Is Bias Current Necessary?

Application Note 987

Introduction

Conventional Schottky detector diodes are tested and specified with 20 microamperes of DC bias. The bias current reduces the junction resistance so that most of the detected voltage appears across the load resistance. In some applications the diode is used to monitor power rather than to detect a low level signal. In this case, the signal level may be high enough to reduce the junction resistance sufficiently without the use of DC bias.

The Need for Low Junction Resistance

A detector diode may be considered as a voltage source in series with the diode resistance. The output voltage is taken from a load resistance in series with the diode. This circuit is a voltage divider. The detected voltage is divided between the diode and the load. The useful output voltage is

$$V_o = \frac{V_{oc} R_L}{R_L + R_D} = \frac{V_{oc}}{1 + \dfrac{R_D}{R_L}}$$

For best performance the ratio of diode resistance to load resistance should be small. In many cases load resistance cannot exceed 100 K ohms in order to keep the response time small enough to handle fast pulses.

Junction Resistance Value

Junction resistance may be calculated from the diode equation

$$I = I_S (e^{\frac{V}{0.027}} - 1)$$

with V the voltage across the junction and I_S a constant. The inverse derivative is the junction resistance

$$R_j = \frac{0.027}{I + I_S}$$

The constant, I_S, called saturation current is about 0.7×10^{-9} amperes for the Agilent 5082-2755 detector diode. With 20 microamperes of DC
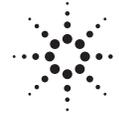
bias the junction resistance is 1350 ohms. At zero bias the resistance is about 40 megohms.

Measured Detected Voltage

Figure 1 shows the detected voltage with 20 microamperes bias and with zero bias. Above -20 dBm the rectified current is high enough to change the diode junction resistance. The upper curves show the detected voltage when the circuit is tuned at each input power level to match the changing diode impedance. The lower curves show the reduced output level when the tuning is not changed.

The lower diode resistance with DC bias is small compared to the load resistance. In this case the measured voltage is the open circuit voltage.

With zero bias the diode resistance is much higher than the load resistance so most of the detected voltage appears across the diode rather than across the load. However, at higher input levels rectified current flows through the diode and reduces the junction resistance. The voltage divider action is no longer significant and the output approaches the detected voltage of the biased diode.

Summary

With a load resistance of 10^5 ohms or less, zero bias detection with the Agilent 5082-2755 diode is not successful at low levels. The junction resistance is much higher than the load resistance so that very little detected voltage appears across the load resistance. At higher input levels the junction resistance is reduced by rectified current. At power levels above -8 dBm the zero bias performance is within one dB of the biased performance. When larger values of load resistance are permitted the bias may be omitted at even lower input power levels.
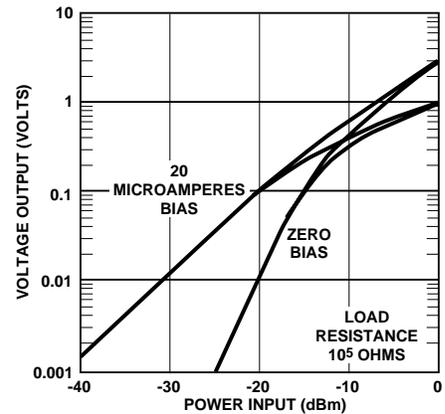

Figure 1. Detection Characteristics of Schottky Diode 5082-2755