SUMMIT MICROELECTRONICS, Inc.

Application Note 26

SMT4004 - Advanced Voltage Tracking Methods Boost Efficiency, Reliability

Advance Information

BACKGROUND

Numerous systems with high performance ASICs, processors and other devices place stringent demands on the order in which the power supply voltages are turned on. Most of these requirements culminate from the design of VLSI circuits consisting of an I/O interface and a Logic or µP Core on the same die. The I/O interface operates at a higher voltage than the Core and this voltage must not exceed the Core voltage according to the manufacturers' specifications until the core nominal voltage is reached or catastrophic failure can occur. Further, most devices and daughter cards operate at intermediate supply levels and also need to be turned-on at different intervals during system power-up.

This application note describes the tracking function as well as a new loss-less tracking method that eliminates the pass MOSFET in the power path by directly controlling the power supply regulator. This method reduces board space and boosts efficiency.

Multiple Supply Voltage Tracking

Often, the VLSI vendor specifies the maximum voltage differential that may exist between the I/O and Core voltages. To keep this voltage differential well below the specified maximum, voltage tracking of the power supplies is employed.

Although several methods are available for tracking the voltage of individual supplies, the most reliable ensures the I/O and Core supply voltages are equal from the instant the tracking interval begins to the time at which the Core voltage is fully turned-on.

Optimal Voltage Tracking Realized

Optimal tracking of multiple supplies requires a sophisticated means of simultaneously measuring the I/O and Core voltages during the tracking interval while adjusting the pass elements (usually N-Channel Power MOSFETs) to correct for even the slightest voltage differential. Summit Microelectronics' SMT4004 Quad Tracking Power Supply Manager holds voltage differentials of as many as 4 power supplies well below ±50mV during the tracking (on or off) interval. Figure 1 displays the SMT4004 configured to track 4 power supply voltages. N-Channel MOSFETs are used as the pass elements. Also shown are current-sense resistors used to monitor and react to system overcurrents. Figure 2 depicts the resulting tracking waveform (source terminal of the MOSFETs) of 4 power supplies obtained when using the SMT4004. As shown, tracking the power supplies minimizes the differential voltages between each output thereby preventing latch up or catastrophic failure of the VLSI circuits.

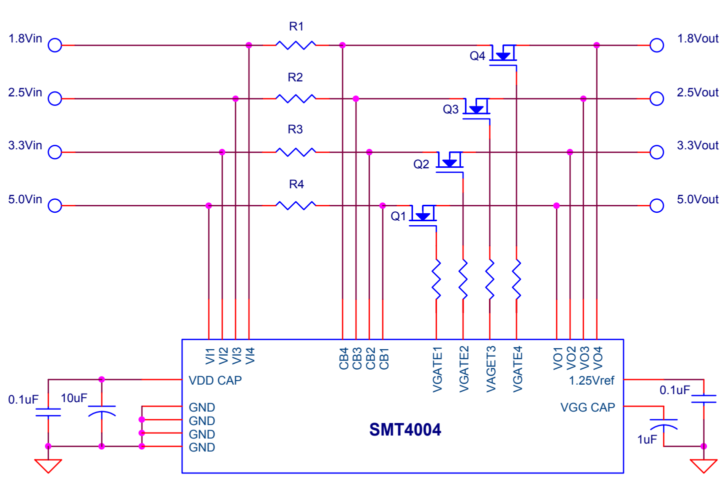

Figure 1: SMT4004 Quad Power Supply Manager Tracks 4 Power Supplies

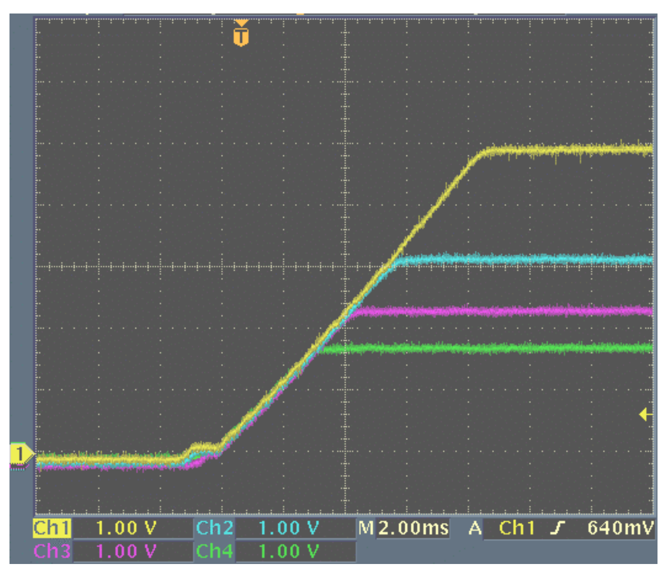

Figure 2: Quad-Voltage Track-Up Event: (5V, 3.3V, 2.5V, 1.8V)

 • 300 Orchard City Drive, #131 • Campbell CA 95008 • Phone 408 378-6461 • FAX 408 378-6596 www.summitmicro.com

Common Tracking Pitfalls

As system complexity grows, higher power supply currents are needed. Tracking low voltage, high-current supplies (<3.3V) is more difficult due to the tight voltage tolerances required by the VLSI and other related circuits. As an example, a system using a 1.5V supply requires 10A of current. The system specs tolerate no greater than ±4% deviation of the supply voltage. The power supply manufacturer guarantees a maximum tolerance of ±2% allowing a maximum combined voltage drop of only 30mV across the sense resistor and MOSFET. This is a difficult task unless the power supply sense leads can be switched from the bus-side (MOSFET drain terminal) to the card-side (MOSFET source terminal) once the tracking event is complete (see AN20).

Loss-Less Voltage Tracking

The unique tracking control method used in the SMT4004 extends its usefulness beyond that of interfacing to and controlling a discrete power MOSFET. The SMT4004 is easily adapted to control the tracking of a power supply voltage derived from many of the commercially available monolithic switch-mode power supply controllers.

System boards employing DC-DC converters designed using a monolithic controller contain the means for tracking the output voltages without using a power MOSFET.

On the last page of this document is an abbreviated list of manufacturers offering monolithic controllers that are easily interfaced to the SMT4004 without incurring additional losses with the pass MOSFET and sense resistor. A practical example follows using Texas Instrument's TPS5602.

Loss-Less Voltage Tracking: A Practical Example

A system card requires 3 of the 4 voltages be tracked. Use the SMT4004 to soft-start one of the pre-existing backplane supplies (5V). Track the remaining supplies once the 5V is switched on and is stable. The power supply specifications are:

5V	*10A*	*Backplane pre-existing*
3.3V	*6A*	*Backplane pre-existing*
2.5V	*10A*	*Derived from the TPS5602*
1.8V	*10A*	*Derived from the TPS5602*

A simplified schematic of the circuit diagram configured for switching only the pre-existing voltages is displayed in Figure 3. For simplicity, current-sensing is not shown with the SMT4004.

Managing the controller's start up behavior is accomplished using its Soft-Start (SFT) pin. This pin is normally connected to a capacitor to control the rate at which the output voltage supply rises. This pin outputs a constant current source used to charge the external capacitor. The duty cycle of the controller increases in proportion to the Soft-Start pin voltage. The output voltage is proportional to the duty cycle and increases until reaching its nominal setting. Figures 4 and 5 illustrate the transfer functions of the output voltages versus the Soft-Start pin voltages using the TPS5602.

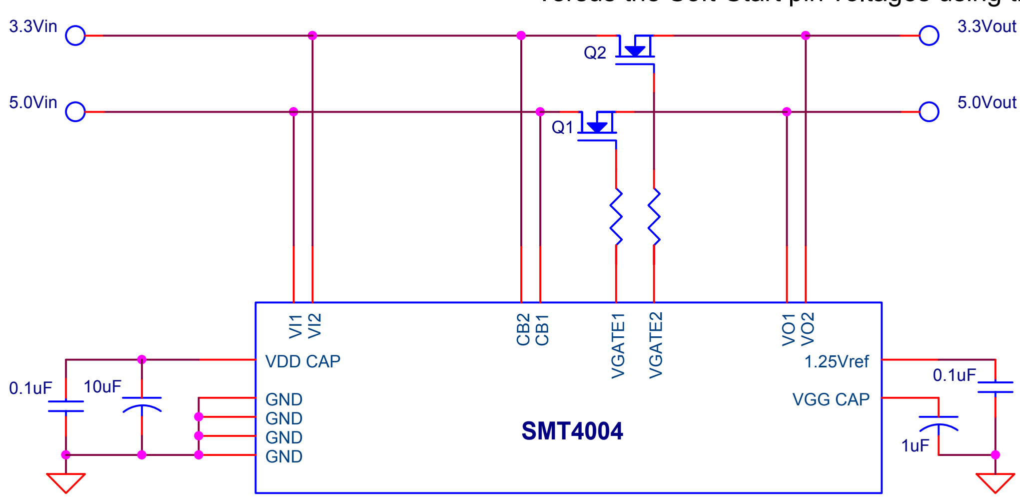

Figure 3: Managing the Pre-Existing Voltages

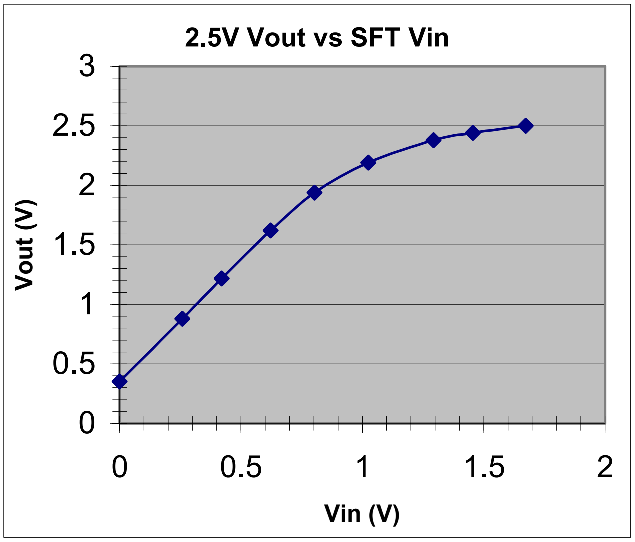

Figure 4: 2.5V Output Transfer Function

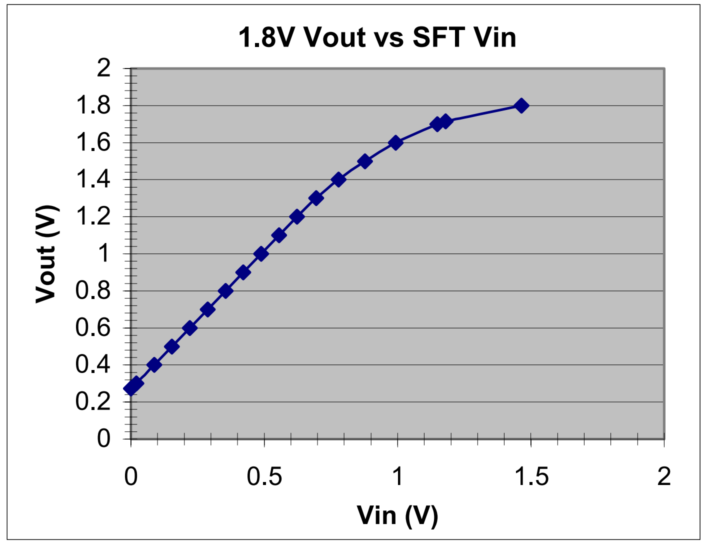

Figure 5: 1.8V Output Transfer Function

Consult the manufacturer's data sheet for the Soft-Start current, compliance voltage and the absolute maximum voltage that may be applied to the Soft-Start pin.

For the TPS5602:
$I_{SS(Max)}$ = 3uA
V_{CV} = 1.185V
$V_{SS(Max)}$ = 7V

Choose a resistor value that effectively shunts the Soft-Start pin current to ground (0 volts) yet large enough to minimize power consumption. For this example use a 1kΩ.

The interface between the SMT4004 and the monolithic controller is displayed in Figure 6. The 2N7000 small signal MOSFET (SOT-23) replaces the power device, providing the tracking voltage information to the TPS5602 Soft-Start pin. The SMT4004 monitors the 2.5V output using the VO3 pin in a manner similar to that when a power MOSFET is used as the pass element. A small valued capacitor (CVG3) is added to make Q3's input capacitance appear equivalent to that of the power MOSFETs used in the circuit. The circuit is completed when the 1.8V volt output of the TPS5602 is interfaced with the SMT4004 using the 4th channel for supervision. Figure 7A and 7B shows the power-on and off tracking waveforms and Figure 8 and 9 displays the complete schematic.

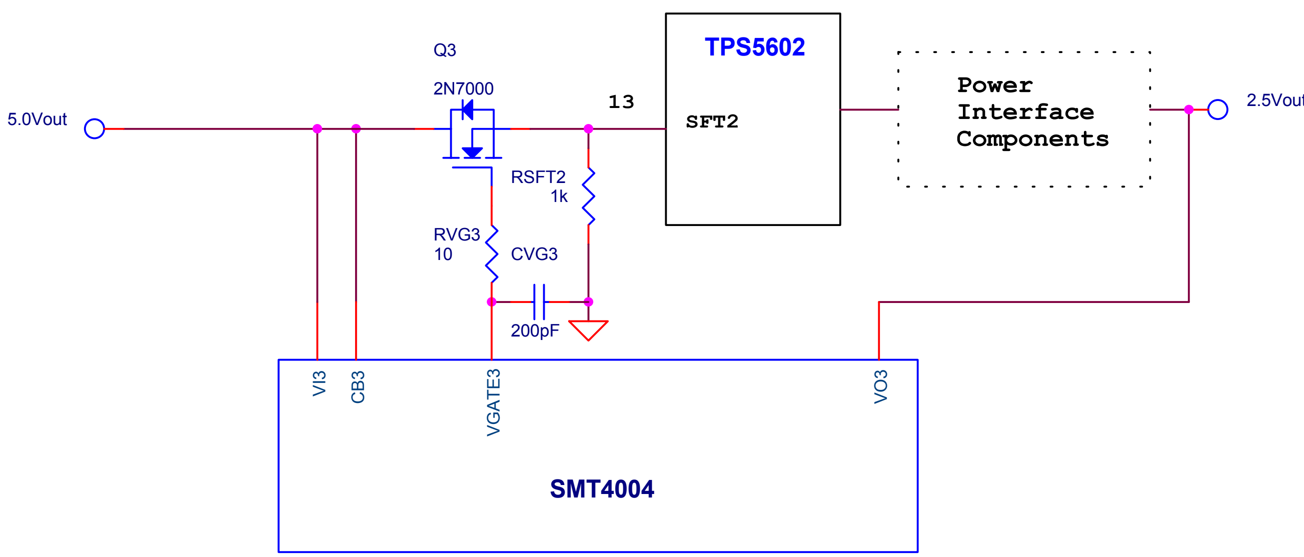

Figure 6: SMT4004 to TPS5602 Interface (2.5V output)

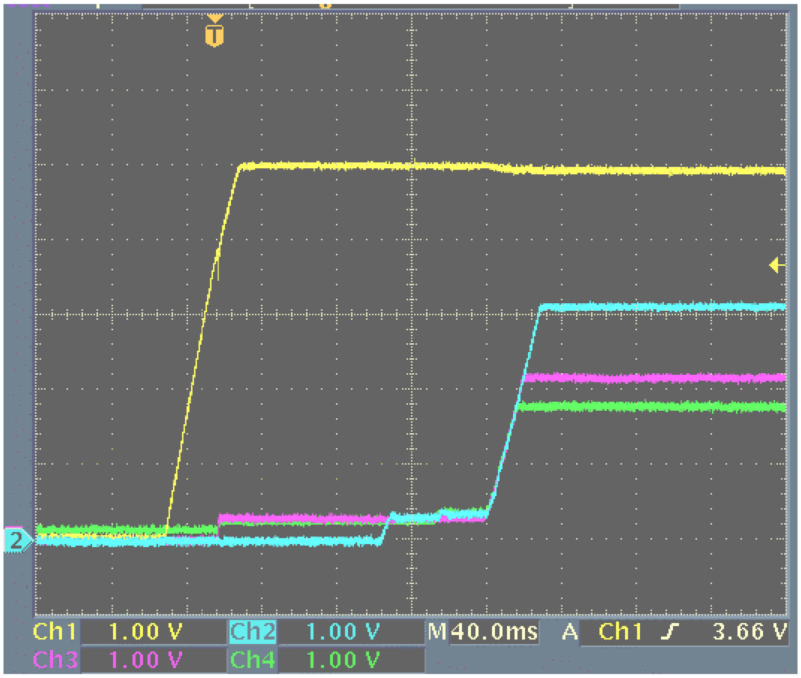

Figure 7A: Loss-less Triple-Voltage Track-Up Event: (3.3V, 2.5V, 1.8V)

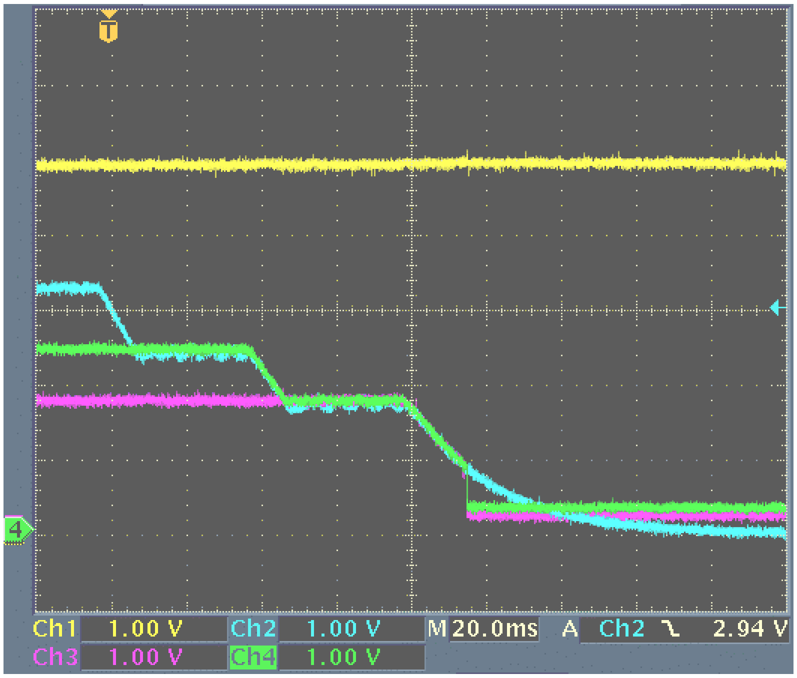

Figure 7B: Loss-less Triple-Voltage Track-Down Event: (3.3V, 2.5V, 1.8V)

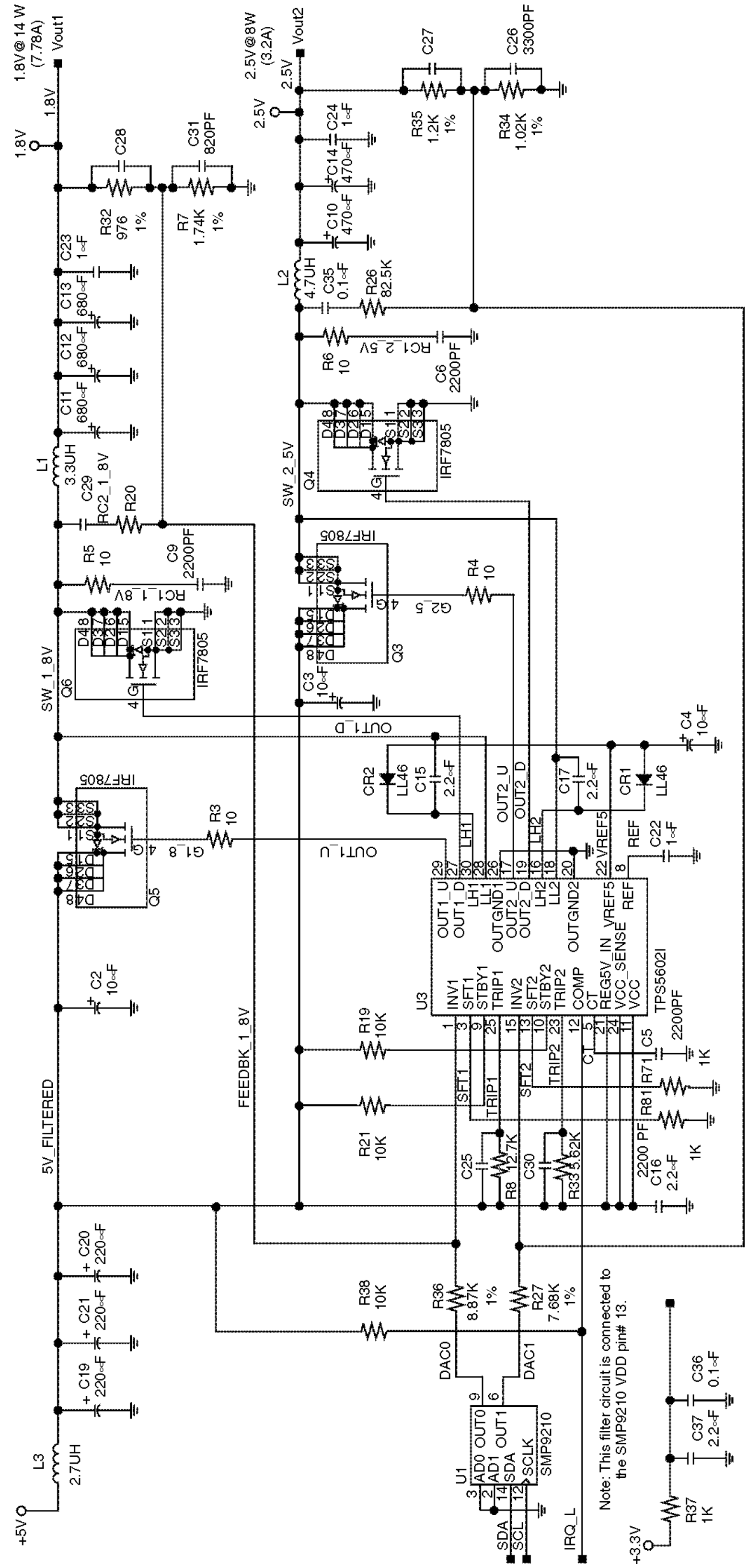

Figure 8: TPS5602 Synchronous Rectifier

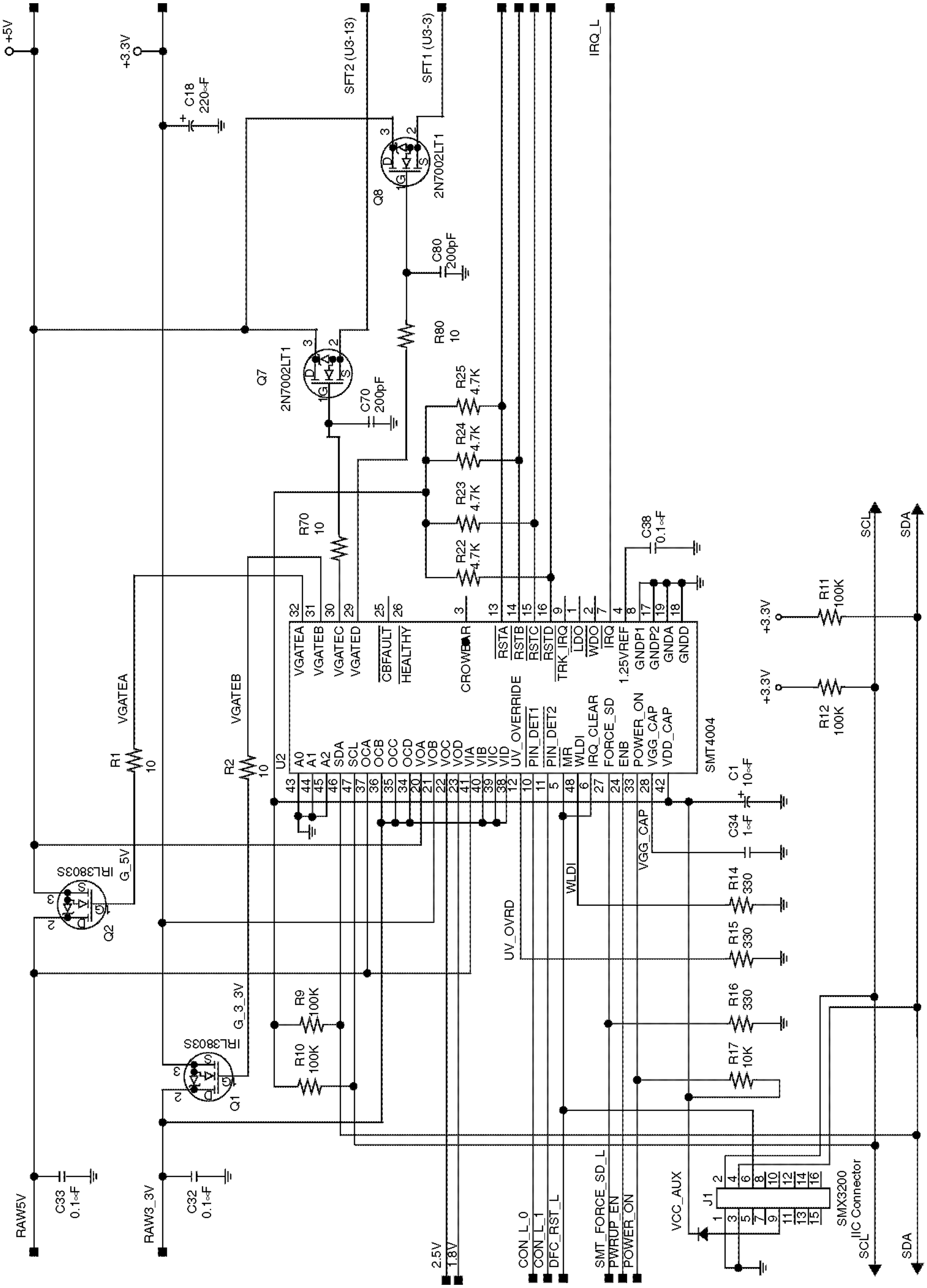

Figure 9: SMT4004 Supply Voltage Tracker

Manufacturers of Monolithic Controllers (partial)

Texas Instruments:
http://www.ti.com/
Fairchild Semiconductor:
http://www.fairchildsemi.com/
Linear Technology:
http://www.linear-tech.com/