

Triple Output LCD Power Supply Delivers 95% Efficiency from a Tiny 3mm x 3mm Package

by John Bazinet

Introduction

Today's handheld products pack more functionality in less space while demanding improved battery life over products of the previous generations. The only way to achieve both is to improve power efficiency in the device wherever possible. The color LCD display system is a good place to start, since it is an increasingly popular, but power hungry feature. The LTC3450 improves battery life and saves space by delivering a 95% efficient color LCD bias solution in a low profile (0.8mm tall), 3mm x 3mm package.

Figure 1 shows a block diagram of the LTC3450—a complete triple output LCD power converter—in a low noise 5.1V, 10mA output synchronous step up DC/DC converter. The charge pump

based voltage tripler develops a 15V output and a voltage inverter develops -10V. The 15V and -10V outputs are used in the LCD display for VGL and VGH supplies, while the 5.1V output is used to provide the main panel power. The 5.1V converter switches at a constant 550kHz, which enables very low AV_{DD} ripple voltage even when using tiny ceramic capacitors and one small inductor. The output voltages of the LTC3450 are sequenced to be compatible with color LCD displays with AV_{DD} powering up first followed by VGL and then VGH.

The LTC3450 also provides inrush current limiting during start-up (Figure 2), as well as output disconnect and active discharge in shutdown

mode. The LTC3450 is stable with ceramic capacitors and its internal compensation eliminates the need for an external R-C compensation network. The LTC3450 also features a wide input voltage range of 1.5V to 4.6V, making it compatible with a wide variety of battery or fixed DC voltage inputs. Very low quiescent currents allow the LTC3450 to deliver excellent efficiency over the entire input voltage range (Figure 3).

Power Saving Mode

Some types of color LCD displays switch to an ultra low power state while the display is static, which allows for increased battery life. The LTC3450 supports this mode of operation by

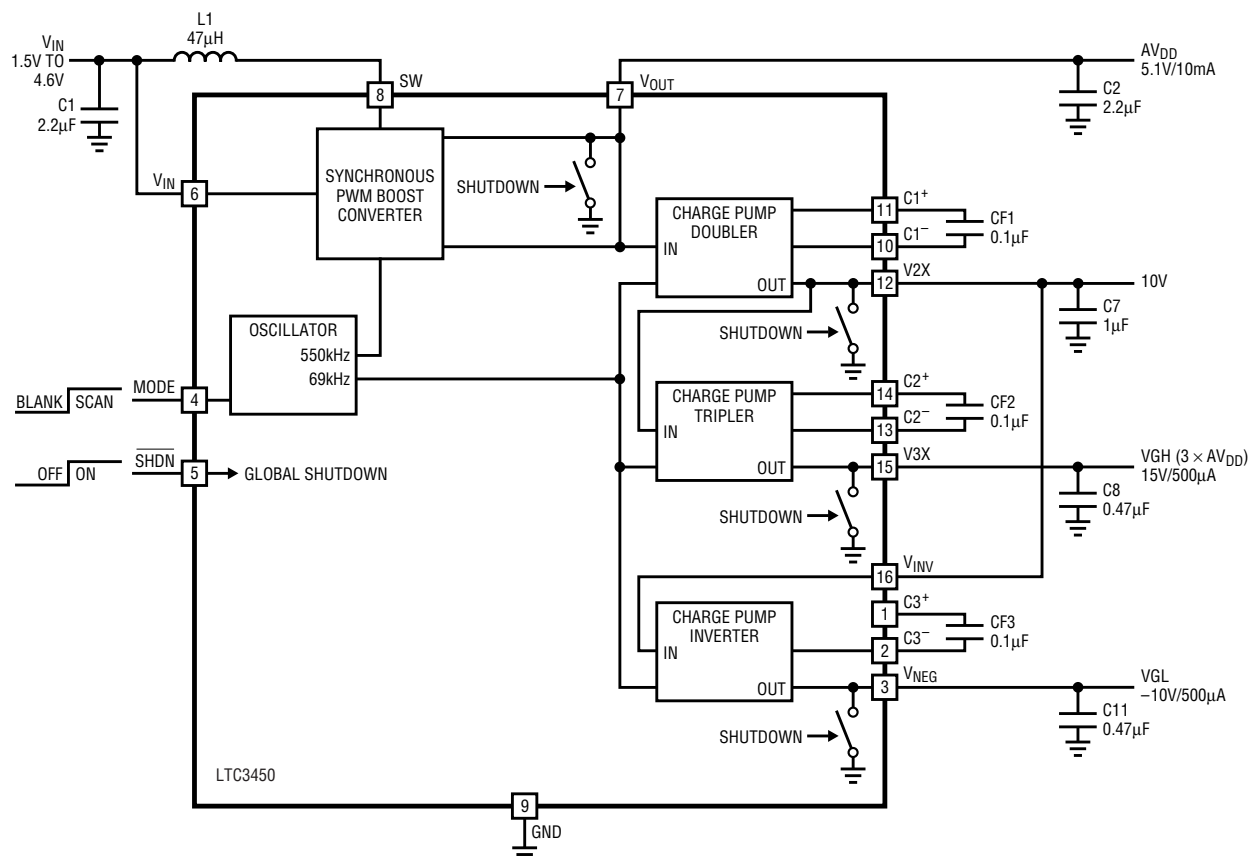


Figure 1. LTC3450 block diagram

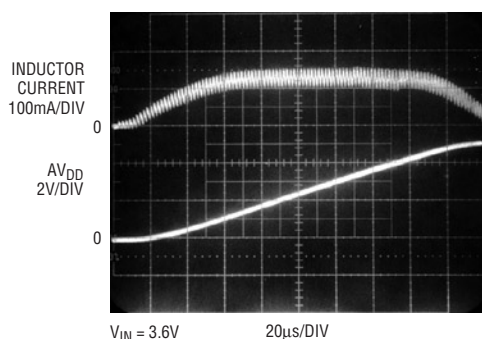


Figure 2. AV_{DD} turn on showing inrush current limiting

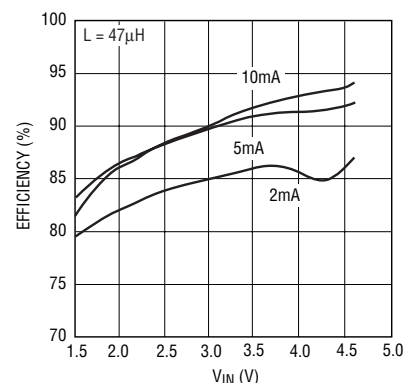


Figure 3. LTC3450 AV_{DD} efficiency vs V_{IN} and load current

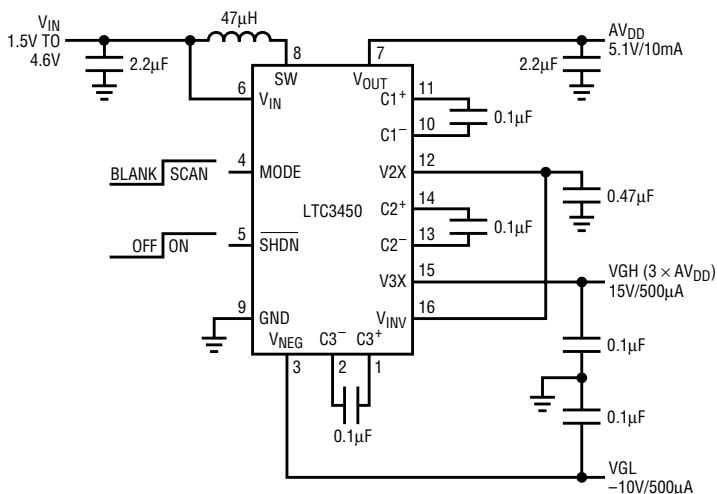
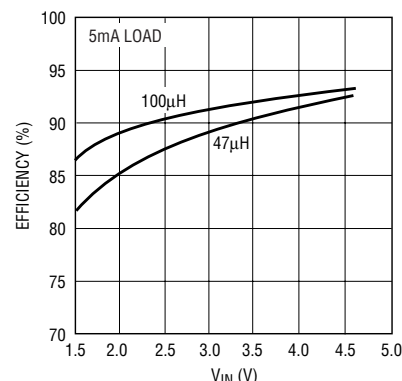


Figure 4. 5.1V, 15V, -10V application circuit and efficiency



reducing its own quiescent current to a mere 30μA from the battery while maintaining all three regulated voltage outputs. This “Blank” mode operation is programmed via the Mode pin of the LTC3450. Driving the SHDN pin low reduces the LTC3450’s quiescent current to 10nA (typical) and all three voltage outputs are actively discharged to ground.

LCD Bias Power Supply Circuits

Figure 4 shows a 1.5V to 4.6V input to a triple output (5.1V/10mA, 15V/500μA and -10V/500μA) application circuit. Greater than 90% efficiency is maintained over the Li-Ion battery’s voltage range. This is far superior to an all charge pump approach that can only deliver efficiency approaching the LTC3450 when V_{IN} is approximately 1/2 of AV_{DD}.

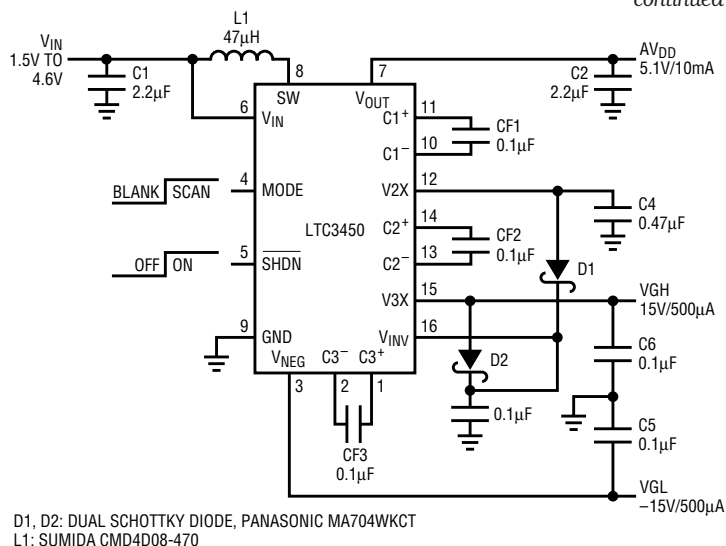
Figure 5 shows a 1.5V to 4.6V input to 5.1V/10mA, 15V/500μA and

-15V/500μA converter circuit. A tiny external dual diode is added to the circuit to get the converter to deliver the -15V and 15V outputs together.

Figure 6 shows a 1.5V to 4.6V input to 5.1V/10mA, 15V and -5V circuit.

Peak efficiency is greater than 90%. The magnitude of the negative output voltage (VGL) is equal to the positive voltage applied to V_{INV}. V_{INV} is connected to either AV_{DD} (for -5V), V2X (-10V), or with the dual diode (Figure 4)

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D1, D2: DUAL SCHOTTKY DIODE, PANASONIC MA704WKCT
L1: SUMIDA CMD4D08-470

Figure 5. 5.1V, 15V, -15V application circuit

Dual 5V Example

Figure 2 shows an example of a redundant 5V supply. In the event that one supply goes down, the back up supply would take over. In this application, back-to-back MOSFETs are used to prevent the body diode of the MOSFET from conducting in the event that a 5V supply loses regulation and goes into an overvoltage condition.

Resistive dividers from IN to UV and OV set the fault detection thresholds. In this example the UV fault occurs at 4.5V with 0.25V of hysteresis and the OV fault occurs at 5.5V.

L1 and D1 are the boost regulator components. The LT4351 creates a V_{DD} supply of 10.5V above IN. If an external supply that can provide sufficient gate drive is available, that supply can be used instead of the boost regulator.

The MOSFETs are sized based on desired voltage drop with considerations for power dissipation. In this case the Si4838DY has a worst case $4.5m\Omega$ $R_{DS(ON)}$ (at temperature) so the back-to-back pair is $9m\Omega$. These MOSFETs come in SO-8 packages so if power is limited to 1W in each then they can handle 14.9A. The

voltage drop across both MOSFETs at this current is $2 \cdot 4.5m\Omega \cdot 14.9A = 0.134V$. If more current is required, use MOSFETs with lower $R_{DS(ON)}$ and/or better thermal resistance, or add parallel MOSFETs.


The LT4351 is useful in any ORing situation benefiting from low power dissipation—not just redundant supplies. Different types of power sources can also be ORed together, and because the LT4351 diode function is gated, power sequencing of different supplies is relatively easy.

For example, Figure 3 shows a system with two redundant supplies and a battery backup. The two redundant supplies are ORed via the ideal diodes, so power is delivered from the higher of the in-range supplies. Their undervoltage and overvoltage thresholds are set based on the input supply range. The LT4351 circuit for the battery disconnects the battery when power is supplied from either system supply. Its OV pin is above threshold if the \overline{FAULT} is off on either system supply (UV is set above threshold). If both system supplies are disabled (\overline{FAULT} of both systems are

low) then the battery's LT4351 OV pin is pulled below threshold to allow the battery to provide power.

Figure 4 shows an example of combining the LT4351 ideal diode function with a Hot Swap controller. This can be used to create ORed redundant supplies on a plug-in board. The Hot Swap controller provides current limiting, circuit breaker functions and reset timing while the LT4351 provides the ideal diode behavior.


Conclusion

The trend in today's power supplies is toward higher currents, lower voltages, higher efficiency and increased reliability. These needs are forcing designers away from traditional Schottky ORing diodes. The LT4351 provides an improved ORing solution by controlling low $R_{DS(ON)}$ MOSFETs to create a near ideal diode. In addition the LT4351 adds increased functionality with supply monitoring that can disable power path conduction. An LT4351 solution has significantly lower power dissipation than a Schottky diode and offers protection features that a Schottky cannot. 

LTC3450, continued from page 20

for -15V. If desired, an independent positive voltage source between 5V and 15V can be connected to V_{INV} to produce any desired negative voltage between -5 and -15V.

Conclusion

The LTC3450 delivers a highly compact and efficient power supply solution for small LCD displays. Its wide input voltage range makes it easy to drop into a variety of applications. Built-in inrush current limiting, output disconnect and power saving controls simplify the task of implementing power friendly LCD displays. 

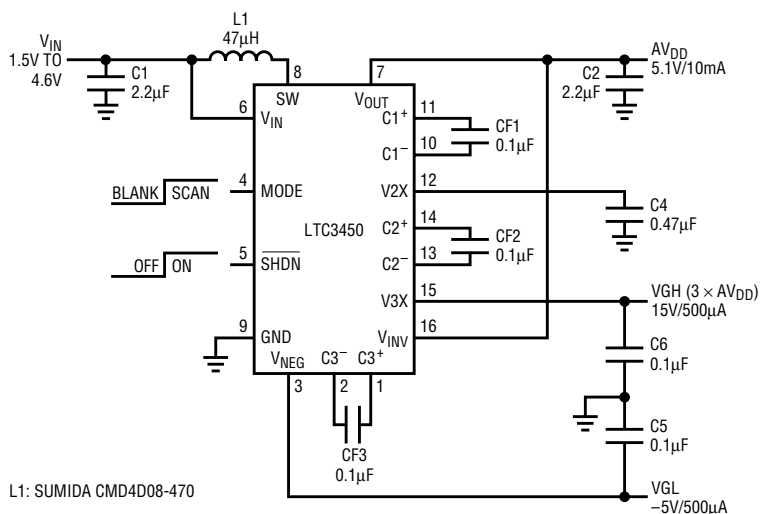


Figure 6. 5.1V, 15V, -5V application circuit

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