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AN-6022TC — FSUSB30/31 兼容 USB2.0 故障條件的要求

概述

設計人員通常利用 FSUSB30/31 開關來加入高速 USB 功能到現有系統設計中。他們常常會問，“我怎麼確定我的設計完全符合 USB 標準？”許多設計者選擇 FSUSB30/31 開關的初衷是它的優良的信號處理能力和低功耗以及較小的封裝。除了維持信號的完整性之外，FSUSB30/31 開關還有能力容許 Vbus 的短路，從而滿足 USB 2.0 標準，以下片斷摘自 USB 2.0 標準 7.1.1 節。

耐短路

一個 USB 收發器被要求經得起持續的短路，這些短路是從 D+ 和/或 D- 到 VBUS, GND 以及其它數據線，或在連接插頭處的電纜屏蔽。短路時間最短 24 小時並要求無性能降低。建議收發器件的設計應承受此種不確定短路故障。在短路的情況下並且在發送和接收時間的 50%（所有支持的速度）裡面設備一定不被損壞，發送期間信號由一對稱的信號組成，發送信號在高低電平之間切換。該短路要求必須滿足 Vbus 的最大值（5.25V）。

FSUSB30/31 開關的 Vcc 最大值是 4.6V。乍一看，人們可能會認為這種開關並不符合 USB 的要求，對於沒有飛兆半導體斷電過壓保護電路的市場上其他標準模擬開關來講，這個結論是正確的。如果 FSUSB30/31 開關被配置恰當，它完全符合 USB 耐短路要求。在兩種不同的情況下 USB 系統將經受斷路故障狀態。它們分別為開關被斷電和開關帶電情況下。

斷電過壓保護

一個沒有保護的模擬開關必須帶電才能確保正確的功能狀態，在開關完全上電以前當一個正的數據信號出現在這種開關上，這個信號無法被保證正確處理。除非這種模擬開關設計有特殊的電路，這一電路能夠確保開關在斷電時擁有關斷隔離度，否則的話，無論 OE 和 S 處於什麼狀態信號泄流都會同時出現在單刀雙擲開關的兩個輸出管腳。當 Vcc 的管腳處於漂浮或下拉的情況下，USB 開關管腳（D+, D-）上的輸入信號有可能給開關內部電路供電而使信號泄流到通道的另一端。圖 1 表明了這種現象，在這裡開關內部的 Vcc 為 Vsw-0.8V。Vsw 為在開關斷電情況下數據端口(D+/D-)上的電壓。在此情況下，內部的 Vcc 使開關再次導通並且輸入信號會穿過，開關無法真正關斷。

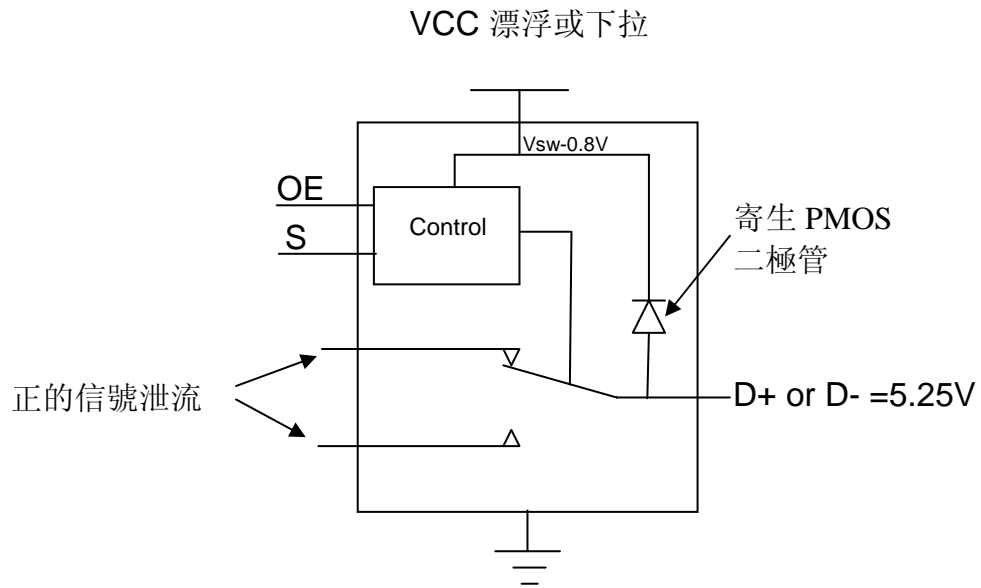


圖 1 傳統模擬開關在掉電情況下無法關斷從而導致信號泄流

通常 USB 開關被置於外圍裝置中用於內部核心器件的隔離。在 USB 短路的例子中，開關被期望長時間耐短路（至少 24 小時）。當一個正的輸入電壓提供給一個沒有保護的開關時，開關可能會損壞，這種損壞來自於從開關的輸入端到 Vcc 之間的過電流。電流的路徑是由於開關的寄生二極管而導致的。當輸入電壓高於 $V_{cc}+0.5$ 伏時二極管正向偏置。通常大約需要 0.5 伏二極管就可以導通。輸入電壓越大電流會越大（呈指數關係），從而電流會很快超過最大電流允許值。當一個元件在過流情況下被破壞后它通常會繼續出現過量漏電流，即使輸入回到正常的操作狀態它可能再也不工作。圖 2 舉例說明了上述情形。

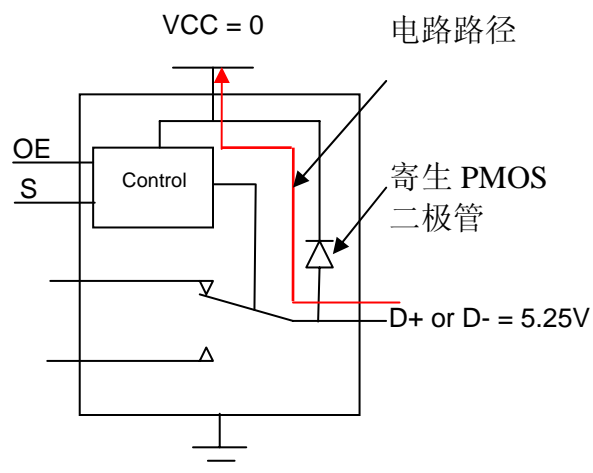


圖 2 傳統模擬開關在過電壓情況下的電流泄流路徑

在斷電過壓的情況下，FSUSB30/31 開關因內部設計有一種電路能夠防止信號泄流而確保系統的可靠性。當 V_{cc} 等於 0 伏時，無論 OE 和 S 處於什麼狀態開關通過隔離輸入和輸出來防止信號泄流，同時開關能夠防止從信號端到 V_{cc} 端的漏電流。當開關被斷電時輸入端看起來是高阻狀態，寄生二極管正向偏置被阻止。值得注意的是 FSUSB30/31 開關斷電過壓保護是在共用端 (D+, D-)，這是因為最常見的應用是 USB 數據端口共享或復用。在這種情況下，共用端是唯一可能遭遇 V_{bus} 短路的端口。因此基於飛兆半導體對於 USB 應用的理解，斷電過壓保護被加在這兩個 I/O 端。圖 3 時一個共同端共享應用的實例。

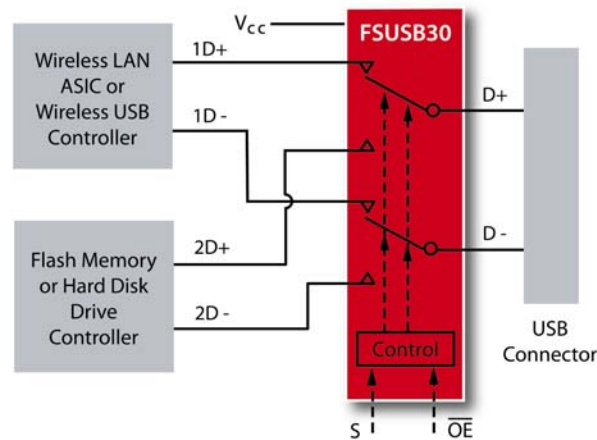


圖 3 典型的 USB 連接器共享應用

帶電過壓保護

USB 2.0 標準還提到 USB 裝置在傳送數據時能夠耐 V_{bus} 短路。因為 USB 開關在帶電狀態下才傳送數據，所以它必須能耐住 D+ 和 D- 端高達 5.25 伏的短路電壓。在此情況下， $V_{cc}+0.5$ 伏對於 D+ 和 D- 是可以接收的。然而沒有其它外圍電路的幫助，過量電壓會導致可靠性失敗，這種情況應該被避免。例如，當開關供電為 3.6 伏並且 D+ / D- 經受 5.25 伏 V_{bus} 短路時，如果沒有輔助電路，無論標準的模擬開關還是斷電過壓保護開關都不能保證可靠的操作。但是在系統供電電源和 USB 開關 V_{CC} 之間加一個 100 歐姆的電阻就可以解決這個問題。這種限流電阻可以限制回流到 V_{cc} 從而使電流保持在安全的操作範圍。在這種應用裡面，5.25 伏電壓會傳輸到被選擇的輸出口。由於這個原因，在 USB 數據路徑上所有的元件能力承受帶電的 5.25 伏 V_{bus} 短路。圖 4 舉例說明了電路板的設計修改，此設計能夠允許 USB 開關(FSUSB30/31)完全符合無論是帶電或掉電情況下 USB2.0 標準的 V_{bus} 短路要求。

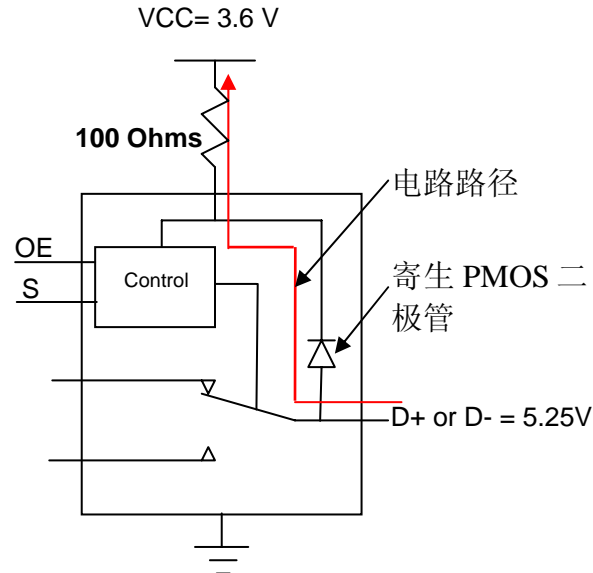


圖 4 通過加入 100 歐姆限流電阻 USB 開關在帶電狀態下滿足 USB 2.0 標準的短路故障要求

結論

FSUSB30/31 開關是第一個量產的帶掉電保護的 USB 開關產品，它的掉電或斷電過壓保護作用可以防止 USB 2.0 標準所述的 V_{bus} 故障狀態。同時加一個如圖 4 所示的 100 歐姆限流電阻可以承受開關帶電時數據線與 V_{bus} 的短路故障。

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