DIODE JUNCTION TEMPERATURE & THERMAL RESISTANCE MEASUREMENTS

The use of diode junction forward voltage for junction temperature (T_J) sensing was discussed previously (see TB-02 DIODE TEMPERATURE SENSING*). When this technique is combined with the application of Heating Power (P_H), the measurement of junction temperature rise (ΔT_J) resulting from applied P_H leads directly to the T_J, thermal resistance (θ_{JX}) or thermal impedance ($Z_{\theta JX}$) of the diode for a specific set of environmental and time conditions; the X subscript defines the reference environmental condition.

The electrical test method (ETM) for diode thermal measurements uses a three-step sequence of applied current levels to determine a change in junction voltage (ΔV_F) under Measurement Current (I_M) conditions. The setup for the measurement is shown in Figure 1. First, I_M is applied and the diode-under-test junction voltage is measured - the measurement value is referred to as V_{Fi}. Second, I_M is replaced with a desired amount of Heating Current (I_H) for a time duration consistent with the steady-state or transient data required. During this time the diode voltage (V_H) is measured for determining the amount of power (P_H) being dissipated in the diode. Third, I_H is removed and quickly replaced with I_M and a final junction voltage measurement is be made - this voltage is referred to as V_{Ff}The three-step operation shown graphically in Figure 2.

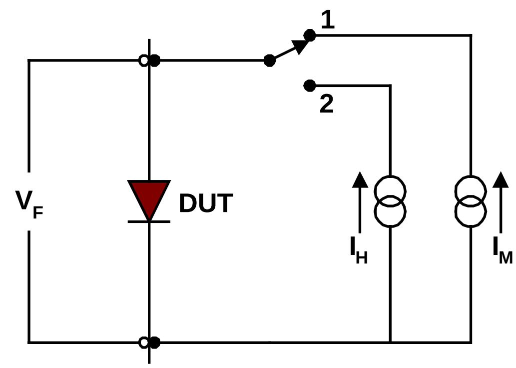

Figure 1 Test circuit for thermal measurements.

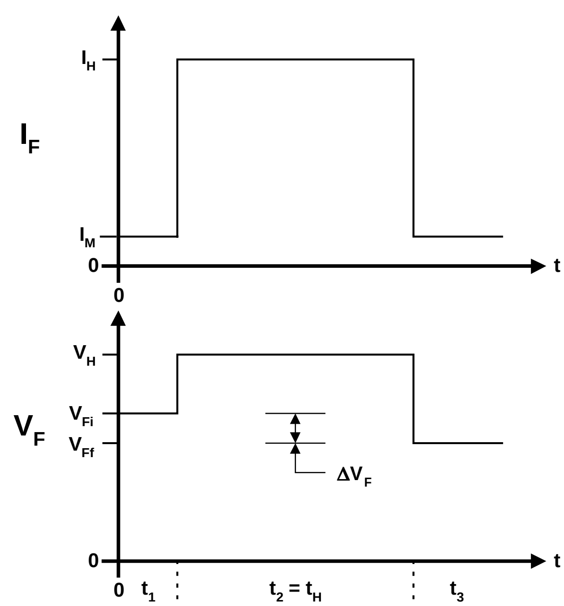

Figure 2 Current and Voltage waveforms for diode thermal measurements.

Once this three-step measurement process has been completed and the appropriate data collected, the next step is to use the data to compute T_J and θ_{JX} (or $Z_{\theta JX}$) as follows:

$$\Delta V_F = \left| V_{Fi} - V_{Ff} \right|$$

$$\Delta T_J = K \times \Delta V_F$$

$$T_J = T_{Ji} + \Delta T_J$$

where T_{Ji} is the initial temperature of the diode junction before the start of the measurement.

DIODE JUNCTION TEMPERATURE & THERMAL RESISTANCE MEASUREMENTS cont'd

The same data with the addition of P_H and the appropriate selection of Heating Time (t_H) can also be used to calculate the diode thermal resistance as follows:

$$\theta_{JX} = \frac{\Delta T_J}{P_H} = \left[\frac{K \times \Delta V_F}{I_H \times V_H} \right]$$

The value of t_H and the environmental conditions determine the meaning of the thermal resistance X subscript. For example, if the diode case is isothermally well heat sunk and the t_H value is in the one second range (typically for most smaller diode packages), then device case (C) becomes the suffix to produce θ_{JC}. (See TB-04 HEATING CURVES AID THERMAL CHARACTERIZATION* for information on examples of other values of t_H.)

One of the most important aspects of electrical test method thermal measurements is centered on the ability to make the second diode forward voltage (V_{Ff}) measurement quickly and accurately enough. This topic is discussed in TB-06 COOLING CURVES CORRECT MEASUREMENT DATA*.

* The Tech Briefs referenced above are available for viewing or download from the TEA web site, http://www.thermengr.com.