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MICROWAVE OVEN RADIO FREQUENCY EMISSIONS

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Introduction

On June 17, 1975, power density measurements were made on two privately-owned microwave ovens. Both units utilized magnetrons operating nominally at 2450 MHz. Oven description is as follows:

Unit #1:	Owner	T. Cram
	Manufactured by ...	Amana
	Model	RR-4D
	Time in use	One year
	Input power	1.6 kW
	RF output	Not listed
	Serial number	A512274675
	Location	House #11, NRAO development
Unit #2:	Owner	W. Cottrell
	Manufactured by ...	Montgomery Ward (Signature)
	Model	KSA-8084A
	Time in use	One year
	Input power	1.5 kW
	RF output	700 W
	Serial number	37F-19554
	Location	Approximately 1 km east of lab

Both dwellings were metal enclosed, except for windows. Unit #1 was located in a ranch style home with aluminum siding. Unit #2 was in a metal mobile home enclosed in a frame building. It is reasonable to expect stronger signals from units located in wood or brick type dwellings. However, no measurements were made to determine attenuation of the metal sided houses.

Equipment Description

The mobile interference detection system was used with the equipment connected as shown in Figure 1.

The following equipment was used:

Antenna	Narda model 645, G = 17 dB
Pre-amp	IMB, 2-4 GHz, noise figure = 10 dB, G = 20 dB
Analyzer	Hewlett Packard 8551B, Serial #823-02263
Power meter	Hewlett Packard 435A, Serial #1312A00519
Head	Hewlett Packard 8481, Serial #1234A00272
Signal generator	Kruse Storke model 500M3, Serial #237
Plug-in	Kruse Storke model 5013, Serial #48
Attenuator	Kay model 461, Serial #5-13

Measurement Technique

The spectrum analyzer was calibrated by injecting a known power level into the antenna port. The IF gain was adjusted for 1×10^{-9} W at mid-scale on the CRT. Linear operation was then checked by varying the input power in 10 dB increments above and below the reference level. No non-linear effects were observed over a ± 20 dB dynamic range. The antenna was then connected to the cable, and the microwave oven was turned on. The antenna was oriented to peak up on the signal, and the amplitude and bandwidth were observed on the CRT. Unit #1 was measured from all four sides of the house. Unit #2 was accessible from only one side of the house, so only one measurement was made.

Results

Unit #1 results were as follows:

Antenna south of house ..... $P \cong 1 \times 10^{-9}$ W ± 5 dB
Antenna west of house ...... $P \cong 1 \times 10^{-9}$ W ± 5 dB
Antenna north of house ..... $P \cong 7 \times 10^{-9}$ W ± 5 dB
Antenna east of house ...... $P \cong 1 \times 10^{-9}$ W ± 5 dB

Approximate distance from oven: 22 meters.
Occupied bandwidth $\approx$ 50 MHz.
Pulse width nominally 0.5 MHz.

Unit #2 results were as follows:
Antenna north of house ..... $P \cong 3 \times 10^{-8}$ W ± 5 dB

Approximate distance from oven: 22 meters.
Occupied bandwidth $\approx$ 50 MHz.
Pulse width nominally 0.5 MHz.

Discussion

Although the power measurement was straightforward, an explanation of bandwidth and pulse width is needed. First, the magnetron is designed to emit a CW signal near 2450 MHz, probably cavity controlled. However, the units are equipped with an agitator to spread the RF energy within the oven. This agitator appears to cause the magnetron frequency to move about ± 25 MHz, probably by changing the load impedance as seen by the magnetron, so the signal appears to be a random pulse with each pulse about 0.5 MHz wide. This spectrum spreading is considered in the calculation for flux density.

Calculations

Power into antenna port ...... $\cong 1 \times 10^{-9}$ W
Frequency .... = 2450 MHz (nominal)
Antenna gain .... = 17 dB
Antenna area .... = 0.0598 m^2
Power flux at 22 meters ...... = $\frac{P}{A} = 1.67 \times 10^{-8} \text{ W m}^{-2}$

If we assume about 3 km to the telescopes, power flux, $S_H B$ would be about -120 dB W m^{-2}, or $\sim$ 50 dB above harmful interference levels of -170 dB W m^{-2} for quiet zone limits.

Spreading the signal over a nominal 50 MHz bandwidth:

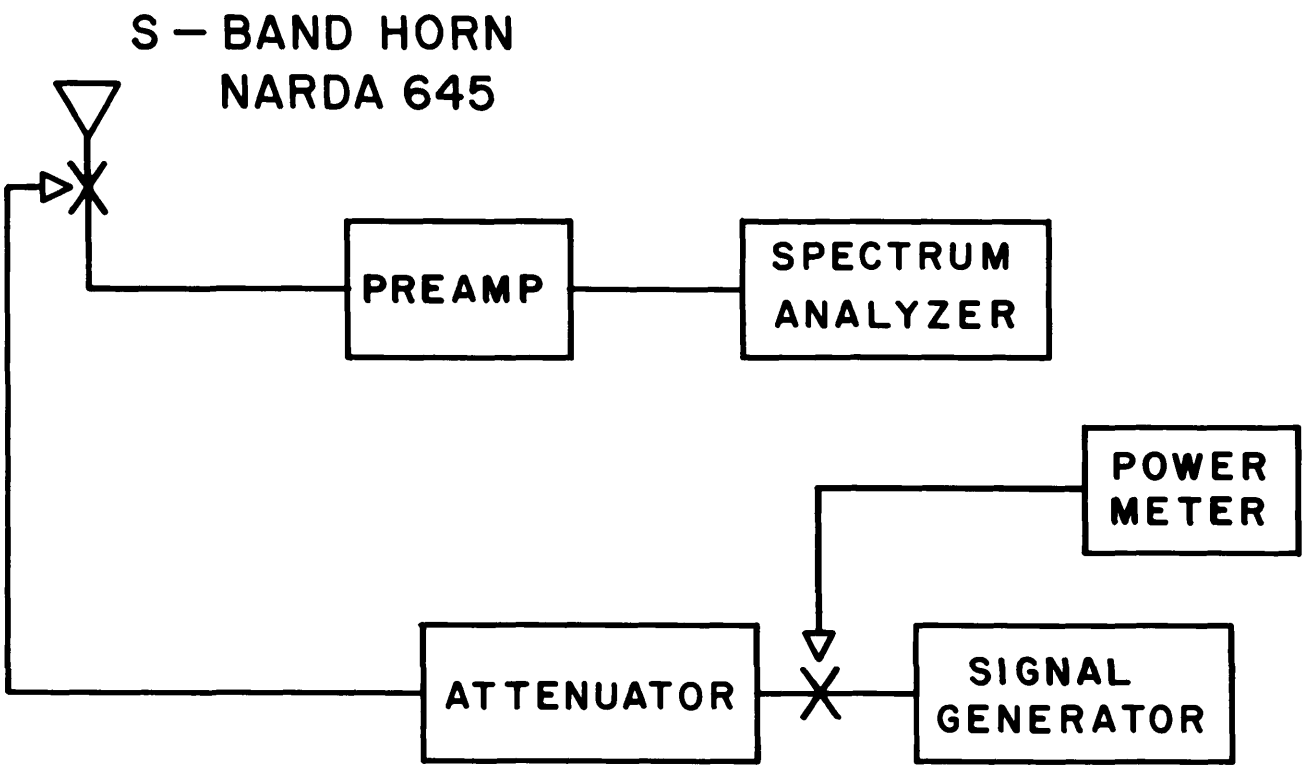
$$\text{Power flux density} = -197 \text{ dB W m}^{-2}\text{ Hz}^{-1}$$

or 50 dB over the harmful level of -247 dB W m^{-2} Hz^{-1}. 1/

These numbers were calculated using the input power of 1×10^{-9} W for Unit #1. If Unit #2 were used (3×10^{-8} W), the power flux $S_H B$ and power flux density S_H would be increased to 65 dB over -170 dB W m^{-2} and 65 dB over -247 dB W m^{-2} Hz^{-1}.

Assuming the ovens as isotropic radiators, and free space attenuation only, the distance required to reduce the power flux to -170 dB W m^{-2} would exceed 2000 km. However, in practical cases, the necessary attenuation would probably be obtained by a separation distance of 15 to 20 km.

1/ From CCIR 224, Annex 1 for 2695 MHz allocation.



TEST EQUIPMENT SET-UP

FIG. 1