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POWER DELIVERY ANALYSIS IN BATTERY POWERED WIRELESS PRODUCTS

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Wireless device typical challenges

- Minimising standby/sleep current
- Maximising RF effective radiated power
- Maximising power delivery efficiency:
  - Power supply efficiency
  - Keeping IR losses to a minimum
Why are IR losses an issue in a low power design?

Typical power consumption on a device:

- Standby current: 500uA to less than 100uA
- RF RX average currents (LTE-M, GSM etc): 10mA – 100mA
- RF TX average currents (LTE-M, GSM etc): 100mA – 500mA
- RF TX peak current (LTE-M1, GSM etc): 500mA – 2A

High currents during transmit and charging can be the source of significant IR losses
Sources of IR losses...

Typical elements which can cause IR losses in a device:

- Power switching elements
- Power rail filtering
- Insufficiently sized vias or pcb traces
- Power supply efficiency
How can PDN* Analysis assist the design process?

- **Visualisation of copper losses in the pcb design**
  - Trace widths
  - Via sizes

- **Evaluate the losses in power pass elements such as:**
  - High/Low side load switches
  - Power line filtering such as inductor and ferrite components
  - Connectors

- **Validate that connector pin current ratings are not exceeded**

- *Power Delivery Network*
A Typical Low Powered Wireless PSU Architecture

- Primary Power Source (AC Mains)
- PMIC
- Battery
- Microcontroller Sensor and Wireless Sub System
Major current paths

- Primary Power Source (AC Mains)
- PMIC
- Battery
- Charge/Discharge path
- Discharge path
- Microcontroller Sensor and Wireless Sub System
A typical Wireless device

Acknowledgements: Thank you to Hanhaa Ltd for permission to share elements of their Parcelive design
A typical Wireless device – pcb view

- U1 PMIC
- CN1 USB Charging Port
- U3 GNSS Supply
- CN3 Battery Connector
- U7 Modem
Battery Charging – USB to PMIC

USB Charging Port

PMIC Power Input
Battery Charging – USB to PMIC
Battery Charging – USB Connector pin current

USB Current

USB Connector pin current margin
Via currents & temperature rise

- PCB 1mm thick ‘FR-4’ with 0.3mm and 0.4mm via hole sizes
  - Allowed temperature rise above ambient 20°C
  - Plating thickness 17.8um

- Via 0.3mm parameters:
  - Rated current 1.27A

- Via 0.4mm parameters:
  - Rated current 1.47A
Via currents limits

• Current limits can be set as shown below:
Charging – via current violation

Via current of 1.676A exceeds 0.3mm via size rating of 1.27A

USB VBUS Violation
Charging – violating via location

Via location with current of 1.676A exceeding rating of 1.27A

Solution – increase via size and add second via
Charging – validating solution with larger 0.4mm diameter and extra via

USB VBUS no violations

Via current of 1.255A through 0.4mm via size meets rating of 1.47A
Battery Charging – location with larger 0.4mm diameter and extra via

Via location with maximum current of 1.255A
Charging – via locations with extra via

Two 0.4mm vias
Charging – via locations with extra via, close up

Two 0.4mm vias, showing lower current density
Battery Charging – PMIC to Battery trace

- PMIC Charging source
- Fuel gauge sense resistor
- Battery Connector
Battery Charging – Battery trace
Battery Charging – PMIC to Battery trace

PMIC charging current

Battery charging voltage @ connector
Battery Charging – PMIC to Battery trace

- PMIC Charging source
- Battery Connector
- Fuel gauge sense resistor
Optimising supply IR drops

- Fuel gauge sense resistor
- PMIC MOSFET $R_{DS_{ON}}$
- Ferrite filter DC resistance
- Power Switch MOSFET $R_{DS_{ON}}$
- Battery Connector
- Modem Load
- Load 1: 50.7mA 3.51V
- Load 2: 2.4A 3.28V
- Source 1: 3.7V 2.08A
- BAT
- VSYS
- Net1_2
- GSM_VBAT
Violation as the Modem supply is less than Modem Vmin

Violation
Fuel gauge sense resistor
PMIC MOSFET $R_{DS\text{ON}}$
Ferrite filter DC resistance
Power Switch MOSFET $R_{DS\text{ON}}$
Modem Load
Battery Connector
Supply $< 3.3V$!
Possible solutions

• Use a lower DC resistance ferrite:
  • 30mΩ instead of 50mΩ part
  • 9mΩ instead of 30mΩ part

• Use a lower $R_{on}$ MOSFET for the power switch
  • 17.5mΩ instead of 58mΩ part
Modem supply is now greater than Modem Vmin

- Passed
- Fuel gauge sense resistor
- PMIC MOSFET RDS\textsubscript{ON}
- Reduced ferrite filter DC resistance
- Power Switch MOSFET RDS\textsubscript{ON}
- Battery Connector
- Modem Load
- Supply > 3.3V!

How much voltage margin do we have?
With lower battery voltage modem supply is now too low...

Violation

Fuel gauge sense resistor

PMIC MOSFET RDS\textsubscript{ON}

Reduced ferrite filter DC resistance

Power Switch MOSFET RDS\textsubscript{ON}

Battery Connector

Modem Load

Supply $< 3.3\text{V}!$

Change to MOSFET with lower RDSon?
With lower battery voltage modem supply is now to low...

Violation
Fuel gauge sense resistor
PMIC MOSFET RDS_{ON}
Reduced ferrite filter DC resistance
Power Switch MOSFET RDS_{ON}
Modem Load
Supply < 3.3V!
Change to ferrite with even lower DC resistance?
Modem supply is now specification with a battery voltage of 3.55V

- Passed
- Battery Connector
- Fuel gauge sense resistor
- PMIC MOSFET RDS\textsubscript{ON}
- Reduced ferrite filter DC resistance
- Power Switch MOSFET RDS\textsubscript{ON}
- Modem Load
- Supply > 3.3V!
Summary

• Power delivery analysis can be used to validate the power networks in wireless devices – especially copper IR losses and validate via currents

• Using the power delivery analysis simulations it is simple to verify component losses and try different component options
Questions...

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Website: xitex.co.uk