

## Extending Battery Life to Portable DVD Players with a PowerSage<sup>®</sup> PMIC

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### Executive Summary

Packet Digital's PowerSage<sup>®</sup> power management integrated circuits (PMIC) have been shown to substantially improve the battery life in portable DVD players compared to designs with conventional voltage regulators. This application note describes how to easily design a Packet Digital PowerSage PMIC into a portable DVD player to reduce power consumption and extend battery life.



## 1 PowerSage Introduction

Packet Digital's PowerSage line of products are highly integrated power management ICs with step-down PWM controllers. Interfaces for monitoring activity, coupled with advanced On-Demand Power® algorithms, enable the regulated output voltages of the integrated switching regulators to be adaptively scaled in correlation with actual power demand. The real-time tracking of supply voltage to activity enables maximum power savings by minimizing the power spent on maintaining worst-case headroom in portable DVD player power distribution. Integrating a PowerSage PMIC into a DVD player will save power during both active and idle states.

## 2 Reference Documents

- PSG5220 and PSG5320 Datasheets
- PSG5220 and PSG5320 Layout Guidelines
- Setting On-Demand Power Registers Application Note

## 3 Portable DVD Player Power Delivery

PowerSage PMICs are well suited for use in portable DVD player platforms, specifically for regulating the 5V and 3.3V voltage domains. The 5V and 3.3V rails are responsible for the largest portion of power consumption in a DVD player, including moving the read head, reading operations and spinning the DVD. Large energy spikes are seen when moving the read-head or changing DVD layers. On-Demand Power operation, integrated in the PowerSage PMIC, allows the regulated output voltage to autonomously adapt to the large spikes while lowering overall power consumption by scaling the voltage during times of less energy need. Compared to competing solutions of providing static voltage regulation, the PowerSage PMIC will significantly reduce energy consumption which will increase battery life.

## 4 Design Implementation

PowerSage PMICs are high-efficiency switching regulators with many different output options, some of which can provide both 3.3V and 5V supplies with a single PMIC. The output voltages and all of the settings for Packet Digital's On-Demand Power may be programmed as default values during manufacturing or could be modified by simple serial bus commands to the PowerSage PMIC.

### 4.1 Power Connections

The input power to the PowerSage PMIC is supplied by the DVD player battery/brick. PowerSage PMICs support wide input voltage ranges, allowing for a wide variety of battery sizes.

Analog circuitry and I/O in the PowerSage PMIC operate at 5V. PowerSage PMICs often have a 5V LDO, which in addition to powering the analog circuitry, can be used to power other low current fixed 5V devices.

Internal digital logic is powered at 1.8V. The PowerSage PMIC supplies this voltage through an internal linear regulator and should not be connected to an external 1.8V supply. The linear regulator output, LDO1V8, must be connected to VDD and be appropriately decoupled as described in the appropriate PowerSage PMIC datasheet.

Table 1 summarizes the power connections to the PowerSage PMIC.

**Table 1: Power Connections to the PowerSage PMIC**

Description	Voltage	PowerSage PMIC Lead	DVD Player Platform
Analog and I/O Input Supply Voltage	5V	V50	N/A – supplied by PowerSage PMIC
Input Voltage	6.5V to 24V	VIN	Battery/Brick
Digital Input Supply Voltage	1.8V	V18	N/A – supplied by PowerSage PMIC

## 4.2 Connections to I/O

The PowerSage PMIC autonomously scales the voltage supplied to the DVD player based on information gathered from sensing current and activity. The activity inputs, nACT1 and nACT2, provide activity information from the 5V and 3.3V rails to PowerSage. Connect the activity indicator signal to nACT with a 10k pull-up resistor to 1.8V at LDO1V8. The PowerSage PMIC will operate without the nACT signals, but the full potential for energy savings may not be fully realized, and is therefore not recommended. Do not leave nACT floating. Pull-up to LDO1V8 when not in use.

Communication to the register map is provided via the SMBUS interface through the SMBDAT and SMBCLK pins. System designers can choose to connect these directly to the Embedded Controller or through an SMBUS hub. The SMBUS pull-up resistors should be connected to 3.3V.

## 4.3 Current Sense Resistor Sizing

PowerSage PMICs typically include current sensing circuitry to monitor load current in real time. The current sense resistor and applicable circuitry for each channel should be sized appropriately for the specific load that will be powered by the channel. For example, a smaller sense resistor should be used for a higher power DVD player to ensure the input differential voltage of the current sense circuit remains in the 80mV working range ( $10\text{mV} < V_{\text{TRIP}} < 90\text{mV}$ ).

These large spikes are used to activate On-Demand Power circuitry. To keep system performance optimal it is beneficial to run equivalent On-Demand Power schemes on both the 5V and 3.3V rails. This is done by tying both On-Demand Power algorithms together externally. See Figure 1 for the detailed application schematic.

## 5 On Demand Power Configuration

Packet Digital developed its innovative, patented On-Demand Power technology to reduce power consumption by autonomously monitoring systems using voltage scaling, distributing only the amount of power needed as demand for energy changes.

On-Demand Power technology unobtrusively senses activity within the system and correlates to the DVD Player demand for energy. Once the energy demand is determined, then the PowerSage PMIC power management will provide dynamic voltage scaling at the power supply to provide load management.

### 5.1 SMBUS Serial Communication

PowerSage PMIC internal registers are programmable via SMBUS to control On-Demand Power circuitry. Activity on each domain or channel is monitored by current sense and activity inputs. Please refer to the appropriate PowerSage PMIC datasheet for SMBUS communication specifications.

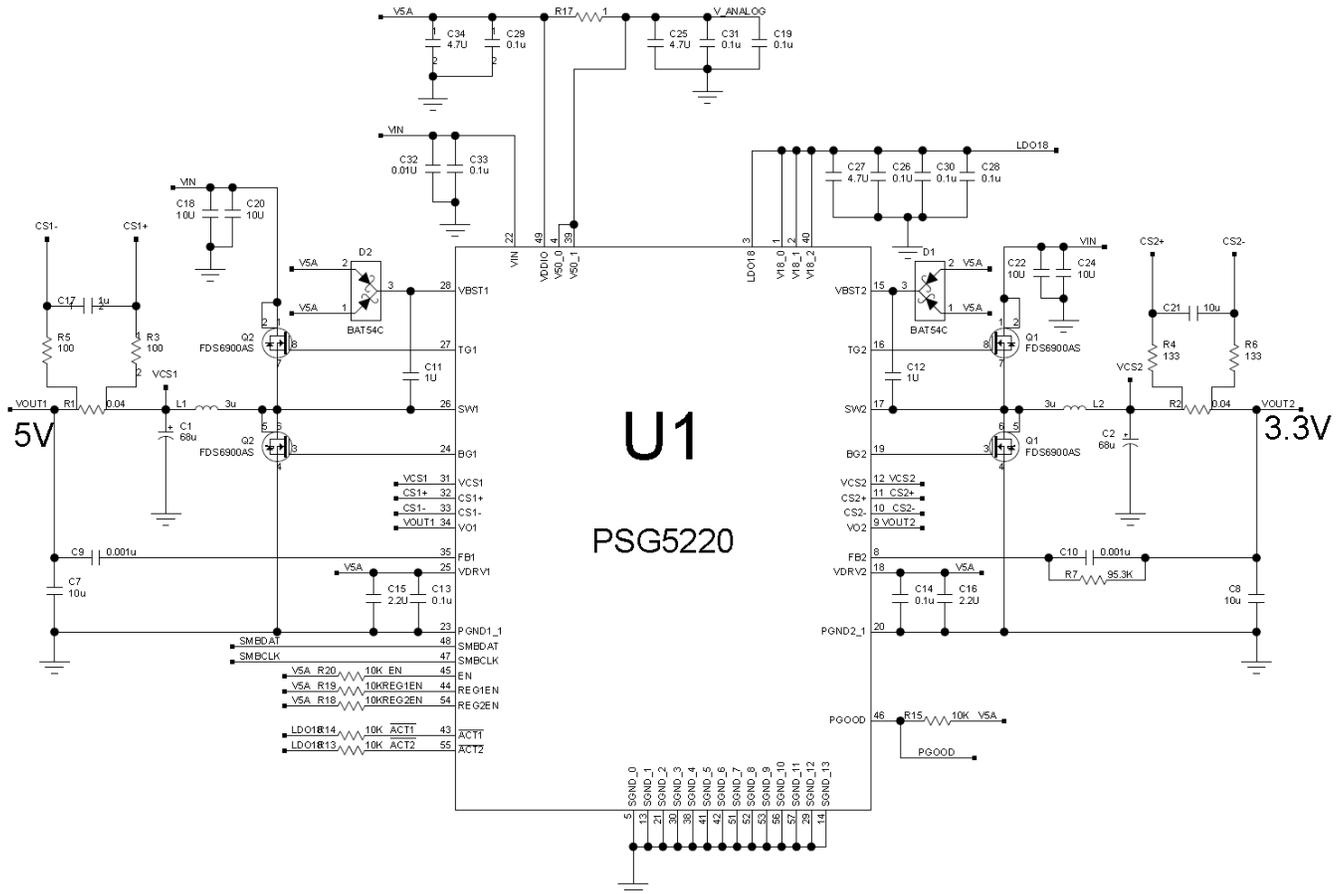
### 5.2 Configuration Registers

A number of configuration registers are set for the On-Demand Power circuitry to run properly in PowerSage PMICs. Voltage, threshold, and timeout registers can be set through the SMBUS interface. Packet Digital can supply the appropriate configurations for specific DVD Player applications.

Output voltage will vary based on system demand, managed by On-Demand Power algorithms. For more information on configuration of registers, please see the “Setting On-Demand Power Registers” application note.

## 6 Application Circuit

Figure 1 displays the PSG5220 5V and 3.3V application schematic. Other PowerSage PMIC application circuits will be similar.



**Figure 1: PSG5220 5V and 3.3V Application Circuit**

## 7 Sample Layout

Figure 2 is a typical 4-layer printed circuit board layout for the PSG5220, but is representative of other PowerSage PMICs as well. Care should be taken to minimize the trace length of high speed switching nodes and critical nets. Please contact Packet Digital for detailed layout guidelines.

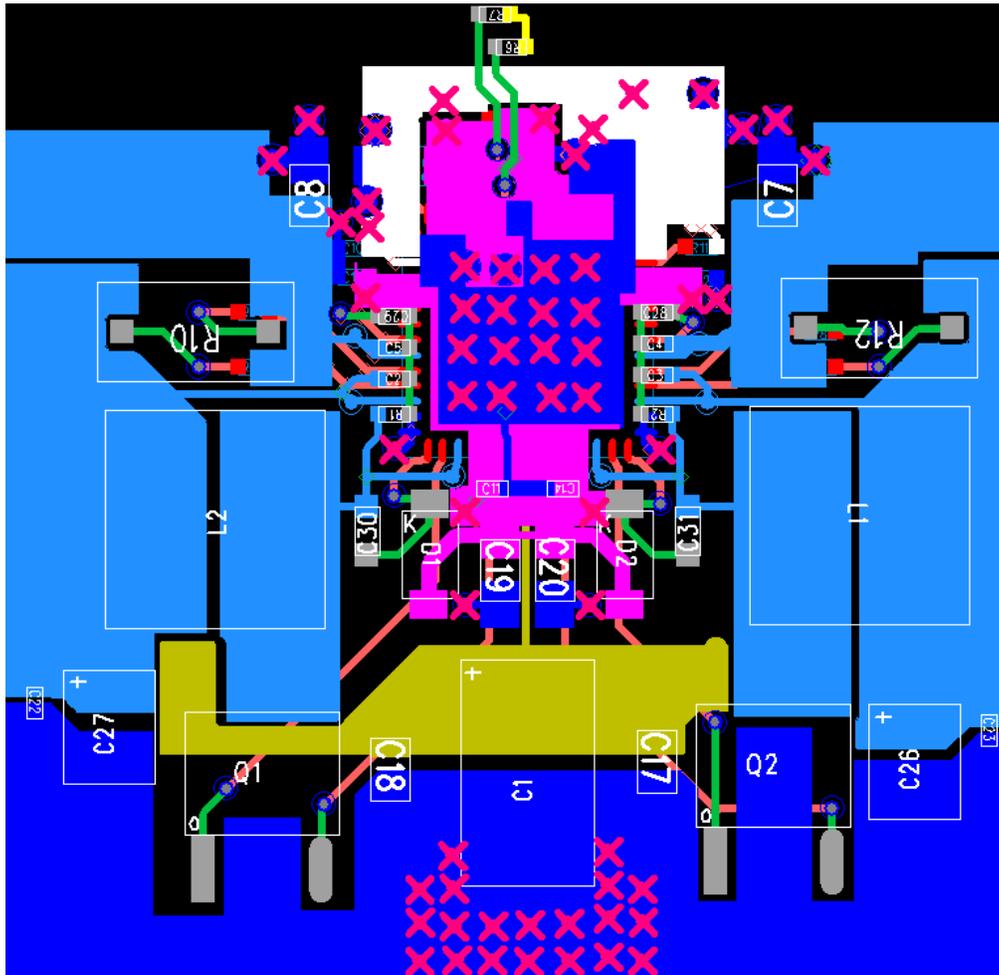


Figure 2: Sample Layout for PSG5220

## 8 Case Study – Power Savings with the PSG5220 for a Portable DVD Player

Packet Digital integrated the PSG5220 into a Phillips PD9000 portable DVD player as a test case to verify power savings.

The PSG5220 PMIC can be implemented in most portable DVD players that have the following characteristics:

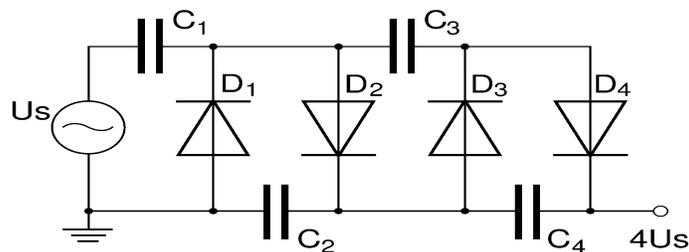
- 1) any battery whose voltage lies within the following range:  $6.5V < V_{IN} < 24V$ .
- 2) logic inputs of  $V_{IL} < 0.8V$  and  $2.1V < V_{IH} < 5.5V$ .

These are the hardware modifications that Packet Digital followed to integrate the PSG5220 into the DVD Player:

- Removed the DVD player's 5V and 3.3V voltage regulators.
- Removed the top and bottom MOSFETs. Note: These needed to be removed if the voltage regulator's top and bottom MOSFETs are not biased in a manner that keeps

them in the cut-off region. In the case where a Schottky diode is used in place of a bottom MOSFET, it can be left in the circuit.

- Removed the voltage regulator inductors to ensure proper functionality of the PSG5220. The large inductor pads provided an ideal place to connect the outputs of the PSG5220.
- Connected Vout1, 5V, of the PSG5220 to the inductor pad which was connected to the output Capacitor of the 5V rail.
- Connected Vout2, 3.3V, of the PSG5220 to the inductor pad which was connected to the output Capacitor of the 3.3V rail.
- Connected the Enable signals which were connected to the previous voltage regulators to the EN pin of the PSG5220. These are diode-OR connected. It should be noted that if this voltage is larger than  $V_{IH,MAX}$  a voltage divider needs to be utilized to ensure it is within the  $V_{IH}$  range of the PSG5220 which was noted above. If the previous voltage regulator's do not have an enable signal, use the DVD player power switch as the enable signal.
- Connected the input voltage from the removed regulator's MOSFETs to  $V_{IN}$  of the PSG5220.
- A simple voltage multiplier can be run off of either switch node to create voltage levels appropriate for the LCD. Figure 3 is an example voltage multiplier circuit (source: Wikipedia).



**Figure 3: Voltage Multiplier example circuit**

## 8.1 Power Savings and Battery Life Extension Results

Packet Digital was able to demonstrate 448mW of average power savings and extend battery life by 21 minutes by integrating PSG5220 into a portable DVD player, and enabling On-Demand Power technology.

## 9 Wrap-up

PowerSage PMICs are ideally suited for portable DVD player designs, bringing significant power savings and greatly extending battery life. A measured battery life improvement of 21 minutes is enough time to watch an additional TV episode on your portable DVD player!

## 10 Contact info

Packet Digital's world-wide engineering support team will assist you in integrating a PowerSage PMIC into your design. Please contact Packet Digital with any questions or for the latest reference design and layout guidelines.

Phone: 701.232.0661

Email: [web-sales@packetdigital.com](mailto:web-sales@packetdigital.com)