The University of Michigan
Radiation Laboratory
3228 EECS Building
Ann Arbor, MI 48109-2122
Tel: (734) 647-1792

Measured Radio Frequency Emissions
From

Microwave Sensors Pedestrian Monitor Model SmartWalk 1800

Report No. 415031-926
June 9, 1998

For:
Microwave Sensors
7885 Jackson Road
Ann Arbor, MI 48103

Contact:
Karen Zias
Tel: (734) 426-0140
Fax: (734) 426-5950
PO: 23397

Measurements made by:
Valdis V. Liepa
Glenn Thibodeau

Tests supervised by:
Report approved by:
Valdis V. Liepa
Research Scientist

Summary
Tests for compliance with FCC Regulations, according to Part 15, Subpart C (Intentional Radiators) and B (Digital Devices), were performed on Microwave Sensors Pedestrian Monitor. In testing performed during May 25 through June 9, 1998, the device tested in the worst case met the allowed specifications for outdoor radiated emissions by 12.8 dB (see p. 6). The maximum RF Exposure Level was measured at 0.11 mW/cm2 (see Sec. 6.5).

The (digital) radiated emissions met Class A limits by 7.7 dB (see p. 6); the conducted Class B limits were met by 5.0 dB (see p. 6).

EXHIBIT A
PAGE 1 OF 17
MICROWAVE SENSORS, INC.

1. Introduction

Microwave Sensors Pedestrian Monitor was tested for compliance with FCC Regulations, Part 15, adopted under Docket 87-389, April 18, 1989, plus the new guidelines to measure harmonics up to 200 GHz. The tests were performed at the University of Michigan Radiation Laboratory Willow Run Test Range following the procedures described in ANSI C63.4-1992 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz" and new FCC Section 15.253, "Operation within the bands 46.7-46.9 GHz and 76.0-77.0 GHz". The attenuation characteristics of the Open Site facility are on file with FCC Laboratory, Columbia, Maryland. (FCC file 31040/SIT)

2. Test Equipment Used

The pertinent test equipment commonly used in our facility for microwave measurements is listed in Table 2.1 below. The second column identifies the specific equipment used in these tests.

Table 2.1. Test Equipment.

Test Instrument	Equipment Used	Manufacturer/Model	Cal. Date/By
Spectrum Analyzer (9kHz-22GHz)		Hewlett-Packard 8593A SN: 3107A01358	July 1997/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8593E SN: 3412A01131	June 1997/HP
Spectrum Analyzer (9kHz-26GHz)	X	Hewlett-Packard 8563E SN: 3310A01174	July 1997/HP
Harmonic Mixer (40-60 GHz)	X	Hewlett-Packard 11970U SN: 2332A00500	Febr 1996/HP
Harmonic Mixer (75-110 GHz)	X	Hewlett-Packard 11970W SN: 2521A00179	Febr 1996/HP
X-band horn (8.2- 12.4 GHz)		Narda 640	1970/Manufacturer
K-band horn (18-26.5 GHz)	X	FXR, Inc., K638KF	1970/Manufacturer
Ka-band horn (26.5-40 GHz)	X	FXR, Inc., U638A	1970/Manufacturer
U-band horn (40-60 GHz)	X	Custom Microwave, WR-19	1996/Manufacturer
W-band horn (75-110 GHz)	X	Custom Microwave, WR-10	1996/Manufacturer

3. Configuration and Identification of Device Under Test

The Device Under Test (DUT) is was a CW Doppler radar operating at 24.125 GHz (K-band) with approx. 5 mW rated output. Its application is for pedestrian detection. The unit is 2.5 x 3 x 6 inches and is intended to mount on a pole at pedestrian crossings. The antenna is 1.395 x 1.710 inches (I.D.) horn and is mounted inside the plastic case. A dual harmonic suppression filter is used between the source and the antenna. The unit uses a mirco timed by a 4 MHz clock, and a switching power supply operating at 50 kHz. It is powered by 12-24 VAC/VDC, usually obtained from door-bell transformer. For testing, the power was supplied by 120/24 VAC transformer. In all four 6-foot wires were attached to the DUT: two power, two relay out.

The DUT was designed and manufactured by Microwave Sensors, 7885 Jackson Road, Ann Arbor, MI 48103. It is identified as:

Microwave Sensors Pedestrian Monitor
Model: SmartWalk 1800
S/N: PROTO8
FCC ID: BJD951800
CAN:

To supply the 24 VAC, an Ault Transformer, 120/24 VAC (0.41 A), PN 306-4024-000E, was supplied and used in the tests.

3.1 Changes made to the DUT
None.

4. Microwave Emission Limits

The DUT tested falls under Part 15, Subpart C (Intentional Radiators) and Subpart B (Digital Devices).

4.1 Radiated Emission Limits
For radiated emissions the applicable testing frequencies with corresponding emission limits are given in Table 4.1.

Table 4.1. Emission Limits (ref. 15.205, 15.209, 15.245).

Fundamental Frequency (MHz)	Fundamental Ave. E_{lim}(3m) (mV/m)	dB(µV/m)	Harmonics* Ave.E_{lim}(3m) (mV/m)	dB(µV/m)	Spurious** Ave.E_{lim}(3m) (mV/m)	dB(µV/m)	Application
24075-24175	2500	128	25.0	88.0	7.943	78	indoor
24075-24175	2500	128	7.5	77.5	0.7943	58	other

* Measure up to 100 GHz
** Other than fundamental and harmonics

4.2 Conductive Emission Limits
The conductive emission limits for intentional radiator are 250 mV, 450 kHZ to 30 MHz. This is same level as for a digital device, Class B.

4.3 (Digital) Radiated Emission Limits

Table 4.2. Radiated Emission Limits (Ref: 15.33, 15.35, 15.109) -- Digital.

Freq. (MHz)	Class A, E_{lim} dB(μV/m)	Class B, E_{lim} dB(μV/m)
30-88	49.5	40.0
88-216	54.0	43.5
216-960	56.9	46.0
960-2000	60.0	54.0

Note: Average readings apply above 1000 MHz (1 MHz BW)
Quasi-Peak readings apply to 1000 MHz (120 kHz BW)

Because the device tested would be used outdoors, it must meet, at least, Class A limits.

5. Radiated Emission Tests and Results

5.1 Test Procedure

Prior to any measurements, all active components of the test setup were allowed a warm-up for a period of approximately one hour as recommended by their manufacturers.

To familiarize with emissions, the unit is held within a meter or less of the receiving antenna and the spectrum scanned from the fundamental through the harmonics.

For the tests, the unit is placed on the pedestal at a 3 or 1 (or even 0.25m) meter distance, depending on the available signal strength, and rotated through 360 degrees to determine the most intense radiation lobe. Due to the rigid connection of the receive antenna to the spectrum analyzer, the DUT is also rotated around its antenna axes to match the polarizations of the emission for maximum reading. Once the maximum lobe and polarization is found, both its maximum intensity and frequency are recorded. Figure 5.1 is a photograph of the measurement set-up.

5.2 Measurements

Starting scans at the fundamental, there were no detectable emissions other than the fundamental and the three harmonics. Table 5.1 shows the received power levels measured at these frequencies. Measurements were made with the normal CW emission. The spectrum analyzer was set to 1 MHz resolution bandwidth and 100 Hz video resolution bandwidth to produce the average readings.

After the in chamber (microwave) measurements, the digital emissions were measured on our outdoor 3-meter site. The measurements were made using standard digital equipment measurement procedures using 100 kHz resolution bandwidth.

5.3 Computations and Results

When the measurement is made at a distance other than 3m, the reading is extrapolated to the 3m. This is done using the 20 dB/decade field behavior relation when translating in the far field ,and 40 dB/decade relation when translating in the near field. The near-field/far-field criterion, N/F, is determined from

$$N/F = 2*D*D/\text{wavelength}$$

where D is the max. of the transmitter or receiver antenna dimension, and wavelength is that of the frequency measured. Suppose N/F = 2 m and the measurement is made at 1 m. Here the 40 dB/decade relation is applied from 1 to 2 m, and 20 dB/decade relation is applied from 2 to 3 m. In dBs, this gives a 15.6 dB adjustment.

To convert the dBms measured or extrapolated to 3 m, the E_3(dBmV/m) is computed from

$$E_3(\text{dBmV/m}) = 107 + P_R + K_A + K_E$$

where P_R = power recorded on spectrum analyzer, dBm (or extrapolated to 3 m distance)
K_A = antenna factor, dB/m
K_E = pulse operation correction factor, dB (see 6.1)

For microwave measurements, either the receive antenna is connected directly to the spectrum analyzer (up to 26 GHz), or it is connected to the mixer followed by an insignificant length cables. Hence, no cable loss term is used. The mixer conversion losses are programmed in the spectrum analyzer and are included in the dB values.

The results are given in Table 5.1. There we see that the DUT meets radiated microwave emission level by 12.8 dB at 48.25 GHz. The radiated digital emissions are met by 7.7 dB, Class A.

6. Other Measurements and Computations

6.1 Spectrum of the fundamental (15.209, 15.245(b)(3)).
Figure 6.1 is a plot of spectrum at fundamental emission. The -50 dB bandwidth is 1.38 MHz, and falls well within the +/-50 MHz limits. The center frequency is 24.134 GHz.

6.2 Correction for Pulse Operation (Ref. 15.35)
None (K_E = 0 dB).

6.3 Effect of Supply Voltage Variation
The DUT has been designed to operate from 115 VAC mains via 24 volt transformer. Using a spectrum analyzer, the relative radiated emissions and frequency were recorded at the "fundamental" (24.125 GHz) as the supply voltage was varied from 30 to 143 VAC. Figure 6.2 shows the emission power variation and figure 6.3 shows the emission frequency variation. The current at 24 VAC is 96.7 mA.

6.4 Conducted Emission Measurements
These measurements were made on the DUT, plus the 24 V transformer. Standard FCC/IC measurement procedures were used and the dominant emissions are presented in Table 5.1. From there we see that the DUT meets the Class B limits by 5.0 dB.

6.5 Potential Health Hazard EM Radiation Level
The maximum radiation level from the unit was determined by using an open-end waveguide probe feeding directly into a spectrum analyzer. In case the 1 mW/cm2 limit is exceeded, the maximum distance from the DUT is determined by measurement where the field density is 1 mW/cm2.

An open-end waveguide probe is as basic as a standard gain horn. Their characteristics have been extensively studied and experimentally verified. (Yaghjian, IEEE/APS pp. 378-384, April, 1984.) For the K-band (WR-42) waveguide at 24.125 GHz, for open-end waveguide Gain is 7.07 dBi and this equates to Aeq = 0.626 cm2 giving p(mW/cm2) = 1.60 P(mW) where P(mW) is power received.

For the subject DUT , the max. power measured was -9.51 dBm or power density of 0.11 mW/cm2. This was at the surface of the plastic case, i.e., the radome.

Table 5.1 Highest Emissions Measured

Microwave Radiated Emissions

Microwave Sensors,1800

#	Freq. GHz	Ant. Used	Ant. D,cm	Meas. dist., m	Pr dBm	N/F m	Pr(3m) dBm	Ka dB/m	Kg dB	E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
1	24.13	K-horn	10.2	3.00	-26.7	1.68	-26.7	32.2	0.0	112.5	128.0	15.5	
2	48.25	U-horn	4.6	1.00	-73.6	0.68	-83.1	40.8	0.0	64.7	77.5	**12.8**	
3	72.38	W-horn	2.5	0.25	-64.7	0.90	-102.5	45.1	0.0	49.6	77.5	27.9	Noise floor
4	96.50	W-horn	2.5	0.25	-61.6	1.20	-97.1	46.5	0.0	56.4	77.5	21.1	Noise floor

NOTES:

Mixer conversion loss is programmed in the spectrum analyzer and automatically adjusts the readings

When extrapolating to 3 m, use Near (40 dB/dec) and Far Fld (20 dB/dec) behavior

To obtain Ave. measurement, a 100 Hz VBW was used; RBW was 1 MHz

DUT max. antenna size, D= 4.34 cm

Digital Radiated Emissions, Class A

#	Freq. MHz	Ant. Used	Ant. Pol.	Pr dBm	Det. Used	Ka dB/m	Kg dB	E3 dBµV/m	E3lim dBµV/m	Pass dB	Comments
1	33.0	Bic	V	-66.0	Pk	13.5	26.2	28.3	49.5	21.2	Noise like signal
2	65.0	Bic	V	-58.0	Pk	11.0	25.7	34.3	49.5	15.2	Noise like signal
3	70.0	Bic	H	-65.0	Pk	11.0	25.6	27.4	49.5	22.1	Noise like signal
4	70.0	Bic	V	-53.0	Pk	11.0	25.6	39.4	49.5	10.1	Noise like signal
5	81.0	Bic	H	-63.0	Pk	11.2	25.4	29.8	49.5	19.7	Noise like signal
6	81.0	Bic	V	-51.0	Pk	11.2	25.4	41.8	49.5	**7.7**	Noise like signal
7	109.0	Bic	H	-68.0	Pk	12.5	25.0	26.6	54.0	27.4	Noise like signal
8	110.0	Bic	V	-68.0	Pk	12.6	25.0	26.6	54.0	27.4	Noise like signal
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											

Conducted Emissions, Class B

#	Freq. MHz	Line Side	Det. Used	Vtest dBµV	Vlim dBµV	Pass dB	Comments
1	4.80	Hi	Pk	37	48.0	11.0	
2	13.80	Hi	Pk	39.5	48.0	8.5	
3	5.00	Lo	Pk	39.5	48.0	8.5	
4	13.50	Lo	Pk	43	48.0	**5.0**	

Meas. 5/25-6/9/98

EXHIBIT A
PAGE 6 OF 17
MICROWAVE SENSORS, INC.

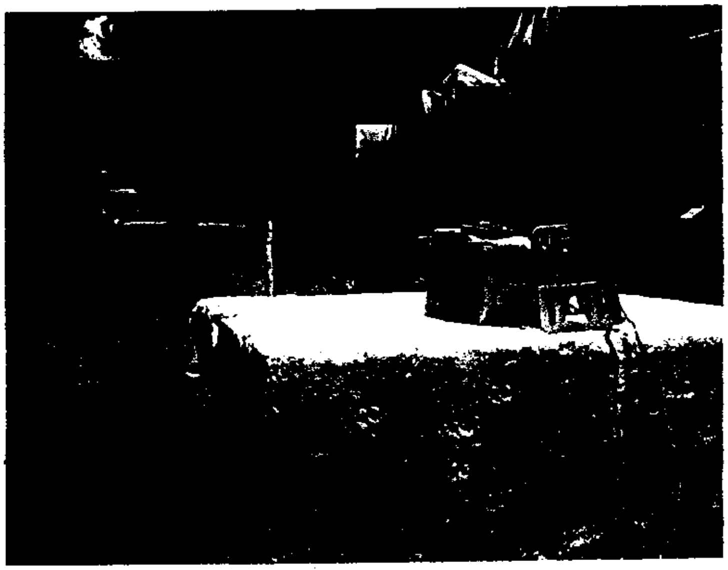


Figure 5.1. DUT tested at fundamental.

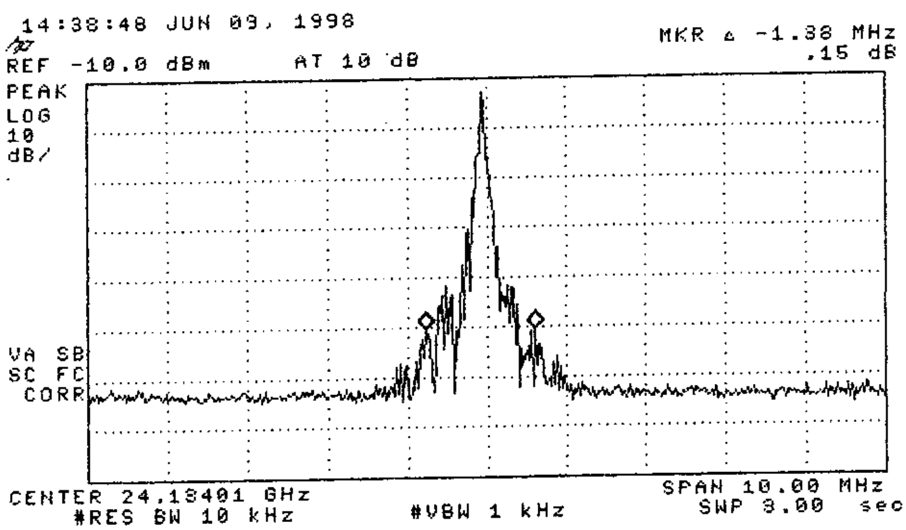


Figure 6.1. Fundamental emission spectrum.

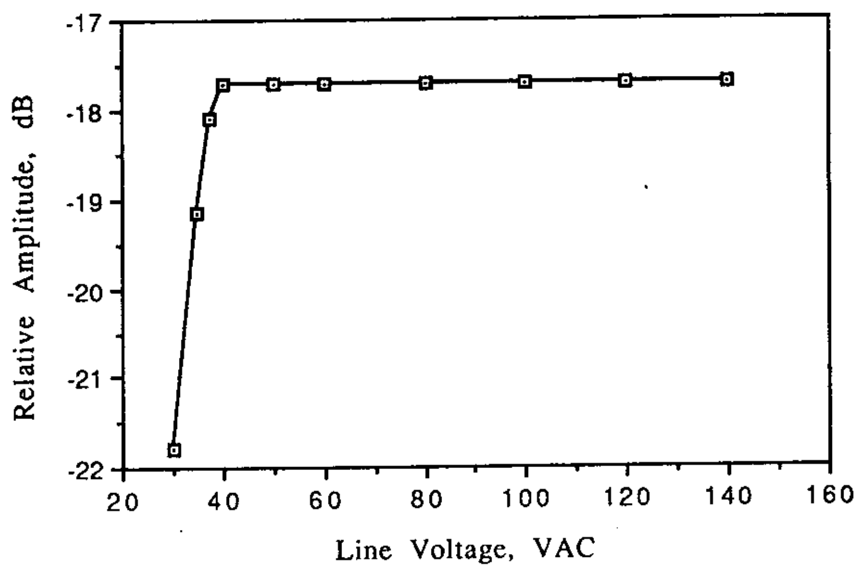


Figure 6.2. Relative emission at fundamental vs. supply voltage.

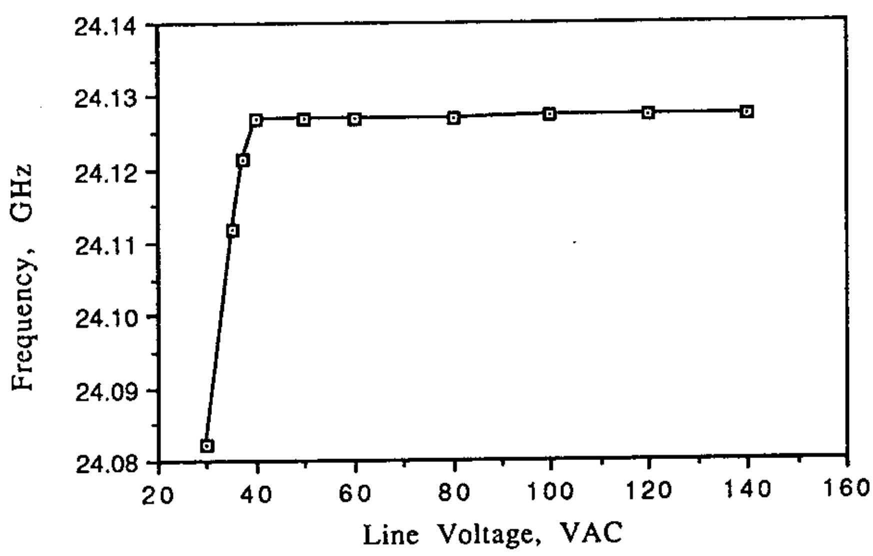


Figure 6.3. Fundamental frequency vs. supply voltage.

SmartWalk™ 1800 Pedestrian Sensor

Preliminary Installation Instructions

Description

The SmartWalk™ 1800, from Microwave Sensors, Inc., allows state-of-the-art detection of pedestrians crossing an intersection at the crosswalk. Using Microwave Sensors' proprietary MICRO-MOTION™ technology, the SmartWalk™ 1800 reliably detects even very slow moving pedestrians, allowing for an extension of the pedestrian signal when necessary. Slow moving pedestrians no longer need to worry about making it across the road before the light changes.

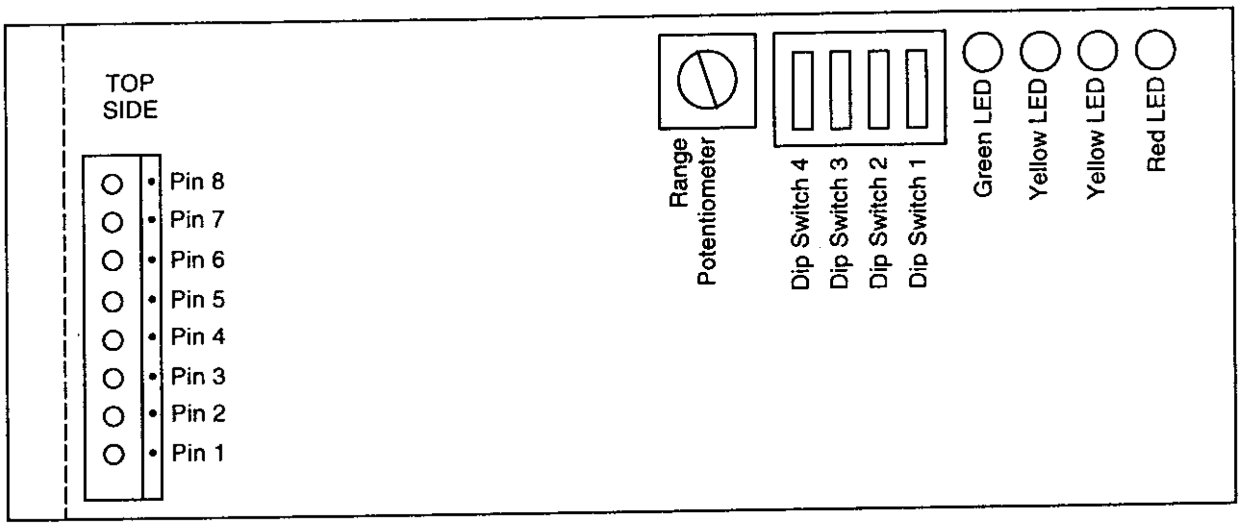
Features & Benefits

Features:	***Benefits:***
Provides hands free detection of pedestrians in the crosswalk	Detects slow moving pedestrians in the cross-walk, allowing an extension of the walk signal when needed.
Employs Microwave Sensors' proprietary MICRO-MOTION™ technology	Provides enhanced pedestrian detection, able to sense motion down to a fraction of an inch per second.
Installs in minutes	Saves time and money by using existing poles.
Easy to set-up	No specific training is required; simply follow the easy-to-use instructions.
User selectable sensitivity	The installer can select the sensitivity, using a range potentiometer, ensuring proper coverage.
User selectable MICRO-MOTION™ time delay	Allows the installer to select the amount of time that the relay will remain held after the crosswalk clears (2 or 5 seconds), helping ensure proper detection.
Environmentally secure:	Insensitive to heat, cold, rain, snow, reducing the need for service calls.
Stable detection pattern	Once the unit is mounted and aligned, additional service / adjustment calls are not necessary.
Tamper resistant, non-obtrusive enclosure	Unit is mounted out of reach of would-be vandals, further reducing the need for service calls. Captive screws help to ensure the integrity of the enclosure.

Wiring Instructions/Input Connector

Pin 1 .... Voltage in (12V to 24V AC or DC)
Pin 2 .... Voltage in (12V to 24V AC or DC)
Pin 3 .... Relay Normally Open (N.O.)
Pin 4 .... Relay Common (COM)
Pin 5 .... Relay Normally Closed (N.C.)
Pin 6 .... Ground

Pin 7 – 8 .... NOT USED



Dip Switch

The four-position dip switch sets directionality, sensitivity and MICRO-MOTION™ delay time (the amount of time the pattern must be clear to reset the relay). The table below defines each switch position.

Switch 1 directionality	On Off	- Unidirectional (detects motion moving toward unit only) - Bi-directional (detects motion moving toward or away from unit)
Switch 2 MICRO-MOTION™ off delay	On Off	- Delay 2 seconds - Delay 5 seconds
Switch 3 Slow threshold	On Off	- 2/20 (more sensitive) - 5/50 (less sensitive)
Switch 4 MICRO-MOTION™ threshold	On Off	- 25 (more sensitive) - 50 (less sensitive)

NOTE: SUGGESTED MOUNTING HEIGHT IS 14' FOR OPTIMUM RESULTS.

Theory of Operation

The Model MODEL 1800 One Way Motion/Micro-Motion™ Sensor, designed and manufactured by Microwave Sensors, Inc., is a field disturbance sensor intended for use under FCC Rules, Part 15. Attached to this description is the schematic and block diagram to aid in understanding the operational principles.

Block #1 is designated for the transceiver. The 86843 series CW, K-Band doppler transceiver consists of a Gunn diode oscillator and two Schottky diode mixers assembled into a diecast waveguide package, designed for commercial applications in directional motion sensing. Through use of the Doppler effect, the mixers generate two I.F. output signals whose frequencies are proportional to the velocity of the target, and whose phase difference depends on the direction of motion, towards the antenna. If the motion is toward the transceiver, channel A signal will lead channel B signal by about 90 degrees. The frequency of the signals produced by the transceiver for an average man at 1.466 feet per second within the range of the MODEL 1800 unit is 72 Hz.

The signals from the transceiver, channel A and channel B, are coupled through coupling capacitors CA1 and CA3 into a preamplifier blocks 2 and 3. Amplifiers (blocks 2 and 3) have again of 101 using both halves of op-amp U3.

The amplified signals from blocks 2 and 3 are coupled through capacitors C10 and C12 to the main amplifiers depicted in blocks #4 (U1:A) and block #7 (U1:B) using two of the four op-amps in U1. A third channel is picked from the preamplifier depicted in block #9, using the third op-amp of U1:D, the fourth op-amp of U1:C is not used.

Block #4 and Block #7 further amplify the signals from Channel A and Channel B and have a threshold adjustment for each, depicted in Block #5 (R16) and Block #6 (R8). By adjusting the gain a threshold can be set for block #10 and block #11 which is configured as a voltage comparitor circuit (U2:A and U2:B).

Block #9 is a separate amplifier (U1:D) with a gain adjustment (R6) that provides the microprocessor with an analog signal that shall be referred to as micro motion.

The microprocessor depicted in Block #13 looks at channel A and channel B for a rising edge. When this edge is detected and the proper conditions are met, the processor will set an output port high enabling the relay driver in Block #15. While the relay is enabled, the microprocessor continues to scan channel A and channel B and looks at the signal, fromBlock #9. If the microprocessor has an active relay output and there is also activity on the micro motion channel the microprocessor will hold the output high until there has been an absence of activity of the micro motion channel for 5 seconds at which time the relay will become inactive.

Block #12 allows the end user to adjust the range of the unit. This is accomplished by comparing the A\D signals from blocks 9, 10 and 11 to the range potentiometer (R28).

Block #14 is a four-position dipswitch, which allows for custom user settings.
Switch Settings (On/Off)

1. Direction
   On = Unidirectional
   Off = Bi-directional
2. Micro-motion ™ Time Delay
   On = 2 seconds
   Off = 5 seconds
3. Motion Sensitivity
   On = More Sensitivity
   Off = Less Sensitivity
4. Micro-motion ™ Sensitivity
   On = More Sensitivity
   Off = Less Sensitivity

Block #15 is relay with a transistor driver Q1. When the microprocessor port goes to a logic high, it turns on the transistor which completes a ground path for the relay coil.

MICROWAVE SENSORS

7885 Jackson Road • Ann Arbor, Michigan 48103-9568
Phone: (734) 426-0140 Fax: (734) 426-5950
(800) 521-0418 (800) 847-5762
www.microwavesensors.com

June 12, 1998

Federal Communications Commission
Equipment Approval Services
P.O. Box 358513
Pittsburgh, PA 15251-5315

Re: Certification for Microwave Sensors, Inc.
Field Disturbance Sensor Product ID: Smartwalk™1800
FCC ID: BJD9B518ØØ

Dear Sir,

Please find enclosed application materials for Certification under Part 15 of the FCC rules. If there are any questions regarding this application, please contact me at the above address or call (734) 426-0140 or fax (734) 426-5950.

Your prompt attention to this matter will be greatly appreciated.

Sincerely,

Karen Zias
Vice President

Enclosures:
Form 731 with payment and relevant materials