Power Solutions for Mobile TV Applications in Cellular Handsets

Mobile phones have evolved from simplistic devices of portable communication to dynamic multi-functional pieces of technology. Today, despite drastic reductions in size, users demand more and more features, ranging from internet connectivity to video highlights. These features necessitate modifications to the power solutions deployed in the handset; very efficient power management solutions that are small in real estate are required in order to maintain battery life. This article looks at delivering the miniature high-efficiency power management solutions needed to power up processor applications such as DVB-H modules. **Jose Escobar, Applications Engineer, Portable Power, National Semiconductor, USA**

A processor application such as Digital Video Broadcasting Handheld (DVB-H) is a good example of a new technology being included in cell phones. Figure 1 illustrates a common DVB-H module and Table 1 highlights the module's typical power requirements. Battery consumption is a major concern for processor applications and is addressed with the use of high-efficiency regulators. Switching and linear regulators are used for powering up DVB-H modules and the combination of these regulators - when implemented correctly - can provide an improved DVB-H power solution and prolong phone battery life.

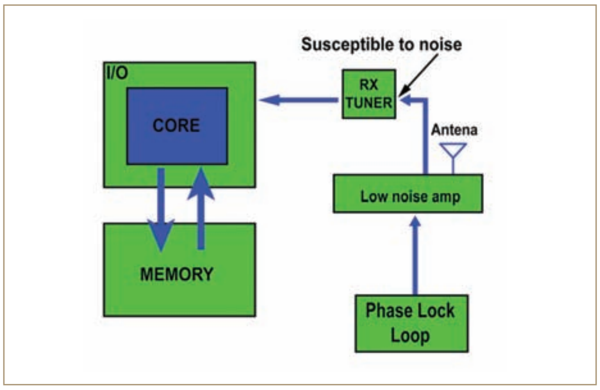

Figure 1: Common blocks for a DVB-H module

Block	Supply Voltage	Current
Memory	1.8V – 2.8V	< 100mA
RX tuner	1.8V – 3.3V	< 150mA
I/O	1.5V – 2.8V	< 250mA
Core	1.2V – 1.8V	< 350mA
PLL	2.5V – 3.2V	< 100mA

Table 1: Power requirements for DVB-H

Smaller solution size via post regulation

As previously mentioned, solution size is critical for mobile phones, especially for the implementation for DVB-H modules. The switching regulators in Figure 2a are efficient when powering up two important blocks for a DVB-H module; however, they

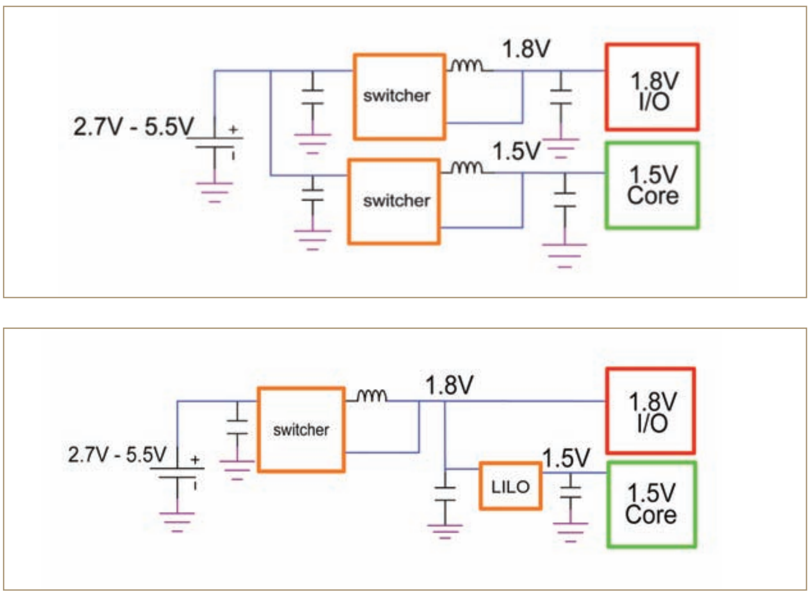

Figure 2: Dual output with six external components (a) and dual output with four external components (b)

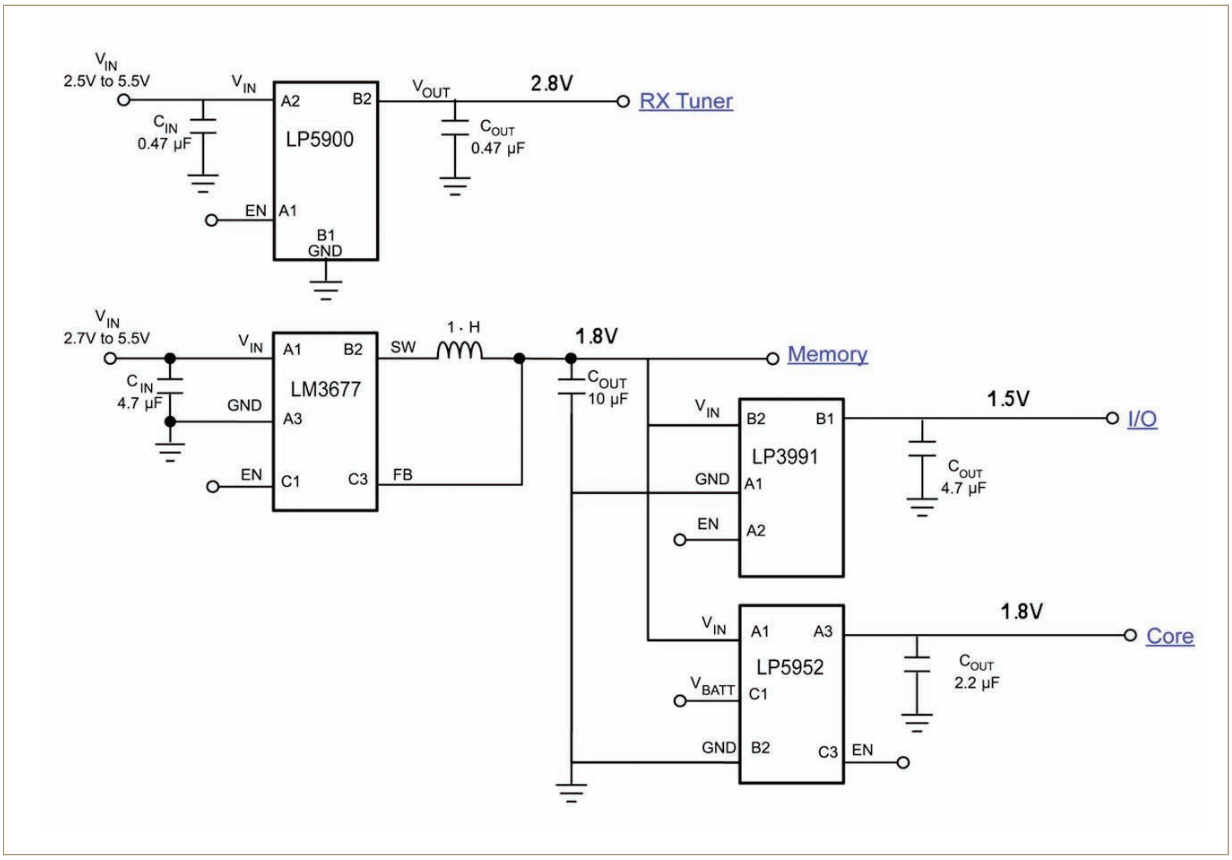

Figure 3: **Schematic representation of 65mm² PCB for powering up DVB-H module**

require four capacitors and two inductors. A more convenient and better approach for powering the I/O and core is to use a post-regulation scenario as shown in Figure 2b. A simple high-efficiency switching regulator with the combination of a low-input low-output LDO (LILO) leads to a significant reduction in component count as well as maintaining high efficiency.

A special trait of the LILO LDO is that it can perform with low input voltages, (less than 2V), and still provide a constant output voltage. A typical LDO's' efficiency is very low when powered from a standard Lithium-ion battery (V_{IN} = 3.2 to 4.5V). At lower input voltages the efficiency is high, while at higher V_{IN} values, the efficiency starts to roll off. The efficiency is higher at lower V_{IN} because the voltage drop across the LDO is lower. This is why a typical LDO with a V_{IN} range of 2.7 to 5.5V should not be used in post regulation. Instead, a LILO LDO is preferred since it delivers higher efficiency values due to its input supply requirements.

Using its own product range, National Semiconductor has been able to demonstrate a solution for powering up a DVB- H module that measures just 65mm² (Figure 3) thanks to MicroSMD package devices and low profile small

Device	Test on Device	Secondary Effect from Test =
Switcher	Line Transient "A"	Line Transient on LILO "B"
Switcher	Load Transient "C"	Line Transient on LILO "D"
LILO	Load Transient "E"	Load Transient on Switcher "F"

Table 2: A typical line/load transient on the switcher or LILO has secondary effects on the system

external components. The board consists of an LM3677 - the smallest 3MHz buck regulator - an ultra low noise LP5900 linear regulator, and two LILO LDOs (LP3991 and LP5952). The LP5900 is ideal for powering up RF tuners that are susceptible to noise.

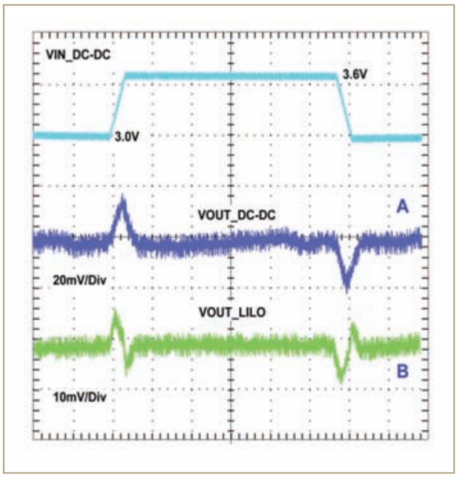

Figure 4: Typical line transient for LM3677TL (switcher)

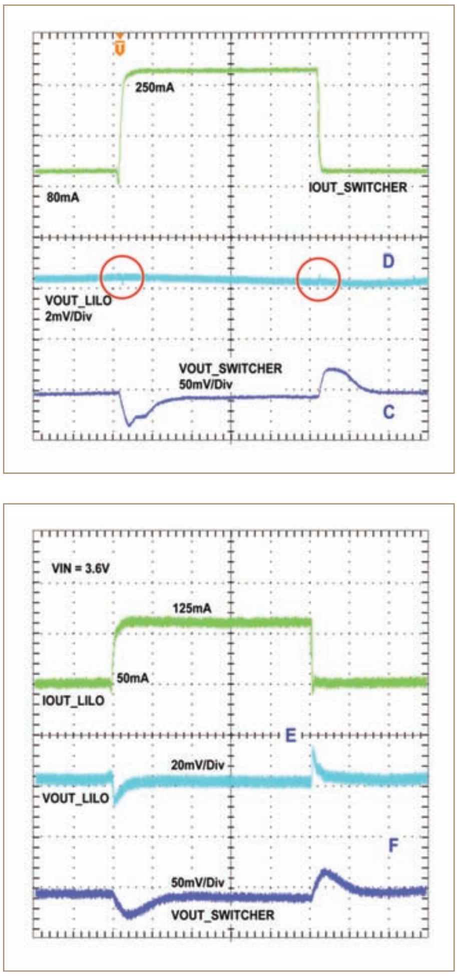

Figure 5: Typical load transient for switcher LM3677TL (a) and typical load transient for LILO LP3991 (b)

The 1.8V output of the LM3677 drives both the LP3991 (1.5V_{OUT}) and LP5952 (1.2V_{OUT}) for the core. This post-regulation arrangement delivers overall efficiency greater than 75%, due to a minimal difference between V_{IN} and V_{OUT} of both LDOs. These LDOs not only minimize component count, but the output capacitors also filter away any sub-harmonics from the LM3677 switching regulator. This filtering is effective up to 10MHz, which is the resonant frequency of the LDOs' output capacitors.

Intelligent automatic switching

The LM3677 offers up to 600mA output current while using intelligent automatic switching between PWM and PFM modes for high efficiency. The device is in PWM mode when the output current is approximately 80mA or greater. For lighter loads the part switches to PFM which reduces the current consumption (I_Q = 16µA, typical).

Both the LP3991 and LP5952 are ideal for post regulation applications where accurate low output voltages are needed. The V_{IN} range for the LP3991 is 1.65V $\leqslant V_{IN} \leqslant$ 3.6V and the V_{IN} range for the LP5952 is 0.7 $\leqslant V_{IN} \leqslant$ 4.5V.

The LP5900 is an ultra low noise (6.5µV RMS) LDO appropriate for supplying voltages for sensitive nose blocks such as RF tuners and receivers.

Requirements for LILO in post-regulation scheme

Besides efficiency and noise management, V_{OUT} tolerance of the switcher is a design consideration to the system. The V_{OUT} tolerance of the switching regulator must be considered to satisfy the minimum input voltage of the LILO. For example, the input voltage range of the LP5952 for post regulation = 0.7V $\leqslant V_{IN} \leqslant$ 4.5V and the minimal input voltage for a given output voltage is $V_{IN\_min} = V_{OUT\_NOMINAL}$ + 0.3V. If the target output voltage of the LP5952 is 1.5V, the following must be taken into account: For the LM5952TL – 1.5V $_{VIN\_min} = V_{OUT\_NOMINAL}$ + 0.3V = 1.5V + 0.3V = 1.8V (input supply requirement); for the LM3677TL – 1.8V (assuming +/- 2.5%) V_{OUT_min} = 1.755V (cannot support V_{IN_min} for LILO – LILO in dropout mode) V_{OUT_max} = 1.845V; choose LM3677TL – 2.0V V_{OUT_min} = 1.95V (will support $_{VIN\_min}$ for LILO, and enough head room for transients) V_{OUT_max} = 2.05V.

Transient performance for LILO in post regulation

Transients can occur often in the system. Whether it is a line transient (a change in the input supply) or a load transient (a change in the output current), the output voltage of either the switcher or LILO will vary. Below are some examples of line and load transients in the system. Every time the switcher's output voltage undershoots/overshoots due to a line or load transient, the LP3991 and LP5952 will also experience a slight undershoot/overshoot. Although this variation occurs, the magnitude of these undershoots/overshoot are less than 10mV (Table 2, Figures 4, 5a, and 5b).

Conclusion

When a post regulation configuration is constructed properly, it will reduce component count, establish a miniature solution size, extend battery life, and achieve an overall efficiency of about 80%. Design must be looked at carefully when building the ideal post regulation network - a simple switcher along with a typical LDO will not do the trick. Instead, a combination of a high switching regulator with a low input low output LDO is the perfect way for powering up processor applications such as DVB-H modules mobile phones.

Literature

'Novel Architecture for Capacitor-Free Low Drop-Out Regulators', Power Electronics Europe, pages 28 – 29.