June 23, 2010

Power Management Design for Mobile Devices

FTF-CON-F0896

Daryl Bergstrom
Power Management System Architect
Agenda

► Market summary
► Key considerations when selecting a PMIC
► SMOS10 technology advantages
► Features of the MC13892
► Next generation PMIC MC34708
► Key features of the MC34708
► Design considerations
► Examples of end-products using MC13892 PMIC
► Summary
Market Summary

<table>
<thead>
<tr>
<th>Market</th>
<th>2012 SAM</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smartphone</td>
<td>$1.9B</td>
<td>33%</td>
</tr>
<tr>
<td>MID</td>
<td>$343M</td>
<td>225%</td>
</tr>
<tr>
<td>Smartbook</td>
<td>$247M</td>
<td>51%</td>
</tr>
<tr>
<td>eReader</td>
<td>$37M</td>
<td>126%</td>
</tr>
</tbody>
</table>
Power Management IC Focus Markets

Consumer

- Cell Phone
- Smartphone
- Mobile Internet Device
- Media Player
- Portable Navigation/GPS
- eReader
Key Considerations for Power Management IC’s

► Maximize the efficiency and battery life of the application
  • Optimize switcher efficiency (targeting where the processor is used most of the time)
  • Use PFM, PWM-PS to improve efficiency in low power conditions

► Minimize bill of material (BOM) cost and area

► Battery technology (1, 2 or 3 Li-ion cells)

► Keep power dissipation within operation range of application

► Software driver support

► Flexible power up sequences/default voltages to support multiple processors and peripheral devices

► Audio internal or external to PMIC
  • Internal advantages
    ▪ Decreases cost, saves board space
  • External advantages
    ▪ Less noise
    ▪ More flexible
15 years of portable power management experience

Industry-leading SMARTMOS™ technology enables system-on-chip integration of analog, power and logic functions
  • Down to 0.13µm
  • Up to 80V capability

Extensive IP portfolio
  • Focus on efficiency, small size and low cost

Compelling portfolio of analog and power management solutions for the consumer, industrial and automotive markets
Power and Battery
- Four multi-mode buck switchers – 1.05A, 3x800mA programmable outputs, 2 with DVS/DPTC interface
- One boost switcher – 5V
- 12 LDO regulators, 4 GPOs, power gating
- Main battery and coincell chargers, GP ADC
- Series WLED backlight drivers (main/aux, keypad)
- One bank RGB drivers, charger LED drive
- Standalone battery charging with auto disable if battery is out of temperature range
- Standby / user off configurations
- Coulomb counter

Interface and Control
- SPI / I²C control and register interface
- Resistive touch screen
- 32 KHz crystal oscillator, real time clock / calendar alarms
- Package
  - 7x7mm BGA, 0.5mm pitch, 139 pins
  - 12X12mm BGA, 0.8mm pitch, 186 pins

Applications
- Netbook, eReader, MID’s, portable media players, portable navigational devices
Complete system lineup with highly integrated

► **Power Management & User Interface features:**
  
  • Switching and linear regulators with coordinated sequencing for system power tree
  • Battery charging with backup cell
  • Real time clock / calendar / alarm
  • Serial WLED backlighting / flashlight
  • Touch screen interface and GPADC

► **Key Benefits:**
  
  • Optimized power management companion to i.MX51, i.MX37, i.MX35, i.MX27 applications processors
  • EBOM efficiency, software simplicity and product scalability
  • Audio in separate IC to allow greater flexibility
Key Features of the MC13892

► Buck Switching Regulators

- High switching frequency of 3 MHz allows smaller components and board area
- Multi-mode (PWM, PWM-PS, PFM, Auto)
  - Configurable by SPI, standby, low power off modes, and adaptive with load current.

► LDO Regulators

- Mix of internal / external pass devices and dual configuration LDOs to optimize EBOM and balance power dissipation.
- Adaptive mode control (internal pass FETs) or programmable Low Power mode (low cost external PNPs)
Key Features of the MC13892

► Power control
  • Memory hold and user off modes allow application to retain state and turn on faster
    ▪ Memory Hold – keeps the DDR memory supply active
    ▪ User Off – All processor supplies are still active in low power mode
    ▪ Power Gates – Isolate power rails from peripherals to prevent leakage

► Charger
  • Linear with PMOS power FETs external
  • Supports dead battery operation in serial path mode
  • Standalone and software controlled charging
  • Disables battery charging when battery is out of temp range
MC34708 (In Development)

► POWER & BATTERY
• 5/6 multi-mode buck switchers – 1 x 1.6A, 3 x 1A, 1x0.5A
  • Programmable outputs, DVS, PWRGDB
  • 2 Singe/Dual phase switchers 1.6A, 1.0A
• 1 boost switcher – 5V, 380mA
• 8 LDO regulators, 4 GPIO’s, 2 PWM’s
• Switching Main Battery Charger, 1 Cell Li-Ion, with 2 LED status drivers, Aux Charger Input
• Coin cell charger
• Standalone battery charging with auto disable if battery is out of temperature range
• Programmable charge timer
• Auto charge detection of CEA936/Apple/USB/Host
• UART/Audio switching to USB D+/D- and ID pins
• 10 bit General Purpose ADC
• Coulomb counter
• 4 wire resistive touch screen

► INTERFACE & CONTROL
• SPI / I2C control & register interface
• 32KHz crystal oscillator, real time clock / calendar alarms
• Package
  • 8x8 mm BGA, 0.5mm pitch, 207 pins
  • In development 1st samples Aug 2010
  • Production 3rd Quarter 2011

► APPLICATIONS
• Netbooks, Ebooks, MID’s, Smartphone’s
Key Features of the MC34708

► Buck Switching Regulators
  - 4MHz Fs decreases size of inductors ~ 9% from MC13892
  - Added single phase/dual phase capability
    - Dual phase
      - Improved ripple and output accuracy
      - Improved transient response
  - Output FET scaling for higher efficiency at all loads
    - Lower RDS-on devices for improved efficiency
  - Added 5th switcher to support LPDDR2 memory
    - Single/Dual phase or independent operation
    - Added wider output capability to 3.3V
Key Features of the MC34708

► Buck Switching Regulators
  • Increased capability to support i.MX53, i.MX51 (1GHz) load currents for Core supply rails

► LDO Regulators
  • Optimized power tree to allow input from 1.8V switcher for VGEN1, and can use SW4 when configured at 3.15V for 2.5V LDO outputs
  • VREFDDR support for DDR2 memories

► General Purpose I/O’s
  • Added 2 PWM outputs to allow control of LED’s
  • 4 General purpose input and output pins
    ▪ Inputs can be configured as interrupts
    ▪ Configurable Pull-up/Down resistors
    ▪ Output level CMOS or Open Drain
Key Features of the MC34708

► Power Control
  • Power up sequence to support i.MX50 and i.Mx53 processors
  • Backwards compatibly to support i.MX51/37 and i.M35 processors

► Charger
  • Switching charger operating at 2 MHz
  • Supports USB charge and Auxiliary charge path
    ▪ USB has priority over Aux path
    ▪ Charge input current limited at 950mA
    ▪ Programmable charge current and charger termination
    ▪ Programmable charge timer from 1 to 16 Hrs
    ▪ Configurable pre charge timer up to 6.5 Hrs
Key Features of the MC34708

► Charger
  • Support for weak input supply on USB and Aux input
  • Selectable trickle charge current 70mA, 325mA, 550mA
  • Standalone and software controlled charging
  • Disables battery charging when battery is out of temp range
  • 2 Charge LED’s to indicate charge mode

► Mini/Micro USB
  • Auto detects Charger and configures the charger input current limit
The MC34708 manages the Universal Charging Solution and other wired accessories with a single micro-USB connector.

**Universal Charging Solution**
- The mobile industry is moving to adopting a universal charging solution (UCS) – using a mini/micro USB connector as the only charging interface.
- The GSMA and 17 leading mobile operators and manufacturers, including Nokia, Samsung, Moto, LG, and others, have announced that they are committed to the universal charger.
- The UCS will result in huge savings in resources. Traditionally every new phone ships with a new charger. With a universal charging interface, old chargers can be reused.
- The UCS will make life much simpler for the consumer, who will be able to use the same charger for future handsets and to charge their device anywhere from any available charger.

**Eliminates Connectors**
- The trend requires the handheld/mobile device to become smaller and thinner – mechanical connectors usually limit the height reduction and cost money.
- A traditional mobile device has usually three connectors for charging, audio/mic, and data exchange (such as USB). Some have an audio jack and a large multi-pin connector.
- These connectors are takes board space and limit the thickness of the mobile device.
- FSL’s solution allows the mobile device to use the micro or mini-USB connector as the only wired connector, eliminating all the others.

**Supports Multiple Accessories**
- FSL’s solution allows users to use the micro/mini-USB connector as the only connector and offers features more than what original multiple connectors can offer.
- The FSL solution supports multiple charging specifications, including the UCS. The device will help to identify the charger plugged in and set the charge current based on the identified charger.
- The FSL solution supports multiple forms of data exchange – it supports high-speed USB, UART, as well as using the micro-USB connector for firmware downloading.
- The FSL solution offers more features than the multiple connectors. It supports all-passive headset with microphone and a cord remote control.
MC34708 Mini/Micro-USB Supported Accessories

Various chargers:
- USB port/hub
- Dedicated chargers
- USB charger
- Carkit chargers
- Other customized chargers

PASSIVE headsets with any of the following functions:
- Stereo/mono audio
- Microphone
- Remote control w/ up to 12 push buttons (play/stop/FF/FF/…….)

USB/UART
- Charging (USB only)
- Data exchange
- USB2.0 (480 Mbps)
- Test/download firmware

Phone-powered devices
- Active headset
- Smart accessory
- USBOTG

Phone-powered devices with the following functions:
- Stereo/mono audio
- Microphone
- Remote control w/ up to 12 push buttons (play/stop/FF/FF/…….)
Freescale’s architecture is unique in the industry because it enables the headphone to have a microphone, stereo audio and remote control with no special active components inside.
Switcher Losses:

- IR in switches, bond wires, substrate & board level routing
- DCR of inductor
- Dynamic losses: parasitic reactance's, switch synchronization

\[
\text{Efficiency} = \frac{P_{\text{out}}}{P_{\text{in}}} = \frac{P_{\text{out}}}{P_{\text{out}} + \text{Losses}}
\]

\[P_{\text{out}} = V_{\text{out}} \times I_{\text{out}}\]

At a given \( I_{\text{out}} \), if \( V_{\text{out}} \) is reduced, efficiency drops (losses ~ constant)
Buck Design Considerations

Layout recommendation:
- Take care of layout resistivity WRT to the efficiency
- SWFB is a sense but acts as a brake during overshoot
- Vin cap recommended, very near of the pin
Boost Design Considerations

External components design recommendation:

- Coil 2.2µH
- Capacitor 10µF (Cout)
- Capacitor 4.7µF (Cin)
- Schottky Diode

Layout recommendation:

- Take care of layout resistivity WRT to the efficiency
- SWFB is a sense but acts as a brake during overshoot
- SWIN will drive Iload max up to Ilimit max.
- Vin cap recommended very near of the pin
External components design recommendation:
Low Esr Capacitor 2.2µF

Layout recommendation:
► Cout should be as close as possible of Vout pin.
► Trace from BP should have very low resistivity.
External PNP LDO Design Considerations

External components design recommendation:

- Low Esr Capacitor $2.2 \mu F$ (Cout)
- External bipolar transistor:
  - NSS12100XV6T1G for $\leq 250mW$
  - NSS12100UW3TCG for $250-500mW$

**Layout recommendation for regulator with external Pass Device:**

- Cout ESR should be $> 20$ mOhm (Cout esr or layout or additional resistor)
- Trace from BP to the emitter should have very low resistivity.
Typical Applications

► Single Cell Lion battery applications (eReaders, MIDs, Smartphone's)
  • Support for dead battery operation
  • Allows for system optimization of battery charging where dead battery support is not required (single path charging mode)

► Capability to support multi cell battery packs using a pre regulated buck supply for applications such as Netbooks, Smartbooks, Auto infotainment

► Several end products are using the MC13892 PMIC have been launched to market (e.x. Kindle, Sharp Netwalker, Acer Monitor)
Examples of End-Products Using MC13892/SGTL5000

► The MC13892 PMIC and SGTL5000 CODEC are used in Acer’s Display Plus D241H
Examples of End-Products Using MC13892/SGTL5000

The MC13892 PMIC and SGTL5000 CODEC are used in Freescale’s Smartbook/Tablet reference design
Examples of End-Products Using MC13892

The MC13892 PMIC is used in Kindle
Session Summary

► Freescale is focused on providing power management solutions for the i.MX series of processors for eReaders, Netbooks, Smartbooks, MIDs, personal navigational devices, as well as auto infotainment applications.

► Several generations of PMIC design and system level expertise. Freescale SMOS10 technology provides for differentiated and optimized solutions to the customer.

► MC34708 will address i.MX50 series and i.MX53 series and be backwards compatible to support the i.MX51/37 and i.MX35 series of processors.

► Coupled with i.MX, and SGTL5000 codec, offers a complete Freescale platform for eReaders, Netbooks, PMP, PND’s, Smartphone applications.