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Supporting Legacy 5 V SIM Cards with the ADP3408 and ADP3522

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INTRODUCTION

SIM cards for GSM handsets have evolved from using a 5 V supply to a 3 V supply, and currently to a 1.8 V supply. If the service provider requires the handset to be able to support legacy SIM cards, it is necessary for the handset designer to provide a 5 V SIM supply.

The ADP3408 and the ADP3522 contain a SIM LDO that is used to supply the SIM module and interface circuitry. Designed for newer handsets, they do not have the capability to generate a 5 V supply. The ADP3408 supports 3 V SIMs only and the ADP3522 supports 3 V and 1.8 V SIMs. To support legacy SIM cards, it is necessary to add an external 5 V supply. This application note outlines several possible configurations and the problems with each, and then it describes a circuit that overcomes these issues.

CONFIGURATION ISSUES

The SIM LDO cannot be directly hooked up to the output of a 5 V charge pump as shown in Figure 1. Although the simplest solution, this configuration will cause reverse current to flow from the 5 V supply to the battery input of the SIM LDO, regardless of whether or not the SIM LDO is on.

To prevent the reverse current from flowing, a blocking diode can be added to the output of the SIM LDO, as shown in Figure 2. However, this adds a diode drop to the output of the SIM LDO, and all the inaccuracies that go along with it such as variation in voltage due to changes in current and temperature.

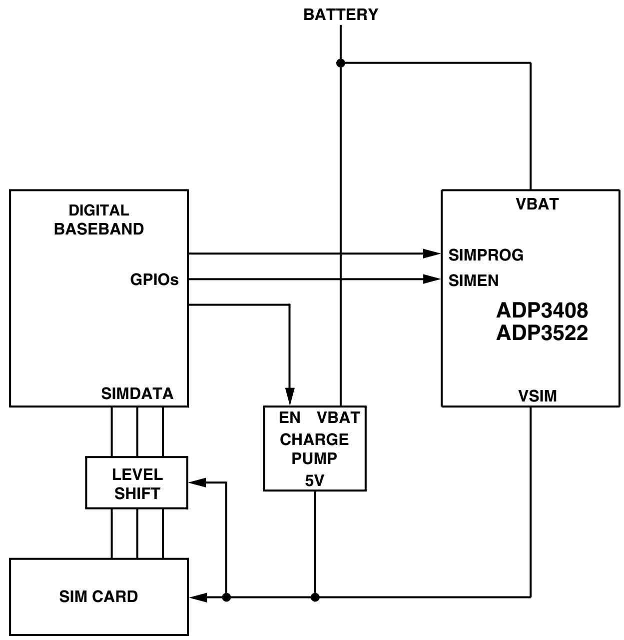

Figure 1. 5 V SIM Block Diagram

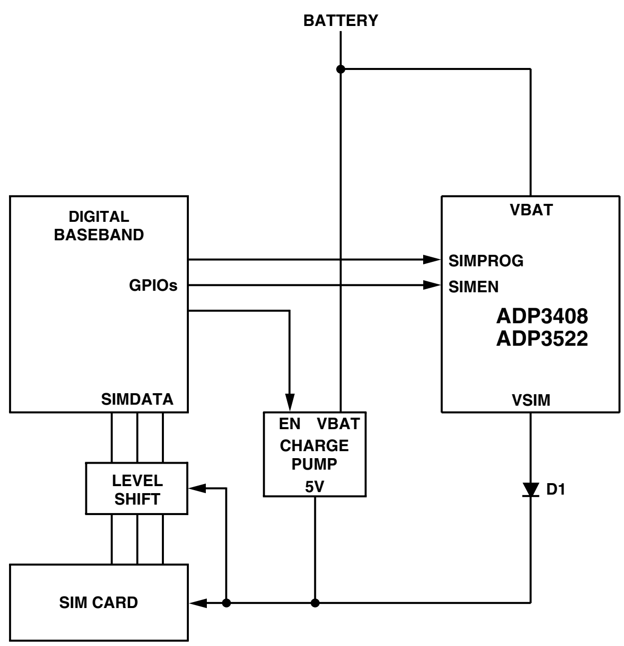

Figure 2. Blocking Diode on SIM Output

Another possibility is to add the blocking diode to the battery side of the SIM LDO, as shown in Figure 3. This solution eliminates the SIM output accuracy issue, but introduces a larger dropout voltage. As a result, the battery voltage will be higher when the SIM LDO begins to drop out of regulation. Additionally, the blocking diode does not eliminate the reverse current problem. A current path through the BATSNS pin still exists.

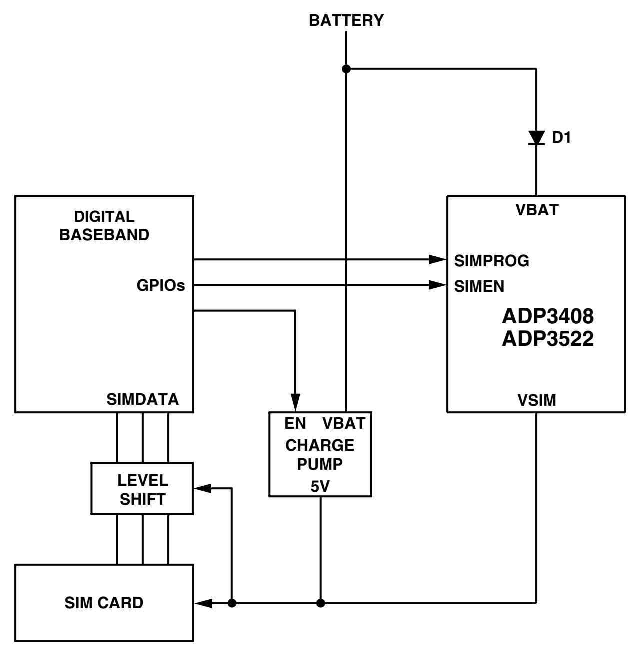

Figure 3. Blocking Diode on BAT Input

THE SOLUTION

To add a 5 V SIM capability to the ADP3408 and ADP3522, it is recommended to add a load switch to the output of the SIM LDO, as shown in Figure 4. This effectively eliminates the reverse current and output accuracy issues. The load switch needs to be closed when the SIM LDO is enabled and open when the 5 V charge pump is enabled.

The circuit shown in Figure 4 is conceptual, but the circuit has been tried in the lab as both a discrete solution as well as with an integrated load switch, as shown in Figure 5. The load switch is made up of Q1, Q2, and R1. When the SIMEN signal is high, the SIM LDO and Q2 are switched on. Q2 will pull the gate of Q1 to ground while the body diode of Q1 will pull the source up toward the SIM LDO output voltage. This will exceed Q1's threshold voltage turning on Q1 (VGS > VGS(th)). As a result, the SIM LDO's output appears at the source side of the switch, SIMOUT. When the SIMEN signal is low, the SIM LDO and Q2 are switched off. R1 will pull the gate of Q1 up to the source voltage turning Q1 off (VGS = 0). When the 5 V charge pump is enabled, SIMEN must be held low. This will keep Q1 off and prevent any reverse current from flowing back to the battery.

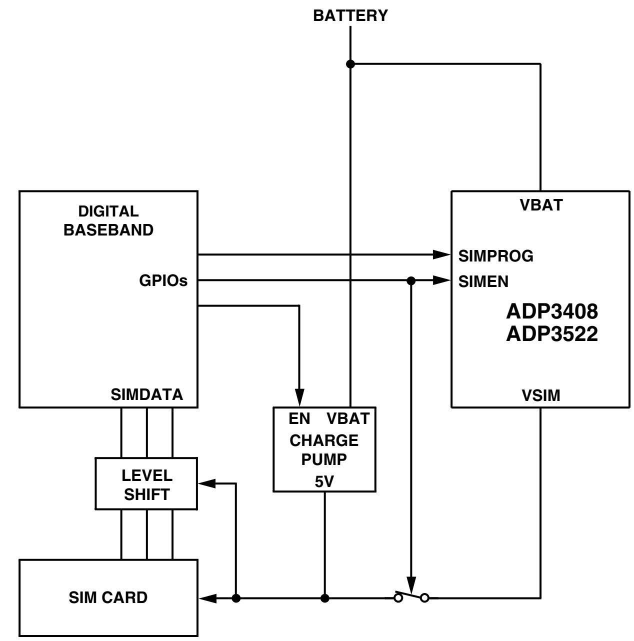

Figure 4. Load Switch on SIM Output

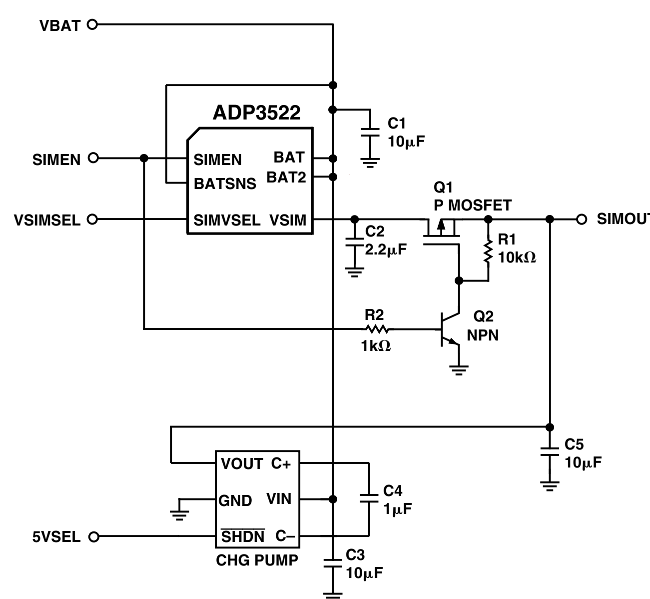

Figure 5. Load Switch Circuit

It is necessary for the digital baseband to control the sequencing of the SIM bus voltage. By controlling the SIMEN, SIMVSEL, and 5VSEL inputs, the processor can properly sequence the SIM voltage. A logic table for the different states is given in Table 1.

The dc results are given in Table 2. Note the difference in the SIM and SIMOUT current. The current in the pull-up resistor, R1, causes this difference. Also notice the SIM current for the 5 V SIMOUT case is 0, indicating no reverse current flow.

The ac results are shown in Figures 6 to 11.

Table 1. SIM Supply Control Logic

	SIMEN	SIMVSEL	5VSEL
SIM OFF	L	X	L
SIM = 1.8 V	H	L	L
SIM = 3.0 V	H	H	L
SIM = 5.0 V	L	X	H

X = Don't Care

Table 2. DC Tests

VSIM (V)	ISIM (mA)	VSIMOUT (mA)	ISIMOUT (V)	Q1	Q2	R1(Ω)	R2(Ω)
1.796	20.6	1.793	20.5	FDN340P	2N2222	10 k	1 k
2.836	20.7	2.834	20.5	FDN340P	2N2222	10 k	1 k
0.001	0.0	5.035	20.4	FDN340P	2N2222	10 k	1 k
1.796	20.7	1.792	20.5	FDC6325		10 k	0
2.837	20.8	2.834	20.6	FDC6325		10 k	0
0.000	0.0	5.035	20.5	FDC6325		10 k	0

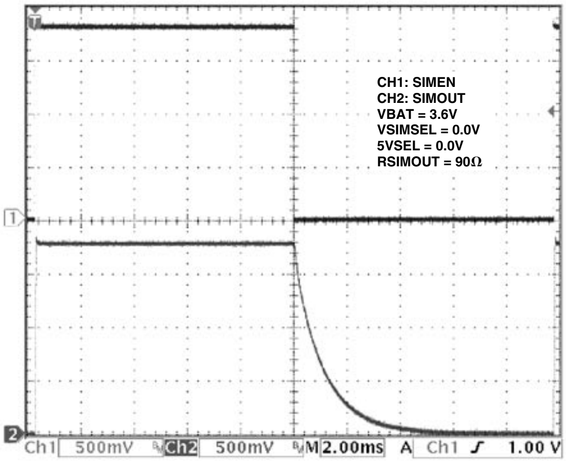

Figure 6. 1.8 V SIM Response

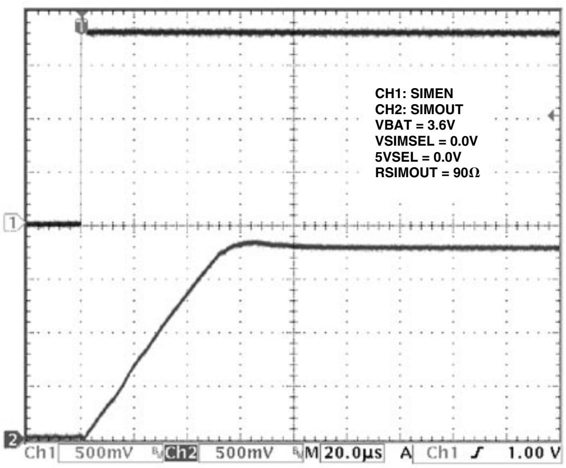

Figure 7. 1.8 V SIM Rise Time

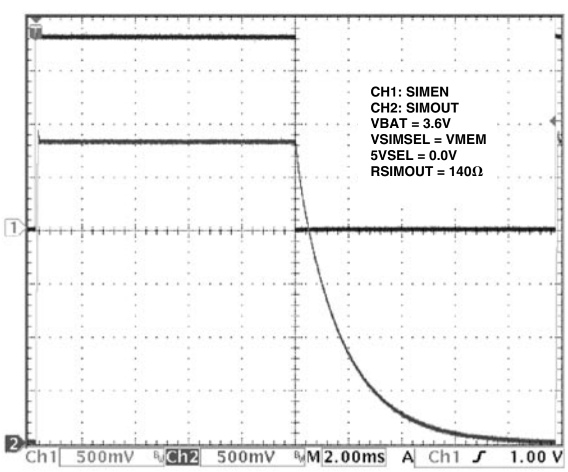

Figure 8. 2.8 V SIM Response

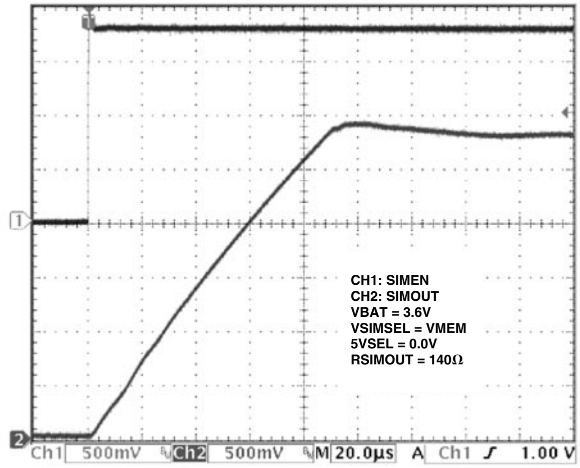

Figure 9. 2.8 V SIM Rise Time

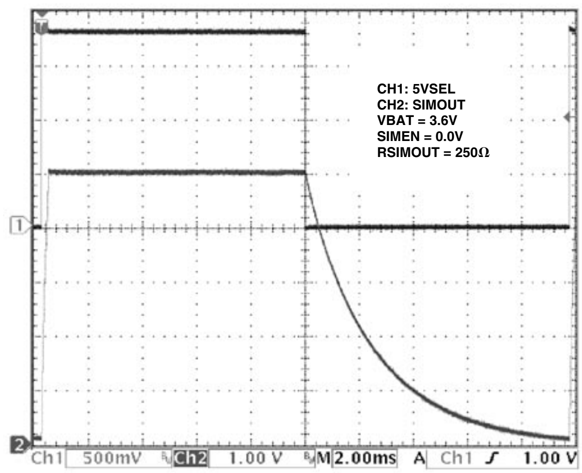

Figure 10. 5 V SIM Response

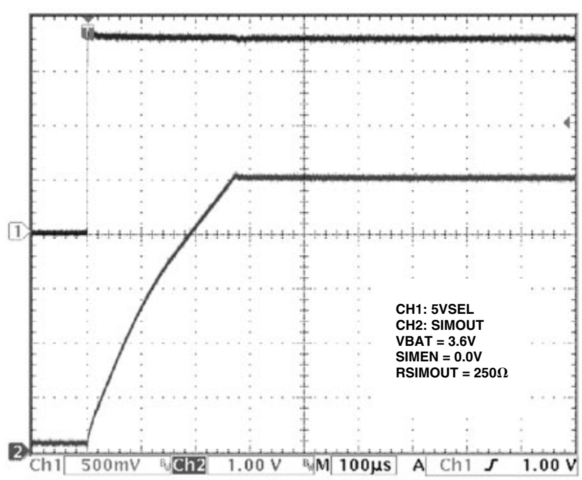

Figure 11. 5 V SIM Rise Time

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