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Pyroelectric Thermometer as a mm-Wave Detector

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It has been known that pyroelectric detectors based upon $LiTaO_3$ crystals were developed as terahertz detectors. For instance, Microtech Instruments offers the SN-series detectors with a reasonable response from 0.1 to 3 THz [1].

I was curious whether the common PIR detectors used in alarm systems and low-cost IR thermometers might also be sensitive at mm-wave frequencies. Having a low-power sweep oscillator for 75-110 GHz on hand, I tested an alarm detector sensor, and yes, I observed a response of several mV, similar to my hand moving before the detector, when a 90-100 GHz signal with ~10 dBm was brought to the detector. However, the problem with alarm-type sensors is that they are quite sensitive to heat from surrounding objects, and the output voltage is low and unstable.

Next I tested my Omega OS642C-LS IR thermometer [2]. Its response is quite stable and I have used it to detect temperatures of various warm RF components. This was my second experiment.

The Omega PIR sensor is built in the case with a Teflon® lens and placed deep in a black tube to limit its field of view to ~10 deg. With this construction, the waveguide WR-10 flange cannot be brought closer to the sensor lens than ~1 inch. The results I obtained are shown in Table 1 as dTA.

I then modified the WR-10 waveguide flange so that it could be inserted in the sensor tube closer to the lens. It turned out that for the best response of the thermometer, the distance between the waveguide end and lens should be adjusted at each signal frequency for the best response. In Table 1, the strongest response is shown as dTB.

For reference, the mm-wave power is shown in Table 1 as "Cal dBm" over the test frequency.

The IR thermometer response shows that it does respond to a low power level, but below ~85 GHz the sensor window apparently starts blocking mm waves from getting to the sensitive layer. Also, PIR detectors and thermometers react to the sensitive layer temperature, and nothing is known about its absorptivity at mm wavelengths.

These results show that some IR thermometers could be used to detect mm waves (possibly above 110 GHz, but I have no signal source for it). A significant problem appears to be how best to deliver the mm-wave energy to the sensor.

Freq. GHz	Cal dBm	dTA	dTB
75	5	4	40
80	7	4	15
85	9	10	70
90	11	22	75
95	11	30	265
100	11	40	267
105	11	30	250
110	11	22	130
112	12	45	215

Notes:
- Cal dBm signal power measured with HP W8486A power sensor
- dTA was measured with the WR-10 flange to PIR sensor distance ~1 inch.
- dTB was measured with the waveguide to sensor distance "tuned" for maximum temperature indication on an Omega OS642CLS infrared thermometer
- Ambient temperature was 22ºC. dTA and dTB are the differences of the indicated temperature and the ambient, in Kelvins or deg. C.

Table 1 · IR Thermometer response over frequency.

Perhaps such devices may be used to detect power leakage, or as low-cost dosimeters for persons handling higher-power mm waves at W-band and above. For such applications, the low-cost IR thermometers may be an interesting alternative to costly Schottky-diode detectors such as the Spacek model DW-2 [3].

References

1. SN xxx THz detectors, www.mtinstruments.com/thzdetectors/index.htm
2. IR thermometers: see www.omega.com, www.fluke.com, and others.
3. Model DW-2 WR-10 wideband detector, www.spaceklabs.com.

Ideas for this column are always welcome. Almost any high frequency appilcation or design technique is appropriate: experimental work (as above), tutorial review, circuit design example, software application, test method, etc.

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