C_{SS} vs Loading Matching Guidance for FPF2890

AND90282/D

For FPF2890, an internal soft−start circuit controls inrush current due to highly capacitive loads and the slew rate can be adjusted vias an external capacitor.

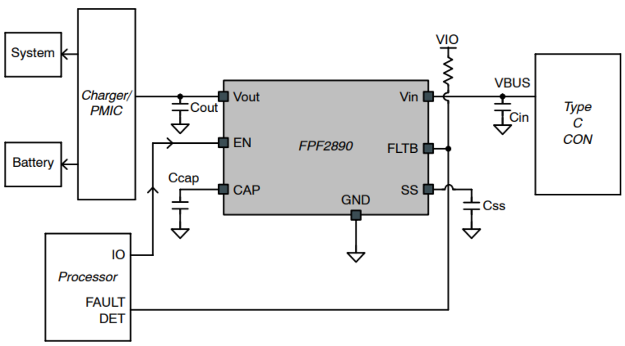

Figure 1. Shows an Example of the FPF2890 Typical Application

Slew Rate

Slew rate can be a fixed value or adjusted by external components. For the FPF2890, the slew rate can be controlled by the C_{SS} capacitor value. The output ramps up time (t_{ON}) is programmable by an external soft−start capacitor (C_{SS}). The following formula provides the estimated 10% to 90% ramp up time. Equation 1:

$$t_{ON} = \left(\frac{2 \cdot C_{SS} \cdot V_{IN}}{112.5} \right) \times 1000 \qquad \text{(eq. 1)}$$

Where C_{SS} is nF and t_{ON} is μs.

Figure 2 shows an example that uses a power supply to start up the FPF2890.

Figure 2. V_{IN} = 22 V, C_{SS} = 5.6 nF, C_{IN} = C_{OUT} = 10 μF

Type of Load

- *Capacitive Load:* In most systems, capacitors are placed throughout a design to ensure there are no voltage drops at the application. While charging these capacitors can result in an inrush current that can cause several problems for the system.
- *DC Load and Capacitor Load:* Most of the notebooks have two or more charging ports, if one of these ports is working then there is DC current at this port. If a high voltage level source plugs into other ports, there is switching between the two ports. The second port needs to work well, not only charging the output capacitors but also the DC current of the

As the voltage increases, an inrush of current flows into the uncharged capacitors. This inrush current can also be generated when a capacitive load is switched onto a power rail and must be charged to that voltage level. The amount of inrush current into the capacitors is determined by the slope of the voltage ramp, expressed as Equation 2:

$$I_{inrush} = C_{load} \times \left(\frac{d_V}{d_t} \right) \qquad \text{(eq. 2)}$$

Where *INRUSH* is the amount of inrush current caused by a capacitance, *C* is the total capacitance, d_V is the change in voltage during ramp up and d_t is the rise time during voltage ramp up.

Inrush Current Limit at Start Up of FPF2890

FPF2890 has the current limit protection functions at start up period. There are two power limitation levels will be applied according to different voltage level of V_{OUT}, when $V_{OUT} < 1$ V like V_{OUT} was short to ground directly, power limitation is 24 W and current limitation is 4.8 A, while Vout goes up above 1.1 V, the power limitation increased to 42/60 W, but the load current will not over 8 A max at any condition, and when this limitation last more than 512 s, then FPF2890MN will turn off switch. Detailed information please refer to FPF2890 (onsemi.com).

Challenges with Inrush Current

One key challenge is if the power supply cannot handle the amount of inrush current needed to charge that capacitor, then the voltage on that rail will be pulled down. Another key challenge is if the load is too big then the inrush current will become huge which may trigger FPF2890 power limit and cause the system cannot start up normally.

Figures 3 and 4 shows examples that use start up the FPF2890 with bigger capacitor load.

Figure 3. V_{IN} = 22 V, C_{SS} = 5.6 nF, C_{IN} = 10 μF, C_{OUT} = 250 μF

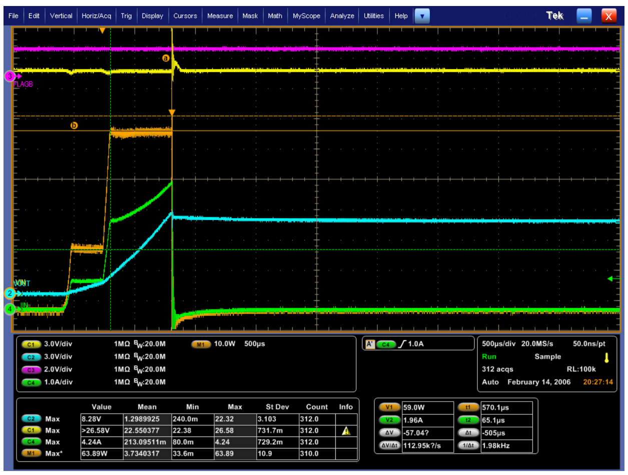

Figure 4. V_{IN} = 22 V, C_{SS} = 5.6 nF, C_{IN} = 10 μF, C_{OUT} = 280 μF

(For this file the yellow line is V_{IN}, Blue is V_{OUT}, Green is I_{IN}, Orange is Power of (V_{IN} − V_{OUT}) × I_{IN}, Purple is FLTB signal.)

From Figure 3, V_{OUT} could be powered up successfully but there is around 410 μs time trigged the power limit. If we increase the C_{OUT} value more, showing as Figure 4, then the V_{OUT} cannot power up successfully. If 280 μF capacitor is needed to power up for customer system, then you can reduce inrush current by increasing the voltage rise time on the load capacitance and slowing down the rate at which the capacitors charge. Figure 5 shows an example that powers up C_{OUT} 280 μF capacitor using 10 nF C_{SS} capacitor.

Figure 5. V_{IN} = 22 V, C_{SS} = 10 nF, C_{IN} = 10 μF, C_{OUT} = 280 μF

As mentioned earlier, there is DC current with capacitor load at actual application scenarios. Figure 6 shows two load switch switching function. For example, VIN_1 is the 5 V type C charger and VIN_2 is a 20 V DC jack charger. When type C charger is charging the downstream system of 3 A current with 300 μF capacitor, then 20 V DC jack is plugged in and enabled the FPF2890_2 channel. Because of the IDTRCB function of FPF2890, the V_{OUT} value is higher than FPF2890_1 channel, so this switch will be turned off and then the system needs FPF2890_2 to control the charging function for downstream system successfully.

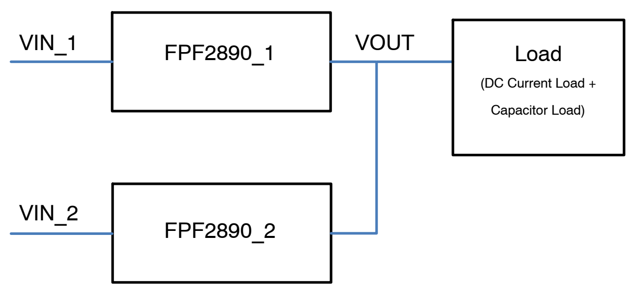

Figure 6. Two Load Switch Switching Application Block

Figure 7 and 8 shows examples that using different C_{SS} to switch two load switches with 3 A DC current and 300 μF capacitor. When the C_{SS} value is 10 nF, the FPF2890_2 can start up normally while the power margin is small. Once changed the value to 20 nF, the power margin becomes larger for this application.

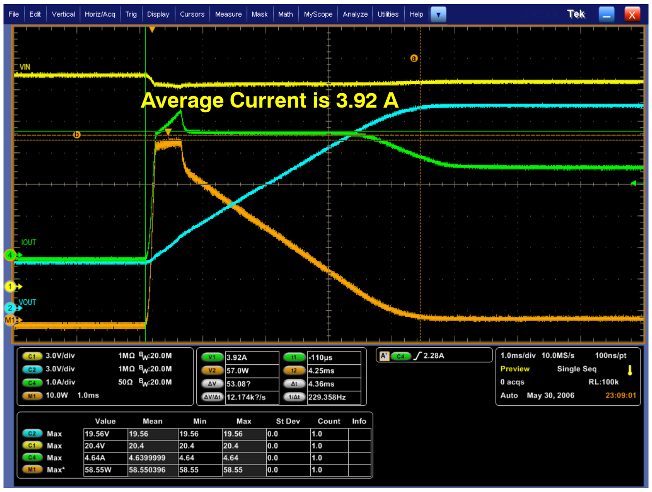

Figure 7. V_{IN} = 20 V, C_{SS} = 10 nF

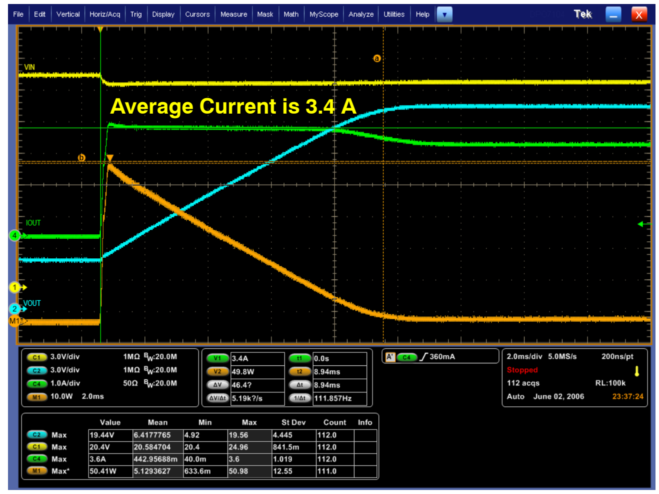

Figure 8. V_{IN} = 20 V, C_{SS} = 20 nF

How to Design for Inrush Current

For the application of above cases, we can increase the startup time of V_{OUT} to solve the power limitation and enable the system to start up normally. But we also need to check the SOA curve for the max current limitation of safety application. For Figure 8, the average current is 3.4 A, based on SOA curve, the average SOA current around 8 ms is 5.5 A Figure 9.

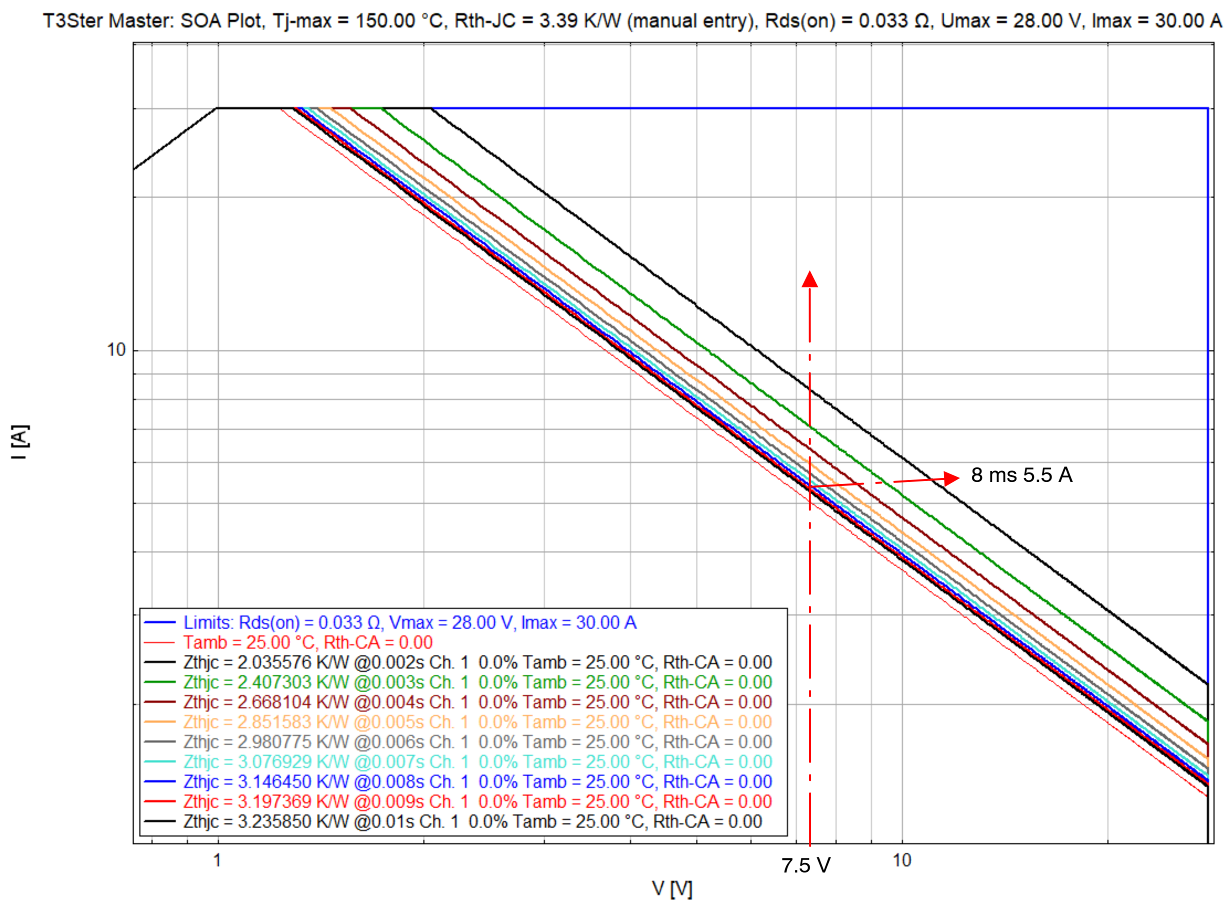

Figure 9. Safe Operating Area (SOA) Curves for Power Switch

This setting condition is reasonable and safety. In addition, when two switches change, customers can use this software to reduce the DC current.

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