PI3HDMI412AD, PI3HDMI412FTxx, PI3HDMI413
The Circuits for Leakage Prevention in Source Application

by Paul Li

Introduction

There is a possible condition in which a current leakage may occur caused by the ESD diodes in PI3HDMI412FTxx, PI3HDMI413 and PI3HDMI412AD, for notebook and DVI card source applications.

The current leakage caused by the ESD diodes in PI3HDMI412FTxx, PI3HDMI413 and PI3HDMI412AD

In the notebook and DVI card applications using PI3HDMI412FTxx, PI3HDMI413 or PI3HDMI412AD, a current leakage "I-Leak" (figure 1) could occur when the notebook (or DVI card) is in stand-by mode (sleep mode), in which the 3.3V output of the main regulator is turned-off its while the LCD monitor is powered on.

The "I-Leak" is caused by the ESD diode (figure 1), which will forward the 3.3V from the LCD monitor (powered-on) and will rise up the VDD voltage to 2.5V when it is supposed to be 0V in stand-by mode, thereby the other circuits loaded to the main regulator will not be able to get into the stand-by mode.
The current of "I-Leak" will also violate the DVI/HDMI specs, which require that the source output must be high-Z in a stand-by mode.

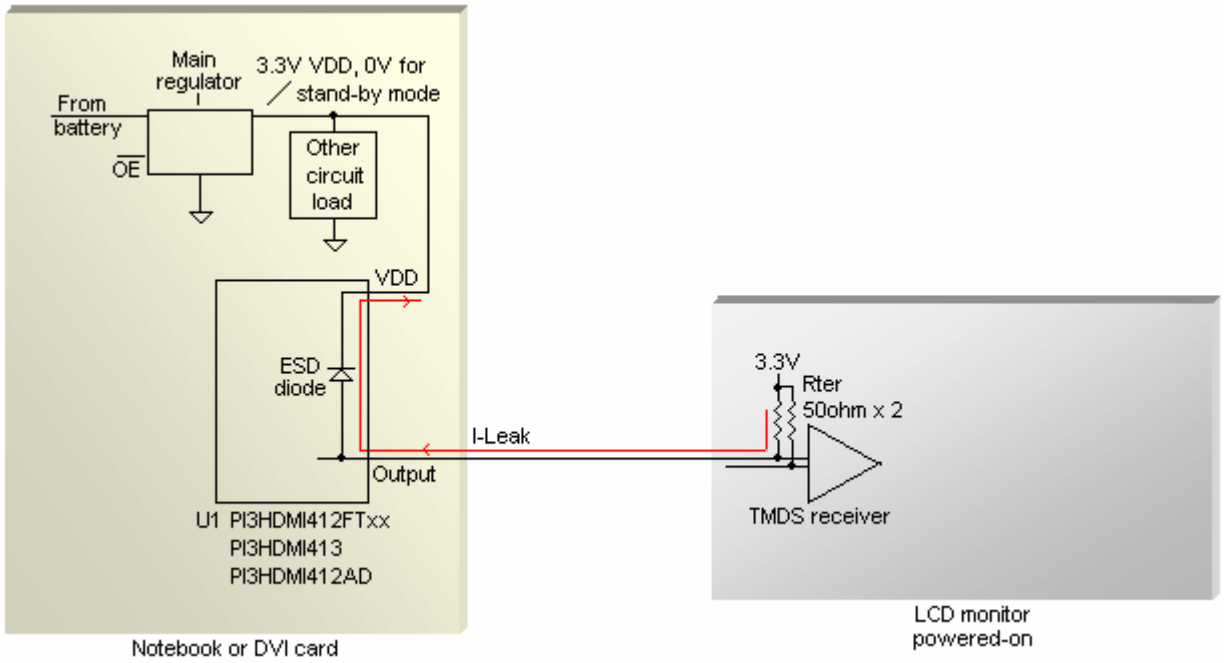

Figure 1: The current leakage "I-Leak" caused by the ESD diode

The solution of using Schottky diode

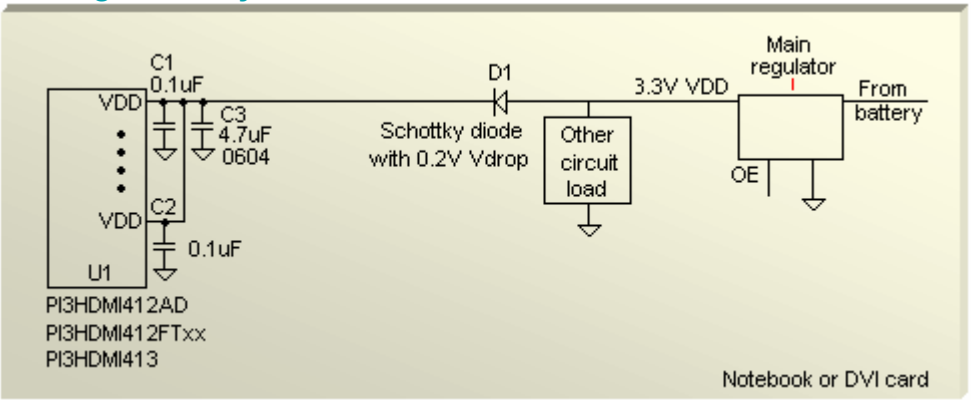

Figure 2: The leakage prevention circuit using Schottky diode

The D1 in figure 2 will stop the current leakage flowing back from the LCD monitor to the main regulator. To facilitate the PCB space arrangement, the Schottky diode D1 can either be located close to U1, or away from U1 as in figure 2, with a Vdd trace width wider than 30mil.

C3 can be cancelled for PI3HDMI412FTxx or PI3HDMI413 due to their small ICC current, but keep C3 for PI3HDMI412AD because of its larger Icc current.

For applications using passive switch PI3HDMI412FTxx with small AC Icc current, use a 0.5A (or 1A) Schottky diode is good enough for low forwarding voltage drop about 0.2V.

For applications using redriver PI3HDMI412AD with 130mA typical AC Icc current, use a 1A (or above) Schottky diode for low forwarding voltage drop about 0.2V at 130mA.

A reference of the 1A Schottky diodes can be found at www.digikey.com

1. Digikey part number 641-1015-1-ND, a 40V 1A Schottky diode “CDBA140-G” from “Comchip”, SMA package, $0.031/125000 units, datasheet: http://www.comchiptech.com/docs/CDBA120-1100.pdf

2. Digikey part number MBR130T1GOSCT-ND, a 30V 1A Schottky diode “MBR130T1G” from “On Semiconductor”, SOD-123 package, $0.074/102000 units, datasheet: http://www.onsemi.com/pub/Collateral/MBR130T1-D.PDF

The price of the 1A Schottky diode can be lower if it was at higher volume and directly purchased from the manufacturer’s wholesale channel.
Even though the Schottky diode solution mentioned above will resolve the leakage issue, but it is recommended to use the transistor circuit in figure 3 below for lower VDD voltage drop.

The solution of using transistors

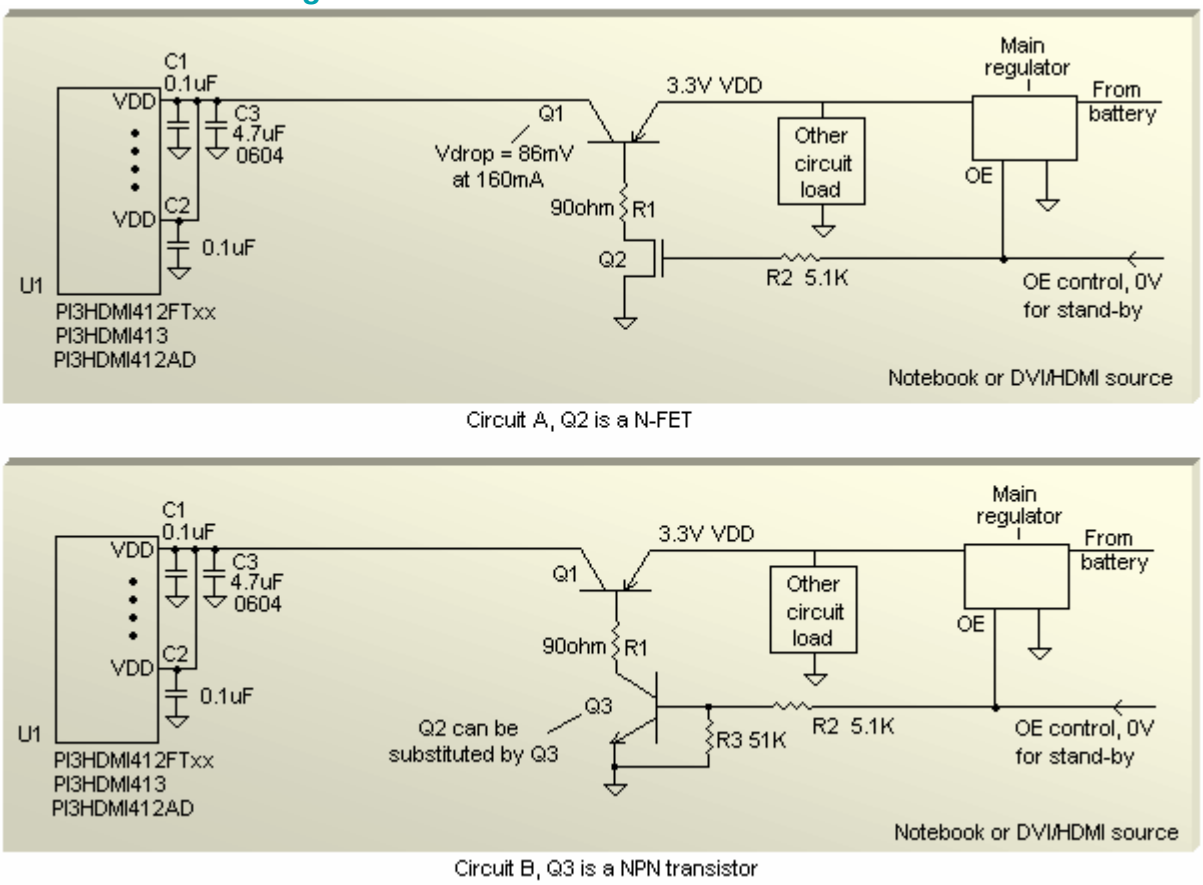

Figure 3: The leakage prevention circuit using transistors

The Q1 and Q2 in figure 3 will stop the current leakage flowing back from the LCD monitor to the main regulator. The advantage of using transistors versus using Schottky diode is that the transistors will have lower VDD voltage drop, typically 86mV at 160mA (tested using BC80725MTF from Fairchild). Therefore, the VDD of PI3HDMI412AD can be above 3.2V at 130mA AC Icc current.

It is not recommended to connect the gate (or base) of Q2 (or Q3) to the 3.3V VDD out from the main regulator directly, because otherwise when the main regulator is turned-off as in a stand-by mode, the voltage charged in the 3.3V VDD bypass capacitors will keep the Q2 (Q3) to be “on”, thereby the Q1 will not be able to stop the 3.3V leakage from the LCD monitor.

The key is to ensure a 0V voltage at the gate (or base) of Q2 (or Q3) in the stand-by mode.
In case the 0V gate control voltage is not available in the application, use the Schottky diode solution.

The reference transistors of the Q1, Q2 and Q3 can be found at www.digikey.com

- Q1, Digikey part number BC80725MTFCT-ND, a 45V 0.8A PNP transistor “BC80725MTF” from “Fairchild”, SOT-23 package, $0.022/12000 units. As a real test result, BC80725MTF will have 86mV saturation voltage drop (Vce-saturation) at 160mA, using a load circuit similar to the circuit in figure 3. Datasheet: http://www.fairchildsemi.com/ds/BC/BC807.pdf.
- Q2, Digikey part number 2N7002LT1GOSCT-ND, a 60V 115mA MOSFET N-Channel transistor “2N7002LT1G” from “On-Semiconductor”, SOT-23 package, $0.024/102000 units, datasheet: http://www.onsemi.com/pub/Collateral/2N7002L-D.PDF.
- Q3, Digikey part number BC817-25LT1GOSTR-ND, a 45V 500mA NPN transistor “BC817-25LT1G” from “On-Semiconductor”, SOT-23 package, $0.013/102000 units, datasheet: http://www.onsemi.com/pub/Collateral/BC817-16LT1-D.PDF.

The total price of the Q1, Q2 (or Q3) can be even lower, estimated less than 4 cents, if it was purchased at higher volume and directly from the manufacturer’s wholesale channel.

It is recommended using the transistors solution rather than use the Schottky diode for lower VDD voltage drop.

To facilitate the components PCB arrangement, the Q1 and Q2 (or Q3) can either be located close to U1, or away from U1 as in figure 3.