Application Report
SLUA468–May 2008

TPS2350, A High-Negative Voltage ORing Controller

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ABSTRACT

This application note addresses a method to OR the high side of the power source as well as the low side using N-channel MOSFETs, thus replacing diodes D1 and D2 with more efficient MOSFETs in the high current path. The MOSFET switch of the return current is referred to here as the high side switch. A circuit schematic for high side switching is recommended and component selection discussed. High side switching can be used in ATCA and other Telecom applications.

1 Introduction

The TPS2350 is a high-negative voltage ORing controller. Two power supplies are input to the TPS2350 at pins –VINA and –VINB, see Figure 1. The more negative voltage is switched to the load by N-channel MOSFETs, Q2 or Q3. The TPS2350 provides hysteretic selection of the more negative supply, enabling only one switch, Q2 or Q3. The TPS2350 controls Q1 to ramp the inrush current to the load at power up and provides circuit breaker protection to the load. If the load current exceeds the programmed limit transistor Q1 is disabled.

Diodes, D1 and D2, in the upper left hand side of Figure 1, OR the power supply return currents. These diodes may be replaced with MOSFETs to increase the system's efficiency and eliminate ground loops.

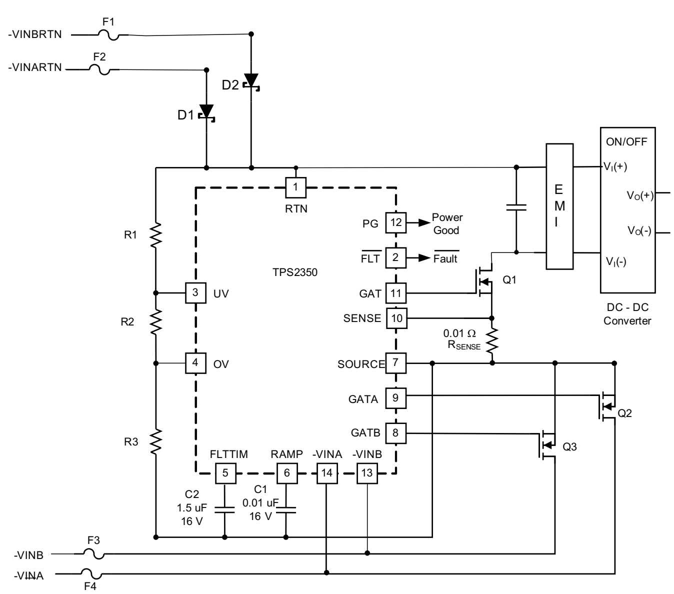

Figure 1. Typical TPS2350 configuration

2 Description

MOSFET switches, Q4 and Q5, inserted in each return path and controlled by the TPS2490 provide a low resistance current path on the return side. The TPS2350 pins GATA and GATB that select the input power MOSFET, Q2 and Q3 in Figure 2 also select the return path switch, Q4 and Q5, respectively, via the enable pins of the TPS2490 controllers.

2.1 High-Side Controller

N-channel MOSFETs, are preferred over P-channel because of the lower $R_{DS(on)}$ and resultant reduced heat dissipation. The N-channel MOSFET gate requires a positive voltage with respect to its source terminal. The onboard charge pump of the TPS2490 drives the gate voltage well above the source of Q4 and Q5 to fully enhance the MOSFETs. Diodes D1 and D2 provide a low current path to power the TPS2350.

Designed for high-positive voltage systems, the TPS2490 can be used in this application because it doesn't share a ground with external circuits. The hot swap features of the TPS2490 are not used so there is no sense resistor, power limit programming resistors or timing capacitor. Figure 2 shows the TPS2350 ORing controller of Figure 1 modified for high-side switching.

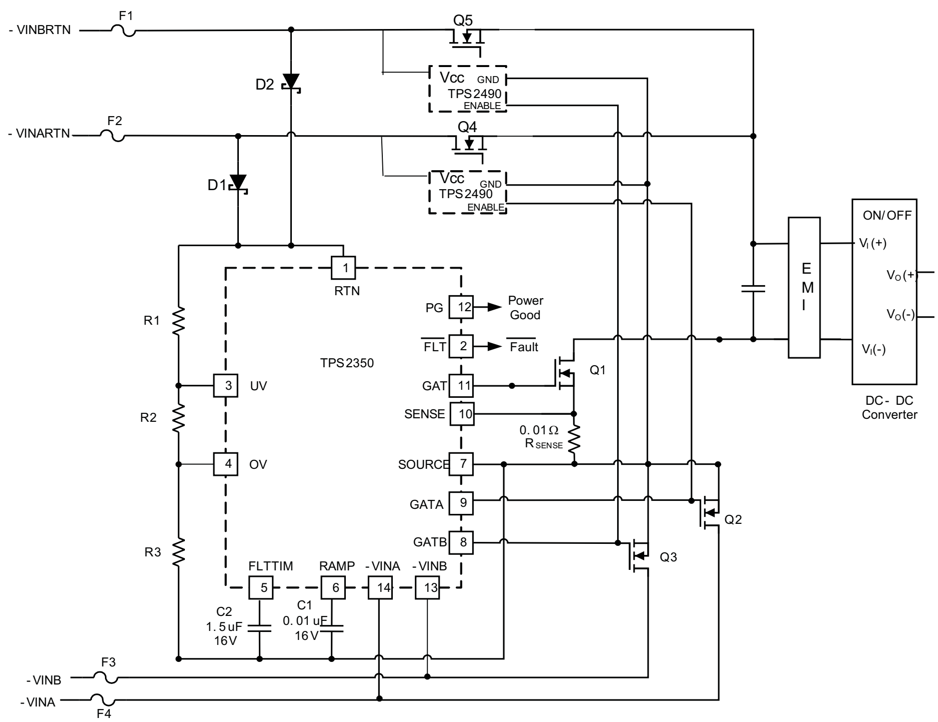

Figure 2. TPS2350 ORing controller modified for high-side switching

2.2 TPS2490 High-Side Schematic

The detailed schematic of the TPS2490 block in Figure 2 is shown in Figure 3 for the single switch configuration.

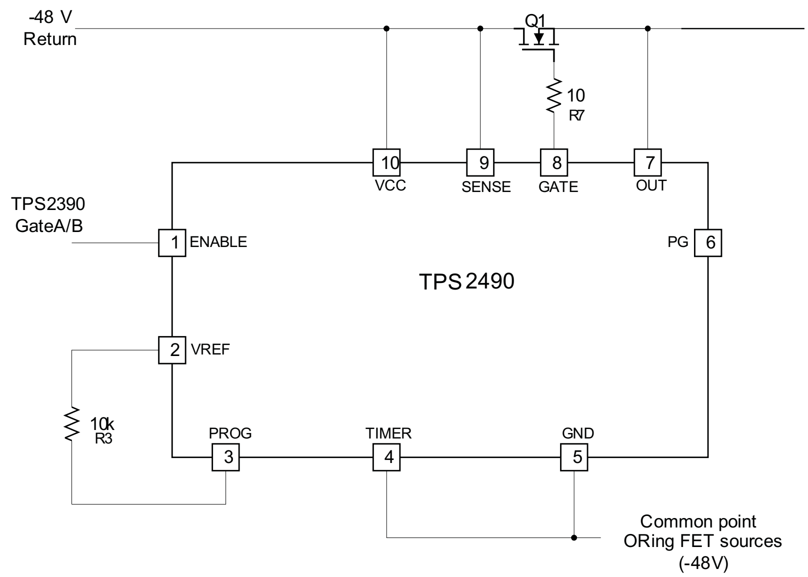

Figure 3. TPS2490 High Side Schematic

2.2.1 Back-to-Back MOSFETS

Alternatively, for isolation of the MOSFET body diode, a back-to-back MOSFET configuration may be used, see Figure 4. The TPS2490 OUT pin connects to the MOSFET sources, which allows the TPS2490 to control the MOSFETgate to source voltage.

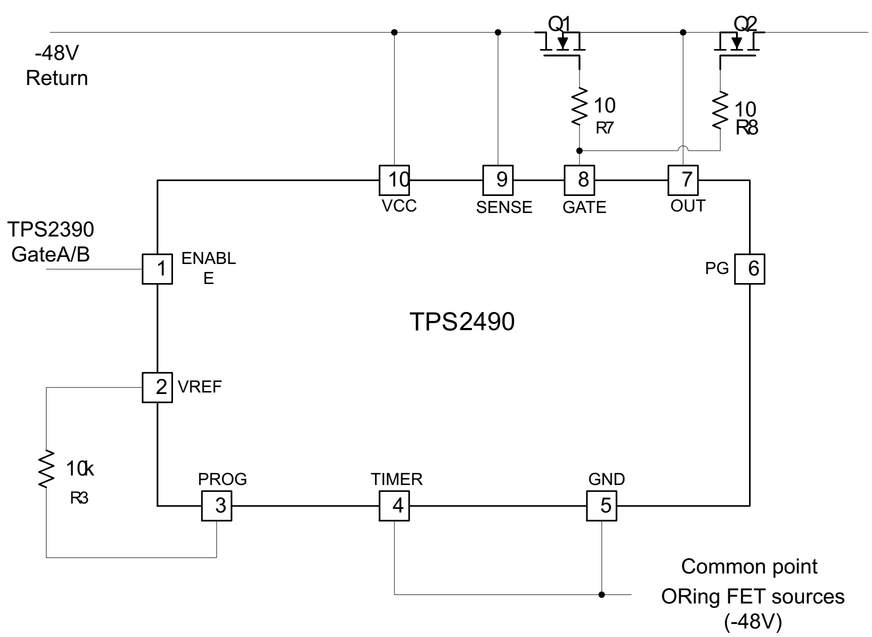

Figure 4. TPS2490 Back-to-Back MOSFET Isolation Schematic

3 Electrical Performance

Should the selected power supply fail, the TPS2350 transitions the load to the alternate power supply. During this transition, the voltage across the load drops as the bypass capacitance is discharged by the load current. The longer the time to switchover the power supply the more the load voltage drops. The voltage drop during the switchover time is called a droop. The switchover time can be compensated by bulk or holdup capacitance on the load.

3.1 MOSFET Selection

The MOSFET switch speed is directly related to its gate-to-source charge, Q_{GS}, listed in the MOSFET datasheet. The switchover time, T, is the gate to source charge Q_{GS} divided by the gate drive current, I_G:

$$T = \frac{Q_{GS}}{I_G} \quad (1)$$

Where the gate to source charge for the IRF530NS is 5.5 nC and the typical gate drive current for the TPS2490 of 22 µA, the switchover time T equals:

$$T = \frac{5.5 \text{ x } 10^{-9}}{22\text{x}10^{-6}} = 250\mu s \quad (2)$$

Other factors influencing MOSFET selection are listed in Table 1.

Table 1. MOSFET Selection Parameters

PARAMETER	SYMBOL	TYPICAL FOR ATCA
Operating voltage	V_{DS}	100 V
Operating current	I_{DS}	2 to 3 or more times load current steady state
Gate voltage	V_{GS}	+ / - 20 V
Gate threshold	$V_{GS(TH)}$	< 5 V
Gate charge	Q_{GS}	As calculated
On resistance	$R_{DS(on)}$	Low to minimize power and heat loss

3.2 Load Bypass Capacitance

Bypass capacitance reduces voltage droop across the load during supply transition. Using the transition time, T, calculated above, the maximum voltage drop allowed during transition, ΔV, and the load current, I, the required bypass capacitance may be calculated:

$$C \geq \frac{I \times T}{\Delta V} \quad (3)$$

4 Performance Data

The output voltage, V_{OUT}, at the point where the power supplies transition is shown in Figure 5. In this example, the load is 0.6 A with 300-µF bypass capacitance. The IRF530S MOSFET is used in all four switching positions, Q2, Q3, Q4 and Q5, because of its low gate to source charge, Q_{GS}. The switchover time is less than 0.5 ms and the output droop is about 0.7 V.

Figure 6 shows the output voltage droop for the same load and bulk capacitance as the previous example, however IRFS4710 MOSFETs are used for switching at Q2, Q3, Q4, and Q5. The IRFS4710 gate charge is 43 nC typical. This example is included to demonstrate the importance of Q_{GS} in MOSFET selection. The 5-ms switchover time for the IRFS4710 allows the load voltage to droop 3.0 V.

Figure 7 and Figure 8 show the IRF530S MOSFET gates when transitioning the power supply between on and standby.

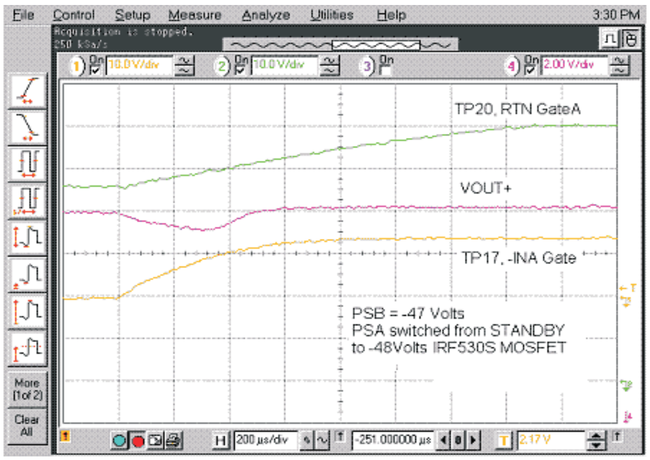

Figure 5. V_{OUT} at 0.6 A with 300-µF bypass capacitance

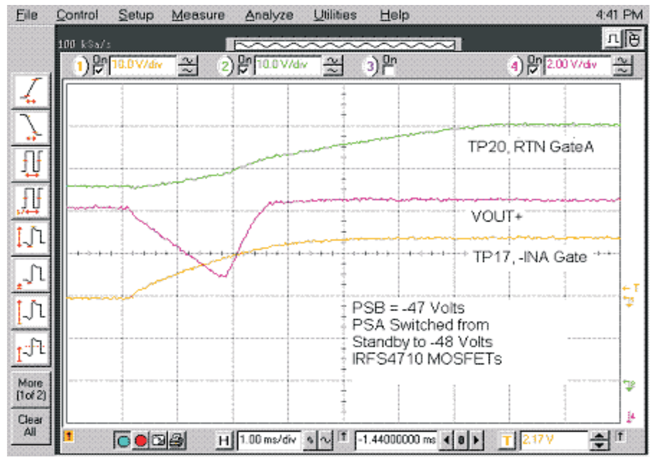

Figure 6. Output Voltage Droop Under Load and Bulk Capacitance

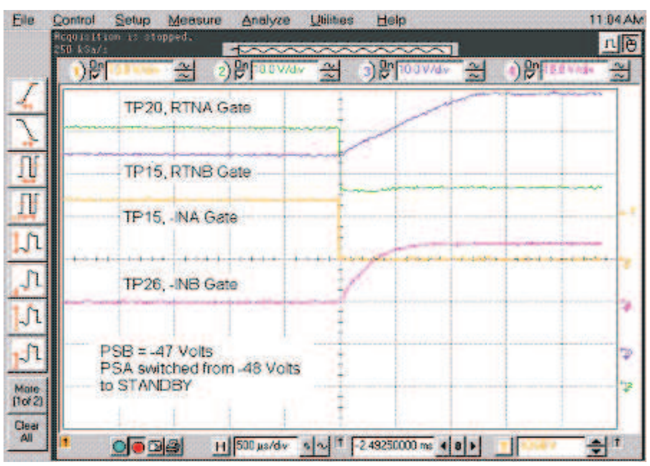

Figure 7. Transitioning the Power Supply Between ON and Standby

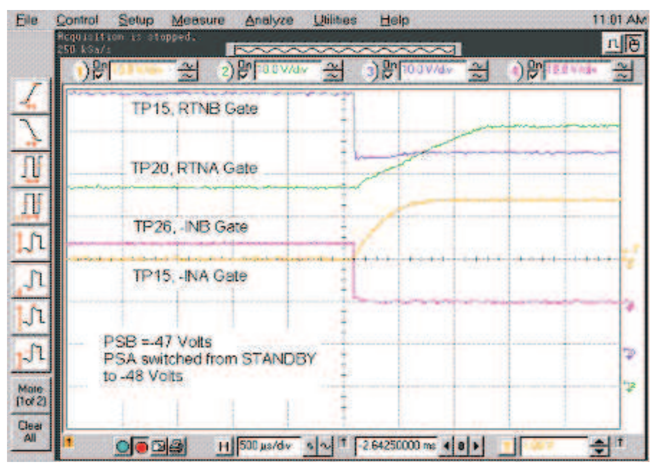

Figure 8. Transitioning the Power Supply Between ON and Standby

5 Schematic

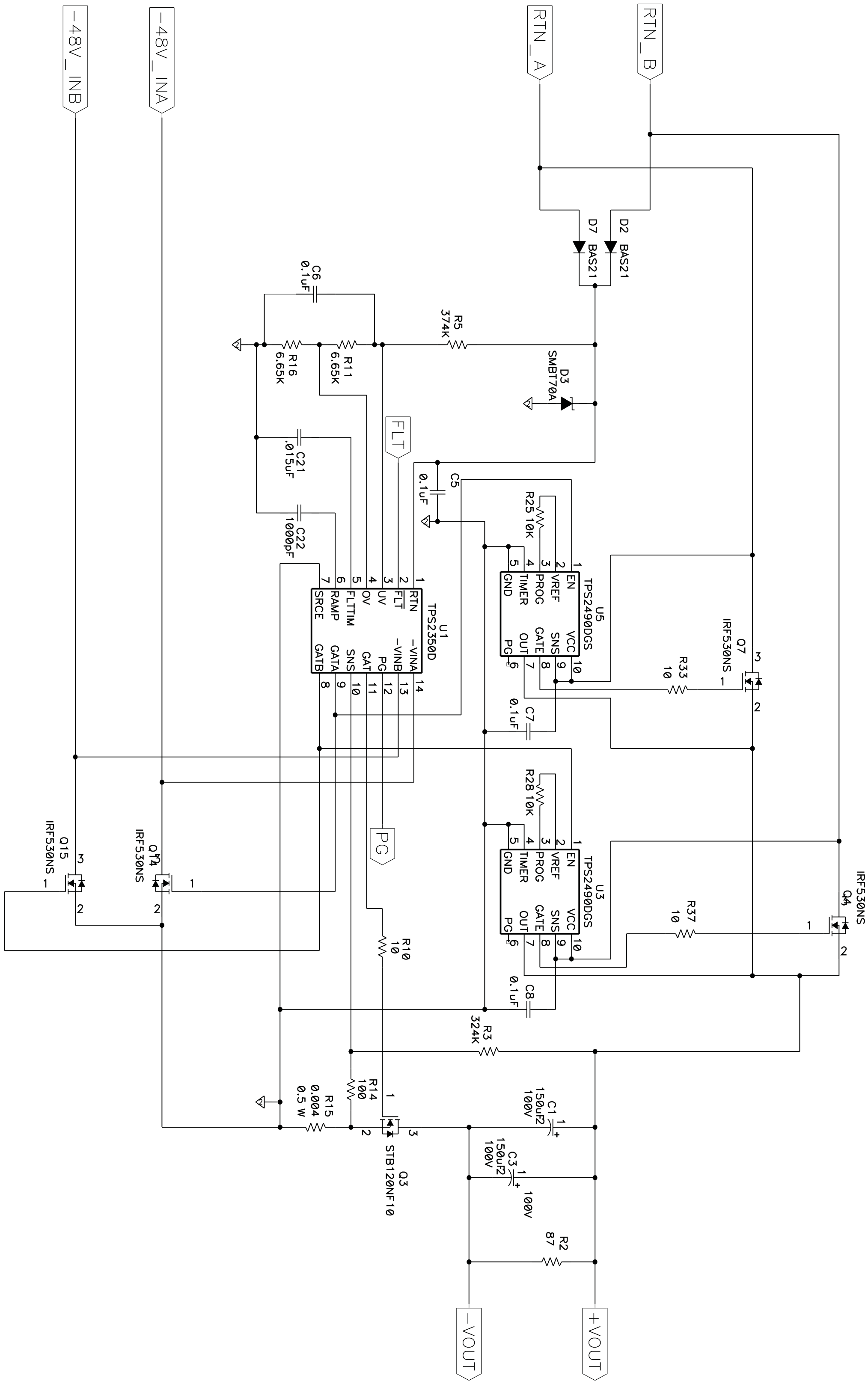

Figure 9. Typical Application

6 List of Materials

Table 2. List of Materials

COUNT	REF DES	DESCRIPTION	MFR	PART NUMBER
2	C1, C3	Capacitor, aluminum, SM, 150 µF 20%, 100 V		EEV-FK2A151M
1	C21	Capacitor, ceramic, 1000 pF, 16 V, X7R, 10%		STD
1	C22	Capacitor, ceramic, 1000 pF, 16 V, X7R, 10%		STD
3	C5, C7, C8	Capacitor, ceramic, 0.1 µF, 100 V, X7R, 10%,		ECJ-3YB2A104K
1	C6	Capacitor, ceramic, 0.1 µF, 16 V, X7R, 10%,		STD
2	D2, D7	Diode, switching, 200 mA, 200 V, 330 mW		BAS21
1	D3	Diode, TVS, 70 V, 600 W		SMBT70A
1	Q3	MOSFET, N-channel, 100 V, 120 A, 0.009 Ω		STB120NF10
4	Q4, Q7, Q14, Q15	MOSFET, N-channel, 100 V, 75 A, 0.014 Ω		IRF530NS
1	R10	Resistor, chip, 10 Ω, 1/10 W, 1%		Std
2	R11, R16	Resistor, chip, 6.65 kΩ, 1/10 W, 1%		Std
1	R14	Resistor, chip, 100 Ω, 1/10 W, 1%		Std
1	R15	Resistor, chip, 0.004 Ω, W, 1%		WSL-2010.004<1%
1	R2	Resistor, chip, 20 kΩ, 1 W, 5%, 87		CRCW2512-203J
2	R25, R28	Resistor, chip, 100 kΩ, 1/10 W, 1%,		Std
1	R3	Resistor, chip, 324 kΩ, 1/10 W, 1%		Std
2	R33, R37	Resistor, chip, 100 kΩ, 1/10 W, 1%		Std
1	R5	Resistor, Cchiphip, 374 kΩ, 1/10 W, 1%		Std
1	U1	Device, Hot-Swap Power Manager For Redundant -48 V		TPS2350D
2	U3, U5	Device		TPS2490DGS