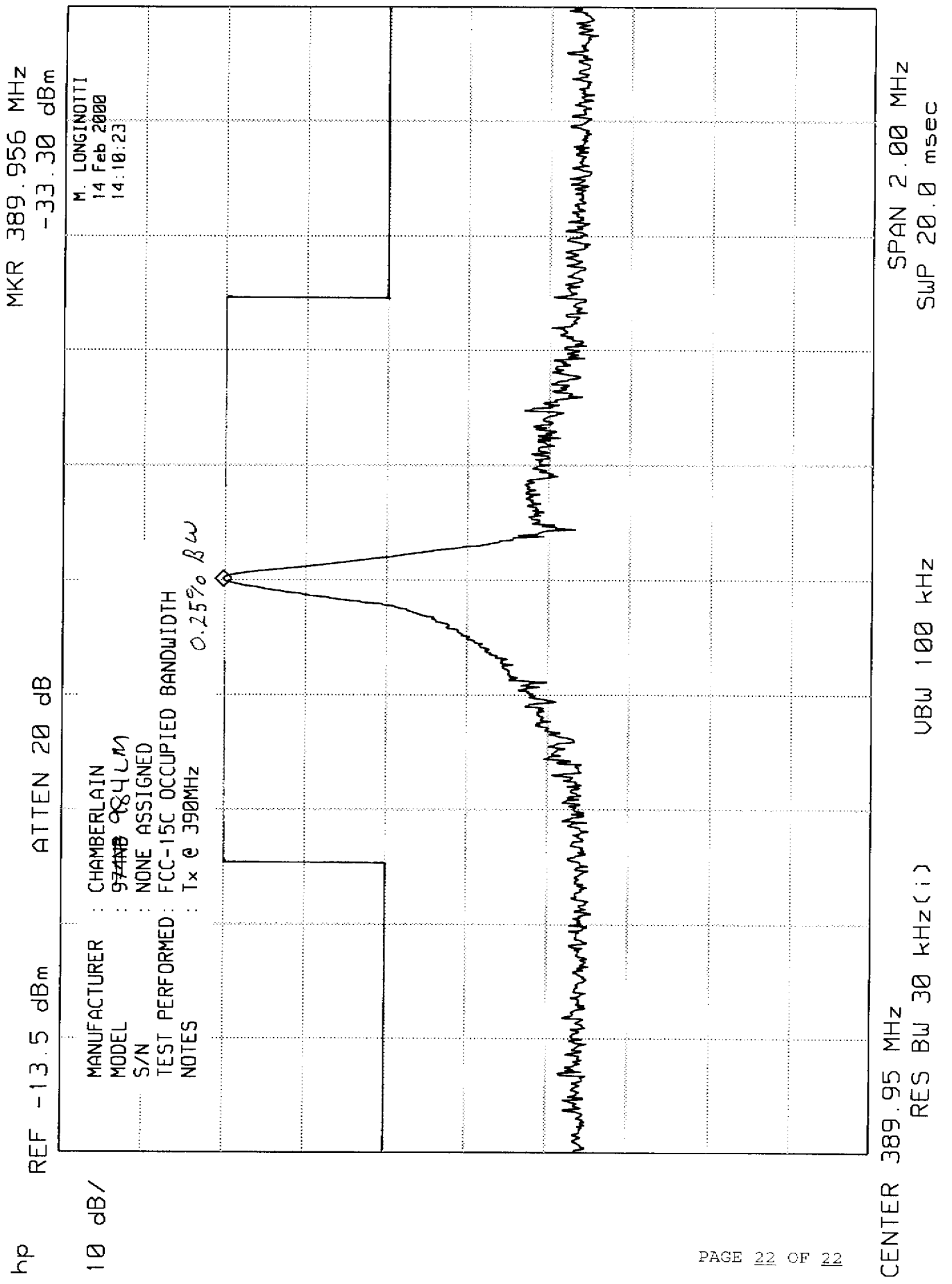
SPECIFICATION : FCC PART 15C(REV OCT 1, 94) TRANSMITTER OPEN FIELD DATA
MANUFACTURER : CHAMBERLAIN
MODEL : ~~974NB~~ 984LM
S/N : NONE ASSIGNED
TEST DATE : 10 Feb 2000
NOTES : Tx @ 390MHz
TEST ANTENNA : ROBERTS DIPOLE & DRWG ANTENNAS

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	NOTE
390.00	H	65.9	2.2	20.8	-10.0	78.8	8725.7	9166.7	
390.00	V	65.0	2.2	20.8	-10.0	77.9	7875.9	9166.7	
780.00	V	30.7	3.0	26.9	-10.0	50.6	339.1	916.7	
780.00	H	31.4	3.0	26.9	-10.0	51.3	367.2	916.7	
1170.00	H	29.6	3.1	24.4	-10.0	47.1	226.1	500.0	*
1170.00	V	31.3	3.1	24.4	-10.0	48.8	276.6	500.0	*
1560.00	V	20.4AMB	3.5	25.6	0.0	49.5	297.1	500.0	*
1560.00	H	21.6	3.5	25.6	-10.0	40.7	108.1	500.0	*
1950.00	H	23.0AMB	3.9	27.4	0.0	54.3	520.8	916.7	
1950.00	V	23.8AMB	3.9	27.4	0.0	55.1	568.4	916.7	
2340.00	H	16.1	4.3	28.7	-10.0	39.2	90.7	500.0	*
2340.00	V	15.7	4.3	28.7	-10.0	38.8	86.6	500.0	*
2730.00	H	15.1	4.7	30.0	-10.0	39.9	98.5	500.0	*
2730.00	V	16.9	4.7	30.0	-10.0	41.7	121.2	500.0	*
3120.00	H	10.2AMB	5.2	31.3	0.0	46.6	214.4	916.7	
3120.00	V	10.5AMB	5.2	31.3	0.0	46.9	222.0	916.7	
3510.00	H	15.5	5.6	32.3	-10.0	43.4	148.1	916.7	
3510.00	V	10.9AMB	5.6	32.3	0.0	48.8	275.7	916.7	
3900.00	V	18.8	6.0	33.0	-10.0	47.8	246.6	500.0	*
3900.00	H	22.4	6.0	33.0	-10.0	51.4	373.3	500.0	*

20K
100

* DENOTES A FREQUENCY CONFLICT WITH RESTRICTED BANDS

checked by: _____
M. LONGINOTTI


ELITE ELECTRONIC ENGINEERING CO
hp
REF -13.5 dBm
ATTEN 20 dB
MKR 389.956 MHz
-33.30 dBm
10 dB/
M. LONGINOTTI
14 Feb 2000
14:10:23
MANUFACTURER : CHAMBERLAIN
MODEL : 9744LM
S/N : NONE ASSIGNED
TEST PERFORMED: FCC-15C OCCUPIED BANDWIDTH
NOTES : Tx @ 390MHz
0.25% BW
CENTER 389.95 MHz
RES BW 30 kHz(i)
VBW 100 kHz
SPAN 2.00 MHz
SWP 20.0 msec