

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

ELITE PROJECT: 29697

DATES TESTED: April 12 through 16, 2001

TEST PERSONNEL: Daniel E. Crowder, NARTE® Certified EMC Engineer,  
ATL-0152-E and Duane Kardynalski

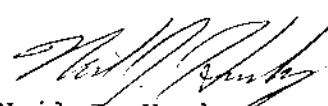
TEST SPECIFICATION: Federal Communication Commission (FCC)  
Parts 2 and 90

ENGINEERING TEST REPORT NO. 23628  
MEASUREMENT OF RF INTERFERENCE FROM  
A PORTABLE INTERROGATOR  
MODEL PI-400

FOR: Badger Meter Incorporated  
Milwaukee, Wisconsin

PURCHASE ORDER NO: 522642

Report By:

  
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ENGINEERING TEST REPORT NO. 23628

ADMINISTRATIVE DATA AND SUMMARY OF TESTS

**DESCRIPTION OF TEST ITEM:** Portable Interrogator

**MODEL NO:** PI-400

**SERIAL NO:** DA-0001

**FCC ID:** GIFPI04

**MANUFACTURER:** Badger Meter Incorporated

**APPLICABLE SPECIFICATIONS:** FCC Parts 2 and 90

**QUANTITY OF ITEMS TESTED:** One (1)

**TEST PERFORMED BY:** ELITE ELECTRONIC ENGINEERING, INC.  
Downers Grove, Illinois 60515

**DATES TESTED:** April 12 through 16, 2001

**PERSONNEL (OPERATORS, OBSERVERS, AND CO-ORDINATORS):**

**CUSTOMER:** No Badger Meter Incorporated personnel were present.

**ELITE ELECTRONIC:** Daniel E. Crowder, Duane Kardynalski

**ELITE JOB NO.:** 29697

**ABSTRACT:** The Model PI-400 Portable Interrogator complies with the technical requirements in FCC Part 90. See test results and data pages for more details.

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MEASUREMENT OF RF INTERFERENCE FROM  
A PORTABLE INTERROGATOR  
MODEL PI-400

**1.0 INTRODUCTION:**

**1.1 DESCRIPTION OF TEST ITEM:** This report presents the results of the radio interference measurements were performed on a Portable Interrogator, Model PI-400, Serial Number DA-0001, (hereinafter referred to as the test item). The tests were performed for Badger Meter Incorporated of Milwaukee, Wisconsin.

The Portable Interrogator is a handheld transmitter used for reading of remote utility meters. The test item is designed to transmit at 451.35MHz using an external antenna.

The test item has a maximum rated output power of 1 Watt.

**1.2 PURPOSE:** The test series was performed to determine if the test item meets the technical requirements of the FCC Part 90.

**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 90, dated 1 October 1999
- Federal Communications Commission "Code of Federal Regulations", Title 47, Part 2, dated 1 October 1999
- 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"

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**1.5 SUBCONTRACTOR IDENTIFICATION:** This series of tests was performed by the Elite Electronic Engineering, Inc., radio interference consultants of Downers Grove, Illinois.

**2.0 TEST ITEM SETUP AND OPERATION:**

**2.1 SETUP:** The test item was powered with an 8VDC internal battery. Since the test item was battery powered, it was ungrounded during the test series.

**2.2 RF OUTPUT:** The test item was operated at its maximum output power level.

**3.0 TEST EQUIPMENT:**

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.

**4.0 REQUIREMENTS, PROCEDURES AND RESULTS:**

**4.1 POWER OUTPUT MEASUREMENTS:**

**4.1.1 REQUIREMENTS:**

The maximum allowable effective radiated power (ERP) is dependent upon the station's antenna HAAT and required service area.

**4.1.2 PROCEDURES:**

- (a) The test item was set to transmit at 451.35MHz.
- (b) A power meter was connected to the output of the test item.
- (c) The output power level was measured and recorded.

**4.1.3 RESULTS:**

The output power measurements are presented on data page 101. The ERP limit does not apply to the power output alone, but the combination of the power output and the antenna. Compliance to the power output will be based on the system configuration and service

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area. Therefore, the ERP requirement cannot be applied to the test item.

**4.2 OCCUPIED BANDWIDTH MEASUREMENTS:**

**4.2.1 REQUIREMENTS:**

In accordance with Paragraph 90.209(b)(5), the maximum authorized bandwidth shall be 20kHz for operations in the bands of 421MHz to 512MHz.

In accordance with paragraph 90.210, Mask C was selected since it represents equipment without audio low pass filter. For Mask C, the peak power of any emission shall be attenuated below the unmodulated carrier power (P) in accordance with the following schedule:

- (1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency of more than 5.0 kHz, but no more than 10.0 kHz: At least  $83 \log (f/5)$  dB;
- (2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency of more than 10.0 kHz, but no more than 250 percent of the authorized bandwidth: At least  $29 \log (f^2/11)$  dB, or 50 dB, whichever is the lesser attenuation;
- (3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency by more than 250 percent of the authorized bandwidth: At least  $43 + 10 \log (P)$  dB.

**4.2.2 PROCEDURES:**

(a) With the spectrum analyzer bandwidth set to 100 Hz and the span set to 100 kHz. The output signal was measured and plotted.

**4.2.3 RESULTS:**

The plots of the occupied bandwidth are presented on data pages 102 and 103. The limits, shown on the plots, are referenced to the power measured from the unmodulated carrier.

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As can be seen from the data, the test item output met the occupied bandwidth requirements.

**4.3 SPURIOUS EMISSIONS AT ANTENNA TERMINAL:**

**4.3.1 REQUIREMENTS:**

This test determines whether the test item produces excessive spurious emissions at the antenna port.

In accordance with paragraph FCC 90.210, the spurious emissions shall be attenuated below the unmodulated carrier power (P) by at least  $43 + 10 \log(P)$  dB. For output at 1 watt, the spurious emissions shall be attenuated by a minimum of 43 dB. This requirement translates to a limit of -13dBm. The peak power of the emissions shall be measured at the antenna terminal from 30MHz up to the 10th harmonic of the fundamental frequency.

**4.3.2 PROCEDURES:**

In general, this test will measure spurious emissions at the antenna terminal.

(a) The test item was connected to the spectrum analyzer.

(b) The analyzer bandwidth was set to 100kHz. The out-of-band signal levels were measured and plotted over the frequency range from 30MHz to 1GHz.

(c) The analyzer bandwidth was increased to 1MHz. The emissions were measured over the frequency range from 1GHz to 5GHz.

**4.3.3 RESULTS:**

The plots of the antenna conducted output measurements are presented on data pages 104 through 106. The limit lines have been adjusted to include the cable loss factors. As can be seen from the data, the test item did not produce spurious emissions in excess of

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the -13 dBm (attenuated 46 dB below unmodulated carrier level).

**4.4 FIELD STRENGTH OF SPURIOUS EMISSIONS:**

**4.4.1 REQUIREMENTS:**

In accordance with Paragraph FCC 90.210(b), the spurious on any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth, the emissions shall be attenuated below the transmitter power (P) by at least  $43 + 10 \log(P)$  dB. This requirement translates to a limit of -13dBm. The emissions shall be measured from 30MHz up to the 10th harmonic of the fundamental frequency.

**4.4.2 PROCEDURES:**

All tests 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 broadband measuring antenna was positioned at a 3 meter distance from the test item. The frequency range from 30MHz to 5GHz was investigated using a peak detector function with the bilog antenna from 30MHz to 2GHz and a double ridged waveguide antenna above 2GHz.

Final radiated emissions were performed on all significant



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broadband and narrowband emissions found in the preliminary sweeps using the following methods:

- 1) Measurements were made using a peak detector and a broadband bi-log of waveguide antenna.
- 2) To ensure that maximum, or worst case, emission levels were measured, the following steps were taken:
  - (a) The test item was placed on a 0.8 meter high non-conductive stand at a 3 meter test distance from the receive antenna.
  - (b) The antenna output was terminated in 50 ohms.
  - (c) Detected emissions were maximized at each frequency by rotating the test item and adjusting the receive antenna height and polarization. The maximum meter reading was recorded.
  - (d) Measurement BW was 100kHz below 1000 MHz and 1MHz above 1000 MHz. Peak reading were recorded. No averaging methods or corrections were applied.
  - (e) The equivalent power into a dipole antenna was calculated from the field intensity levels measured at 3 meters using the equation shown below:

$$P_g = E^2 4\pi d^2 / 120\pi = E^2 d^2 / 30$$

where      P = power in watts  
            g = arithmetic gain of transmitting antenna over isotropic radiator.  
            E = maximum field strength in volts/meter  
            d = measurement distance in meter

Using a dipole gain of 1.67 or 2.2 dB and a test distance of 3 meters, this equation reduces to:

$$P(\text{dBm}) = E(\text{dBuV/m}) - 97.2\text{dB}$$

#### 4.4.3 RESULTS:

The preliminary plots are presented on data pages 107 and 108. The plots are presented for a reference only, and are not used to determine compliance.

The final open area radiated levels are presented on data page 109. The radiated emissions were measured through the 10th harmonic.

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Ambient levels were recorded if the harmonic signals were not detected above the ambient. All emissions were within the specification limits.

**4.5 FREQUENCY STABILITY:**

**4.5.1 REQUIREMENTS:**

In accordance with Paragraph 90.213, the frequency stability shall within +/- 5 parts per million (0.0005%) for mobile stations 2 Watts or less.

**4.5.2 PROCEDURES:**

Two separate procedures were performed for each of the two tests which are as follows:

(a) Frequency Stability vs. Temperature

- (1) The test item was placed in a Thermotron temperature chamber. The test item was powered up.
- (2) The measurement equipment was connected to the test item's antenna port.
- (3) The ambient room temperature was recorded and a reference frequency was recorded.
- (4) The temperature was varied from -30 to +50 degrees centigrade in 10 degree increments. The test item was allowed to soak from 30 to 45 minutes at each temperature. After this time period the unit was set to transmit and the frequency recorded.

(b) Frequency Stability vs. Voltage:

- (1) The measurement equipment was connected to the test item's antenna port.
- (2) The nominal voltage was reduced to reach the battery

operating endpoint.

#### 4.5.3 RESULTS:

The results of the frequency stability vs. temperature tests can be found on data page 110. As can be seen from the data, the frequency stability of the test item is within  $\pm 5.0$  ppm.

The results of the frequency stability vs. voltage variation tests can be found on data page 110. As can be seen from the data, the test item stopped transmitting at 6.8 VDC.

#### 4.6 TRANSIENT FREQUENCY BEHAVIOR:

##### 4.6.1 REQUIREMENTS:

In accordance with Paragraph 90.214, transmitters designed to operate with a 25 kHz bandwidth in the 421MHz to 512MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

| Time Intervals | Maximum Frequency Difference (kHz) | Frequency Ranges (MHz)<br>All Equipment 421-512MHz |
|----------------|------------------------------------|----------------------------------------------------|
| t <sub>1</sub> | $\pm 25$                           | 10.0ms                                             |
| t <sub>2</sub> | $\pm 12.5$                         | 25.0ms                                             |
| t <sub>3</sub> | $\pm 25$                           | 10.0ms                                             |

##### 4.6.2 PROCEDURES:

Transient frequency behavior is a measure of the difference, as a function in time, of the actual transmitter frequency to the assigned transmitter frequency when the transmitted RF output power is switched on or off.

(a) Connect the receiver's Demodulator Output Port (DOP) to the vertical input channel of the storage oscilloscope. Connect the output of the directional coupler to the external trigger on the storage

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oscilloscope. Connect the output of the RF combiner to the receiver.

(b) Set the receiver to measure FM deviation and tune the RF frequency to the transmitter assigned frequency.

(c) Set the signal generator to the assigned transmitter frequency and modulate it with a 1kHz tone at +/-25kHz deviation and set its output level to -100dBm.

(d) Turn the transmitter on.

(e) Supply sufficient attenuation via the RF attenuator to provide an input level to the receiver which is approximately 40dB below the receiver's maximum allowed input power when the transmitter is operating at its rated power level. Note this level on the receiver.

(f) Turn the transmitter off.

(g) Adjust the RF level of the signal generator to provide RF power into the receiver 20dB below the level noted in step (e). this signal generator RF level shall be maintained throughout the rest of the measurement.

(h) Set the horizontal sweep rate on the storage oscilloscope to 10 milliseconds per division and adjust the display to continuously view the 1000Hz tone from the DOP. Adjust the vertical amplitude control of the oscilloscope to display the 1000Hz at +/-4 divisions vertically centered on the display.

(i) Adjust the oscilloscope so it will trigger on an increasing magnitude from the directional coupler at 1 division from the left side of the display, when the transmitter is turned on.

(j) Reduce the attenuation of the RF attenuator so the input to the the RF combiner is increased by 30dB when the transmitter is

turned on.

(k) Turn on the transmitter and observe the stored display. The output at the DOP, due to the change in the ratio of power between the signal generator input power and transmitter output power will, because of the capture effect of the test receiver, produce a change in display: for the first part of the sweep it will show the 1kHz test signal. Then once the receiver's demodulator has been captured by the transmitter power, the display will show the frequency difference from the assigned frequency to the actual transmitter frequency versus time. the instant when the 1kHz test signal is completely suppressed (including any capture time due to phasing) is considered to be  $t_{on}$ . The trace should be maintained within the allowed divisions during the period  $t_1$  and  $t_2$ .

(l) During the time from the end of  $t_2$  to the beginning of  $t_3$  the frequency difference should not exceed the limits set by FCC in Part 90.214 (as above). The allowed limit is equal to the transmitter frequency times its FCC tolerance times  $\pm 4$  display divisions divided by 25kHz.

(m) Turn on the transmitter and observe the stored display. The trace should be maintained within the allowed divisions after the end of  $t_2$  and remain within it until the end of the trace.

(n) To test the transient frequency behavior during the period  $t_3$ , the transmitter shall be switched on.

(o) Adjust the oscilloscope trigger controls so it will trigger on a decreasing magnitude from the RF peak detector, at 1 division from the right side of the display, when the transmitter is turned

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off. Set the controls to store the display. The moment when the 1kHz test signal starts to rise is considered to provide  $t_{off}$ .

(p) The transmitter shall be switched off.

(q) Observe the display. The trace should remain within the allowed divisions during period  $t_3$ .

### 4.6.3 RESULTS:

The results of the transient frequency behavior tests can be found on data pages 111 and 112. As can be seen from the data, the transient frequency behavior of the test item is within the specified limits for time period  $t_1$ ,  $t_2$ , and  $t_3$ .

### 4.7 ADDITIONAL LIMITATIONS:

**4.7.1 SPECTRUM EFFICIENCY REQUIREMENTS:** Applications from part 90 certification of transmitters designed to operate on frequencies in the 421MHz to 512MHz bands, received on or after February 14, 1997, must be capable of supporting a minimum data rate of 4800 bits per second per 6.25kHz of channel bandwidth. The plots of the spectrum efficiency of the test item are shown on data page 113. As can be seen from the data, the test item meets the spectrum efficiency requirements.

### 5.0 CONCLUSION:

The Portable Interrogator, Model PI-400, complies with the RF output, the occupied bandwidth, the spurious emissions at antenna terminal, the field strength of spurious emissions, the frequency stability, the transient frequency behavior and spectrum efficiency requirements of the FCC Part 90 and 2.

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**6.0 CERTIFICATION:**

Elite Electronic Engineering, Inc. 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 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.

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

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TABLE 1: 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 |                            |                 |              |            |                 |          |         |          |
| XDM1                                       | 50DB, 1500W BIDIR. COUPLER | AMPLIFIER RESEA | DC6000       | 14749      | 400-1000MHZ     | 06/14/00 | 12      | 06/14/01 |
| XLJG                                       | 5W, 50 OHM TERMINATION     | JFW INDUSTRIES  | 50T-052      | 17         | DC-2GHZ         | 06/08/00 | 12      | 06/08/01 |
| XYF3                                       | POWER SPLITTER             | HEWLETT PACKARD | 11667A       | 11052      | DC-18GHZ        | 07/19/00 | 12      | 07/19/01 |
| XZG0                                       | ATTENUATOR/SWITCH DRIVER   | HEWLETT PACKARD | 11713A       | 3439A02724 | ---             | 01/31/00 | N/A     |          |
| Equipment Type: AMPLIFIERS                 |                            |                 |              |            |                 |          |         |          |
| APK0                                       | PRE-AMPLIFIER              | HEWLETT PACKARD | 8449B        | 3008A00662 | 1-26.5GHZ       | 02/15/01 | 12      | 02/15/02 |
| Equipment Type: ANTENNAS                   |                            |                 |              |            |                 |          |         |          |
| NTA0                                       | BILOG ANTENNA              | CHASE EMC LTD.  | BTLOG CBL611 | 2057       | 0.03-2GHZ       | 05/09/00 | 12      | 05/09/01 |
| NWH0                                       | RIDGED WAVE GUIDE          | TENSOR          | 4105         | 2081       | 1-12.4GHZ       | 08/01/00 | 12      | 08/01/01 |
| Equipment Type: ATTENUATORS                |                            |                 |              |            |                 |          |         |          |
| T2C9                                       | 20DB, 20W ATTENUATOR       | NARDA           | 768-20       | 19         | DC-11GHZ        | 02/04/01 | 12      | 02/04/02 |
| T2D1                                       | 20DB, 25W ATTENUATOR       | WEINSCHEL       | 46-20-43     | AV5814     | DC-18GHZ        | 03/08/01 | 12      | 03/08/02 |
| T2D5                                       | 20DB, 25W ATTENUATOR       | WEINSCHEL       | 46-20-43     | AY9244     | DC-18GHZ        | 01/12/01 | 12      | 01/12/02 |
| T2D9                                       | 20DB, 25W ATTENUATOR       | WEINSCHEL       | 46-20-34     | BH5445     | DC-18GHZ        | 11/27/00 | 12      | 11/27/01 |
| Equipment Type: CONTROLLERS                |                            |                 |              |            |                 |          |         |          |
| CDD2                                       | COMPUTER                   | HEWLETT PACKARD | D4171A#ABA   | US61654645 | ---             |          | N/A     |          |
| CEA1                                       | HANDHELD PERSONAL COMPUTER | SHARP ELECTRONI | ZAURUS 5700  | ---        | ---             |          | N/A     |          |
| CMA0                                       | MULTI-DEVICE CONTROLLER    | EMCO            | 2090         | 9701-1213  | ---             |          | N/A     |          |
| Equipment Type: METERS                     |                            |                 |              |            |                 |          |         |          |
| MPA0                                       | POWER METER                | HEWLETT PACKARD | 432A         | 1141A08696 | 0.01-40GHZ      | 07/12/00 | 12      | 07/12/01 |
| MPAA                                       | THERMISTOR MOUNT           | HEWLETT PACKARD | 8478B        | 1144A08340 | 0.01-18GHZ      | 08/22/00 | 12      | 08/22/01 |
| MSN0                                       | DIGITAL OSCILLOSCOPE       | LECROY CORP.    | LEC/9354AL   | 2537       | DC-500MHZ       | 03/29/01 | 12      | 03/29/02 |
| Equipment Type: PROBES; CLAMP-ON & LISNS   |                            |                 |              |            |                 |          |         |          |
| PSN7                                       | 10X OSCILLOSCOPE PROBE     | LECROY          | PP002        | ---        | DC-350MHZ       |          |         | NOTE 1   |
| Equipment Type: PRINTERS AND PLOTTERS      |                            |                 |              |            |                 |          |         |          |
| HRE2                                       | LASER JET 5P               | HEWLETT PACKARD | C3150A       | USHB061201 | ---             |          | N/A     |          |
| HRF0                                       | DESKJET 540 PRINTER        | HEWLETT PACKARD | C2162A       | US4CN1H1HW | ---             |          | N/A     |          |
| Equipment Type: RECEIVERS                  |                            |                 |              |            |                 |          |         |          |
| RAC1                                       | SPECTRUM ANALYZER          | HEWLETT PACKARD | 85660B       | 3407A08369 | 100HZ-22GHZ     | 01/16/01 | 12      | 01/16/02 |
| RACB                                       | RF PRESELECTOR             | HEWLETT PACKARD | 85685A       | 3506A01491 | 20HZ-2GHZ       | 05/10/00 | 12      | 05/10/01 |
| RAF3                                       | QUASIPeAK ADAPTER          | HEWLETT PACKARD | 85650A       | 3303A01775 | 0.01-1000MHZ    | 01/17/01 | 12      | 01/17/02 |
| RAK6                                       | RF SECTION                 | HEWLETT PACKARD | 85462A       | 3549A00284 | 9KHZ-6.5GHZ     | 02/13/01 | 12      | 02/13/02 |
| RAKH                                       | RF FILTER SECTION          | HEWLETT PACKARD | 85460A       | 3448A00324 | ---             | 02/13/01 | 12      | 02/13/02 |
| Equipment Type: SIGNAL GENERATORS          |                            |                 |              |            |                 |          |         |          |
| GBQ0                                       | SIGNAL GENERATOR WITH I/Q  | ROHDE & SCHWARZ | SMHU-58      | 843558/039 | 1KHZ-4320MHZ    | 07/14/00 | 12      | 07/14/01 |

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.





ETR 23628  
DATA SHEET

MANUFACTURER : BADGER METER INC.  
MODEL : PI-400  
S/N : DA-0001  
SPECIFICATION : RF POWER OUTPUT  
DATE : APRIL 12, 2001  
NOTES :

RF OUTPUT DIRECTLY OUT OF THE ANTENNA PORT

| FREQ.<br>(MHz) | MTR<br>RDG(dBm) | PADS<br>(dB) | TOTAL<br>(dBm) | TOTAL<br>(Watts) |
|----------------|-----------------|--------------|----------------|------------------|
| 451.35         | -9.3            | 40.0         | 30.7           | 1.2              |

CHECKED BY:

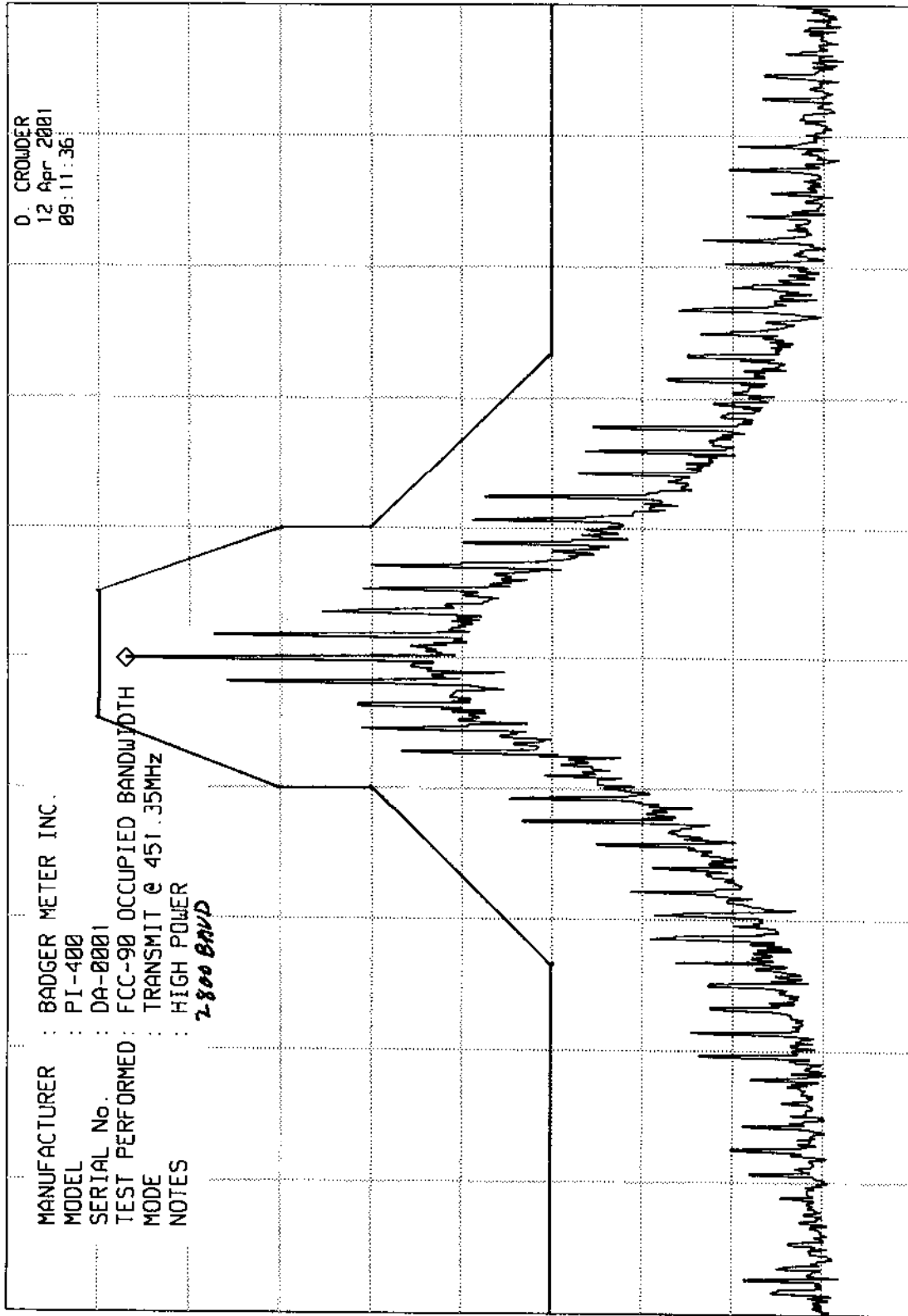
Daniel E. Crowder

ELITE ELECTRONIC ENGINEERING CO

MKR 451.349 8 MHz  
-11.00 dBm

ATTEN 20 dB +40dB EXT

REF 2.0 dBm



D. CROWDER  
12 Apr 2001  
09:11:36

SPAN 100 kHz  
SWP 75.0 sec

VBW 1 kHz

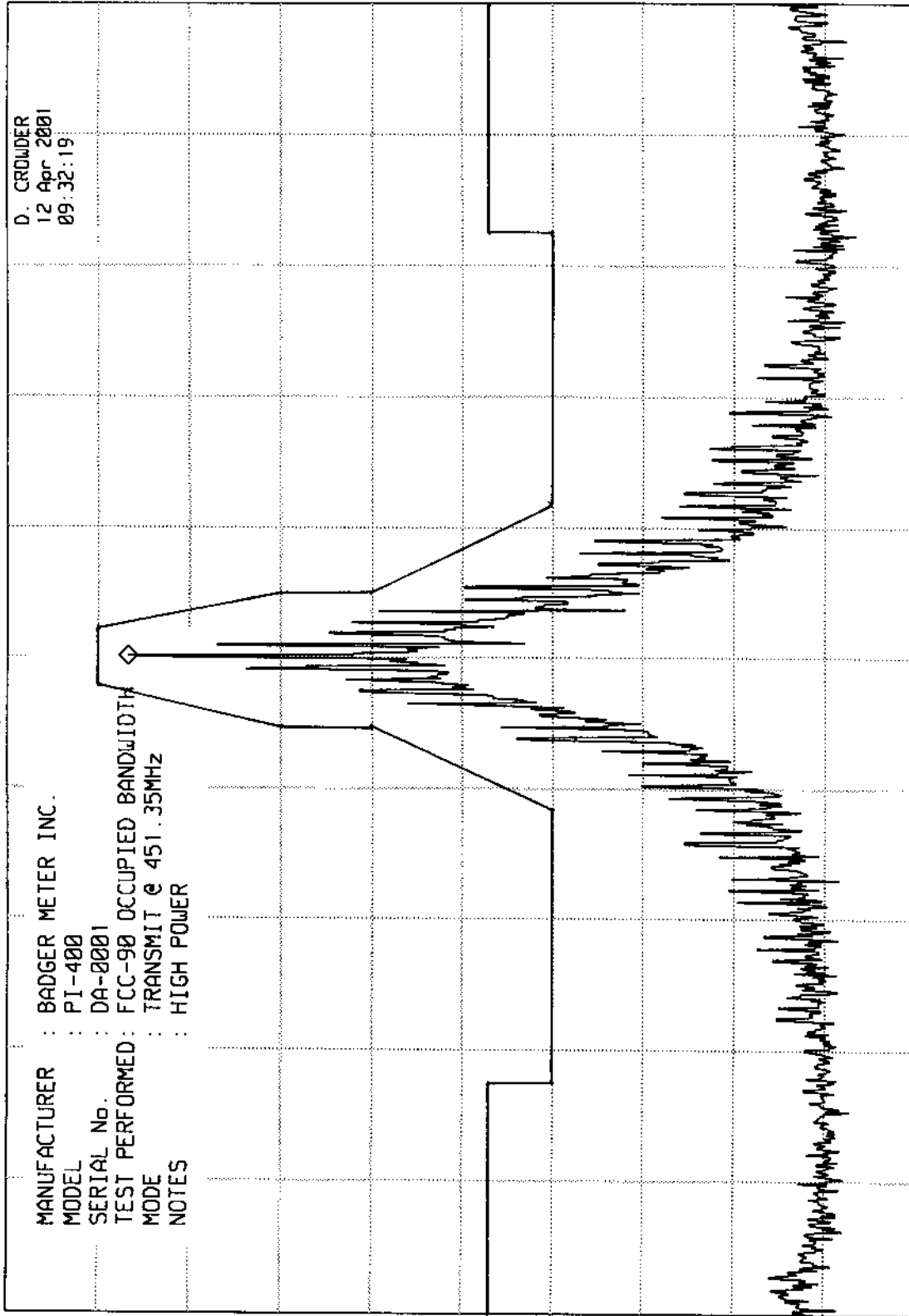
RES BW 100 Hz (i)

CENTER 451.350 MHz

ELITE ELECTRONIC ENGINEERING CO

MKR 451.350 0 MHz  
-11.30 dBm

REF 2.0 dBm      ATTN 20 dB +40dB EXT



hp  
10 dB/

MANUFACTURER : BADGER METER INC.  
MODEL : PI-400  
SERIAL No. : DA-0001  
TEST PERFORMED : FCC-90 OCCUPIED BANDWIDTH  
MODE : TRANSMIT @ 451.35MHz  
NOTES : HIGH POWER

CENTER 451.350 MHz      RES BW 100 Hz (i)      UBW 1 kHz      SPAN 200 kHz      SWP 150 sec

ELITE ELECTRONIC ENGINEERING CO

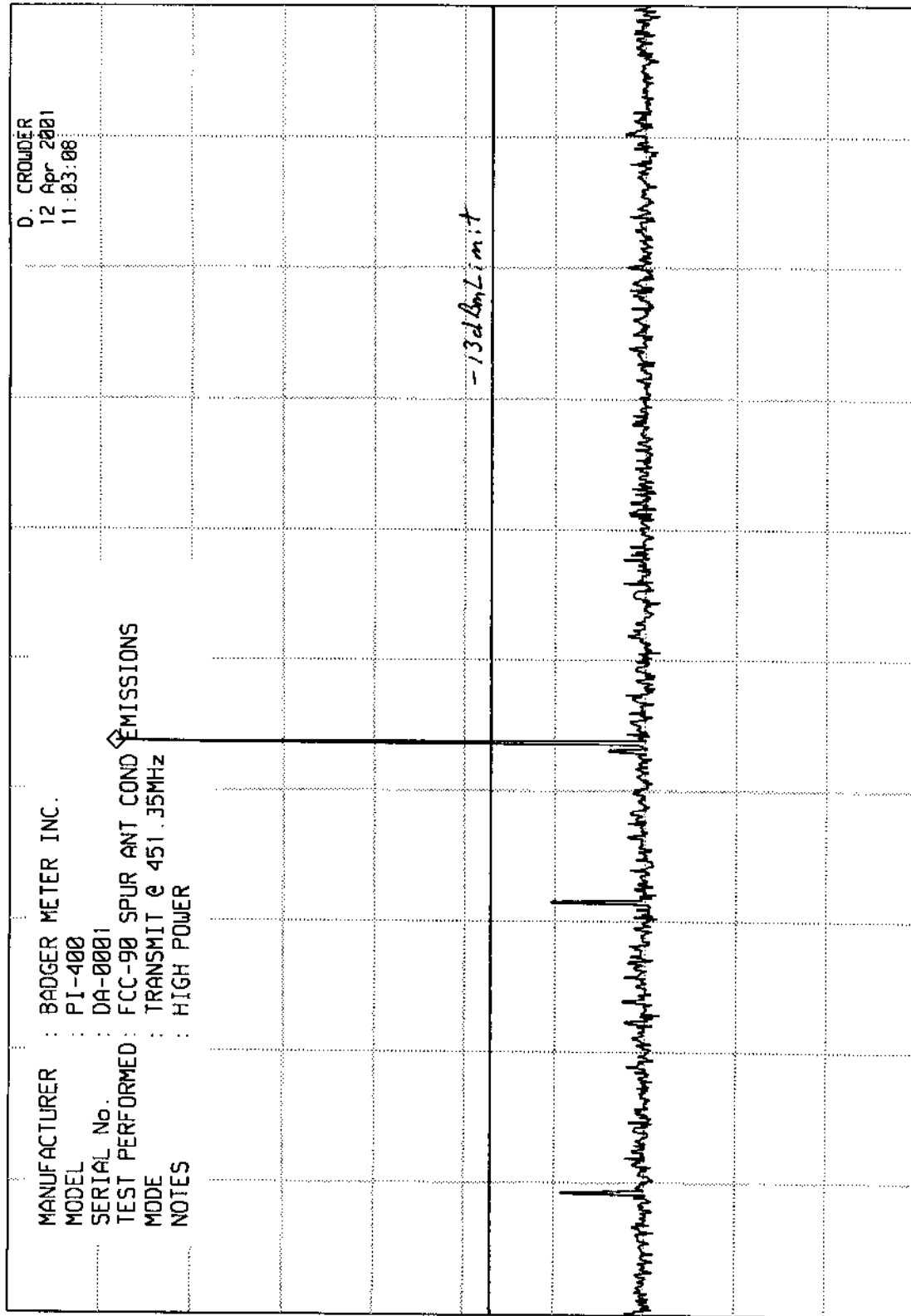
MKR 452.9 MHz  
-9.70 dBm

REF 2.0 dBm  
ATTEN 20 dB +40 dB EXT

hp

10 dB/

OFFSET  
-10.0  
dB



STOP 1.000 GHz  
SWP 728 msec

UBW 1 MHz

RES BW 100 kHz (1)

START 30 MHz

ELITE ELECTRONIC ENGINEERING CO

MKR 1.436 GHz  
-61.30 dBm

REF 2.0 dBm      ATTN 20 dB +40dB EXT

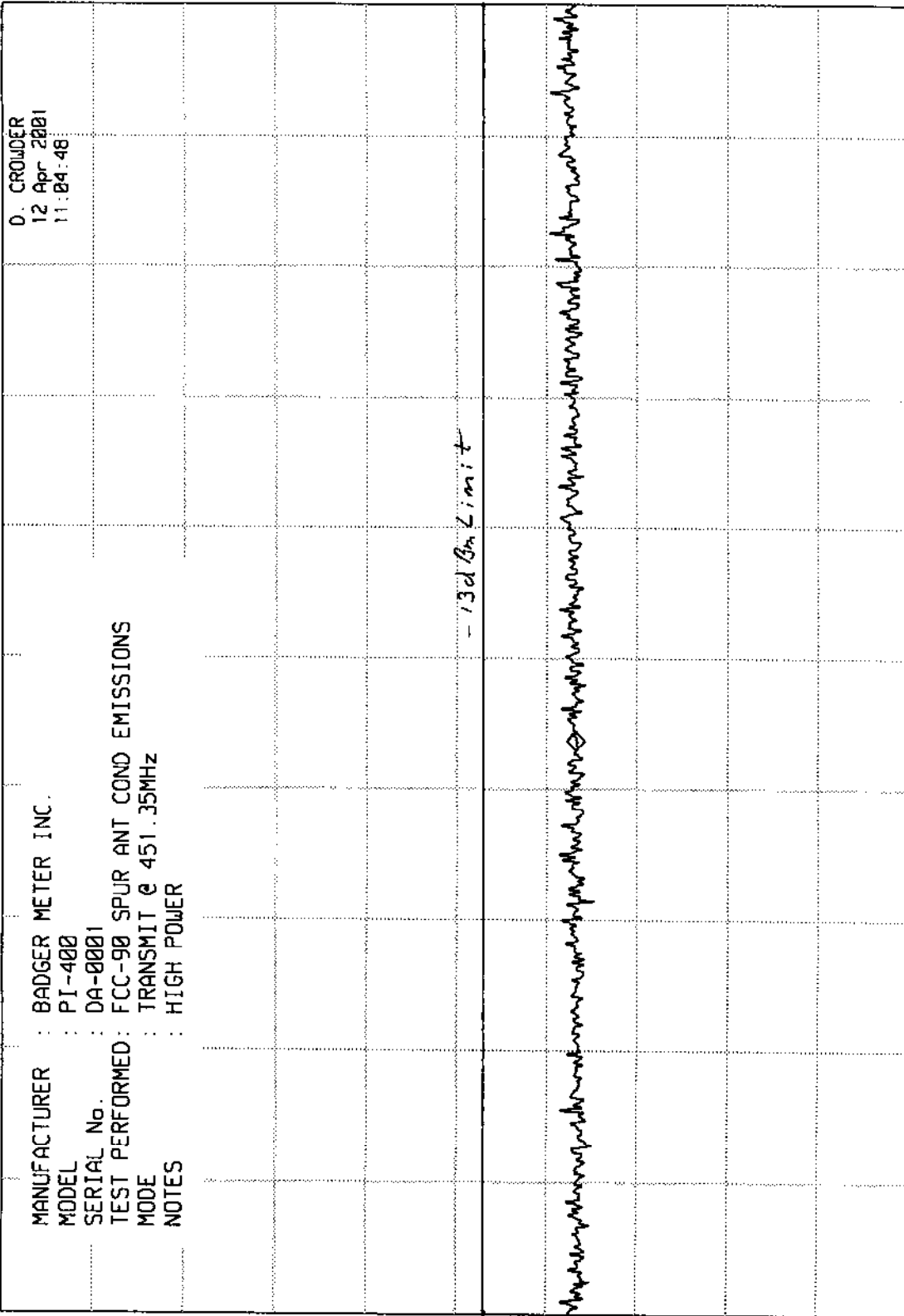
hp

10 dB/

OFFSET

-10.0

dB



START 1.00 GHz      RES BW 1 MHz (i)      STOP 2.00 GHz  
UBW 3 MHz      SWP 25.0 msec

ELITE ELECTRONIC ENGINEERING CO

MKR 3.308 GHz  
-60.60 dBm

ATTEN 20 dB +40dB EXT

REF 2.0 dBm

hp

10 dB/

OFFSET

-10.0

dB

|                                                 |             |
|-------------------------------------------------|-------------|
| MANUFACTURER : BADGER METER INC.                | D. CROWDER  |
| MODEL : PI-400                                  | 12 Apr 2001 |
| SERIAL No. : DA-0001                            | 11:06:00    |
| TEST PERFORMED : FCC-90 SPUK ANT COND EMISSIONS |             |
| MODE : TRANSMIT @ 451.35MHz                     |             |
| NOTES : HIGH POWER                              |             |
| -13 dBm Limit                                   |             |
|                                                 |             |

STOP 5.00 GHz  
SWP 75.0 msec

VBW 3 MHz

RES BW 1 MHz (1)

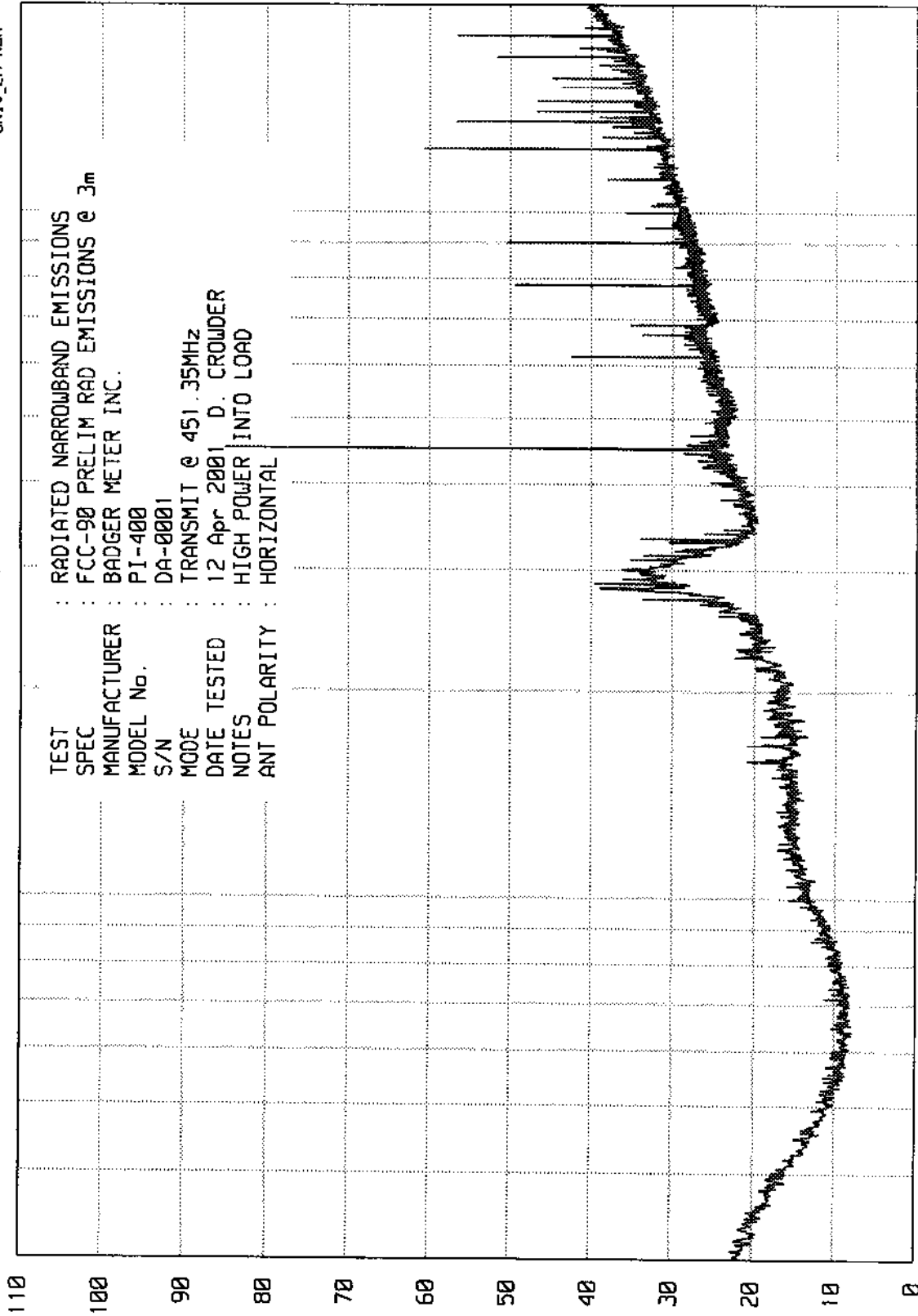
START 2.00 GHz

## ELITE ELECTRONIC ENGINEERING Co.

Downers Grove, Ill. 60515

UNIT EM RUN RUN 1

UKA0 01/19/01



RADIATED NARROWBAND EMISSIONS - dBu/m

DATA PAGE 107

START = 30

FREQUENCY - MHz

1000

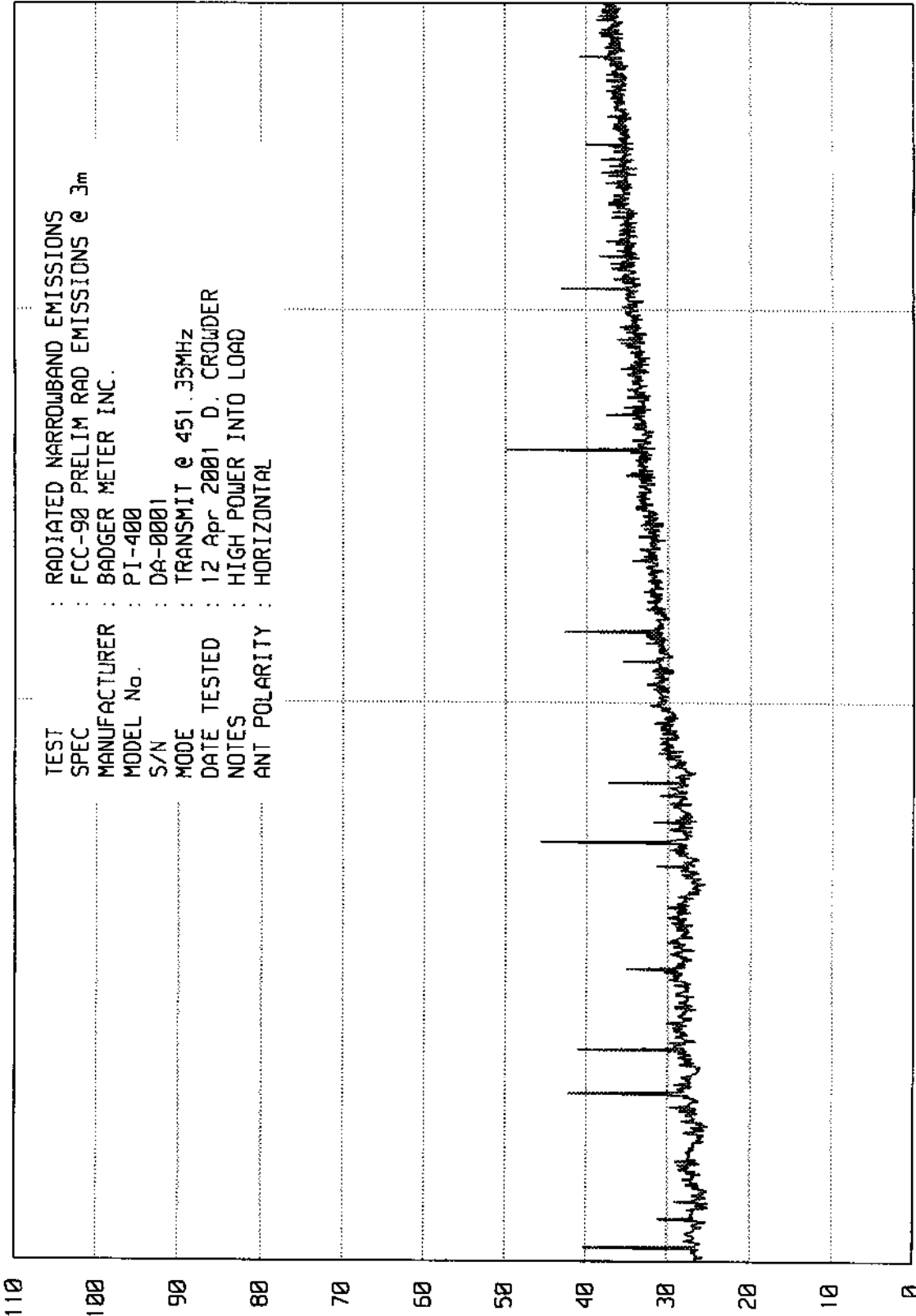
STOP = 2000

ELITE ELECTRONIC ENGINEERING Co.  
Downers Grove, Ill. 60515

UNIU\_EM RUN RUN 2

WJKA00 01/19/01

EE



TEST : RADIATED NARROWBAND EMISSIONS  
SPEC : FCC-90 PRELIM RAD EMISSIONS @ 3m  
MANUFACTURER : BADGER METER INC.  
MODEL No. : PI-400  
S/N : DA-0001  
MODE : TRANSMIT @ 451.35MHz  
DATE TESTED : 12 Apr 2001 D. CROWDER  
NOTES : HIGH POWER INTO LOAD  
ANT POLARITY : HORIZONTAL

RADIATED NARROWBAND EMISSIONS - dBu/m

DATA PAGE 108

START = 2000

FREQUENCY - MHz

STOP = 5000





ETR 23628  
DATA SHEET

MANUFACTURER : BADGER METER INC.  
MODEL : PI-400  
S/N : DA-0001  
SPECIFICATION : FCC-90 OPEN FIELD SPURIOUS RADIATED EMISSIONS  
DATE : APRIL 12, 2001  
NOTES : TRANSMIT AT 451.35MHz INTO 50 OHMS  
: TEST DISTANCE IS 3 METERS

| FREQ.<br>(MHz) | ANT<br>POL | MTR<br>RDG<br>(dBuV) | ANT<br>FAC<br>dB | CABLE<br>FAC<br>dB | PRE-<br>AMP<br>GAIN | CONV.<br>F.L. to<br>dBm(dipole) | TOTAL<br>dBm | LIMIT<br>dBm |
|----------------|------------|----------------------|------------------|--------------------|---------------------|---------------------------------|--------------|--------------|
| 902.7          | H          | 39.9                 | 21.9             | 3.1                |                     | 97.2                            | -32.3        | -13          |
|                | V          | 39.2                 | 21.9             | 3.1                |                     | 97.2                            | -33.0        | -13          |
| 1354.1         | H          | 28.8                 | 24.8             | 4.4                |                     | 97.2                            | -39.2        | -13          |
|                | V          | 33.4                 | 24.8             | 4.4                |                     | 97.2                            | -34.6        | -13          |
| 1805.4         | H          | 40.2                 | 26.3             | 4.8                |                     | 97.2                            | -25.9        | -13          |
|                | V          | 37.1                 | 26.3             | 4.8                |                     | 97.2                            | -29.0        | -13          |
| 2256.8         | H          | 29.5                 | 28.1             | 6.0                |                     | 97.2                            | -33.6        | -13          |
|                | V          | 29.5                 | 28.1             | 6.0                |                     | 97.2                            | -33.6        | -13          |
| 2708.1         | H          | 27.3                 | 29.9             | 7.0                |                     | 97.2                            | -33.0        | -13          |
|                | V          | 27.1                 | 29.9             | 7.0                |                     | 97.2                            | -33.2        | -13          |
| 3159.5         | H          | 27.7                 | 30.9             | 7.9                |                     | 97.2                            | -30.7        | -13          |
|                | V          | 27.5                 | 30.9             | 7.9                |                     | 97.2                            | -30.9        | -13          |
| 3610.8         | H          | 27.0                 | 32.3             | 8.8                |                     | 97.2                            | -29.1        | -13          |
|                | V          | 27.0                 | 32.3             | 8.8                |                     | 97.2                            | -29.1        | -13          |
| 4062.2         | H          | 27.3                 | 33.4             | 9.7                |                     | 97.2                            | -26.8        | -13          |
|                | V          | 27.4                 | 33.4             | 9.7                |                     | 97.2                            | -26.7        | -13          |
| 4513.5         | H          | 28.1                 | 33.0             | 11.0               |                     | 97.2                            | -25.1        | -13          |
|                | V          | 27.7                 | 33.0             | 11.0               |                     | 97.2                            | -25.5        | -13          |

CHECKED BY:

  
Daniel E. Crowder



ETR 23628  
DATA SHEET

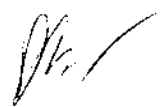
MANUFACTURER : BADGER METER INC.  
MODEL : PI-400  
S/N : DA-0001  
SPECIFICATION : FCC-90 FREQUENCY STABILITY  
DATE : APRIL 13, 2001  
NOTES : TRANSMIT AT 451350054Hz

| TEMP<br>C° | FREQ<br>(Hz) | DEVIATION<br>(PPM) | LIMIT<br>(PPM) |
|------------|--------------|--------------------|----------------|
| -30        | DNO          | ----               | 5.0            |
| -20        | DNO          | ----               | 5.0            |
| -10        | 451350264    | 0.47               | 5.0            |
| 0          | 451350270    | 0.48               | 5.0            |
| 10         | 451350230    | 0.39               | 5.0            |
| 20         | 451350067    | 0.03               | 5.0            |
| 30         | 451349873    | -0.04              | 5.0            |
| 40         | 451349583    | -1.04              | 5.0            |
| 50         | 451349257    | -1.77              | 5.0            |

DNO -- DID NOT OPERATE

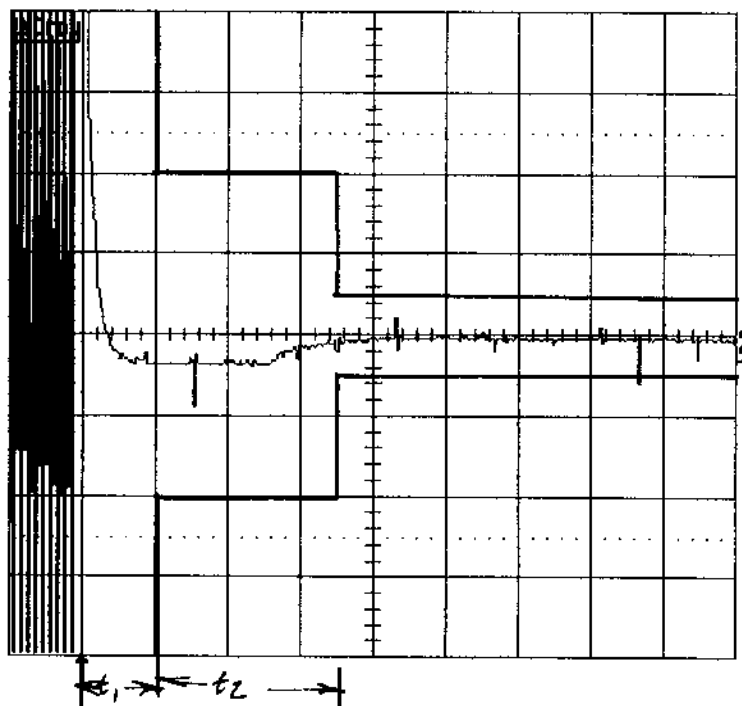
| VOLTAGE<br>(VDC) | FREQ<br>(Hz) | DEVIATION<br>(PPM) | LIMIT<br>(PPM) |
|------------------|--------------|--------------------|----------------|
| 8.0              | 451350181    | ----               | 5.0            |
| 6.8              | 451350180    | <0.02              | 5.0            |

BELOW 6.8VDC THE TEST ITEM DID NOT OPERATE

CHECKED BY: 

13-Apr-01  
10:03:53

2  
10 ms  
450mV



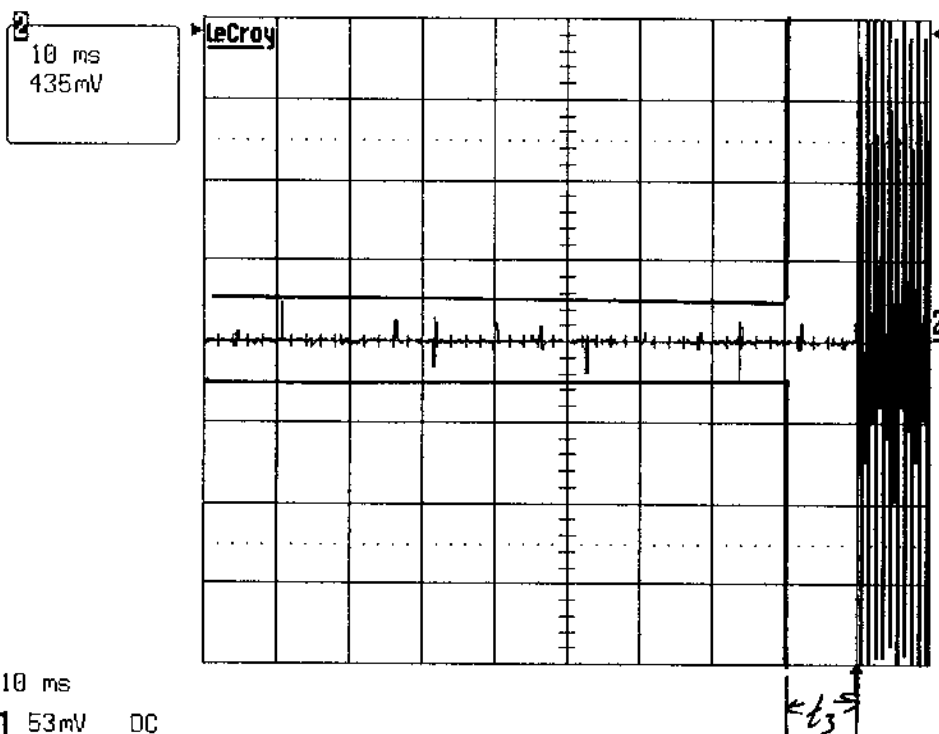
ENGINEERING TEST REPORT NO.

MANUFACTURER : BADGER METER INC.  
MODEL NO. : PI-400  
SERIAL NO. : DA-0001  
TEST DESCRIPT.: FCC-90 TRANSIENT FREQUENCY BEHAVIOR  
WAVEFORM : MODULATION OFF  
TEST MODE : NORMAL

ENGINEERING TEST REPORT NO. 23628

13-Apr-01

10:14:04



10 ms

1 53mV DC  
2 43.5mV DC  
3 2 mV AC  
4 .5 V DC



2 DC 1.653 V

5 kS/s

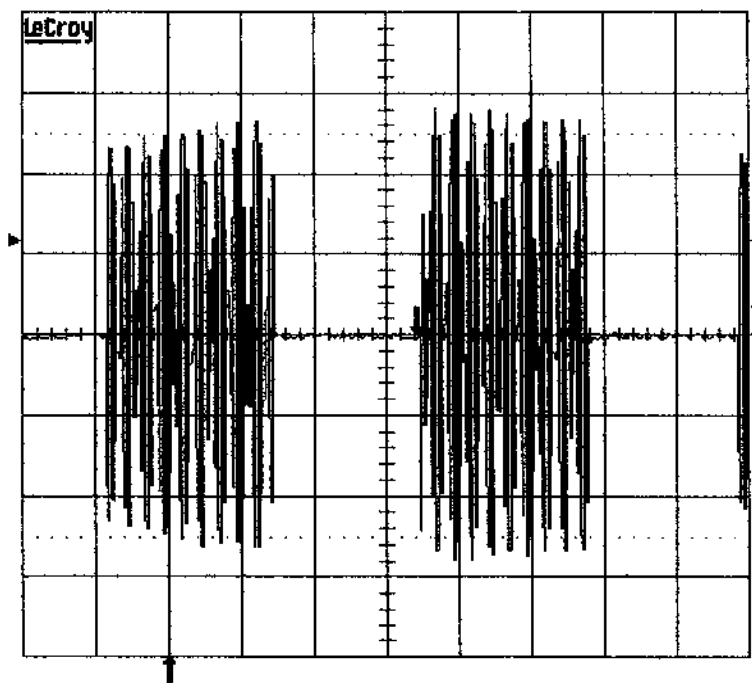
STOPPED

ENGINEERING TEST REPORT NO.

MANUFACTURER : BADGER METER INC.  
MODEL NO. : PI-400  
SERIAL NO. : DA-0001  
TEST DESCRIPT.: FCC-90 TRANSIENT FREQUENCY BEHAVIOR  
WAVEFORM : MODULATION OFF  
TEST MODE : NORMAL

12-Apr-01  
16:09:35

1 20  $\mu$ s  
29.0mV  
0.0mV



20  $\mu$ s

1 29.0mV DC  
2 2.00mV DC  
3 2 V AC  
4 .5 V DC

$\Delta t$  46.3  $\mu$ s  $\frac{1}{\Delta t}$  21.60 kHz

2.5 MS/s

1 DC 33.6mV

STOPPED

ENGINEERING TEST REPORT NO.

MANUFACTURER : BADGER METER INC.  
MODEL NO. : PI-400  
SERIAL NO. : DA-0001  
TEST DESCRIPT.: FCC-90 SPECTRUM EFFICIENCY  
WAVEFORM : 19.2kbps DATA RATE  
TEST MODE : NORMAL

*AM Demodulator output.*