HI-3520
Microwave Monitor
User's Manual

Declaration of Conformity

We,
HOLADAY INDUSTRIES, INC.
14825 MARTIN DRIVE
EDEN PRAIRIE, MN 55344
USA

CE

declare in our own responsibility, that the HOLADAY product described in this instruction manual is in compliance with: EN EMC Directive 89/336/EEC, EN50082-1, EN55011

President
HOLADAY INDUSTRIES, INC.

Manual #600052 10/97 $12.50

Revision Record

Manual # 600052
HI-3520
Microwave Monitor

Revision	Description	Date
---	Preliminary Release	4/93
A	Added CE Label	10/97

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LIMITED WARRANTY

Holaday Industries, Inc. warrants each Model HI-3520 Microwave Monitor to be free from defects in material and workmanship for a period of one year from date of shipment to the purchaser. This warranty extends to the original purchaser only and does not apply to batteries or any product or parts subject to misuse, neglect, accident, unauthorized service or abnormal conditions of operations.

In the event of instrument failure covered by this warranty, Holaday Industries, Inc. will, without charge, repair and recalibrate the instrument if returned to their factory within one year of the original purchase, provided that Holaday Industries' examination discloses to its satisfaction that the product was defective. Holaday Industries, Inc may, at its option, replace the product in lieu of repair. If the defect was caused by misuse, neglect, accident, unauthorized service or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be provided before work is started if requested by the purchaser.

For warranty service, contact Holaday Industries, Inc., giving full details of the failure and the serial number of the instrument. You will then be given service information or shipping instructions. Return the instrument to the factory, transportation prepaid. Repairs will be made at the factory and the instrument returned to you, transportation paid. Holaday Industries, Inc. assumes no responsibility for loss of, or damage to, products in transit.

!! WARNING !!

Special caution is advised when working in environments where contact with high voltage or high current circuits or apparatus is possible. This is particularly true when attempting to obtain induced body current measurements near electrically-powered equipment, such as heat sealers, or in areas marked with warnings about the presence of high voltages, currents, or RF fields. Accidental contact with objects, circuits, or fields operated at high voltages or high current can be lethal! Holaday Industries, Inc. assumes no liability for damages or personal injury which may result from accidents arising out of the use of this equipment.

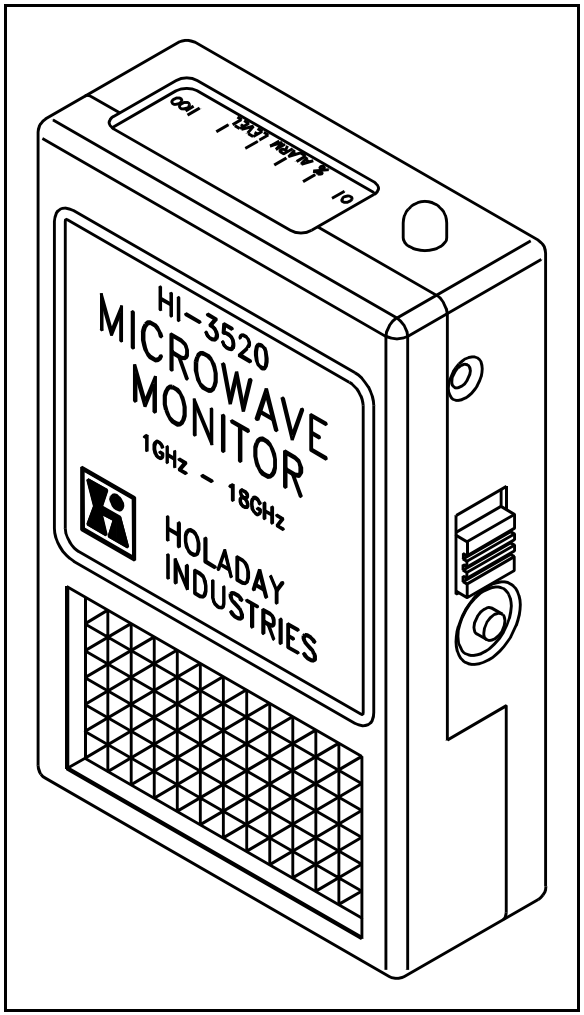
1.0 PRODUCT OVERVIEW

1.1 Introduction

The Model HI-3520 RF Radiation Badge (see Figure 1) is a portable, battery operated, non-ionizing radiation hazard detector intended for personal use. It detects electromagnetic radiation from RF and microwave sources in the frequency range from 1 to 18 GHz and alerts the user to potentially hazardous fields. The Model HI-3520 enables the user to set the alarm warning level anywhere in the range from 0.2 to 20 mW/cm^2. In addition, the user can choose either of two measurement modes: instantaneous exposure level or a six minute average measurement. Both modes are displayed on a three digit LCD panel along with a ten segment bar graph normalized to the selected alarm warning level. Electrical, mechanical and performance characteristics are described in section 2.0.

The Model HI-3520 is intended for use by personnel who work with or service RF and microwave equipment such as:

- Microwave Ovens
- Medical Equipment
- Radar Installations
- Microwave Heaters and Dryers
- Communication Systems
- Electronic Warfare Systems



HI-3520 Microwave Monitor
Figure 2

2.0 SPECIFICATIONS

HI-3520 Technical Specifications

SPECIFICATION	DESCRIPTIVE DATA
Frequency Range:	1 to 18 GHz
Power Density Range:	0.01 to 20 mW/cm^2
Alarm Accuracy:	± 2dB
Half Power Beam Width:	
Horizontally Polarized	90°
Vertically Polarized	120°
Average Power Overload:	0.5 W/cm^2
Peak Power Overload:	100 W/cm^2
Pulse Energy Density Overload:	150 W-:sec/cm^2
Temperature Range:	
Operating	-10° C to +50° C
Non-Operating	-40° C to +65° C
Battery:	
Type	DL2450B, Lithium
Life	1000 hours
Size:	
inches	2.40 x 3.75 x 1.00
mm	61.0 x 95.3 x 25.4
Weight:	
oz	4.8
gm	136

3.0 OPERATION

3.1 General Information

The Model HI-3520 can be carried inside outer garments or fastened to a shirt or jacket pocket or to a belt using the clip provided on the instrument. Metallic objects such as belt buckle, pen, pencil, etc.,could affect the accuracy of the Model HI-3520. Do not locate the unit near any metallic object.

NOTE:
The side of the unit containing the clip should always face towards the wearer's body.

3.2 Safety Precautions

The following precautions should be observed when entering an area where unsafe radiation levels may be expected.

1. Turn on the Model HI-3520. Set it to the "Instantaneous" Measurement Mode as described in section 3.10.

2. Enter the area and do a "walkaround". Should the Model HI-3520 indicate that an alarm condition exists, take corrective action by turning off the source of RF power or leaving the area immediately.

3. Keep the Model HI-3520 turned on and continue to wear it as long as you are in the area.

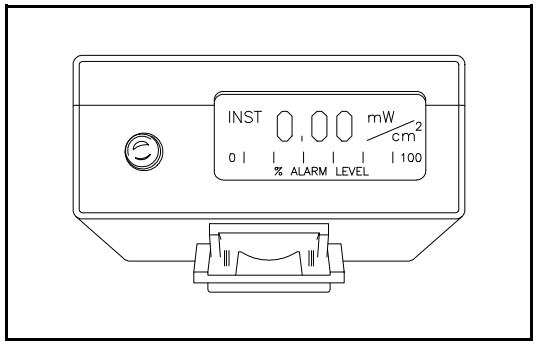
3.3 Operating Controls and Indicators

The operating controls on the Model HI-3520 are the ON-OFF switch and the Mode switch, both of which are located on the side of the unit. In addition, the Model HI-3520 has three alarm indicators: Two visual indicators consisting of an LCD display panel and a red LED warning light, both located on the top of the unit (see figure 2), and an audible alarm produced by a beeper located within the unit. Unless programmed off, the audible alarm operates synchronously with the visual alarm. In addition, there is an audio output jack to which the furnished acoustical earpiece can be connected.

3.4 Operating Procedure

To turn the unit ON, place the ON-OFF switch in the ON position. The unit will respond with a three second beep and its red LED will glow to confirm that the unit is operational. In addition, all segments of the LCD display will be on during this three second interval. The LCD display will then indicate the preset alarm warning level for about seven seconds. The unit will then respond with a short beep and red LED flash. At this time, the unit is operational and will indicate the power density in the area as well as the ratio of the power density in the area to the preset alarm warning level (% ALARM LEVEL bar graph). This display is normalized to the programmed alarm level so that the alarm indicates when the bar graph reaches 100%. Using this display, the wearer can tell how closes he or she is to the alarm without being exposed to an alarm power level. (If you are working in a noisy environment, connect the acoustical earpiece to ensure hearing the audible alarm). When there are no RF fields present higher that the preset alarm warning level, there will be no further alarm indications from the unit. Should the unit detect a field that exceeds the preset alarm warning level, the unit will start to beep and flash.

The beep and the flash rate are directly proportional to the RF field strength. Note that once the alarm starts, it will latch at the minimum flash rate, continuing to warn of an over-exposure even if the RF field that caused the alarm is no longer present. In order to reset the alarm function, the unit must be turned OFF and back ON using the ON-OFF switch. For information concerning disabling the latch function, refer to section 3.11. For information concerning "Instantaneous" vs "Average" measurement modes, refer to section 3.8.



HI-3520 Display
Figure 3

3.5 Set-up Mode

The "Set-up" mode is used to set the alarm warning level and to enable/disable the audible alarm. To enter this mode, set the "ON-OFF" switch to ON. Then depress the MODE switch after the initial three second period referenced in section 3.4. The LCD display will indicate "S.U.". At this point, the alarm warning level can be changed (section 3.10) or the audible alarm indicator can be enabled or disabled (section 3.7).

3.6 Setting Alarm Warning Level

In the "Set-Up" mode (section 3.5), depress and hold the MODE switch. After three seconds, the preset alarm warning level will be displayed. Release the MODE switch. Depressing and holding the MODE switch again at this point will result in a rapidly increasing alarm warning level indication. Continue to depress the MODE switch until the desired alarm level is approached. Then release the MODE switch and pulse it at a convenient rate until the desired alarm warning level is reached. Once it is reached, set the ON-OFF switch to OFF and then to ON again. The alarm warning level that has just been set will remain in memory until changed again as described above.

3.7 Enabling/Disabling Audible Alarm

In the "Set-Up" mode (section 3.5), continue to depress and release the MODE switch and observe that the audible alarm indicator (a small bell in the upper left area of the LCD display) appears and disappears. If an audible alarm is desired, allow the audible alarm indicator to remain visible; if an audible alarm is not required, continued to depress and release the MODE switch until the audible alarm indicator disappears. Using the ON-OFF switch, turn the unit OFF and then ON again.

3.8 Measurement Modes

The Model HI-3520 Measurement Mode can be set to either "Instantaneous" or "Average" by depressing and releasing the MODE switch while the unit is in its normal operating mode. See sections 3.9 and 3.10.

3.9 "Average" Measurement Mode

When the AVG annunciator on the left side of the display area is visible, a six-minute running average is maintained by the unit. Power density is sampled every 3.6 seconds. During the first six minutes (i.e.-360 seconds

or 100 measurements), the running average of all measurements taken will be displayed. After six minutes, each "new" measurement will replace the measurement taken 363.3 seconds prior to the "new" measurement. Therefore, the average of the most recent 100 measurements will always be displayed.

The average of the latest 100 measurements is also compares by the unit to the alarm warning level set by the operator (section 3.6) to determine the % ALARM LEVEL ratio. (During the first six minutes of operation, the running average of all measurements taken will be compared by the unit to the alarm warning level set by the operator to determine the % ALARM LEVEL ratio.) If the % ALARM LEVEL ratio reaches 100%, the unit's alarm circuitry will be activated, the red LED and the ALARM annunciator on the LCD will flash every 3.6 seconds, and the audible alarm will sound every 3.6 seconds.

3.10 "Instantaneous" Measurement Mode

When the INST annunciator on the left side of the LCD display area is visible, the measured power density is sampled and displayed every 1.8 seconds. (Note that the Model HI-3520 saves data for six minutes regardless of the display selected. Switching between "Average" and "Instantaneous" does affect the data being stored.)

3.11 Latched Alarm

A feature of the unit's alarm system is that the beeps and flashes are progressive. Once the alarm level has been reached, the unit will indicate a single beep and flash each 1.8 second with the "INST" annunciator displayed or 3.6 seconds with the "AVG" annunciator displayed. Should the unit detect a field that exceeds the preset alarm level, the unit will start to beep and flash. The

beep and the flash rate are directly proportional to the RF field strength. Note that once the alarms start, they latch at the minimum flash rate, continuing to warn of an over exposure situation even it the RF field that initially caused the alarm is no longer present. In order to reset the alarm function, it is necessary to turn the unit OFF and back ON using the ON-OFF switch. If it is desired to disable the latch function, follow the turn-on procedure described in section 3.4 except depress and hold the MODE switch before placing the ON-OFF switch to the ON position.

3.12 Built-In Test Functions

The unit generates a beep and flash at turn on to verify that the alarm indicators are functioning. At this time, all segments of the LCD display are enabled to indicate that the display is operating properly. Ten seconds after turn on. the unit will generate a second beep and flash which indicated that it is operational. A low battery condition is indicated if the unit beeps and flashes two times after the ten second period. To verify, check the LCD display for a "BAT" indication. In addition, the battery condition is tested automatically every minute. Should the battery measure low, the "BAT" indicator will flash and the unit will beep and flash once a minute. Refer to Section 5.0 for battery replacement procedures.

The unit also contains continuous fault detection circuitry to alert the user to a RF detector failure. In that event, the beeper and light will start to beep and flash at a constant tone and light, and the LCD display will indicate "FAIL". The unit is no longer usable in this condition and should be turned off and serviced.

4.0 THEORY OF OPERATION

4.1 RF Circuit

The Model HI-3520 RF circuit consists of two orthogonal tft[1] (thin-film thermoelectric) arrays, each containing a number of series connecter thermoelectric junctions. These are mounted between a pair of thermally conductive dielectric wafers to enhance the detector sensitivity. When placed in an RF field, the dipoles absorb power which gives rise to thermal gradients across the thermocouple junctions. By keeping the temperature differential small, the detector acts as a true rms device producing a dc output voltage directly proportional to the absorbed power.

The tft elements, acting as resistive screens, operate over the frequency range 1 to 18 GHZ.

[1] tft registered trademark of General Microwave Corporation.

4.2 DC Circuit

The DC output produced by the RF circuit is amplifies by a differential chopper-stabilized amplifier. This circuit has high common mode rejection and low DC drift. The high level output of this circuit is connected to a microcontroller which has a built in A/D converter. The amplifier has two gain ranges that are controlled by the microcontroller.

A self-contained test signal is constantly applied to the RF detector. Should a fault occur in this circuit, a fault signal is generated through the DC amplifier which then generated a fault bit to the microcontroller.

The analog output from the DC amplifier is digitized by the microcontroller's A/D converter. The reference voltage for the A/D converter is generated from a band-gap reference diode which provides excellent long term stability. The microcontroller then controls the measurement rate for instantaneous or average measurements, amplifier ranges. LCD display, fault indications and low battery signals. It store and computes the data for the six minute average readout and stores the alarm warning level trip point.

4.3 RF Shielding

To enable accurate operation of the sensitive circuits within the RF Radiation Badge in the presence of RF fields, an array of shielded and absorbers is used. The circuits are contained within a Faraday shielded area which is then covered by a graded absorber to minimize field disturbances. To prevent reflections from behind the unit giving distorted measurements results, the antenna section is protected by an absorber. The net result is that the sensitivity to any reflection from the rear of the unit is minimized relative to its performance in free space.

5.0 MAINTENANCE

5.1 General

The unit has been designed for rugged field use. Normal maintenance for this unit consists only of battery replacement and calibration.

5.2 Battery Replacement

The unit furnished with a DL2450B lithium cell. Normal operating life is 1000 hours. With the alarm in its latched mode, the battery life is about 80 hours. The shelf-life of the battery is about ten years when stored in a cool environment.

The unit has a built in battery monitoring circuit that generates a single beep and flash at one minute intervals under low battery conditions. To replace the battery, proceed as follows:

1. Turn the unit off. **THIS IS IMPORTANT.**

2. Loosen the screw that secures the battery cover and remove the cover.

3. To remove the battery, pry it up with a small screwdriver to clear the lip of the battery holder before sliding it out.

4. Insert the new battery, making sure to observe the correct battery polarity as indicated on the retaining clip (i.e., +toward the clip).

5. Turn the unit on. The instrument should now be operational and the one minute beep and flash warning indicators should cease.

NOTE:
Should the unit exhibit any form of unusual or erratic performance, or doesn't turn on at all, proceed as follows:

1. Turn the unit off.

2. Slide an insulator such as a piece of paper between the plus battery clip and the battery.

3. Turn the unit on for five minutes.

4. Turn the unit off and then quickly slide out the insulator.

5. Turn the unit on. The instrument should now operate normally.

Once the unit is operating properly, replace the cover and tighten the cover screw.

The instrument should now be operational and the one minute beep and flash warning indicators should cease.

5.3 Trouble Shooting

NOTE:
In general, except for normal battery replacement, trouble shooting and repair of this instrument by the user is not recommended.

As a part of its self-test capability, the unit will produce a tone and flash when it is turned on. In the event it fails to do so, check the condition of the battery by replacing it in accordance with the procedure described in section

5.2 above.

Should the unit continue to malfunction, return it to Holaday Industries Inc. for repair.

6.0 CALIBRATION

NOTE
The following is applicable only to units with serial numbers higher than 220104. Please contact the Holaday Industries Inc. for calibration instructions for units with serial numbers of 220104 and lower.

6.1 General

The Model HI-3520 Radiation Badge should be calibrated at 12 month intervals. To do so requires the use of highly specialized test equipment and facilities, such as a radio-frequency anechoic chamber and test cells, wherein fields of known power density can be accurately established. It should also be noted that to establish the required power densities will require CW sources of 10W or greater together with accurately calibrated test antennae and power monitoring equipment. If facilities of this type are not available, the unit should be returned to General Microwave or to another qualified calibration facility for this service.

6.2 Calibration Procedure

Set the alarm warning level to 0.2 mW/cm^2 as described in section 3.6.
Disable the latch function as described in section 3.11.

1.0 Position the unit in an anechoic chamber. The preferred orientation of the E-field is parallel to the vertical axis of the unit.

2.0 At 1.4 GHz, raise the power density level at the unit until an alarm is indicated. Record this

power density level on the test data sheet in $mW/cm^{2.}$

3.0 Repeat step 2.0 at 2.45, 3.8, 8.0, 12.0 and 18.0 GHz.

4.0 From the data in step 2.0 and 3.0, calculate the average power density measured over the band by taking the square root of the product of the highest and lowest readings recorded. Record the resultant on the data sheet for P_{cal}.

5.0 Divide 0.2 mW/cm^2 by the power density level recorded on the data sheet for P_{cal}. This determines the correction multiplier, M.

6.0 Alignment can now be performed at any one of the calibration frequencies specified in steps 2.0 and 3.0. Select a convenient calibration frequency.

7.0 At the selected calibration frequency, multiply by M the indicated power density from the data recorded in step 2.0 and 3.0 above. Record this as P_{REF}.

8.0 Remove the battery compartment cover and located the calibration potentiometer behind the hole adjacent to the battery cover screw hole.

NOTE:
It is necessary to remove the battery cover door to adjust the calibration potentiometer but the cover must be replaced for the RF test.

9.0 Apply the P_{REF} power at the calibration frequency. Adjust this potentiometer such that

the alarm just starts to indicate. Repeat this adjustment as required.

10.0 This completes the RF calibration. Replace the battery compartment cover. Attach a new calibration sticker with the current calibration date.

NOTE:
Do not place any stickers or labels that contain metal on the bottom surface of the unit or the lower portions (i.e., approximately 1 ½ inches up from the bottom surface) of the front and both sides of the unit. This could seriously affect the accuracy of the unit. Paper or plastic stickers are acceptable.

6.3 Test Data Sheet Model HI-3520

_____ _____ _____

DATE SERIAL NUMBER TESTED BY

STEPS 2.0 AND 3.0

FREQUENCY (GHz)	POWER DENSITY LEVEL (mW/cm^2)
1.4	_____
2.45	_____
3.8	_____
8.0	_____
12.0	_____
18.0	_____

STEP 4.0 $P_{CAL} = (P_{HI} \times P_{LO})^{1/2} =$ _____

STEP 5.0 $M = \frac{0.2}{P_{CAL}} =$ _____

STEP 6.0 CAL FREQ = _____

STEP 7.0 P_{REF} = M (POWER DENSITY AT CAL FREQ)
= _____

STEP 9.0 ALARM SET FOR P_{REF} _____ CHECK

-- NOTES --

-- NOTES --