



Freescale Technology Forum

Design Innovation.

Nov, 2008

Introducing Standard Power Management Lines

PC116



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- ▶ In this lecture, you will learn about new Freescale Power Management ICs that are excellent power supply solutions for embedded products that utilize i.MX, ColdFire®, Power®, or DSP devices.
- ▶ You'll learn about the versatile multiple output MC34704A/B as a low cost substitute for Atlas, the single/dual switching supplies for DDR memory, and the new, low-cost and simple buck regulator family. A power supply design example for the i.MX31, including proper power-up sequencing, will be presented.
- ▶ And you'll learn all about Freescale's new technology that makes it a snap to add a reliable and inexpensive Lithium Ion battery charger.

Standard PS Attach Solutions

- ▶ Stand-alone multi-channel PMU
 - **MC34704A** – 8-channel DC/DC
 - **MC34704B** – 5-channel DC/DC
- ▶ Stand-alone 4-channel PMU
 - **MC34700** – 3 buck + 1 LDO
- ▶ Stand-alone DC/DC buck regulator
 - **MC34727** -- 0.8V to 3.3V @ 300mA 2MHz switching
- ▶ Stand alone DDR and DC buck regulators
 - **MC34712 & MC34713** – single-channel
 - **MC34716 & MC34717** – dual-channel

Standard PS attach solutions

- ▶ Stand alone Li-ion battery charger IC
 - MC34671 (600mA)
 - MC34673 (1.2A)
 - MC34674 (1A travel charger)
 - MC34675 (1.2A + LDO)
 - MC34676 (Dual input AC/USB, 1.2A/400mA)

- ▶ Freescale is focusing the multimedia processor companion chip market
 - PMIC for i.MX51
 - (will NOT be covered in this presentation)
 - MC34704B (i.MX25, i.MX27, i.MX31)

- ▶ Competitor MCUs/MPUs
 - AMCC, AMD, PMC Sierra, Intel, NEC, etc.

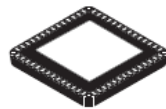
Standard Power Supply Applications

- ▶ Portable devices powered by Li-Ion/Polymer batteries or USB
- ▶ Li-Ion rechargeable battery packs
- ▶ Portable solar battery systems
- ▶ Portable media players
- ▶ Smart phones
- ▶ Wireless PDA
- ▶ Portable navigation devices
- ▶ Security or digital still cameras
- ▶ Remote controls
- ▶ Laser printers
- ▶ Networking appliances
- ▶ Cable modems
- ▶ Laser printers
- ▶ Fax machines
- ▶ Point-of-sale terminals
- ▶ Small appliances
- ▶ Telecom line cards
- ▶ DVD players
- ▶ Medical systems
- ▶ Mobile gaming consoles
- ▶ Set-top boxes
- ▶ PoL power supplies

MC34704A/B 5- & 8-Channel DC/DC regulators

Features

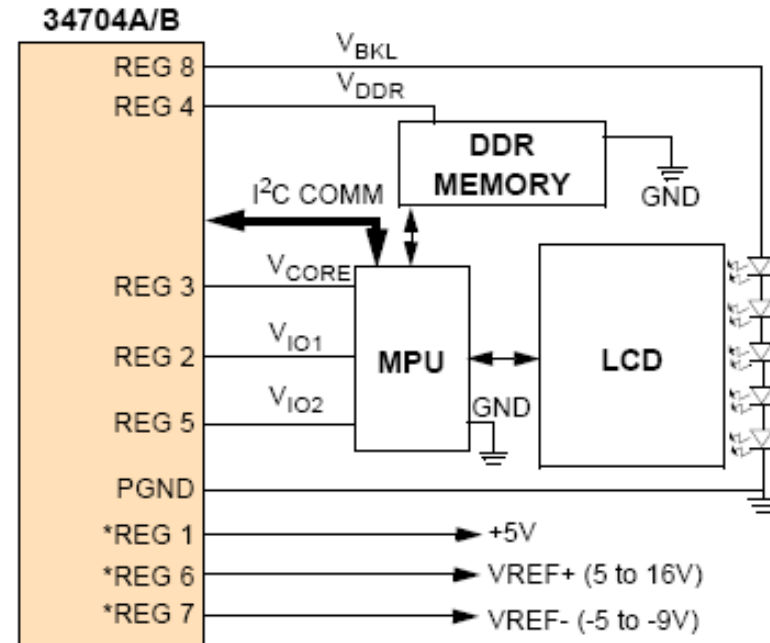
- ▶ $V_{in} = 2.7V$ to $5.5V$ ($7V$ abs max)
- ▶ Up to 8 DC-DC switching REGS
 - High efficiency, synchronous topologies
 - Integrated MOSFETS (except REG7)
 - Up to 2MHz switching
 - Automatic pulse skipping mode
 - Integrated compensation (REGs1, 3, 6, & 8)
 - +/-2% accuracy
- ▶ 1 μA shutdown mode
- ▶ Extensive protection
 - Input UVLO, Output UVP/OVP, OCP
- ▶ I2C control & monitoring
 - ON/OFF control for REG groups
 - Dynamic Voltage Scaling
 - LED back light control
 - Output UV/OV
 - Soft start time for each REG
- ▶ 56-lead 7x7mm² QFN



EP SUFFIX EXPOSED PAD
XX SUFFIX (PB-FREE)
98ASA10751D
56-PIN QFN

Applications

- DSC
- Portable consumer
- PoL (Point-of-Load) DC/DC converter



* Available only in 34704A device

MC34604A/B Output Channels

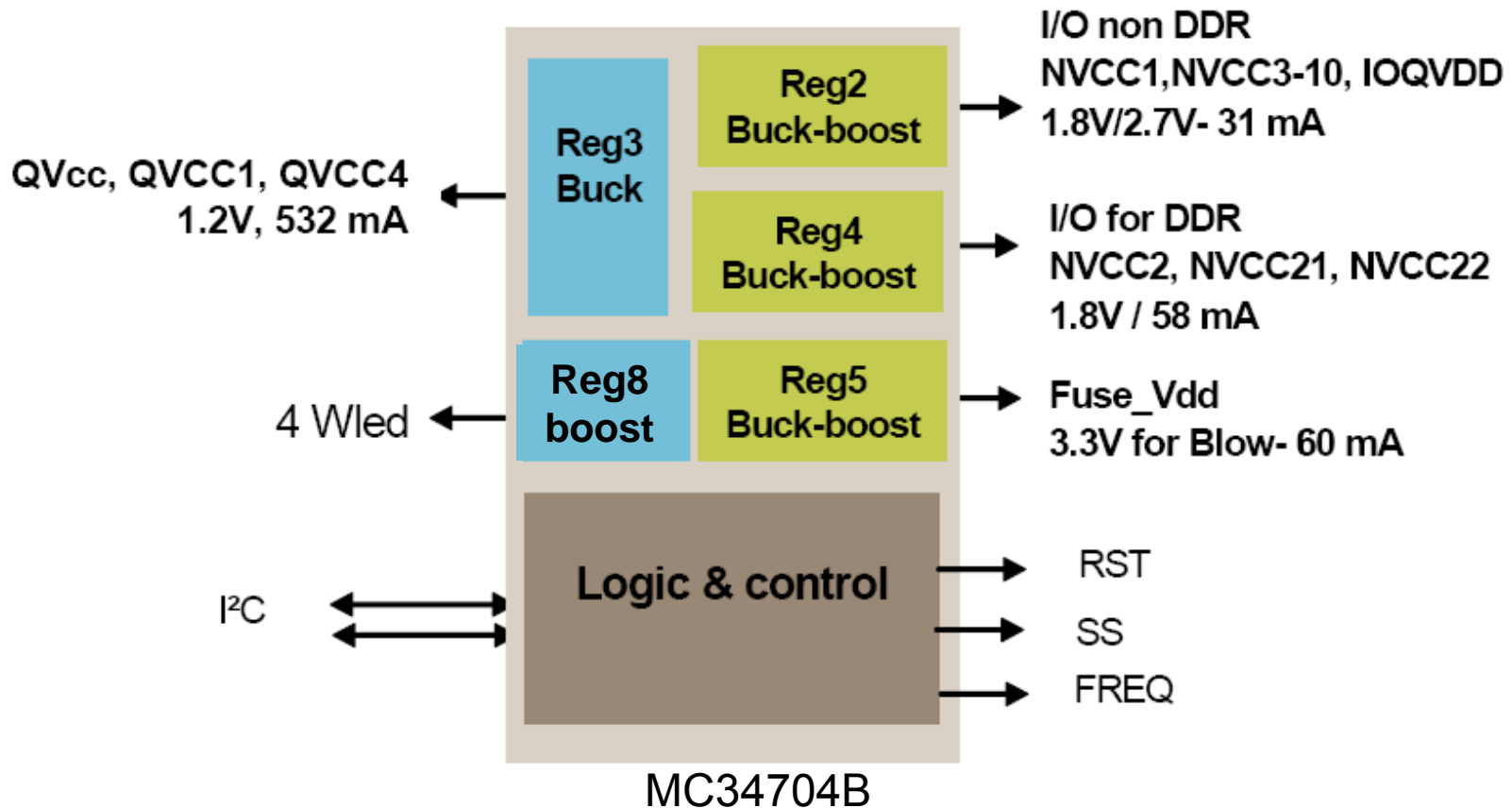
REGULATOR	REGULATOR TYPE	V _{OUT} TYP (V)	I _{OUT} TYP (MA)	I _{OUT} MAX (MA)	TARGET APPLICATION
REG1*	Synchronous Boost	5.0	100	500	+5V REF
REG2	Synchronous Buck-Boost	2.8 / 3.3	200	500	μP I/O **
REG3	Synchronous Buck	1.2 / 1.5 / 1.8	150	550	μP Core
REG4	Synchronous Buck-Boost	1.8 / 2.5	100	300	DDR
REG5	Synchronous Buck-Boost	3.3	150	500	μP I/O
REG6*	Synchronous Boost	15.0	20	60	REF+
REG7*	Inverter Controller	-7.0	20	60	REF -
REG8	Synchronous Boost	15.0	15	30	Backlight Display

* Available on MC34704A only

** Could be used to provide power to DDR memory

- ▶ The MC34704B is an 5-channel power management IC (PMIC).
- ▶ Lower-cost alternative to MC13783 and i.MX51 companion PMIC
- ▶ Efficiency of > 90% at typical loads
- ▶ Input voltage from 2.7V to 5.5V, from various sources:
 - 1-cell Li-Ion/Polymer (2.7V to 4.2V)
 - 5.0V USB supply or AC wall adapter
- ▶ Output voltages can be set between 0.6V to 3.6
 - To whatever the battery input voltage is
- ▶ Dynamic Voltage Scaling (DVS)
 - Allows programming the output voltages (+/-20% of the nominal voltage) with the I2C bus on-the-fly reducing i.MX power consumption
- ▶ MC34704 standard EVB available
- ▶ i.MX27 & i.MX31 internal application note
- ▶ C software layer to be integrated into customer BSP (Linux or WinCE distribution)
- ▶ Disty resale price 10K: \$2.85

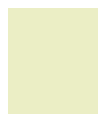
i.MX31 Power Break Down



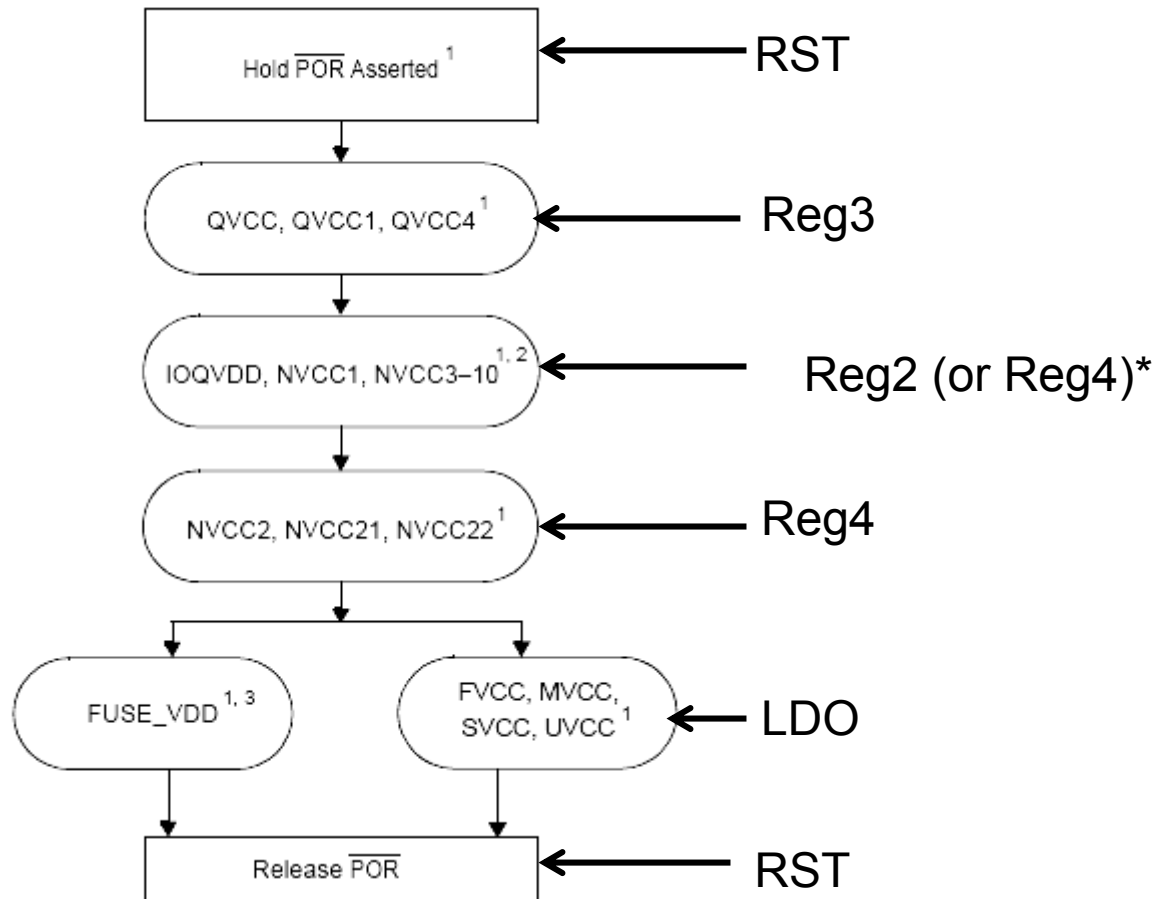
Power up sequence: Reg3→Reg2→Reg4

i.MX31 Power Requirements

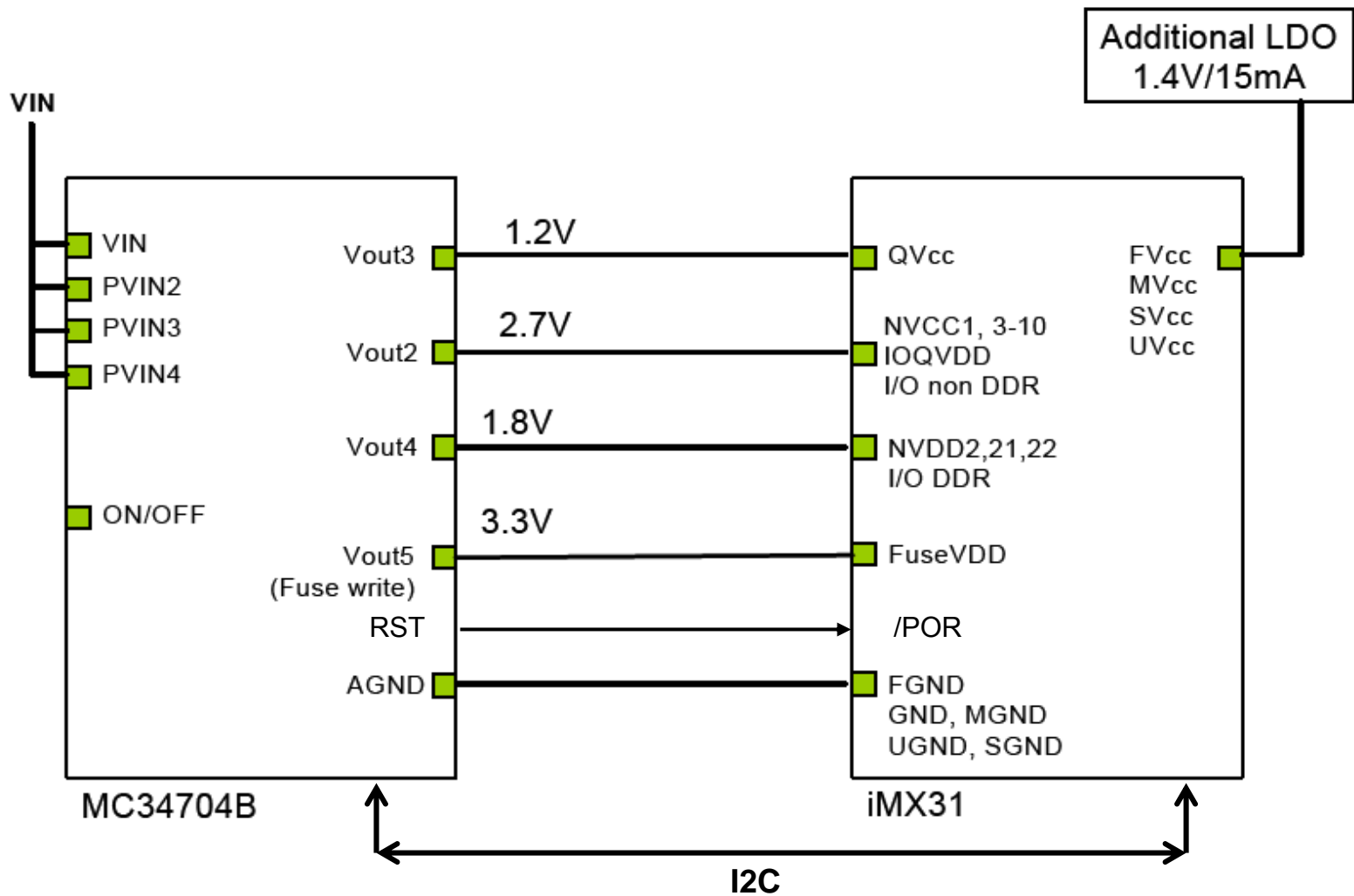
Symbol	Parameter	Min	Max	Units	
QVCC, QVCC1, QVCC4	Core Operating Voltage ¹			V	
	$0 \leq f_{\text{ARM}} \leq 400 \text{ MHz, non-overdrive}$ $0 \leq f_{\text{ARM}} \leq 400 \text{ MHz, overdrive}^2$ $0 \leq f_{\text{ARM}} \leq 532 \text{ MHz, overdrive}^2$	1.220 >1.47 1.55	1.47 1.65 1.65		
	State Retention Voltage ³	0.95	—		
NVCC1, NVCC3–10	I/O Supply Voltage, except DDR ⁴	non-overdrive overdrive ⁵	1.75 >3.1	3.1 3.3	V
NVCC2, NVCC21, NVCC22	I/O Supply Voltage, DDR only		1.75	1.95	V
FVCC, MVCC, SVCC, UVCC	PLL (Phase-Locked Loop) and FPM (Frequency Pre-multiplier) Supply Voltage ⁶	non-overdrive overdrive ²	1.3 >1.47	1.47 1.6	V
IOQVDD	On-device Level Shifter Supply Voltage		1.6	1.9	V
FUSE_VDD	Fusebox read Supply Voltage ^{7, 8}		1.65	1.95	V
	Fusebox write (program) Supply Voltage ⁹		3.0	3.3	V
T _A	Operating Ambient Temperature Range ¹⁰		0	70	°C

 = Use a separate LDO

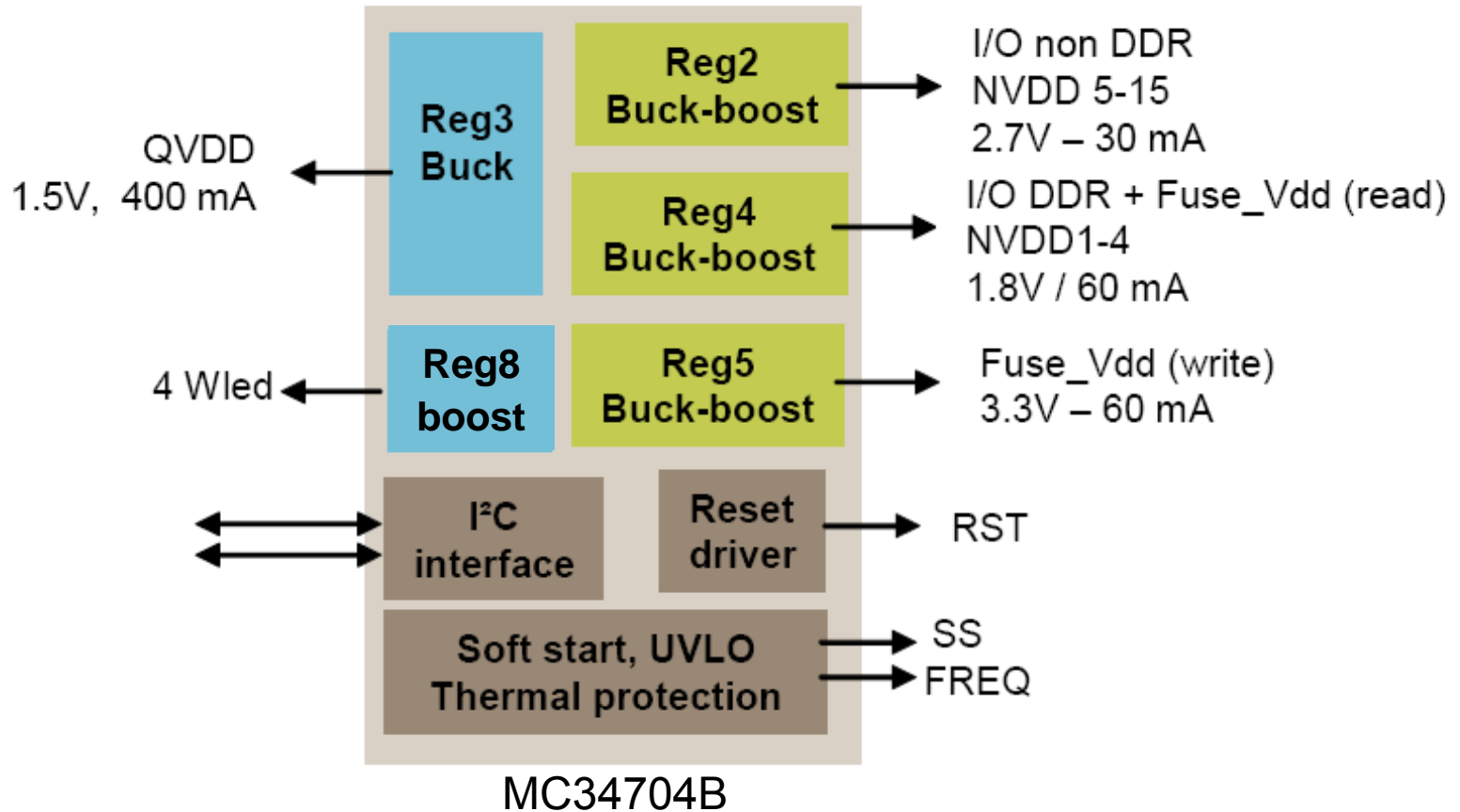
i.MX31 Power Up Sequencing



*Rev 2 silicon allows Reg2 & Reg4 to power up together. Reg2 can then be used for DDR power.



i.MX27 Power Breakdown



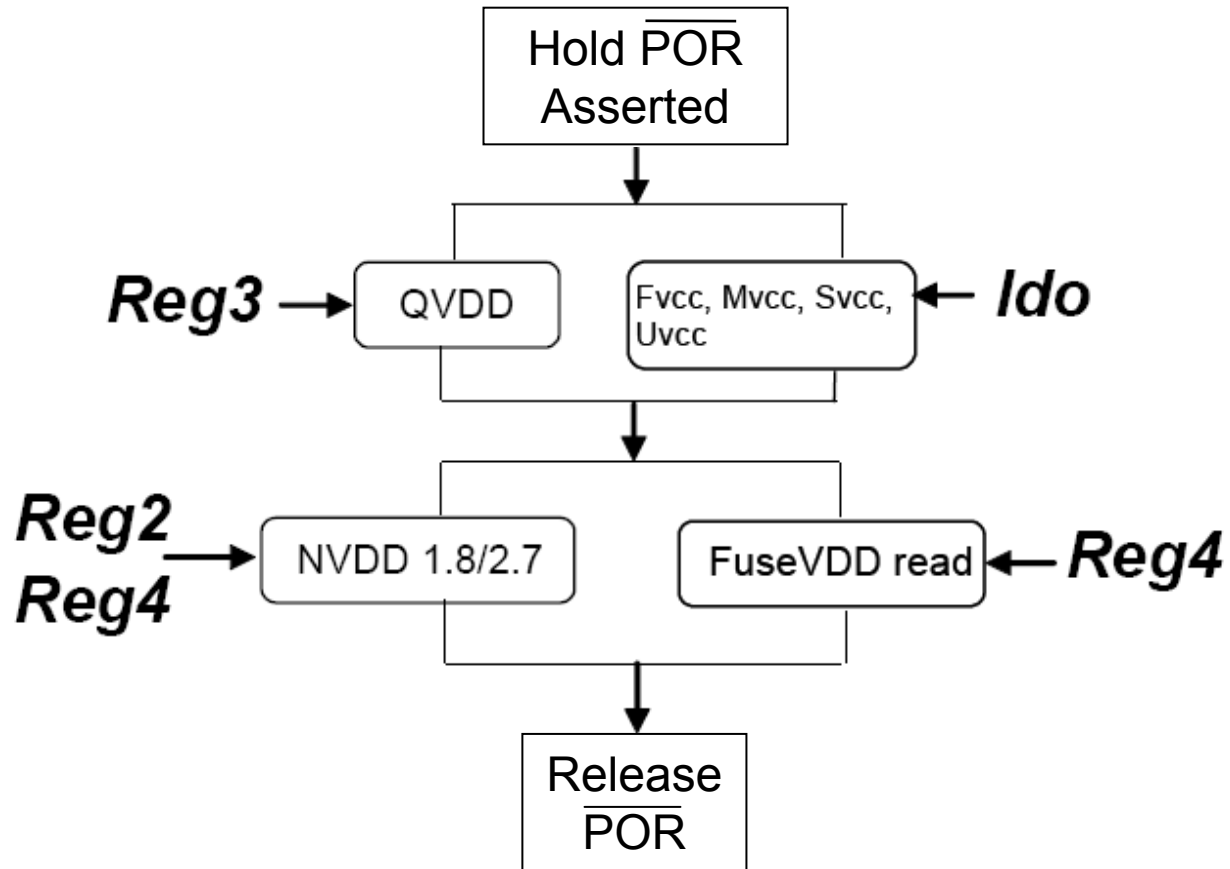
Power up sequence: Reg3→Reg2→Reg4

i.MX27 Power Requirements

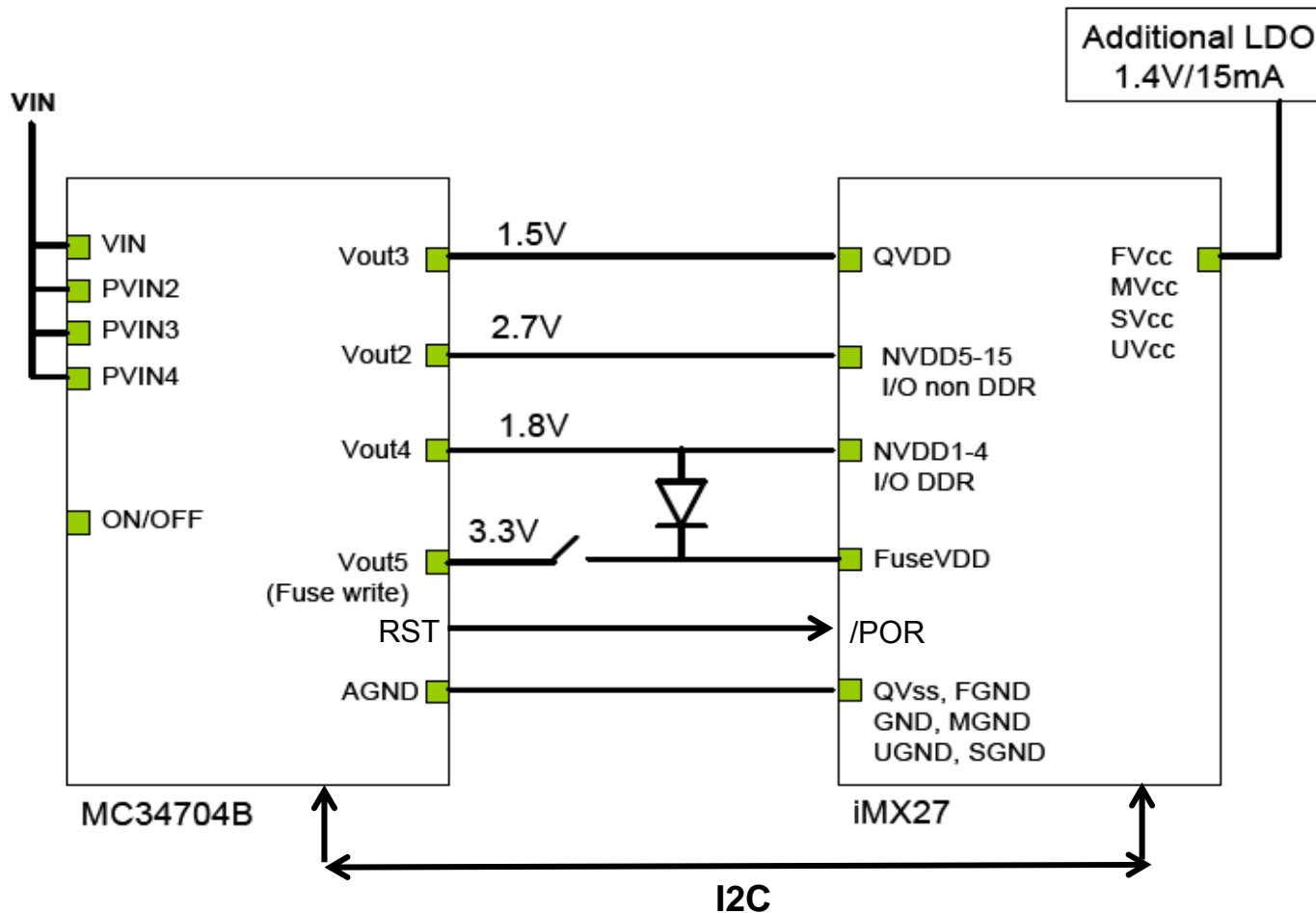
ID	Parameter	Symbol	Min	Typ	Max	Units
1	Core Supply Voltage (@266 MHz)	QV_{DD}	1.2	1.3	1.52	V
2	Core Supply Voltage (@400 MHz)	QV_{DD}	1.38	1.45	1.52	V
3	RTC, SCC separate Supply Voltage	RTC_{VDD}	1.2	—	1.52	V
4	I/O Supply Voltage, Fast (7, 11, 12, 14, 15) ¹	NV_{DD_FAST}	1.75	—	2.8	V
5	I/O Supply Voltage, Slow (5, 6, 8, 9, 10, 13, AV_{DD})	NV_{DD_SLOW}	1.75	—	3.05	V
6	I/O Supply Voltage, Slow (5, 6, 8, 9, 10, 13, AV_{DD}) ²	NV_{DD_SLOW}	1.75	—	3.3	V
7	I/O Supply Voltage, DDR (1, 2, 3, 4) ³	NV_{DD_DDR}	1.75	—	1.9	V
8	Analog Supply Voltage: $FPMV_{DD}$, $UPLL_{VDD}$, $MPLL_{VDD}$	V_{DD}	1.35	1.4	1.6	V
9	Fusebox read Supply Voltage	$FUSEV_{DD}$ (read mode)	1.7	1.875	1.95	V
10	Fusebox Program Supply Voltage	$FUSEV_{DD}$ (program mode)	3.00	3.15	3.30	V
11	$OSC32V_{DD}$	V_{OSC32}	1.1	—	1.6	V
12	$OSC26V_{DD}$	V_{OSC26}	2.68	—	2.875	V
13	Operating Ambient Temperature	T_A	-20	—	85	°C

 = Use a separate LDO

i.MX27 Power up Sequencing



i.MX27 Power Block Diagram



- ▶ The enable pin of the LDO should be tied to the general enable of the system together with the C34704 enable pin
- ▶ Vout5 is used for fuse writing purpose (3.3V)
 - It can also be used for additional 3.3V peripherals (60 mA)
 - Can be turned on or off at any time via I2C
- ▶ Vout8 (LED backlight) can be controlled via I2C
- ▶ Processor can shutdown the 34704 by sending an “ALLOFF” command via I2C
- ▶ Shutdown event can also happen through the ONOFF pin by pressing and holding the pin for a time period
 - Programmable through I2C with a default of 1sec
- ▶ Application notes available for i.MX27, i.MX31 **and** i.MX25

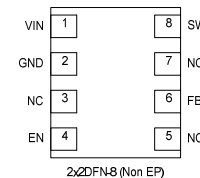
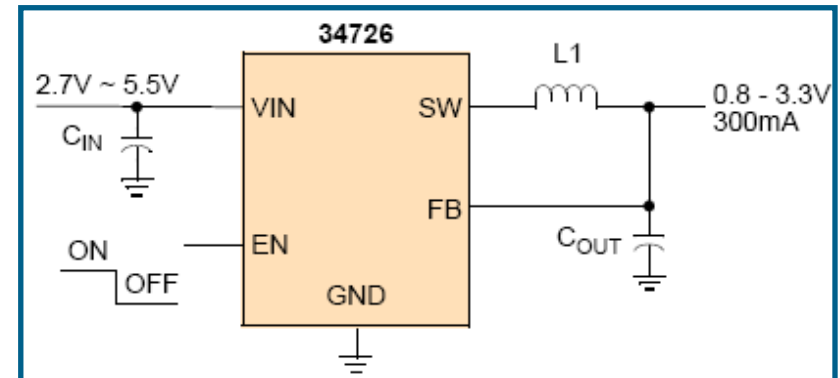
MC34726/7 Synchronous Buck Regulator With Z-Mode

Features

- ▶ High efficiency - up to 94%
- ▶ High switching frequency of 2MHz/4Mhz
- ▶ Automatic transition to energy saving light load Z-Mode (low ripple)
- ▶ Input voltage range of 2.7V to 5.5V
- ▶ Fixed output voltage options from 0.8V to 3.3V
- ▶ 300mA (MC34726) or 600mA (MC34727) maximum continuous output current
- ▶ Internal 2ms soft start
- ▶ 0.1µA quiescent current in shutdown
- ▶ -40°C - +85°C operating temperature range
- ▶ **Tiny 2x2 DFN-8 package**

Applications

- Cell phones/ PDAs / Smart phones
- MP3/4 and PMPs
- Digital cameras
- Other portable consumer devices
- PoL DC/DC converter



MC34726/7 Device Variations

Freescale Part No.	V _{IN} Range	Output Voltage ⁽¹⁾	Maximum Load Current	Switch Frequency (MHz) ⁽²⁾
MC34726AFC	2.7 - 5.5V	1.2V	300mA	2.0
MC34726BFC	2.7 - 5.5V	1.8V	300mA	2.0
MC34726CFC	3.6 - 5.5V	3.3V	300mA	2.0

Notes

1. Output voltages of: 0.8V, 0.9V, 1.0V, 1.1V, 1.3V, 1.4V, 1.5V, 1.85V, 2.0V, 2.5V options available on request. Contact Freescale sales.
2. Factory programmable at 2.0MHz or 4.0Mhz. Contact Freescale sales for availability of the 4.0MHz functionality.

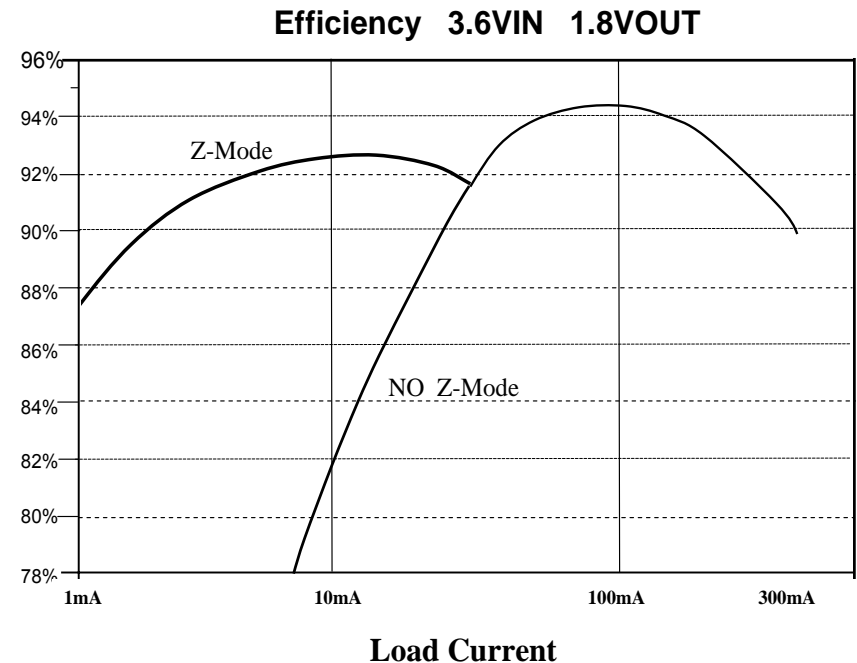
Freescale Part No.	V _{IN} Range	Output Voltage ⁽¹⁾	Maximum Load Current	Switch Frequency (MHz) ⁽²⁾
MC34727AFC	2.7 - 5.5V	1.2V	600mA	2.0
MC34727BFC	2.7 - 5.5V	1.8V	600mA	2.0
MC34727CFC	3.6 - 5.5V	3.3V	600mA	2.0

Notes

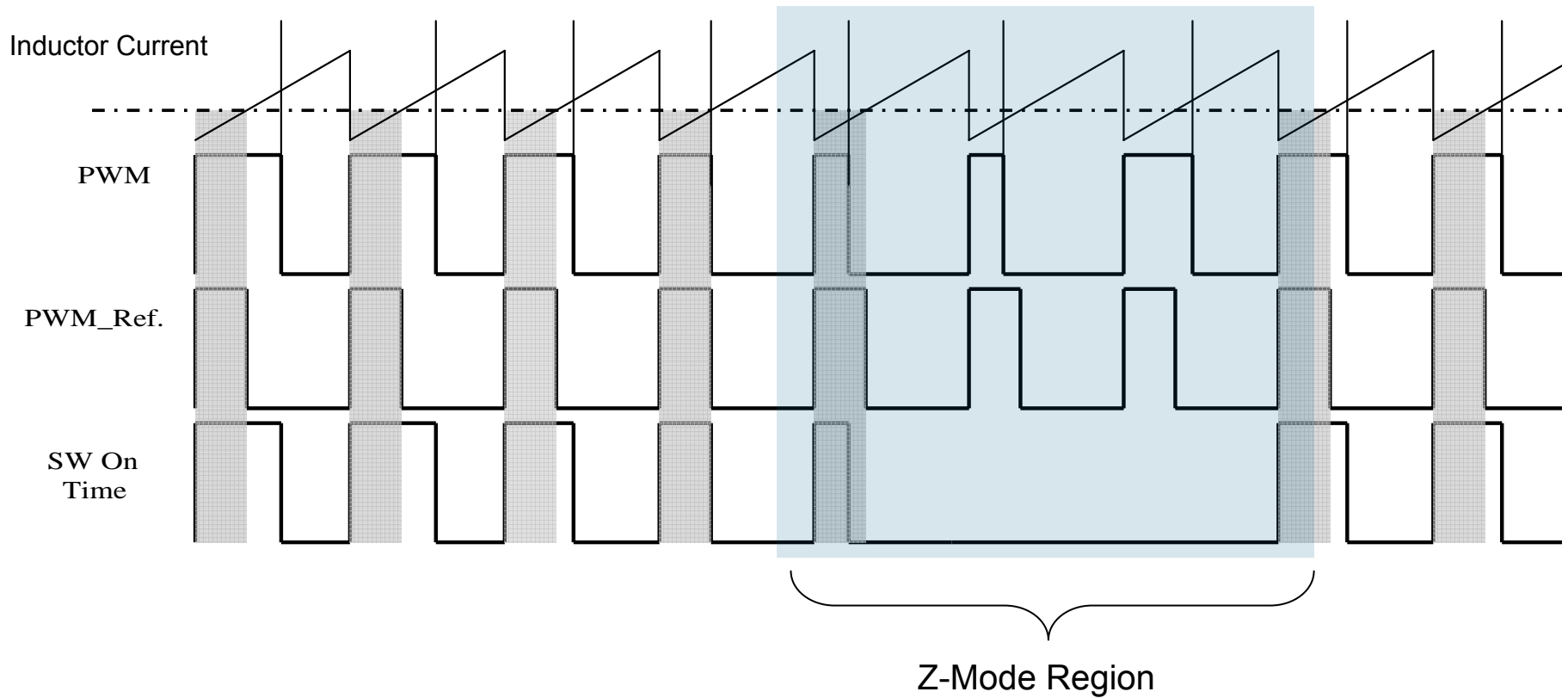
1. Output voltages of: 0.8V, 0.9V, 1.0V, 1.1V, 1.3V, 1.4V, 1.5V, 1.85V, 2.0V, 2.5V options available on request. Contact Freescale sales.
2. Factory programmable at 2.0MHz or 4.0Mhz. Contact Freescale sales for availability of the 4.0MHz functionality.

What is Z-Mode?

- ▶ Operates as a typical fixed frequency PWM regulator at moderate to heavy loads
- ▶ When the load is decreased, the duty cycle will also be reduced until it reaches 0.85 (*Z-mode Factor*) of the full load Duty cycle
- ▶ It then transitions into Z-Mode operation. In Z-mode the regulator will skip pulses whenever the duty cycle is below 85%, as the load decreases this pulse skipping will reduce the switching frequency and will lower the switching losses thus improving efficiency
- ▶ Example:
A light load demanded a 30% duty cycle at 2MHz, with Z-Mode this same load will require only $(0.3 \times 2\text{MHz}) / 0.85 = 0.706\text{MHz}$, hence switching losses have been reduced by three fold.

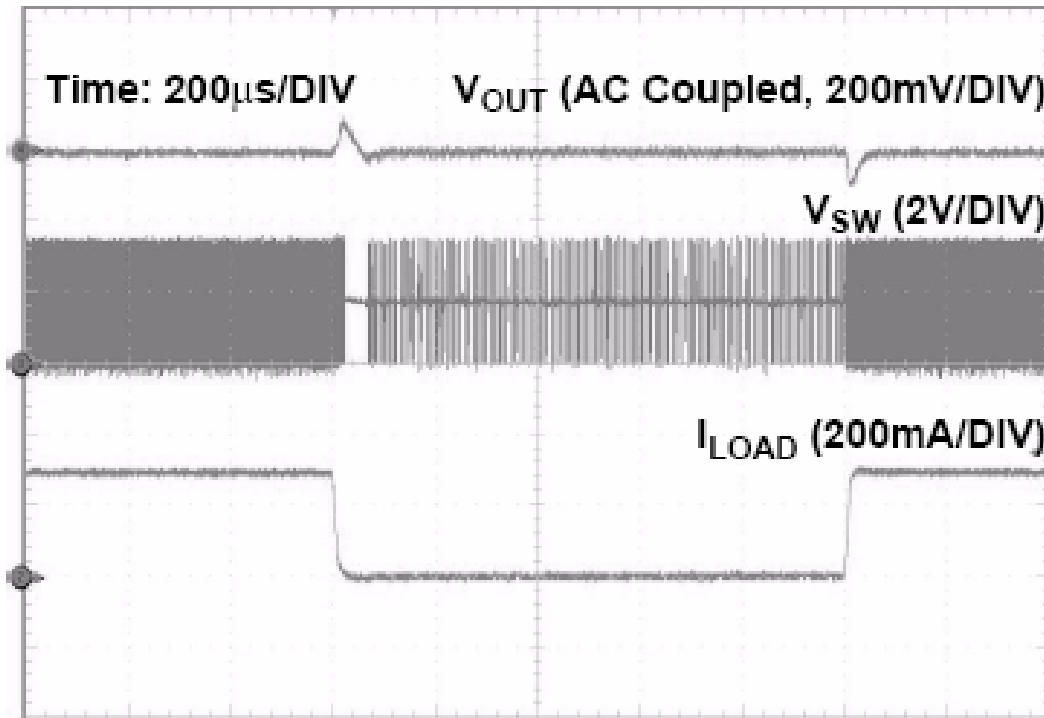


Switching Waveforms



Pulses skipped resulting in lower frequency and lower switching losses.

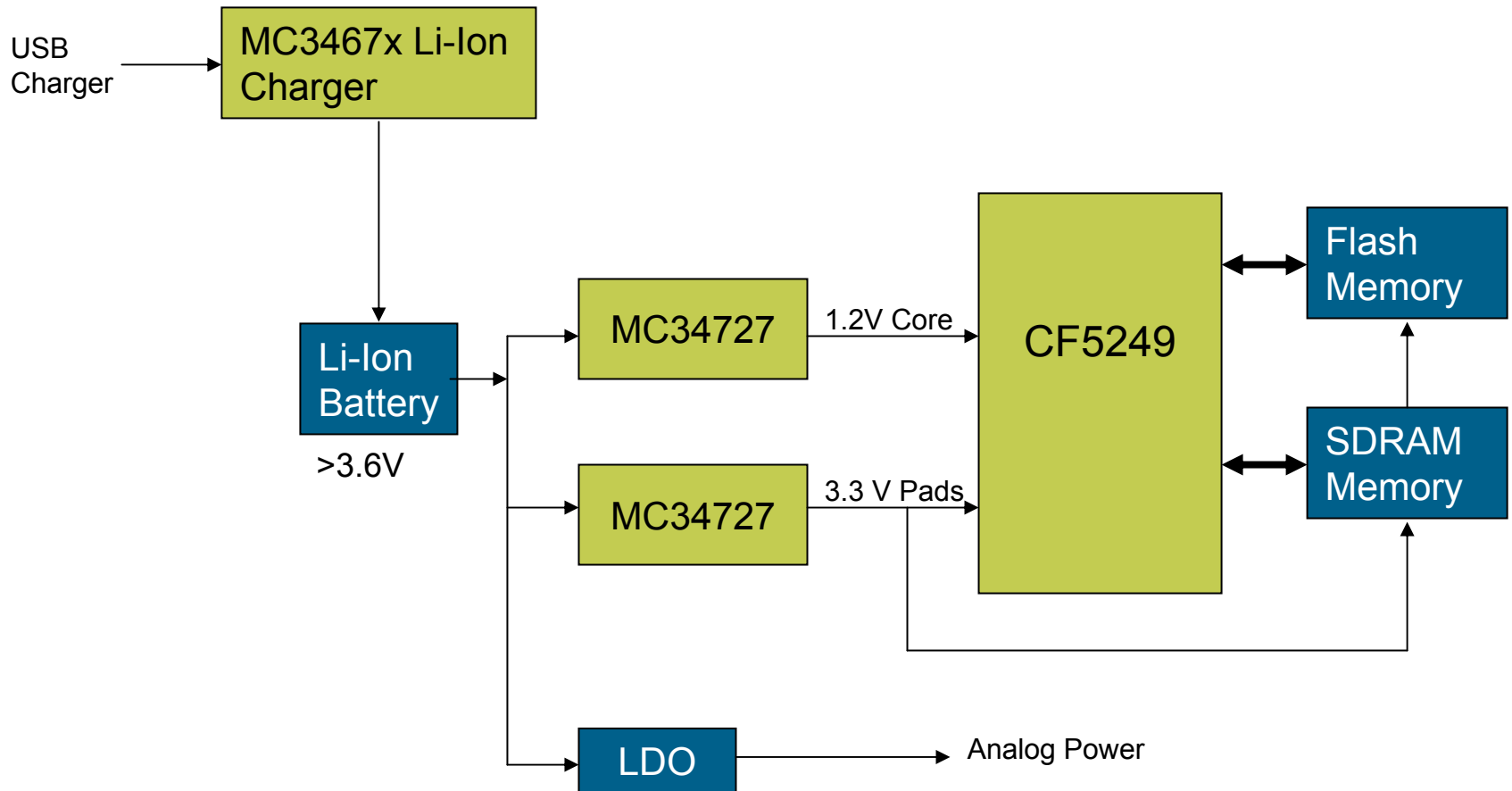
Load Transients in Z-Mode



Oscilloscope display showing transition from normal to Z-Mode due to a transient change in load current

MC34727 Example

ColdFire Portable Media Player



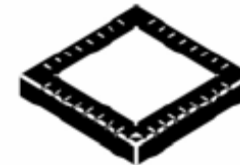
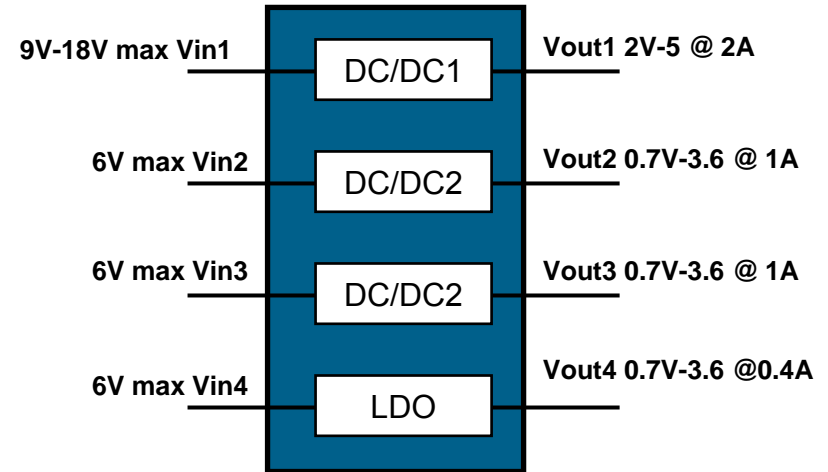
34700 4-Output Regulator

FEATURES:

- ▶ Three switching regulators, two of which are synchronous
- ▶ Low-drop out (LDO) linear regulator
- ▶ High accuracy voltage outputs (+/- 2%)
- ▶ User configurable power up sequencing
- ▶ Cycle by cycle current limit and short circuit protection
- ▶ Thermal shutdown protection
- ▶ Over voltage and under voltage protection
- ▶ Over current protection
- ▶ Supervisory functions
- ▶ Active high power-good output signal
- ▶ Active low SHTDN inputs
- ▶ 32-lead 5x5mm QFN package

APPLICATIONS:

- ▶ Tethered power (9.0-18 volts input)
- ▶ Set-top boxes and receivers
- ▶ Network routers
- ▶ Cable modems
- ▶ Telecom and line cards

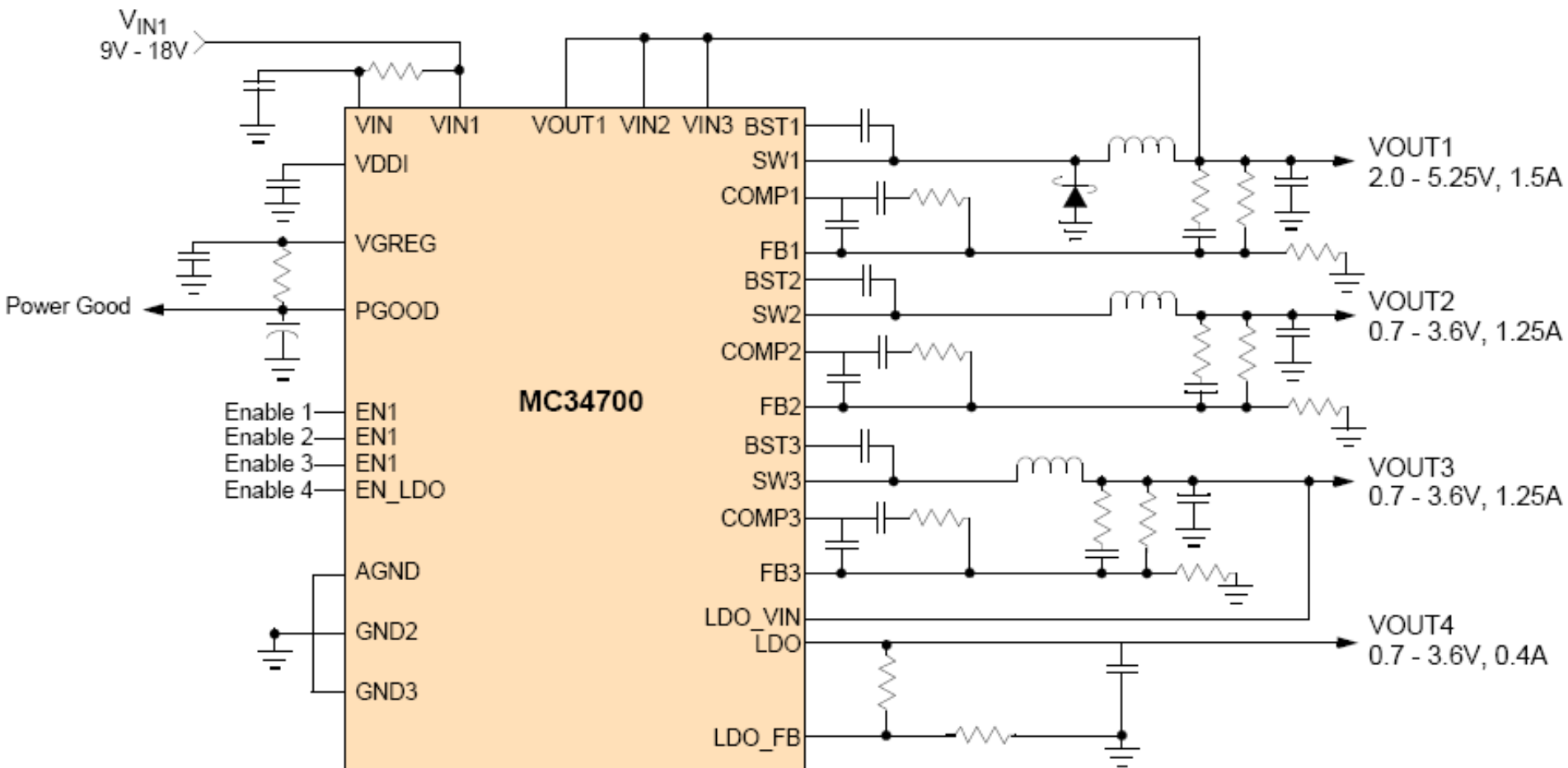


32-lead QFN

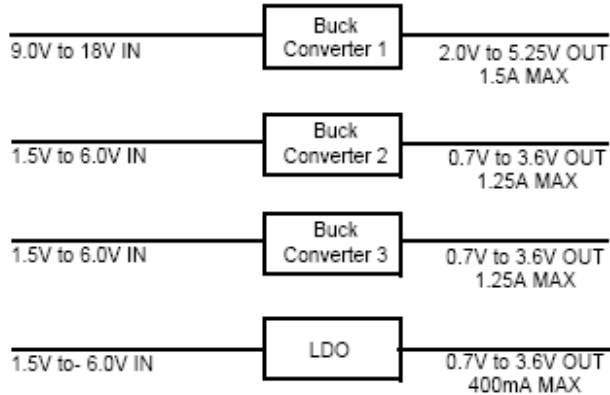
5x5 mm



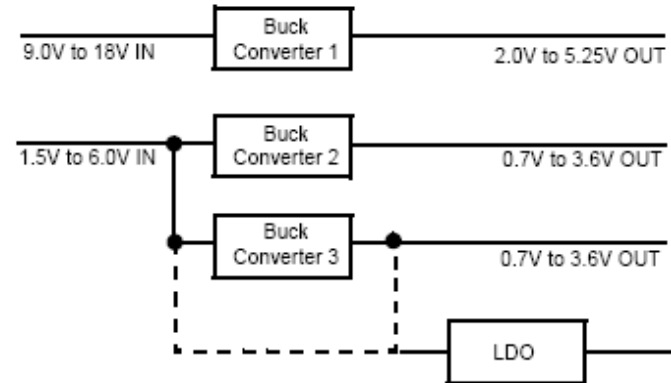
MC34700 Simplified Application Diagram



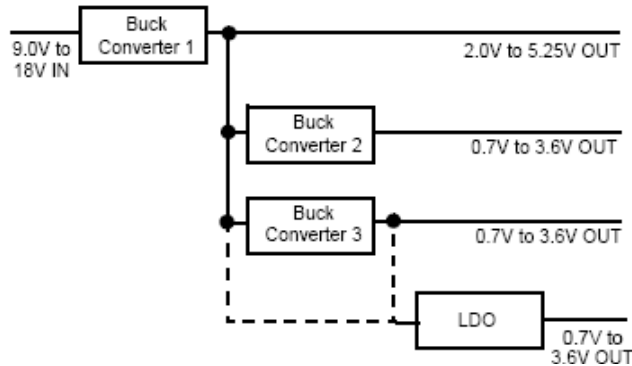
Input / Output Configurations



General Configuration

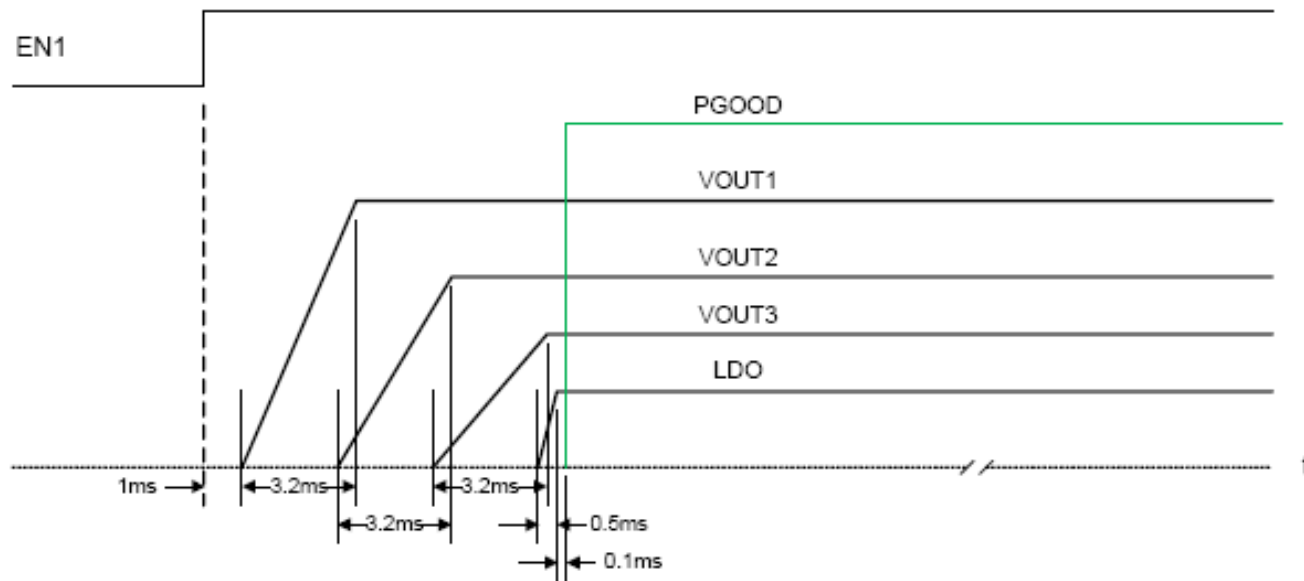
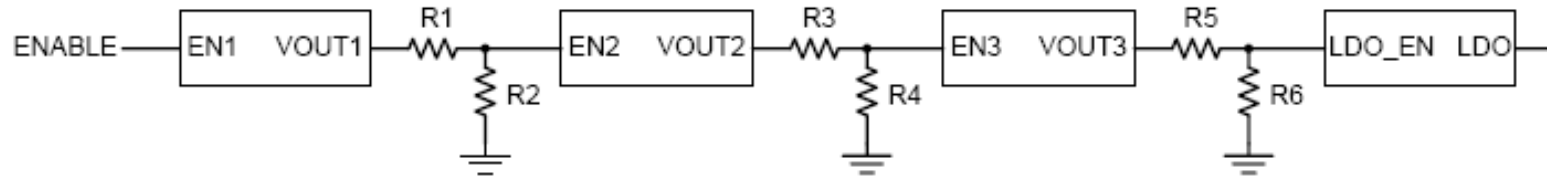


Dual Input Supply Configuration



Single Input Supply Configuration

Cascaded Operation



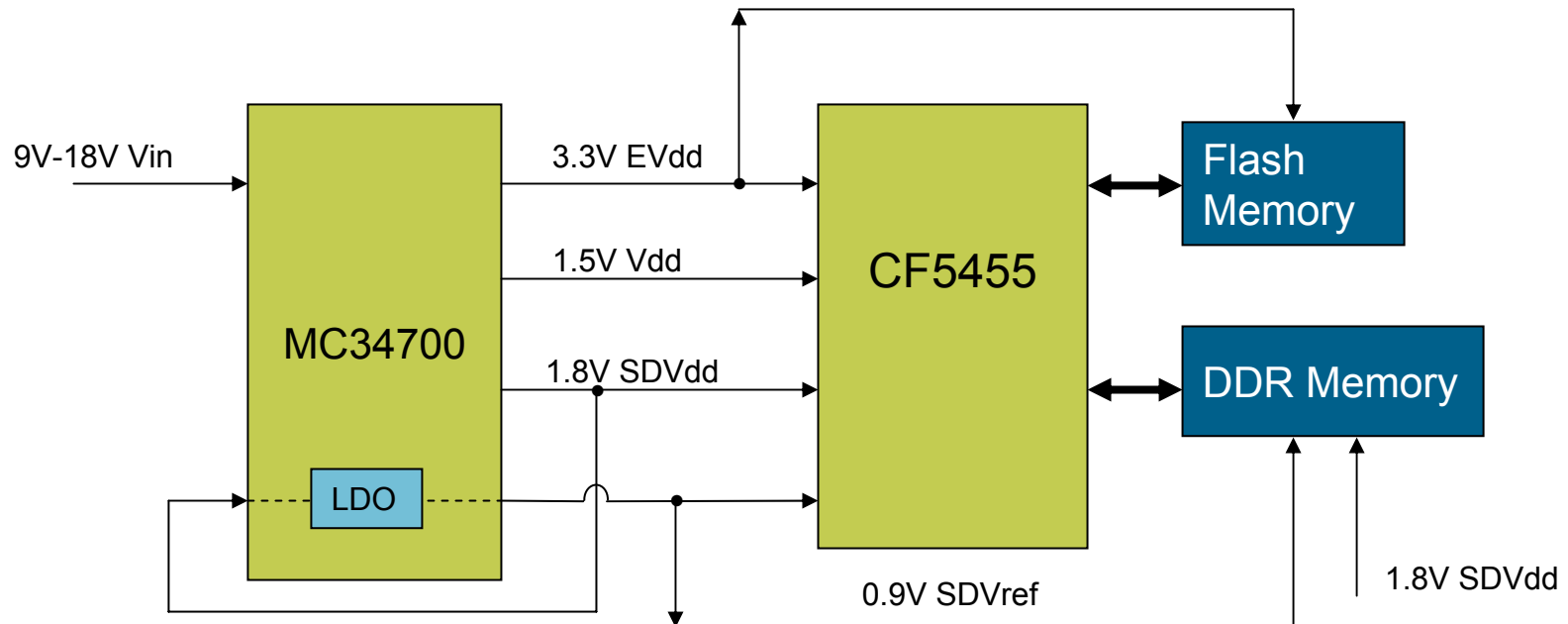
Resistors added to reduce leakage current

Red Stripe Power Budget

Core Freq.		Idle	MP3 Playback	TFTP Download	USB HS File Copy	Units
266 MHz	IV_{DD}	215.6	288.8	274.4	263.7	mA
	EV_{DD}	27.6	33.6	32.6	32.4	
	SDV_{DD}	142.9	158.2	161.1	158.0	
	Total Power	672	829	809	787	mW
200 MHz	IV_{DD}	163.8	228.0	213.8	207.9	mA
	EV_{DD}	29.9	34.7	34.3	33.8	
	SDV_{DD}	142.2	158.5	160.0	153.4	
	Total Power	601	742	722	699	mW

¹ All voltage rails at nominal values: $IV_{DD} = 1.5$ V, $EV_{DD} = 3.3$ V, and $SDV_{DD} = 1.8$ V.

ColdFire CF5455 Power Supply Simplified Block Diagram

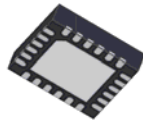


PGOOD and EN pins not shown

Overview of the DDR Family of Devices

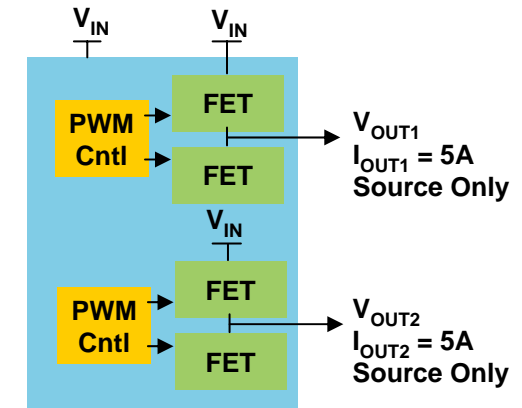
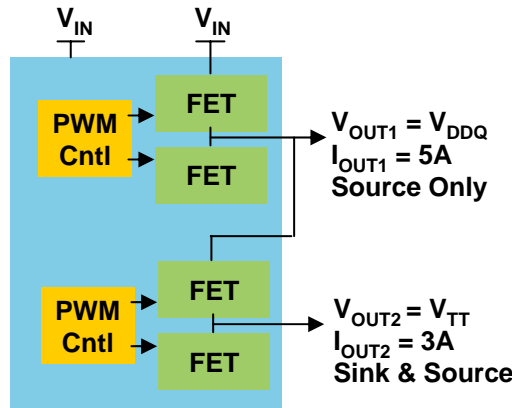
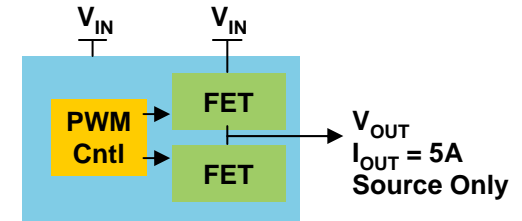
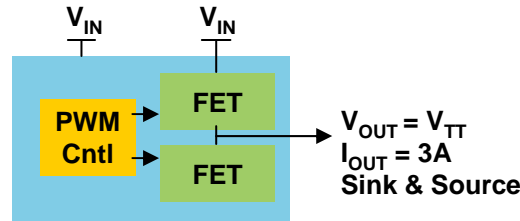
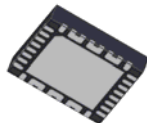
▶ MC34712/3

- Single SMPS
- V_{IN} : 3.0V to 6.0V
- V_{OUT} : 0.7V to 3.6V
- I_{OUT} : 5.0A
- 24Ld 4x4 EP QFN



▶ MC34716/7

- Dual SMPS
- V_{IN} : 3.0V to 6.0V
- $V_{OUT1,2}$: 0.7V to 3.6V
- $I_{OUT1,2}$: 5.0A
- 26Ld 5x5 EP QFN



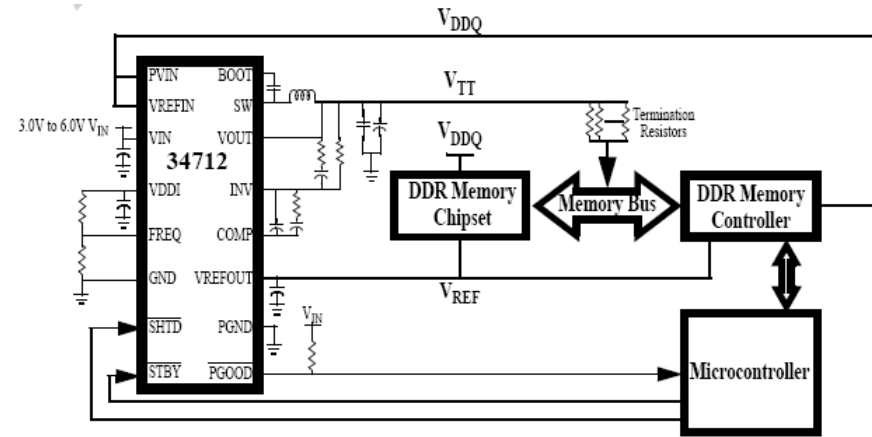
DDR Applications
Maximum 3A peak current
Termination Voltage V_{TT}

General DC/DC Applications
Each output is independent, 5A
current maximum on all rails

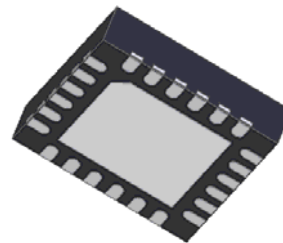
MCZ34712/3 - Single Power Regulator for DDR & DC-DC

FEATURES

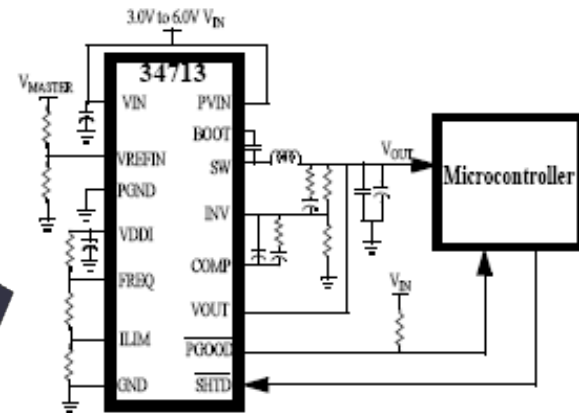
- Input operating voltage 3.0V to 6.0V
- 1MHz synchronous switching regulator
 - Programmable f_s 200KHz to 1MHz
 - Integrated MOSFETs
 - MCZ34712 DDR version: 3A sink/source output
 - MCZ34713 DC-DC version: 5A source output
- Supports V_{TT} for DDR I, II, or III
 - Ref-In pin for tracking voltage output
- Output voltage +/-2% accuracy
 - Adjustable output 0.7V to 3.6V
 - Separate VREF output +/-2% accuracy
- PGOOD, STDBY, & SD inputs (active low)
- Soft Start
- Extensive protection
 - OVP, UVP, OCP, Short ckt, & Thermal
 - Programmable OC limit on MZC34713



DDR Simplified Apps Diagram



24Ld 4x4 EP QFN
ROHS Compliant

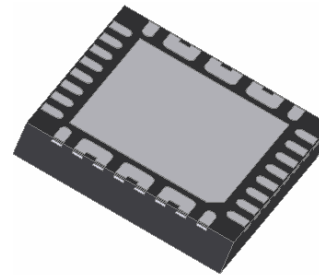


DC-DC Simplified Apps Diagram

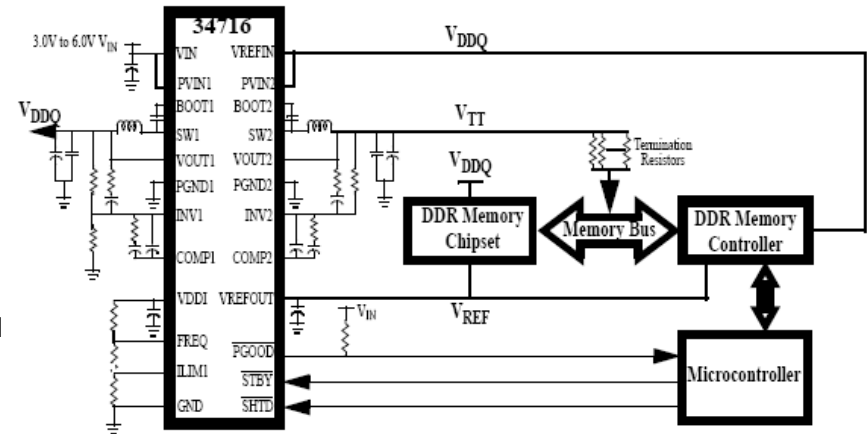
MCZ34716/7 - Dual Power Regulator for DDR & DC-DC

FEATURES

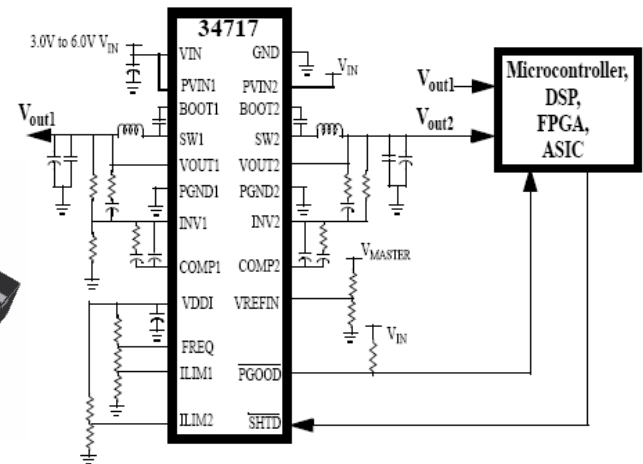
- Input operating voltage 3.0V to 6.0V
- Dual 1MHz synchronous switching regulators
 - Programmable f_s 200KHz to 1MHz
 - Integrated MOSFETs
 - MCZ34716 DDR version: 5A/3A sink/source output
 - MCZ34717 DC-DC version: 5A/5A source output
- Supports V_{DDQ} & V_{TT} for DDR I, II, or III
- Output voltage +/-2% accuracy
 - Adjustable output 0.7V to 3.6V
 - Separate VREF output +/-2% accuracy
- PGOOD, STDBY, & SD inputs (active low)
- Soft Start - both outputs
- Extensive protection
 - OVP, UVP, OCP, Short ckt, & Thermal
 - Programmable over current limit on Ch1
 - Default over current limit on Ch2



26Ld 5x5 EP QFN



DDR Simplified Apps Diagram



DC-DC Simplified Apps Diagram

MCZ34712,13,16,17 Benefits

- ▶ Flexible solution for any version of DDR
 - DDRI, DDRII and DDRIII compatible
 - 3.0V to 6.0V input voltage
- ▶ Provides a very small solution for space constrained applications
 - Integrated Controller & MOSFETs
 - Small QFN packages (34712/3 - 4x4mm², 34716/7 - 5x5mm²)
 - High switching frequency (up to 1MHz) for small inductor and caps
- ▶ Reduces total component count
 - No external MOSFETs necessary
- ▶ High efficiency
 - Synchronous buck switching converter(s)
 - Typical efficiencies up to 93%
- ▶ Extensive interface and control
 - PGOOD output
 - Standby & shutdown inputs

MPC8260 Voltage Requirements

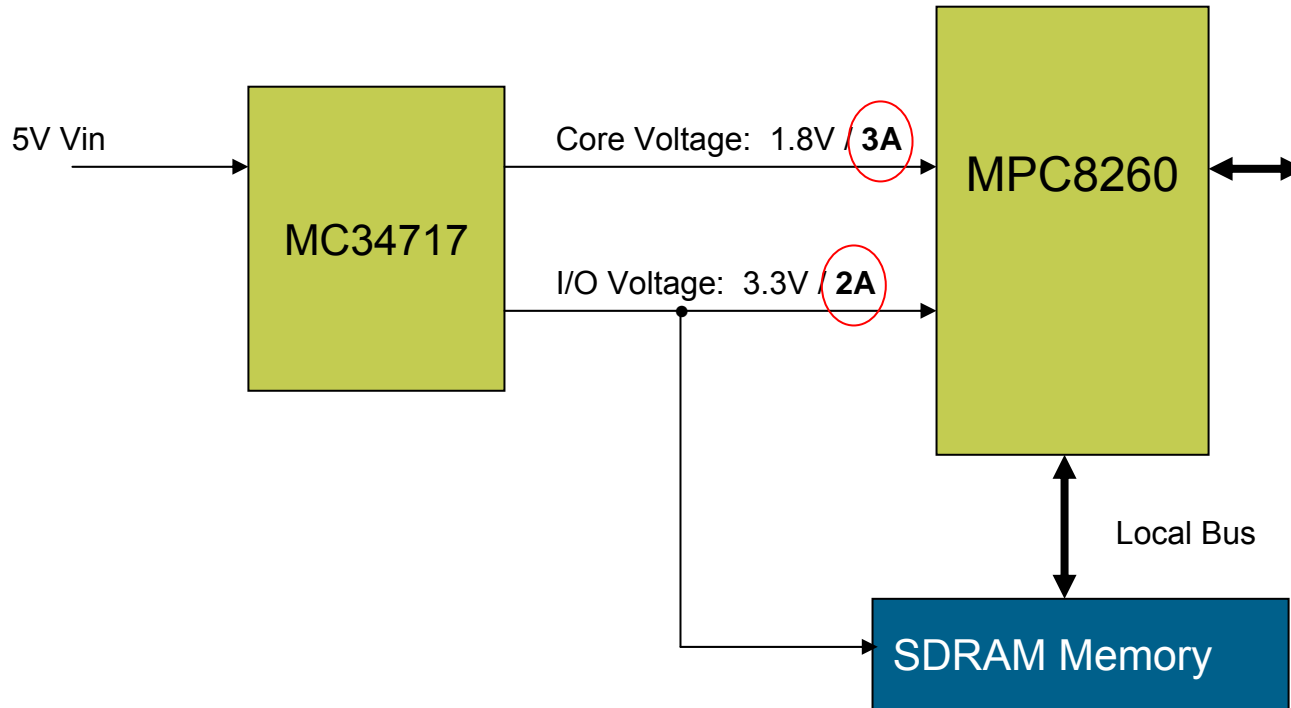
Rating	Symbol	Value			Unit
Core Supply Voltage	V_{DD}	1.7 - 1.9 ⁽²⁾	1.7 - 2.1 ⁽³⁾	1.9 - 2.2 ⁽⁴⁾	V
PLL Supply Voltage	V_{CCSYN}	1.7 - 1.9 ⁽²⁾	1.7 - 2.1 ⁽³⁾	1.9 - 2.2 ⁽⁴⁾	V
I/O Supply Voltage	V_{DDH} ⁽⁵⁾	3.135 - 3.465			V
Input Voltage	V_{IN} ⁽⁵⁾	GND (-0.3) - 3.465			V
Junction Temperature (Maximum)	T_J	105 ⁽⁶⁾			°C
Ambient Temperature	T_A	0 - 70 ⁽⁶⁾			°C

Notes:

1. Caution: These are the recommended and tested operating conditions. Proper device operation outside of these conditions is not guaranteed.
2. CPU frequency less than or equal to 200 MHz.
3. CPU frequency greater than 200 MHz but less than 233 MHz.
4. CPU frequency greater than or equal to 233 MHz.
5. V_{DDH} and V_{DD} must track each other and both must vary in the same direction; in the positive direction (+5% and +0.1 V_{DC}) or in the negative direction (-5% and -0.1 V_{DC}).
6. Note that for extended temperature parts, the range is -40°C T_A - 105°C T_J .

MC34717 and PowerQUICC II -- MPC8260

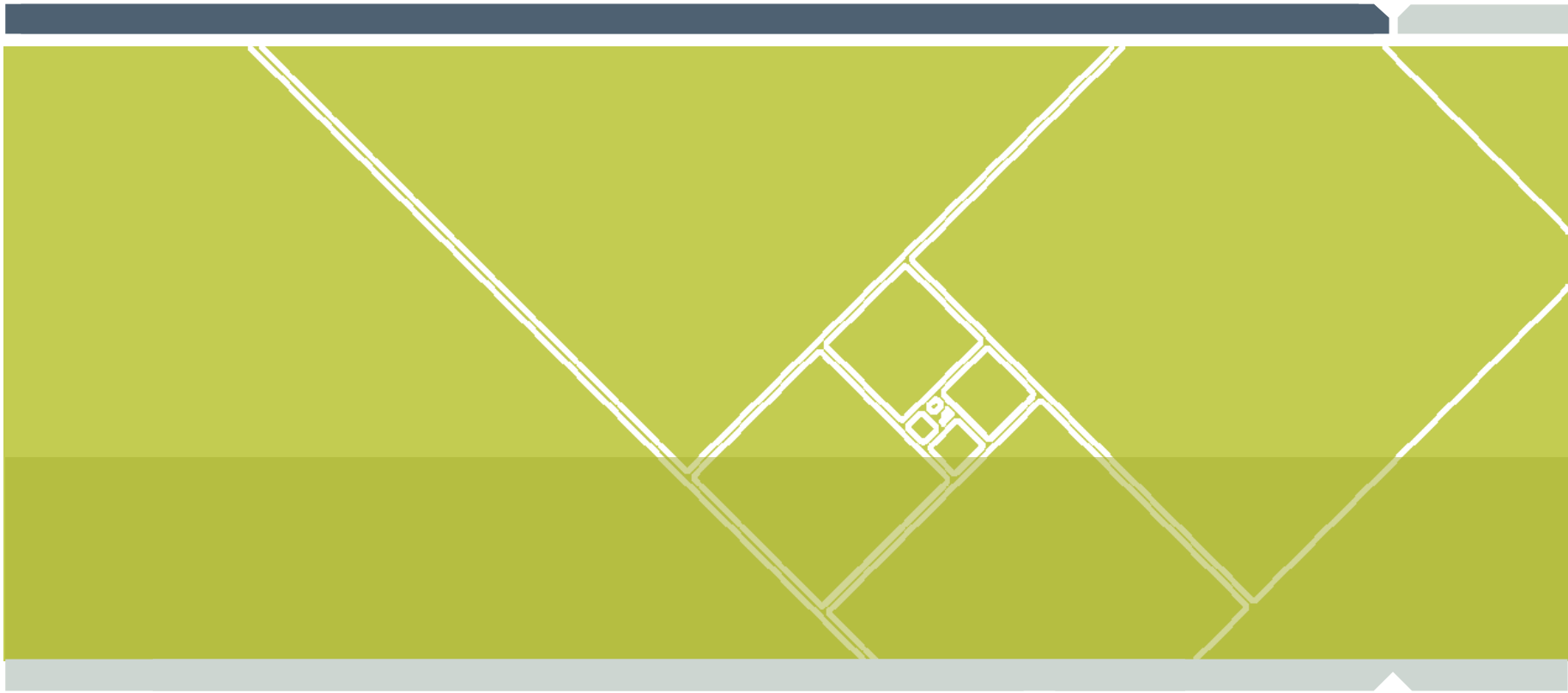
Simplified Block Diagram



PGOOD, STANDBY, and SHUTDOWN pins not shown

Layout Considerations

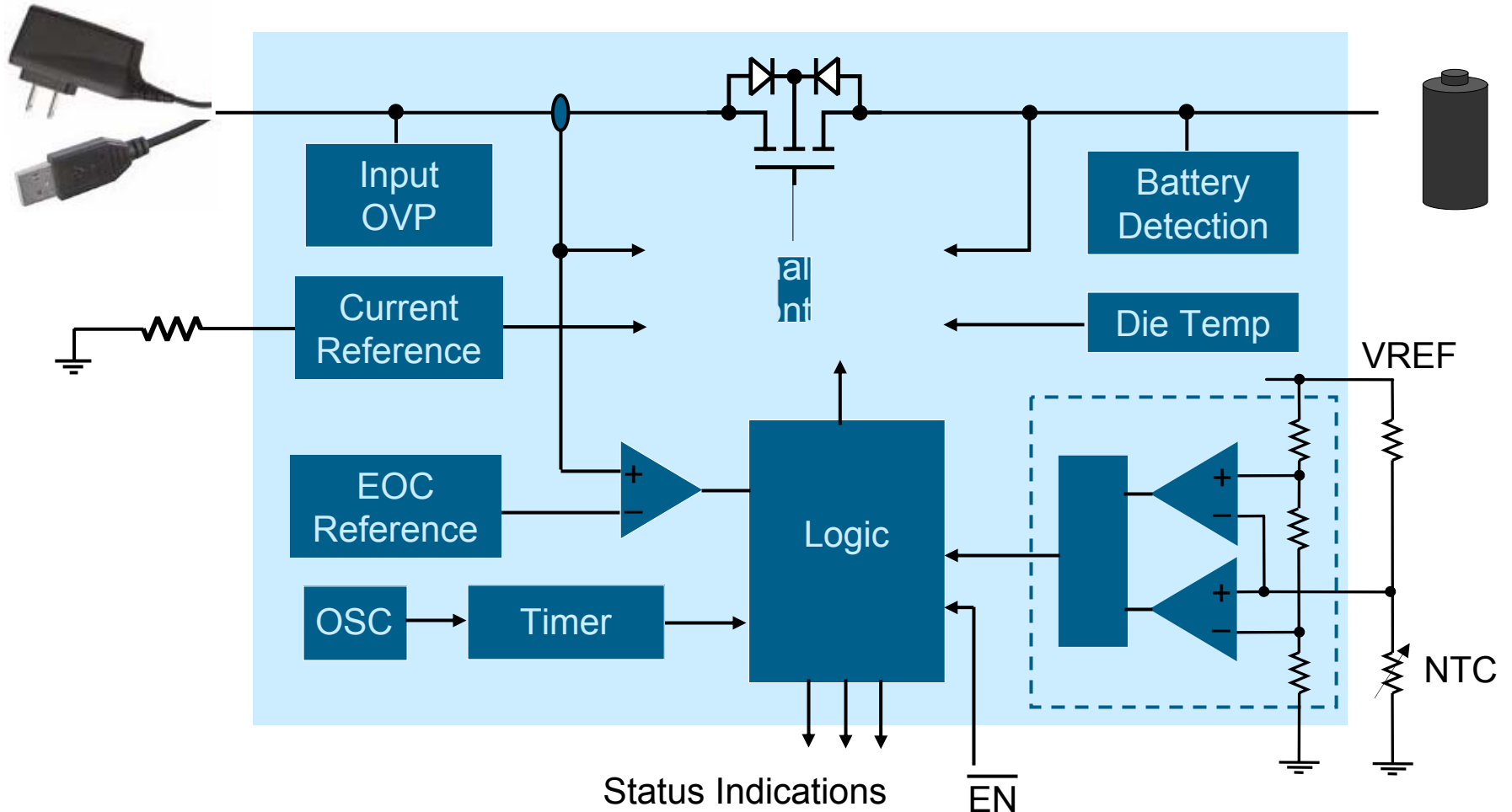
- ▶ When designing high-switching frequency power supplies, care must be observed when it comes to the layout. We strongly recommend:
 - Power components should be placed close to each other.
 - Their connections should be made with wide traces, and if possible copper-filled areas.
- ▶ In order to reduce EMI, inductor and output capacitors should be as close to each other as possible
- ▶ Input capacitors should be placed right on the drain of the LDO MOSFET and the input terminal of the MC34704B device. Output capacitors should be placed right after the sense resistor
- ▶ Feedback traces for the switcher and the LDO should be kept away from any noisy source (power traces)
- ▶ Power planes greatly improve the overall behavior
- ▶ Whenever possible, use a power ground plane for power traces and an analog ground plane for the device control circuitries
- ▶ Avoid using switcher supply outputs for analog sections
 - PLL voltages, CODECs, sensors



Li-Ion Battery Chargers



MC3467x – Single Input Charger






Battery Charger ICs Differentiators

- ▶ Most advanced charger in the industry
 - One design targeting many applications
 - Factory-configurable pinout (pin 2/3/6/7) & feature set using e-fuses
 - Single inventory for different variants
 - New products without going through fab cycles – fast time to market
- ▶ Highest performance charger
 - 0.4% output voltage accuracy over temperature (-20 to 70°C)
 - 5% current accuracy
 - 28V input voltage rating
- ▶ Very cost-effective solution
 - By taking advantage of FSL's 0.25u high-voltage process
 - Minimum external component count



USB-powered evaluation kit

Charger Variants

Part #	Current Rating	Target Applications	Examples
MC34671	600mA	Small-cell-capacity-battery-powered applications: Bluetooth headset, mouse, PHS phones, MP3/4 player	
MC34673 MC34675 MC34676A MC34676B	1.2A 1.2A/450mA	Higher cell capacity battery powered applications: Cell phone, smart phone, DSC, GPS/PND, PMP	
MC34674	1A	Travel chargers	

- ▶ Freescale line of standard power supply products is focusing on the multimedia processor companion chip market
 - **MC34704B** (i.MX25, i.MX27, i.MX31)
 - **MC3467x** Li-Ion/Polymer battery chargers
 - PMIC for i.MX51

- ▶ Freescale is focusing on standard power supply products to support Freescale MCUs, MPUs, networking, and DSP companion chip market
 - Stand alone multi channel PMU
 - **MC34704A** – 8-channel DC/DC
 - **MC34704B** – 5-channel DC/DC
 - Stand alone 4-channel PMU
 - **MC34700** – 3 buck + 1 LDO
 - Stand alone DC/DC buck regulator
 - **MC34727** – 0.8V to 3.3V @ 300mA 2MHz switching
 - Stand alone DDR and DC buck regulators
 - **MC34712 & MC34713** – single-channel
 - **MC34716 & MC34717** – dual-channel

Related Session Resources

Session Location – Online Literature Library

<http://www.freescale.com/webapp/sps/site/homepage.jsp?nodeId=052577903644CB>

Sessions

<i>Session ID</i>	<i>Title</i>

Demos

<i>Pedestal ID</i>	<i>Demo Title</i>

