

EXHIBIT E

LLB6717

RADIO-FREQUENCY EMISSIONS TEST REPORT

FOR

HEXAGRAM, INC.

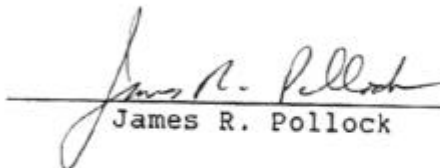
"PIT-SET" TRANSMITTER

FCC ID NO. LLB6717

September 15, 1999

Prepared for: Hexagram, Inc.  
23905 Mercantile Road  
Cleveland, OH 44122

Measurements made  
and report prepared by:

  
James R. Pollock

SMITH ELECTRONICS, INC.  
8200 SNOWVILLE RD.  
CLEVELAND, OH 44141  
440/526-4386

## TEST REPORT

INTRODUCTION

The Hexagram "Pit-Set" transmitter is a battery operated transmitter designed to be attached to a utility meter. This version of the transmitter is designed to be positioned in a "pit" and can be placed through a hole in the "pit" cover. The transmitter will provide a short (milliseconds), intermittent radio frequency transmission suitable for the remote reading of the meter to which it is attached. A microprocessor provides timing, control and data processing functions. A built in antenna is used which is inaccessible to the user and no provision is made for external antennas. Authorization by the FCC is required for operation through the Certification procedure.

MEASUREMENTS PERFORMED

As a result of modifying an earlier model, the following measurements were requested by the manufacturer.

Measurements of field strength were made on the prototype (modified), unit to determine the equivalent output power and the level of spurious emissions in relation to the fundamental frequency.

The bandwidth of the transmitted signal was measured and the emissions from the digital portion of the system were examined.

These measurements were performed to support the Certification application of the manufacturer.

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POWER OUTPUT AND SPURIOUS EMISSIONS

An initial examination of the radiated emissions was made in a shielded room at the Smith Electronics, Inc. laboratory. The data shown in Fig. 1 is for general information only and to determine those frequencies where significant emissions exist.

A series of measurements was made on the Smith Electronics, Inc. open field test site located at 8200 Snowville Road, Brecksville, OH. Information and data pertinent to this test site is on file with the FCC.

Measurements below 1000 MHz were made at a three meter test distance with frequencies above 1000 MHz being measured at one meter. A receiver and a tuned dipole were used below 1000 MHz and a spectrum analyzer and a wave guide antenna above 1000 MHz.

The transmitter was mounted through the top of a small cardboard box to hold it in an upright position similar to its installed position. The box was placed on the non-conducting test table. Because of the intermittent nature of the normally operating transmitter, an external power supply was used and the transmitter was forced to continually transmit for the measurements. Ferrite beads were placed on the power supply wires to minimize their effect on the emissions.

With the modulated signal tuned in on the receiver, the transmitter was rotated to the position of maximum signal. The receiving antenna was then positioned between 1 & 4 meters in height to again maximize the signal. Measurements were made with the antennas positioned both vertically and horizontally and the maximum signal recorded.

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As no difference was observed between the peak and average values of the signal, and the actual signal will be FSK modulated, peak values were used for all measurements. The frequencies measured are tabulated in Table 1 along with the test data, correction factors, field strengths and relative strengths of the spurious emissions compared to the fundamental signal.

The field strength is determined by taking the measured signal level in dBuV and adding the antenna factor and a coax loss factor. Power output is determined by relating the field strength generated by the transmitter to the field that would be generated by a tuned, half-wave dipole antenna by using the equation:

$$E = \frac{(49.2 \times P)^{1/2}}{R} \quad \text{Eq. 1}$$

where E is the field strength in V/m, P is power in Watts and R is the measurement distance in meters.

To determine the effective power from the measured field strength, Eq. 1 must be rearranged to the form:

$$P = \frac{(E \times R)^2}{49.2} \quad \text{Eq. 2}$$

With the measured field strength of the fundamental from Table 1 of 1.380 V/m at a 3 meter distance, the effective power is 0.348 Watts or 348 mW.

According to 90.210(d)(3) all emissions greater than 12.5 kHz from the center of the authorized band shall be attenuated below the unmodulated carrier by  $50 + 10\log(P)$ . Using  $P = 0.348$  the required attenuation is 45.4 dB. An examination of Table 1 shows that all emissions are 45.4 dB or more below the carrier level.

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TABLE 1

FUNDAMENTAL AND SPURIOUS EMISSIONS

HEXAGRAM "PIT-SET" TRANSMITTER

Freq. (MHz)	Value (dBuV)	AF (dB)	CL (db)	Field Strength		Diff. from Fund. (dB)
				(dBuV/m)	(uV/m)	
418.0	2	21.6	1.1	24.7	17	-98.1
*460	99.0	22.7	1.1	122.8	1380384	0.0
468.0	18	22.9	1.1	42.0	126	-80.8
920	42.0	29.1	1.7	72.8	4365	-50.0

ONE METER DISTANCE							
Freq.	Value	AF	CL	(dBuV/m)		(uV/m)	Diff.
				@1 m	@3 m*	@3 m	
1380	47.7	25	0.2	72.9	63.4	1479	-59.4
1840	35.6	28	0.3	70.7	61.2	1148	-61.6
2300	45.7	29	0.3	61.6	52.1	403	-70.7
2760	46.4	30	0.3	76.7	67.2	2291	-55.6
3220	48.6	31	0.4	80.0	70.5	3350	-52.3
3680	44.1	33	0.4	77.5	68.0	2512	-54.8
4140	38.3	33	0.5	71.8	62.3	1303	-60.5
4600	44.4	33	0.5	77.9	68.4	2630	-54.4

\* = Fundamental Frequency

# = Three meter value obtained by subtracting 9.5 dB (linear extrapolation)

AF = Antenna Factor

CL = Coax Loss Factor

Required Attenuation = -45.4 dB

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OCCUPIED BANDWIDTH

Emissions close to the center of the specified channel are limited by the emissions masks described in 90.210. For the frequency range of the "Pit-Set" transmitter, Mask D is specified. From the center of the band  $\pm 5.625$  kHz, 0 dB of attenuation is required. From 5.625 kHz to 12.5 kHz from the center frequency, attenuation must be at least  $7.27(f_a - 2.88 \text{ kHz})$  dB, where  $f_a$  is the displacement frequency from the center of the band in kHz.

At more than 12.5 kHz from the center of the band, the attenuation must be 70 dB or  $50 + 10\log(P)$ , whichever is less. Since P is determined to be 0.348 W,  $50 + 10\log(0.348)$  equals 45.4 dB.

The plot of Fig. 2 shows both the unmodulated carrier, the modulated signal and the emissions mask. The plot indicates that the modulated emission does appear to comply with the requirement for occupied bandwidth as found in 90.210.

For purposes of this test, the transmitter was FSK modulated with a sequence of alternating 0's and 1's. This data was sent at the specified 1200 baud rate.

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DIGITAL DEVICE

A scan of the emissions from the "Pit-Set" transmitter was made in the shielded room with the transmitter in its "standby" mode. This would have the processor operating in the mode that it will be in the majority of the time, waiting to tell the system to transmit.

In this mode, no discernable emissions were observed at close range and with the use of a pre-amplifier. As no emissions could be detected under ideal, close range conditions, no open field measurements were made in this mode. The scan data is found in Figs. 3 & 4 with the FCC Class B limit drawn in for reference. These limits have been adjusted to account for distance, amplifier gain and coax loss.

It has been verified that the prototype "Pit-Set" transmitter does comply with the FCC requirements for radiated emissions for Class B digital devices.



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TEST INFORMATION

SUMMARY

The prototype model of the Hexagram "Pit-Set" transmitter has been shown to be capable of complying with those requirements of the Federal Communications Commission for a Part 90 transmitter that are covered by this report, and also those of a Class B digital device.

EQUIPMENT UNDER TEST

"Pit-Set" Transmitter

MANUFACTURER

Hexagram, Inc.  
23905 Mercantile  
Cleveland, OH 44122

TEST DATES

August 26 & 27, 1999

TEST LABORATORY

Smith Electronics, Inc.  
8200 Snowville Road  
Cleveland, OH 44141  
(440) 526-4386

MEASUREMENT EQUIPMENT

Hewlett-Packard Spectrum Analyzer  
Type 8568B with 8560A RF Section  
S/N 2216A02120  
85662A Display Section  
S/N 2152A03686  
85650A Quasi-Peak Adapter  
S/N 2043A00350  
Calibrated 5/99

Singer Stoddart EMI Field Intensity  
Meter Model NM 37/57  
S/N 0366-06168  
Calibrated 5/99

Hewlett-Packard Spectrum Analyzer  
Model 8593EM, S/N 3536A00147  
Calibrated 8/97

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ANTENNAS

EMCO Biconical Antenna  
Model 3104  
Freq. Range 20 - 200 MHz

EMCO Log-Periodic Antenna  
Model 3146  
Freq. Range 200 - 1000 MHz

Stoddart Tuned Dipole Antenna  
Model 91598-2  
Freq. Range 400 - 1000 MHz

EMCO Double Ridged Guide Horn  
Model 3115  
Freq. Range 1 - 18 GHz

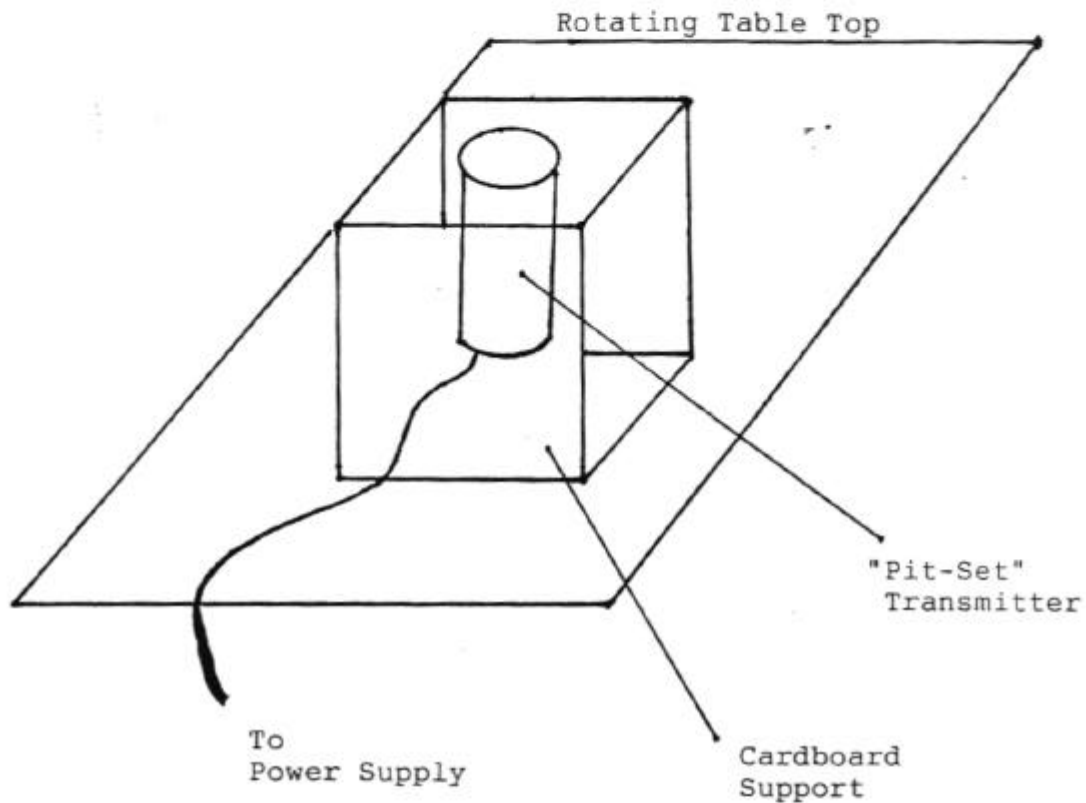
MISCELLANEOUS

Hewlett-Packard Preamplifier  
Model 8447D S/N 1725A01282

12.2 m RG-214/U coaxial cable

0.6 m RG-214/U coaxial cable

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 **SMITH ELECTRONICS, INC.**  
8200 SNOWVILLE ROAD  
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PICTORIAL 1  
SPURIOUS EMISSIONS  
HEXAGRAM "PIT-SET"

TEST SET UP

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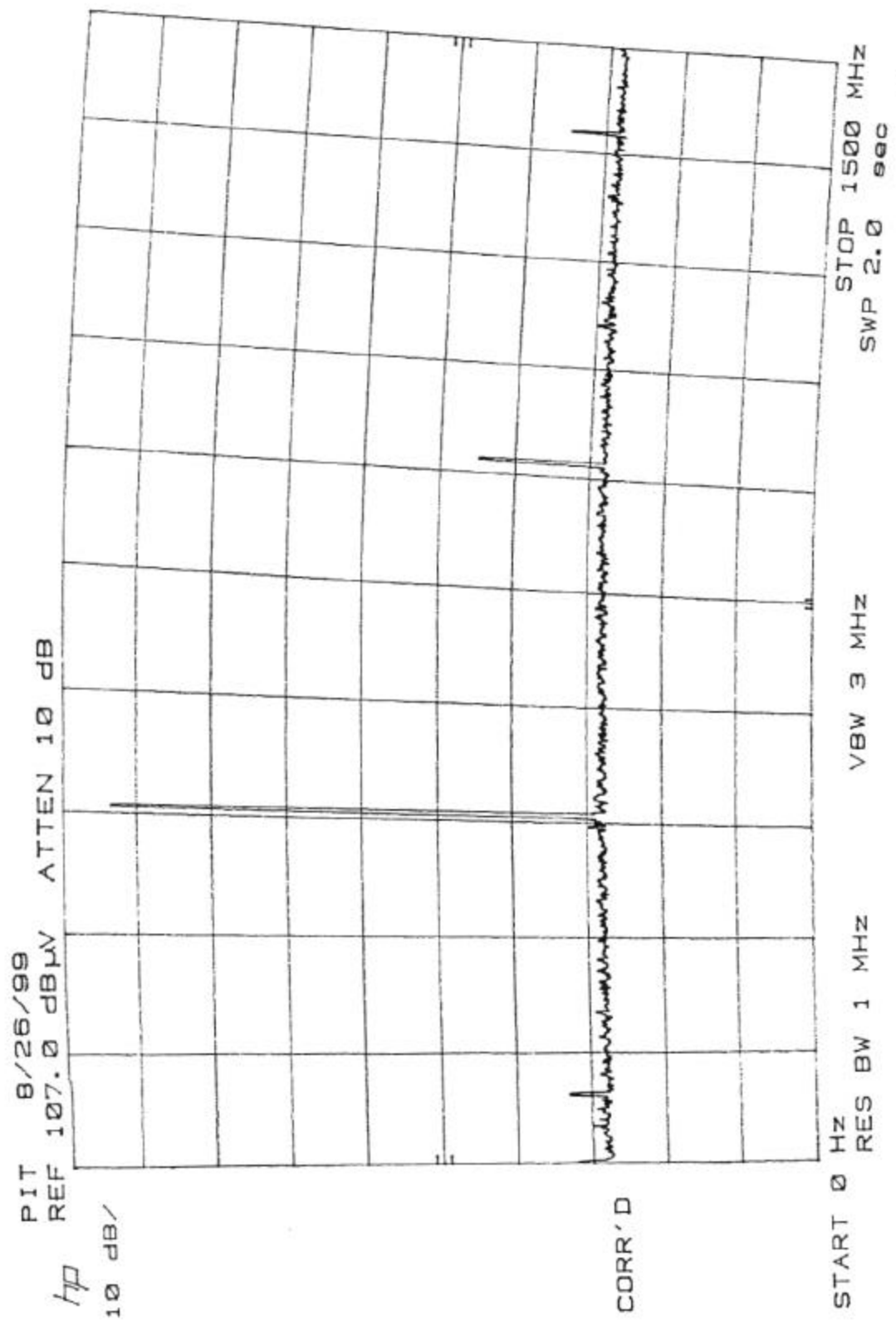


Fig. 1  
RADIATED EMISSIONS  
HEXAGRAM "PIT-SET"  
TRANSMITTER MODE  
30 MHz - 1500 MHz

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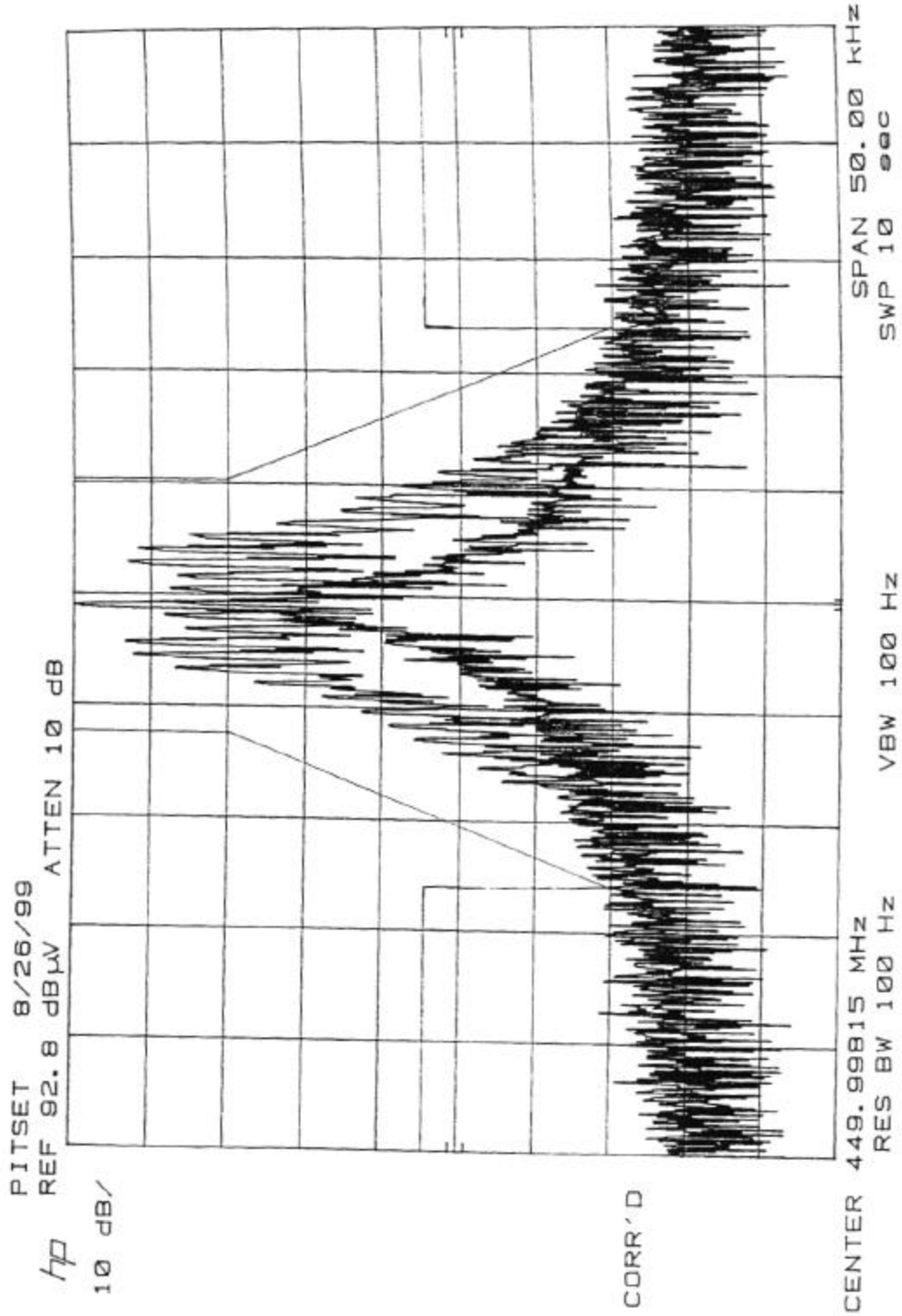
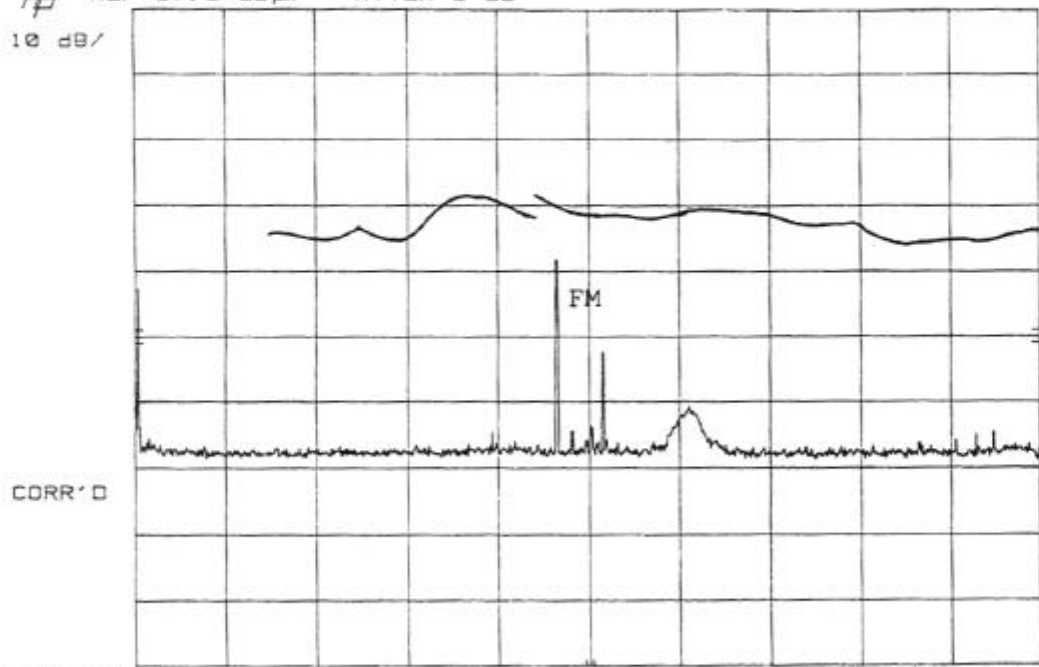


Fig. 2  
OCCUPIED BANDWIDTH  
HEXAGRAM "PIT-SET"

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PITSET 8/27/99  
REF 97.0 dBμV ATTEN 0 dB

hp 10 dB/

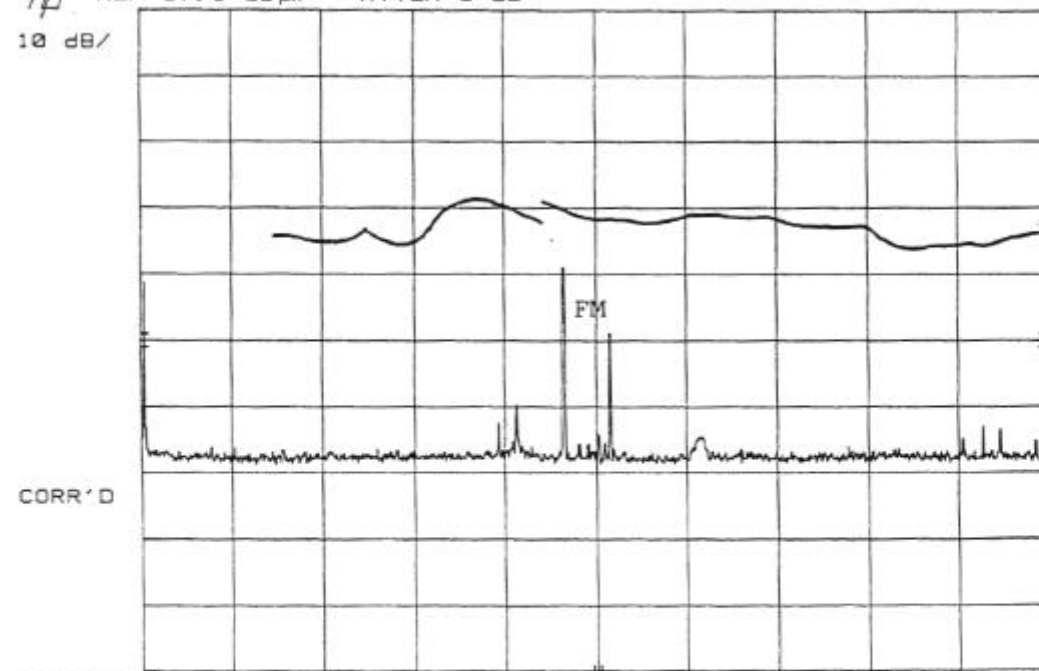


START 0 Hz RES BW 1 MHz VBW 3 MHz STOP 200.0 MHz SWP 100 sec

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PITSET 8/27/99  
REF 97.0 dBμV ATTEN 0 dB

hp 10 dB/



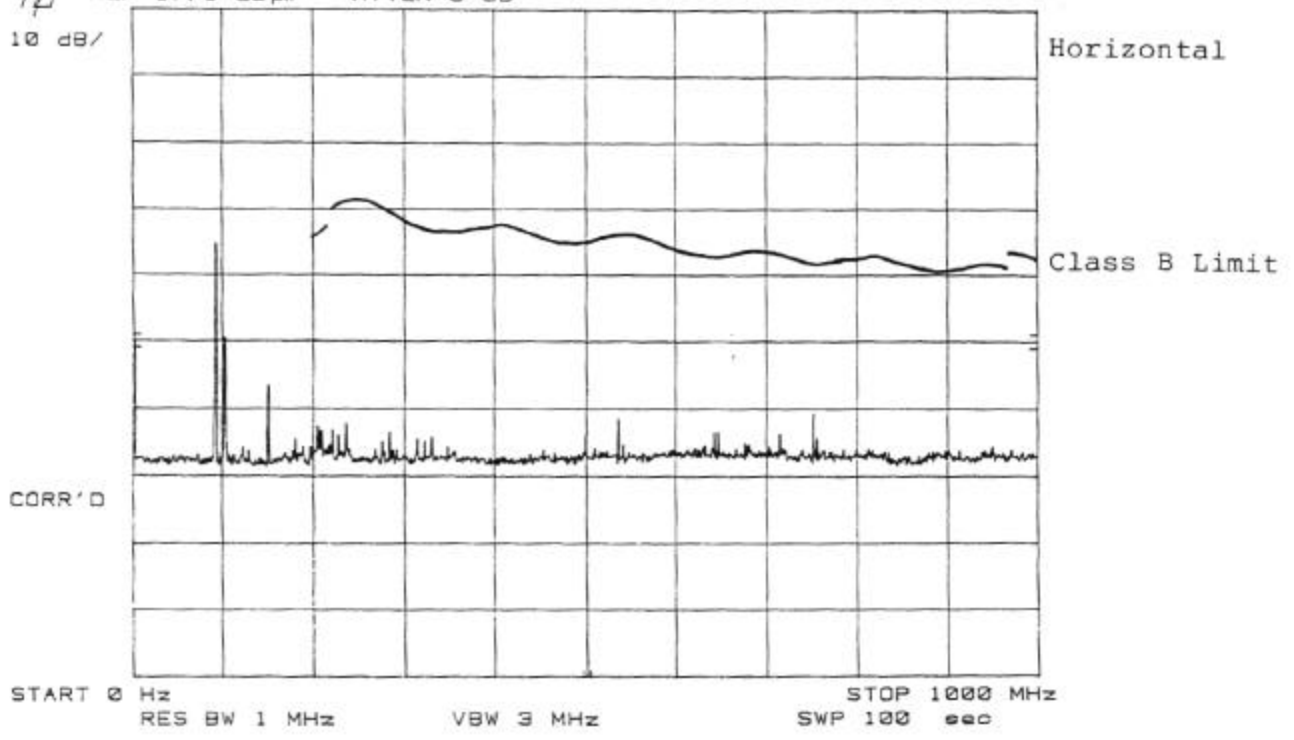
START 0 Hz RES BW 1 MHz VBW 3 MHz STOP 200.0 MHz SWP 100 sec

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Fig. 3  
RADIATED EMISSIONS  
HEXAGRAM "PIT-SET"  
DIGITAL DEVICE  
30 MHz - 200 MHz

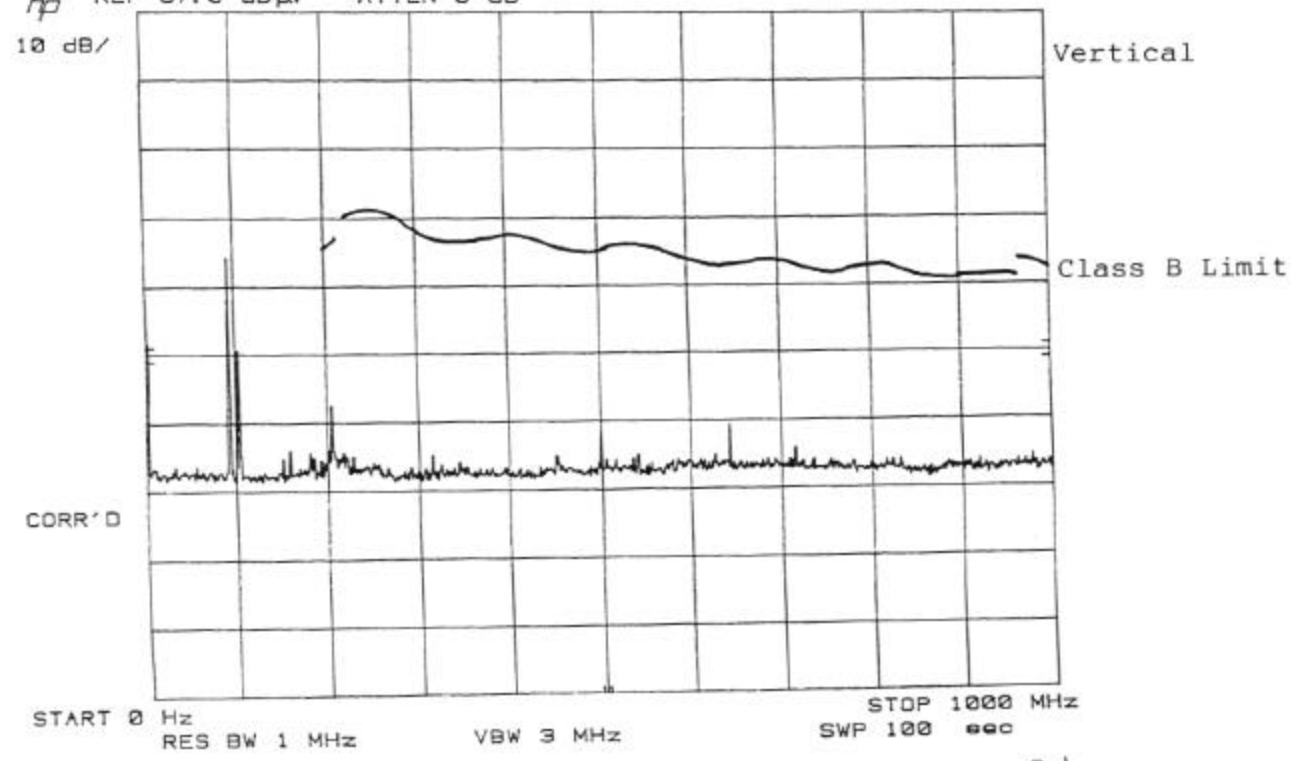
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PITSET 8/27/99  
hp REF 97.0 dBμV ATTN 0 dB



4 H

PITSET 8/27/99  
hp REF 97.0 dBμV ATTN 0 dB



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Fig. 4  
RADIATED EMISSIONS  
HEXAGRAM "PIT-SET"  
DIGITAL DEVICE  
200 MHz - 1000 MHz