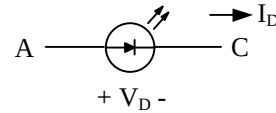
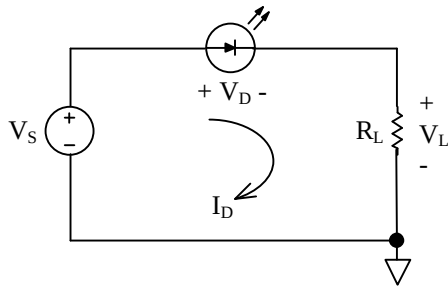


Ping-Pong-Ball Sensor and Interface Fundamentals

Prepared by: P. David Fisher and Diane T. Rover

This application note presents an overview of the theory behind the operation of the ping-pong-ball sensor circuit and its interface to the microcontroller. The concepts presented are fundamental and can easily be extended to other sensor and interface applications.

1. The Light-Emitting Diode—General



A = Anode

C = Cathode

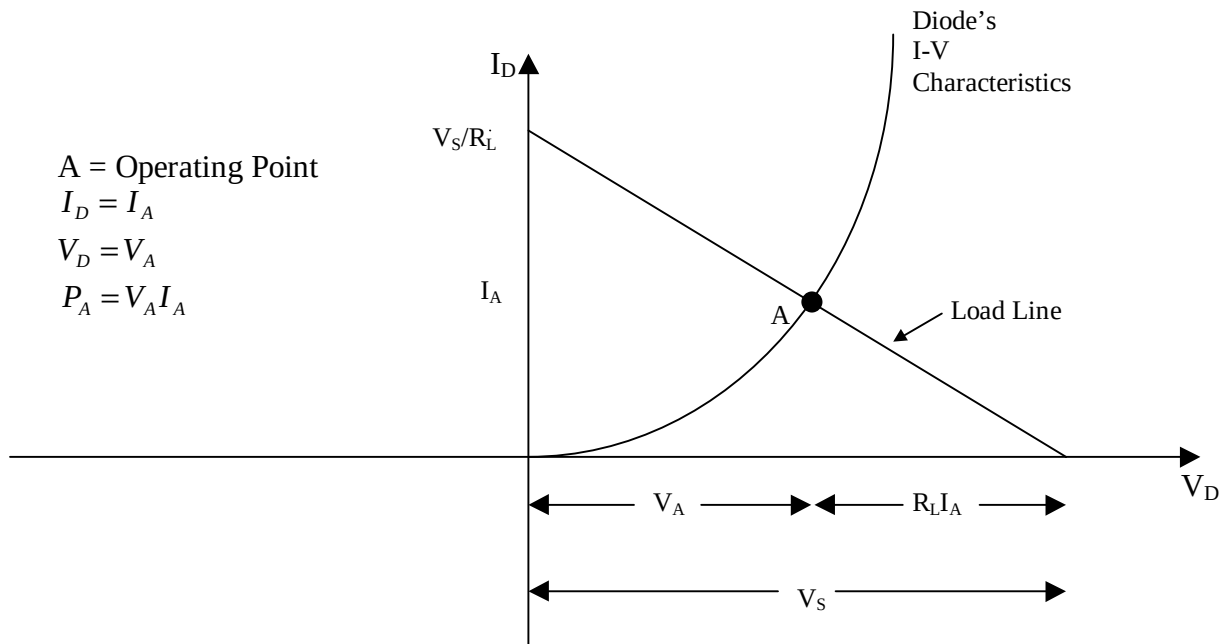
$$-V_S + V_D + R_L I_D = 0$$

$$V_D = V_S - R_L I_D \quad (1)$$

=====

$$\text{When } I_D = 0A; \quad V_D = V_S \quad (2)$$

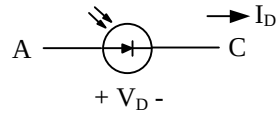
$$\text{When } V_D = 0V; \quad I_D = V_S / R_L \quad (3)$$



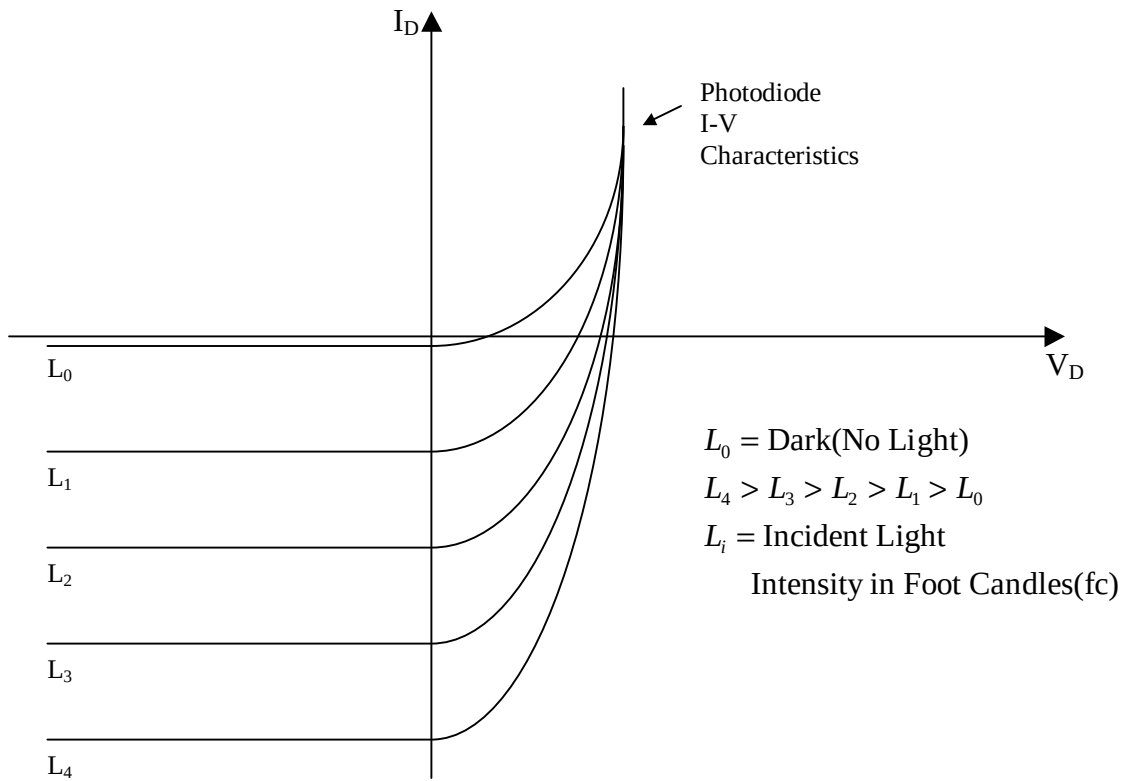
From the data sheet for the IN6264 LED,

$$I_{\max} = 100\text{mA} @ V_F = V_A = V_D = 1.7\text{V}, \text{ and } P_{\max} = 0.17\text{W}.$$

2. The Photodiode—General



The same bias circuit applies and the same circuit equation; hence, the same load line applies.

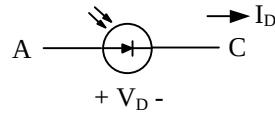


3. The Photodiode—Forward-Biased Case

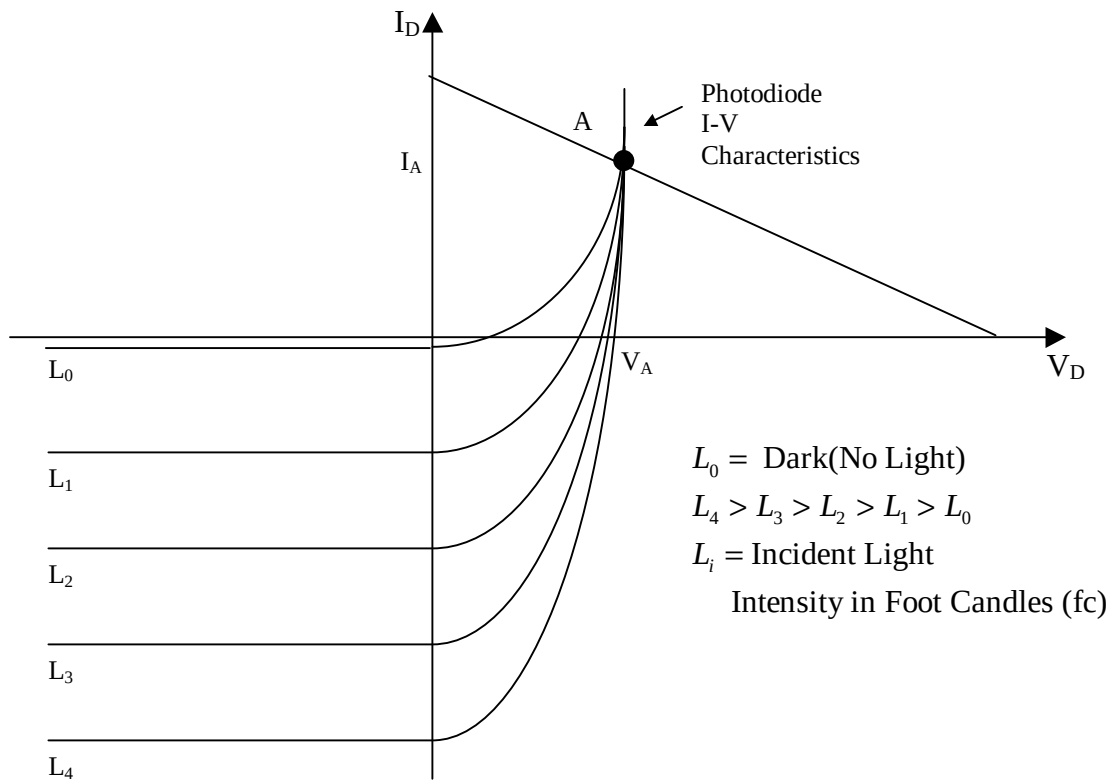
Case 1— $V_s > 0$ (Diode is forward biased)

$$I_A > 0; V_A > 0; P_A = V_A I_A > 0$$

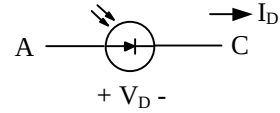
Behaves like a normal diode.



The same bias circuit applies and the same circuit equation; hence, the same load line applies.



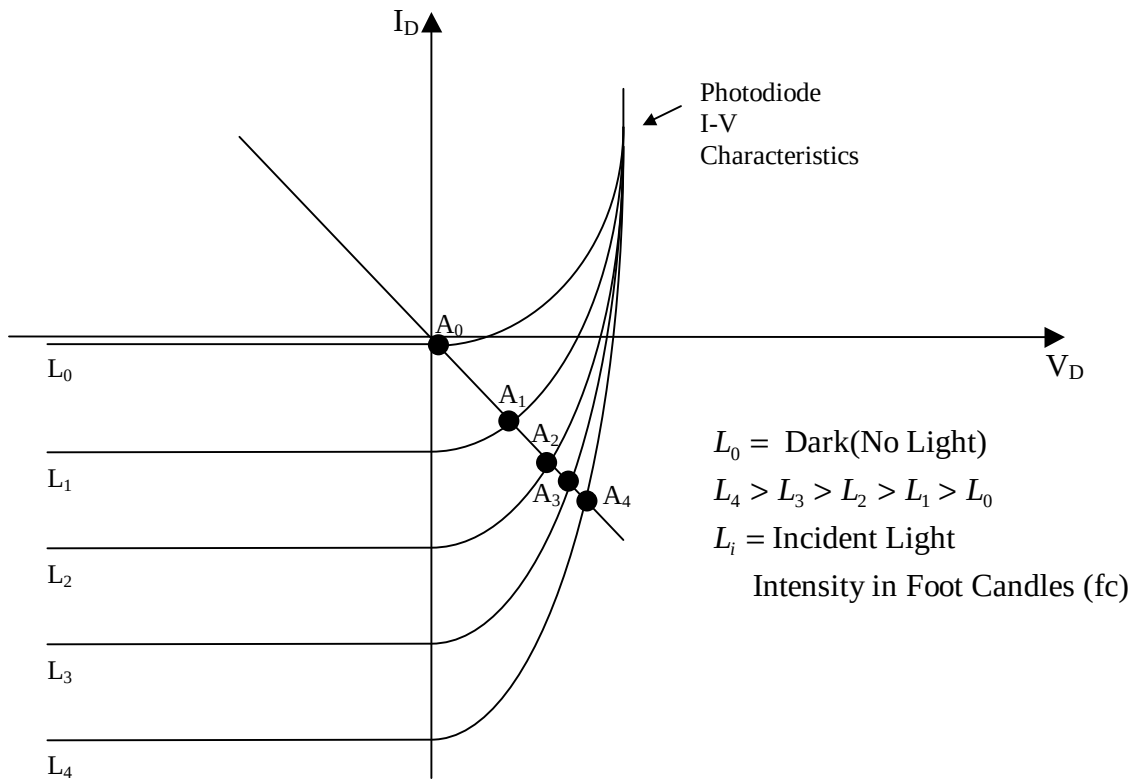
4. The Photodiode—Unbiased Case



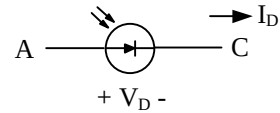
Case 2 – No Supply Voltage ($V_s = 0V$)

1. Operating point depends upon light intensity.
2. In general, the stronger the light the more positive V_D is and the more negative I_D is.
3. $PA = V_A I_A < 0W$. The photodiode (solar cell) is supply electric power.

The same bias circuit applies and the same circuit equation; hence, the same load line applies.



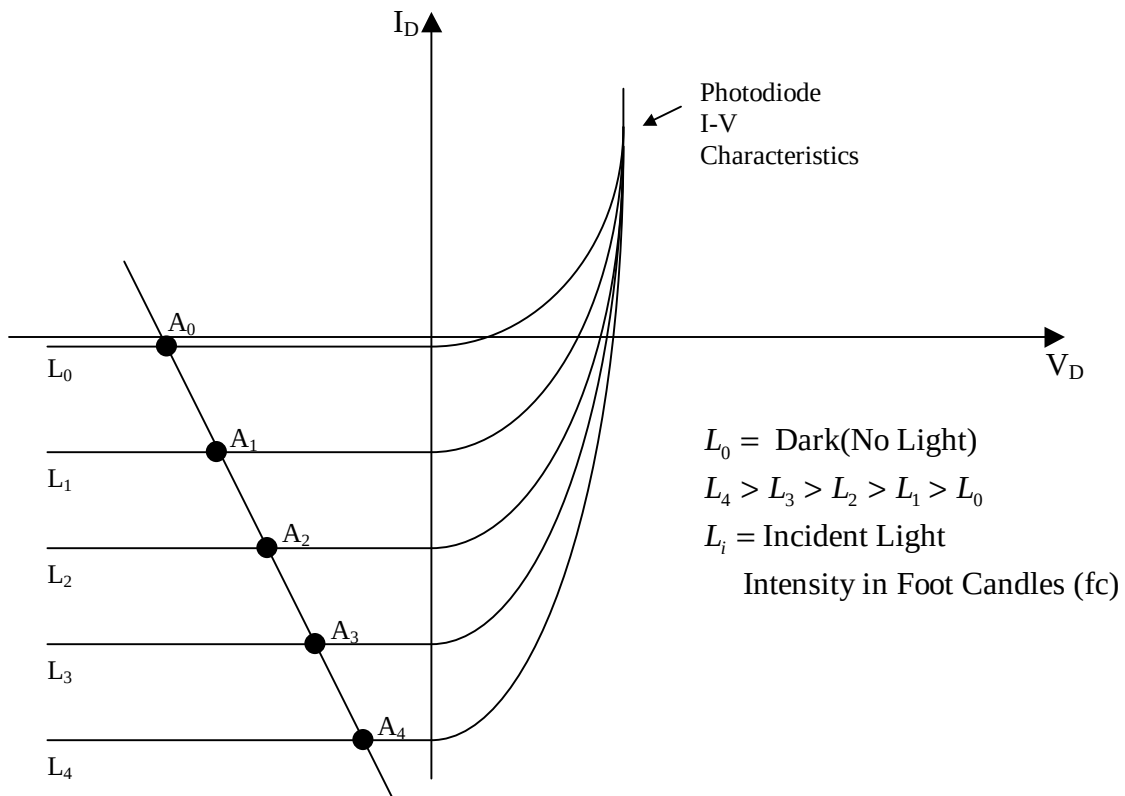
5. The Photodiode—Reverse-Biased Case



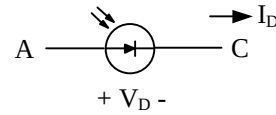
Case 3 – Photodiode is reverse biased ($V_D < 0V$)

1. $V_D < 0$; $I_D < 0$; $P_A = P_D > 0W$
2. Increasing the light intensity, causes $I_D = I_A$ to increase and $V_D = V_A$ to decrease.

The same bias circuit applies and the same circuit equation; hence, the same load line applies.



6. The Photodiode—Detecting a Ping-Pong Ball



Case 4 – Ping-Pong-Ball Operating Points

A_0 = PPB blocking LED in dark room.

A_1 = PPB blocking LED in a lit room.

A_2 = PPB not blocking LED in a lit room.

$$V_L = R_L I_A \quad \left\{ \begin{array}{l} V_{L0} = R_L I_{A0} \\ V_{L1} = R_L I_{A1} \\ V_{L2} = R_L I_{A2} \end{array} \right. \quad \text{PPB Detector Circuit Equations}$$

The same bias circuit applies and the same circuit equation; hence, the same load line applies. The design engineer's challenge is to convert voltages V_{L1} and V_{L2} into logic-level signals; i.e., logic-level "0" and logic-level "1", respectively. The challenge is compounded by the fact that operating points A_1 and A_2 may vary from sensor to sensor and will vary with ambient room lighting conditions.

