PR210

Spartan™-IIE Design 2

Single-Channel Linear Regulator Power Management Solution Providing up to 1.5 A from V_{IN} = 3.3 V and 950 mA from V_{IN} = 5.0 V

FEATURES:

- Independent linear regulators allow higher power dissipation than an integrated dual-channel solution.
- Linear regulator solution saves cost and space over a switching DC/DC solution.
- Control cost by using lower current linear regulators from the TPS79xxx family for U2 and U3 to meet specific application requirements.
- Linear regulators start-up fast, allowing large in-rush currents for charging decoupling caps and FPGA start-up. The current draw on the input power supply is minimized by the use of the:
    - External supervisory (SVS) IC, U1, which monitors the input rail and prevents the regulator from enabling until the input bulk capacitors (not shown in the schematic) are fully charged.
    - Soft-start circuit consisting of the external PMOS transistor Q3 and supporting passive components to provide 10 ms rise time for V_{CCINT}.
    - Sequential sequencing of V_{CCINT} then V_{CCO} using the discrete SVS circuit formed by bipolar transistors Q1 and Q2 and supporting passives to enable the V_{CCO} regulator, U3.
- The design meets Xilinx's V_{CCINT} and V_{CCO} start-up profile requirements, where applicable, including monotonic voltage ramp, in-rush current and power voltage ramp time requirements.

IMPORTANT WEB LINKS:

- Link to the TI home page for Xilinx FPGA power management solutions at http://www.ti.com/xilinxfpga for more information and other reference designs.
- Link to datasheets at http://focus.ti.com/lit/ds/symlink/TPS78601.pdf, http://focus.ti.com/lit/ds/symlink/tps79601.pdf, and http://focus.ti.com/lit/ds/symlink/tps3809k33.pdf.
- Link to application note SLVA118 http://focus.ti.com/lit/an/slva118/slva118.pdf to explore the thermal considerations in using linear regulators.
- Link to application note SLVA156 http://focus.ti.com/lit/an/slva156/slva156.pdf for more details on the soft start circuit.

IMPLEMENTATION NOTES:

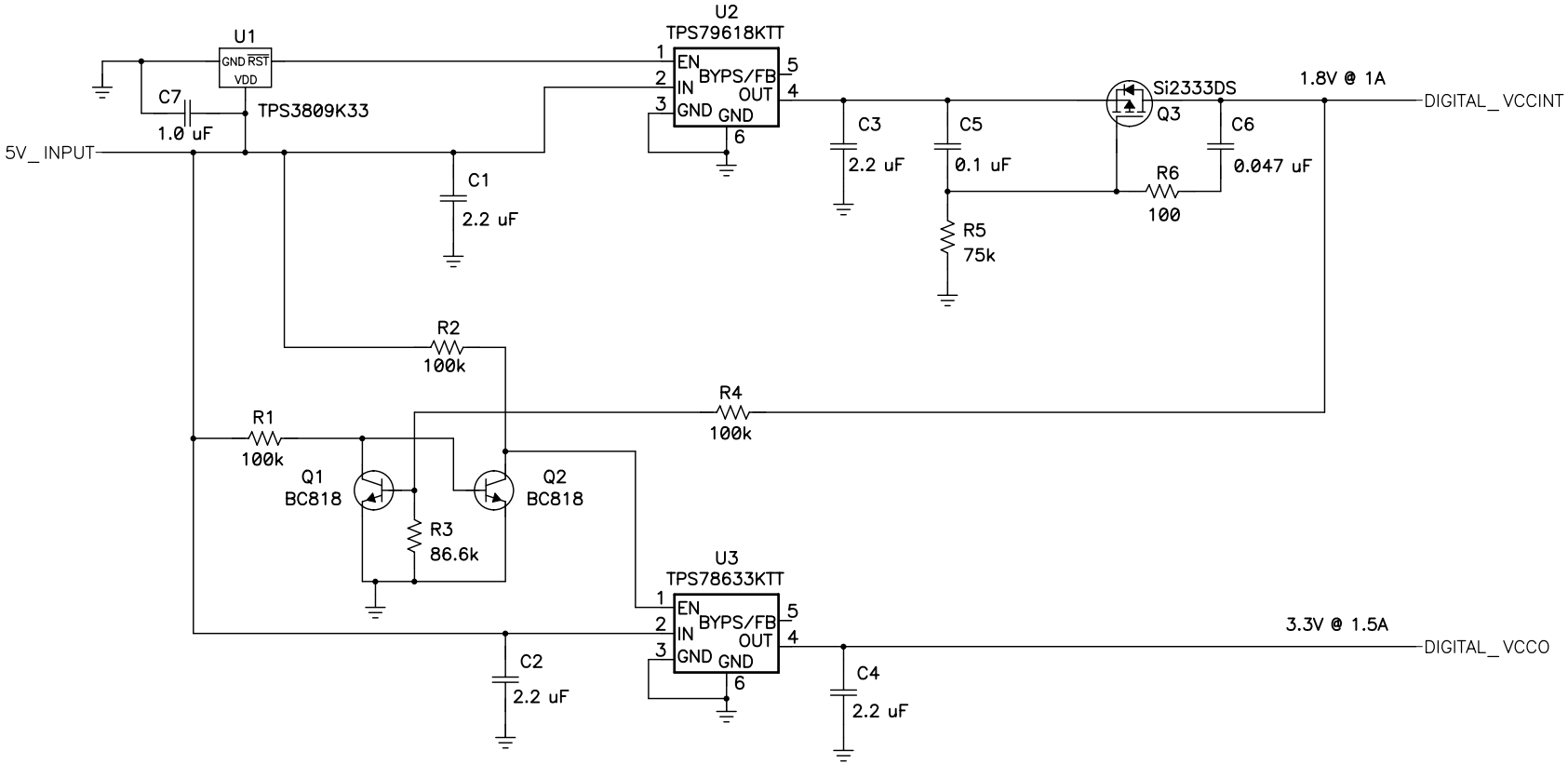
- **Sequencing:** Although Xilinx FPGAs **do NOT require it**, this reference design employs sequencing. This practice is consistent with good power supply design and prevents the input power supply from being pulled down due to supporting in-rush currents for charging large capacitive loads.

- **I_{CCINT} inrush current:** Mitigated by softstart.
- **V_{CCINT} minimum ramp time:** Met by Q3 softstart circuit.
- **Power Dissipation/Thermal Issues:** The DDPAK packaged regulators in this design are limited to 3W @ $T_A = 55^o$ C and no airflow, due to power dissipation limitation of the package.
    - Refer to the application section of the datasheet for maximum power dissipation at different ambient conditions as well as guidance on sizing the ground plane area underneath the package for heatsinking.
    - The linear regulator's output current can be computed by rearranging the following equation:
      $P_{Dmax} = (V_{IN} - V_{CCINT}) * I_{CCINTmax}$.

      As an example, with $V_{CCINT} = 1.8V$ and $P_{Dmax} = 3$ W:
        - $I_{CCINTmax} = P_{Dmax} /(V_{IN} - V_{CCINT})$.
        - $I_{CCINTmax} = 2$ A when $V_{IN} = 3.3$ V. The TPS786xx has a guaranteed dc current rating of 1.5 A but can provide up to its minimum current limit of 2.4A for short periods. $I_{CCINTmax} = 0.938$ mA when $V_{IN} = 5.0$ V.
- **Soft Start Circuitry:** PMOS transistor Q3 should be selected so that its threshold voltage, V_{TH}, is at least 0.9 V below the V_{CCO} voltage or lower (e.g., $V_{TH} < 1.8$ V – 0.9 V = 0.9 V). In addition, the transistor's R_{DSon} should be low enough, when driven by V_{CCINT}, that the voltage drop across the transistor at maximum current (e.g., $I_{CCINTmax}*R_{DSon}$) does not cause V_{CCINT} to fall below its -5% tolerance.
- **Modifications:**
    - Select the appropriate voltage option from the TPS786xx (1.5A rating) or TPS796xx (1.0A rating) family. TPS78601 and TPS79601 are the adjustable versions, and V_{OUT} is set by a voltage divider (external resistors) on the FB pin.
    - Select the appropriate TPS3809 option to monitor the input supply voltage. TPS3809L30 is recommended for monitoring 3.3V.
    - For a low-cost, discrete Supply Voltage Supervisory Circuit alternative to U1, please see reference design PR286 (Active-High Reset Output) or PR281 (Active-Low Reset Output).
    - Note that with lower input supplies, such as 3.3V, the linear regulators can support higher output currents (see previously presented power dissipation calculations).

QUESTIONS?

- Send an email to **mailto:fpgasupport@list.ti.com**



Title	Spartan–IIE Single LDO		
Size B	Number PR210		Rev
Date	4/22/04	Drawn by	
Filename	pr210.sch	Sheet	of

Filename: PR210_bom.xls

Date: 04/22/2004

PR210 BOM

COUNT	RefDes	DESCRIPTION	SIZE	MFR	PART NUMBER
4	C1, C2, C3, C4	Capacitor, Ceramic, 2.2-uF, 6.3-V, X5R, 10%	805	muRata	GRM21BR60J225KC01
1	C5	Capacitor, Ceramic, 0.1-uF, 25-V, X7R, 10%	603	muRata	GRM188R71E104KA01
1	C6	Capacitor, Ceramic, 0.047-uF, 16-V, X7R, 10%	603	muRata	GRM188R71C473KA01
1	C7	Capacitor, Ceramic, 1.0-uF, 6.3-V, X5R, 10%	603	muRata	GRM188R60J105KA01
2	Q1, Q2	Bipolar, NPN, 30-V, 800-mA, 310-mW	SOT23	Vishay	BC818
1	Q3	MOSFET, P-ch, -12 V, 4 A, 51 milliohm	SOT23	Vishay	Si2333DS
3	R1, R2, R4	Resistor, Chip, 100k-Ohms, 1/16-W, 1%	603	Std	Std
1	R3	Resistor, Chip, 86.6k-Ohms, 1/16-W, 1%	603	Std	Std
1	R5	Resistor, Chip, 75k-Ohms, 1/16-W, 1%	603	Std	Std
1	R6	Resistor, Chip, 100-Ohms, 1/16-W, 1%	603	Std	Std
1	U1	IC, 3-Pin Supply Voltage Supervisor	SOT23	TI	TPS3809K33
1	U2	IC, Ultra Low-Noise, High PSRR, Fast RF 1.8V 1.0A LDO Linear Regulator	DDPAK-5	TI	TPS79618KTT
1	U3	IC, Ultra Low-Noise, High PSRR, Fast RF 3.3V 1.5A LDO Linear Regulator	DDPAK-5	TI	TPS78633KTT

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
		Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments
Post Office Box 655303 Dallas, Texas 75265