Applications

Agilent Technologies broadband detectors span frequencies from 100 kHz to 50 GHz. These detectors are widely used on the design and production test bench, as well as for internal components of test system signal interface units. They find use in a variety of test and measurement applications.

- Power monitoring
- Source leveling
- Video detection
- Swept transmission and reflection measurements

Technology

Agilent detectors are available in two families – Silicon Low Barrier Schottky Diode (LBSD) and Gallium Arsenide Planar Doped Barrier Diode (GaAs PDBD) detectors. The Gallium Arsenide detector technology produces diodes with extremely flat frequency response to 50 GHz. Also, the GaAs PDB detector has a wider operating temperature range (-65 °C to +100 °C), and is less sensitive to temperature changes.

Key specifications:

- Frequency range
- Frequency response
- Open circuit voltage sensitivity
- Tangential sensitivity
- Output voltage versus temperature
- Rise time
- SWR
- Square-law response
- Input power

Frequency range

Frequency range can be one of the most important factors to consider when specifying detectors. In the past, broadband frequency coverage was equated with high performance. It is important to note that though broadband coverage may be desirable in multi-octave applications, a good octave range detector may be your best solution for non-swept applications. Broadband coverage saves you from the inconvenience of having to switch between detectors when making measurements, but you may be sacrificing SWR and frequency response flatness. All of Agilent's 8474 family of coaxial detectors are available in both octave band and broadband versions. The guaranteed performance of the octave band models are characterized for frequency response flatness and SWR.

Frequency response

Frequency response is the variation in output voltage versus frequency, with a constant input power. Frequency response is referenced to the lowest frequency of the band specified. Agilent typically uses -30 dBm to measure frequency response. Agilent uses precision thin-film input circuitry to provide good, broadband input matching. Exceptionally flat frequency response is provided by the very low internal capacitance of the PDB diode. Also, excellent control of the video resistance of the PDB diode is obtained by the precision growth of molecular beam epitaxy (MBE) layers during diode fabrication.

Figure 1 displays frequency response characteristics comparing Agilent LBSD and PDBD detectors. The figure indicates typical performance of each device and the published specifications. Frequency response specifications include the mismatch effects of the detector input SWR specifications. Note that the Agilent 8474E, representative of PDB detectors, is exceptionally flat beyond 26.5 GHz.

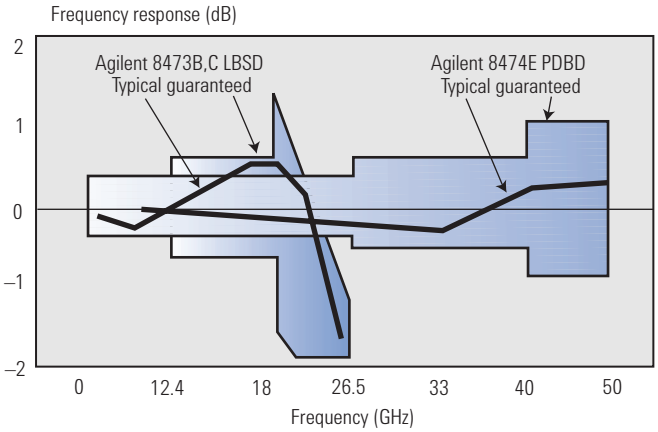


Figure 1. Detector frequency response characteristics.

Open circuit voltage sensitivity

The open circuit voltage sensitivity (K) describes the slope of the transfer function of the detectors. This represents the conversion of RF/microwave power to a voltage at the output connector, typically specified in mV/mW. The value is an indication of the efficiency of the diode in converting the input power to a useful voltage.

Sensitivity is measured with the detector terminated in a high impedance. When used in video pulse applications, the sensitivity will appear to be much lower when terminated in 50 or 75 ohms for connection to an oscilloscope. Another factor, called the Figure of Merit, gives an indication of low-level sensitivity without consideration of a load circuit. It is useful for comparing detectors with different values of K and R_V. Figure of Merit equals $K/\sqrt{R_V}$, where R_V = internal video resistance.

Tangential sensitivity

Tangential sensitivity is the lowest input signal power level for which the detector will have an 8 dB signal-to-noise ratio at the output of a test video amplifier. Test amplifier gain is not relevant because it applies to both signal and noise. Agilent detectors are designed for optimal flatness and SWR. Figure 2 shows typical tangential sensitivity.

$$P_{tss\ (watts)} = \frac{3.23 \times 10^{-10}\sqrt{BFR_V}}{K} \quad @\ 300\ ^\circ K$$

Where:
B = Video amplifier bandwidth (Hz)
F = Video amplifier noise factor = 10 (Noise figure/10)
R_v = Video resistance (Ω)
K = Open circuit voltage Sensitivity (mV/mW)

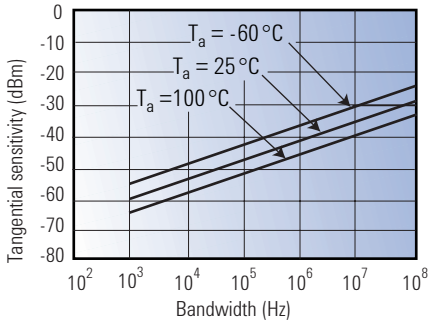


Figure 2. Typical tangential sensitivity performance.

Output voltage versus temperature

For applications such as power monitoring and leveling that require stable output voltage versus input power, the designer can choose a resistive termination that will optimize the transfer function over a wide temperature range. Figure 3 shows how sensitivity changes over temperature with different load resistances. In this case, a value between 1 kΩ and 10 kΩ will be optimum for 0 to 50 °C.

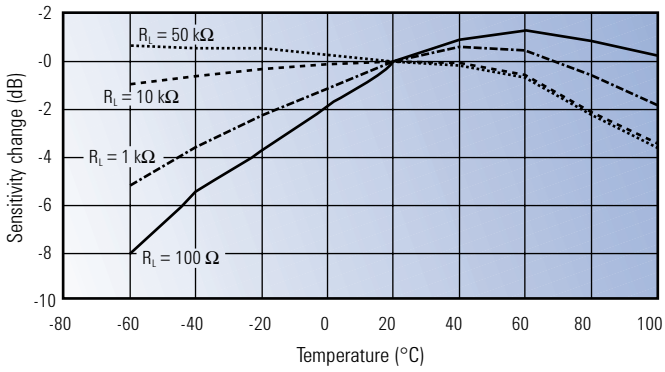


Figure 3. Typical output response with temperature (Pin < -20 dBm) (Schottky diode).

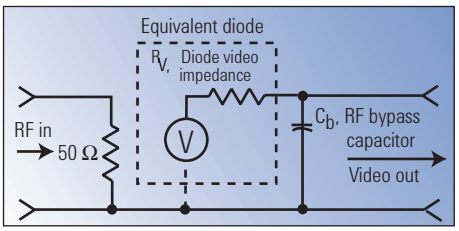
Rise time

In applications where the frequency response of another microwave device is being measured, or where a fast rise time response is required for accurate measurements, the rise time of the detector becomes very important. It is critical to note that the rise time is dependent upon the characteristics of the detector AND the test equipment.

Figure 4 shows the typical equivalent circuit of a test detector, and can help in devising the external terminations and cables to connect to an oscilloscope or other instrument. The following equation gives the approximate rise time for different conditions of load resistance and capacitance. Note that rise time can be improved (lowered) with a termination less than 50 Ω. This rise time improvement comes at the expense of lower pulse output voltage. The lower voltage can be overcome with the gain of a high performance oscilloscope.

$$\mathbf{T_r}\ (10\%\ \text{to}\ 90\%) = \frac{2.2 * \mathbf{R_L} * \mathbf{R_v} * (\mathbf{C_L} + \mathbf{C_b})}{\mathbf{R_L} + \mathbf{R_v}} = \frac{0.35}{\mathbf{BW}}$$

Where
$\mathbf{R_L}$ = Load impedance
$\mathbf{R_v}$ = Video impedance
$\mathbf{C_L}$ =



Typical values:

R_v (diode video impedance) = 1.5 kΩ [1]

C_b (RF bypass capacitor) = 27 pF nom.

[1] @ 25 °C and P_{in}<-20 dBm. Extremely sensitive to power and temperature.

Figure 4. Detector model.

Broadband match (SWR)

In many applications, the match (SWR) of the detector is of prime importance in minimizing the uncertainty of power measurement. If the input of the detector is not well matched to the source, simple and multiple mismatch errors will result, which reduces the accuracy of the measurement.

Figure 5 represents the mismatch error introduced by multiple reflections caused by mismatch between the detector and the source. For a detector SWR of 2.0 and source SWR of 2.0, this uncertainty is ±1.0 dB. For the LBSD and PDBD models, the integration of the diode with the 50 Ω matching resistor results in excellent broadband match. Both LBSD and PDBDs utilize thin-film technology which yields a precision matching circuit that minimizes stray reactance and yields very good performance. Figure 6 displays typical SWR for the Agilent 8473B,C LBSD detector and the Agilent 8473D PDBD detector.

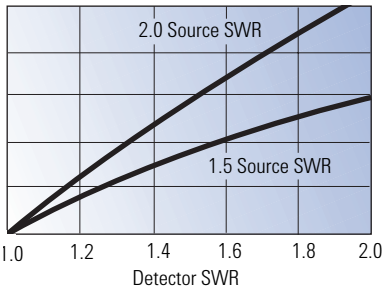


Figure 5. Mismatch error from detector and source mismatch.

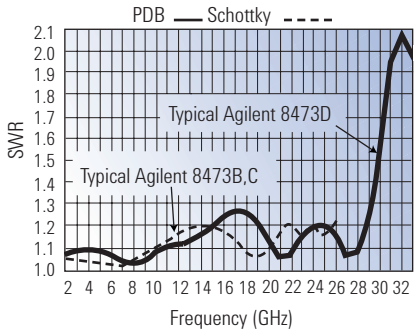


Figure 6. Typical SWR of detectors.

Square law performance

When detectors are used in reflectometer and insertion loss setups, the measurement uncertainty depends on the output voltage being proportional to input power. The term square law comes from the output voltage being proportional to the input power (input voltage squared). Most microwave detectors are inherently square law from the P_{tss} level up to about -15 dBm. Figure 7 shows this characteristic.

Figure 8 shows detector output in dB relative to P_{in} = -20 dBm. As P_{in} exceeds -20 dBm, the detector response deviates from square law. The user can select a load resistor that will extend the upper limit of the square law range beyond ±15 dBm. By choosing Option 002, 102 (optional square law load), the deviation from ideal square law response will be ±0.5 dB (although the sensitivity specification is decreased by a factor of 4).

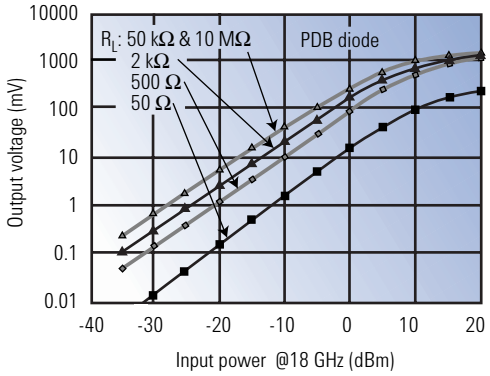


Figure 7. Typical detector square law response (mV).

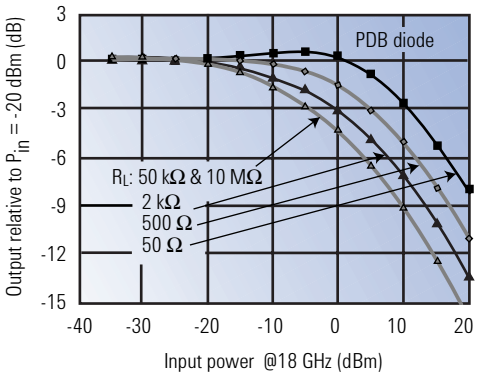


Figure 8. Typical detector square law response (dB).

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