Guidelines for bring-up of a PowerPSoC based system

The importance of this document lies in the fact that PowerPSoC based systems normally involve voltages up to 32V and currents as high as a few amps flowing through the power channels. This makes these systems unique with respect to standard programmable digital systems. Therefore, when a board is manufactured to run a high power system using PowerPSoC, a certain method must be used to perform board bring up. Failure to do this could result in a destroyed board, destroyed device and destruction of other components on board.

Basic Equipment required:

a) **Programmable power supplies** with adequate current supply capability and current limiting feature. For example, consider a system that runs at 30V and 1A with 4 channels of 2 LEDs each.

- 2 LEDs @ 1A will have a Vf of approx 3.5 – 4V.

So total voltage drop per channel = 8 V

- Current through LEDs = 1A
- Therefore, power consumed per channel = 1A x 8V = 8Watts.
- Conversion efficiency for each channel can be assumed at 90% (it is usually more). This brings input power for each channel to 8/0.9 = 8.88Watts
- Total Power = 8.88 x 4 = 35.5 Watts
- At an input voltage of 30V, the input current required = 35.55 / 30 V = 1.19A.
- So the power supply should be able to supply at least 1.4A (with a margin of safety) at 30V.

The current limiting feature is very important for this power supply because it will help protect damage to the PowerPSoC and other components on board in case of short circuits or board design faults.

b) **Digital Multimeter** with high precision to measure voltages at various points such as the

- Input de-coupling capacitor
- LED load
- 5V rail of the system
- Any other digital signals

c) **Oscilloscopes** with the following features:

- Probes that can withstand more than the maximum voltages present in the system
- Bandwidth of a few 100 MHz
- Preferably a hall effect based current probe and interface to the oscilloscope.
- Basic trigger functions based on signals coming in from probes.

Stages of System bring up

Stage 1 – 5V rail and digital system bring up

It is not recommended to configure PowerPSoC for its final functionality especially if it involves the power channels. The proper functionality of the power channels depends on the stability of the 5V rail. *If the on chip switching regulator is not used in the design, this step can skipped.* However, a blank project should still be programmed into the system and the power supply given to check the 5V rail.

In brief, the first step should be to program PowerPSoC with a simple program that does not turn on any of the power channels, ensure that the 5V regulator is enabled. A standard digital block like a PWM can be populated and turned on to drive a low current LED to indicate functionality of the core and processor.

- Start a new project in PSoC Designer for PowerPSoC.
- In the global configuration settings in the interconnect or chip view, the final option pertains to the switching regulator. Make sure it is enabled if the design uses the regulator on the chip. If the design does not use this regulator, then make sure it is disabled.
- Optionally, populate an 8 bit PWM in one of the PSoC Digital blocks, set up the parameters for it and connect its output to a GPIO that can be connected to an LED for instance (this is optional and just indicates that the processor and PSoC core is functioning)
- Generate application (using the build menu).
- Open the file main.c and in the main() function, start the PWM if populated. Run an infinite while loop (while (1);)
- Build the project (from the build menu) and program the device using a miniprog and PSoC programmer. The PSoC programmer can be opened by using the Program menu in PSoC Designer.
- Provide power to the part (this need not be the voltage level of the final application – any voltage above 7V and below 32V is acceptable).
- Measure the 5V rail using a multi-meter to ensure the voltage is at that level. Probe the 5V rail using an oscilloscope and check to make sure the supply is constant and has minimal noise on it.
- It is also a good idea to probe the inductor node of the switching regulator circuit to see the switching waveform of the regulator. The regulator will be switching at approximately 1MHz.
- If the PWM is populated and an LED is connected up to the GPIO which carries the PWM output, it should light up.

Once it is established that the 5V rail is steady and as expected, the next step can be performed.

Stage 2 – Power Channel bring up

The basic idea is to bring up the design in small steps to its full rated functionality. As an example, consider a PowerPSoC based LED drive system driving 4 channels of LEDs at 1A with a supply of 30V.

- In the chip view of the project in PSoC Designer, populate the power channels, configure them and connect the modules up.
- This usually at a minimum involves the Current Sense Amplifier (called CURSENSEHW user module) and the Hysteretic controller (called HYSCTRL user module). Follow the guidelines in application note AN51012 – Firmware Design Guidelines for using PowerPSoC to perform this.
- Generate the application.
- The idea is to try **one power channel at a time** starting with low currents and low voltages. Follow the instructions in the application note AN51012 to do this.
- For example, in this system, in main.c set up and start channel 1 to drive a current of 300mA at an input voltage of 10V (try this with a small load like 1-2 LEDs at first so that low voltages are possible). Keep increasing the voltage in small steps every time.
- At each voltage level, monitor the following:
    a. The FET drain-source (pin SWx to PGND of that channel) voltage. If it is an external FET, monitor the signal at the FET drain to its source.
    b. The current through the load by using a hall effect based current probe around the wires.
    c. If an external FET is in use, monitor the gate to source voltage also.
    d. If possible, it is also good to monitor the power supply and 5V rail when the channel is on to check if there is noise on it. Noise on the power rail could mean layout issues or inadequate decoupling capacitors on the 5V or high voltage power rails.

The waveforms should show regular, periodic switching. The ramp up time of the current waveform should match the time when the V_{DS} (drain-to-source voltage) is 0V and V_{GS} is 5V; ramp down time should match the time when V_{DS} is at the input high voltage and VGS is at 0V.

The following screenshot is an example of what the waveforms should look like. The green signal is the current, below which is the yellow V_{DS} signal below which is the blue V_{GS} signal.

At any point if the waveforms have noise on them, are irregular, there is sudden increase in intensity of the LEDs, the power supply clamps the current or the board/device are getting very hot, the system should be turned off and examined for faults.

- Once it is ensured that the system is functioning as expected up to the rated voltage for the system, the current should be increased in steps. For example, in this system, increase the current in steps such as 350mA, 450mA, 600mA, 750mA, 900mA, 1A. At each step, monitor the signals and the power supply to make sure all signals look as expected.
- Perform this process for each power channel by itself. Once it is ensured that all the power channels necessary are functioning properly on their own, then turn on 2 at a time and then 3 at a time and so on each time doing a quick check of the signals. Sometimes, turning on 2 or 3 power channels together can expose layout issues or decoupling capacitance issues.

Stage 3 – Other auxiliary feature bring up

If the system had other features needed to be implemented, like communication interfaces, analog inputs for temperature or potentiometers or anything else, it can be done finally. It is important to make sure the power channels work first.

Following these guidelines as much as possible will help in bringing up the system quickly and in a manner safe for the system and the devices on board.