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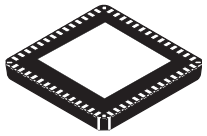
RoHS

Multiple Channel DC-DC Power Management IC

34704

MULTI-CHANNEL IC



EP SUFFIX (PB-FREE)
98ASA00712D
56-PIN QFN

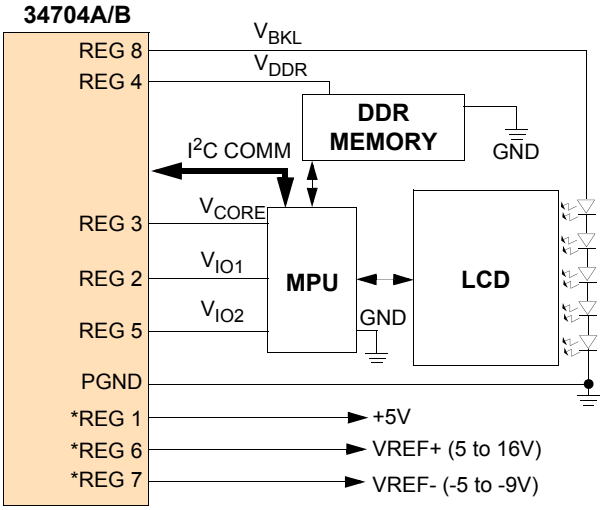
The 34704 is a multi-channel Power Management IC (PMIC) used to address power management needs for various multimedia application microprocessors. Its ability to provide either 5 or 8 independent output voltages with a single input power supply (2.7 and 5.5 V) together with its high efficiency, make it ideal for portable devices powered up by Li-Ion/polymer batteries or for USB powered devices as well. This device is powered by SMARTMOS technology.

The 34704 is housed in a 7x7 mm, Pb-free, QFN56 and is capable of operating at a switching frequency of up to 2.0 MHz. This makes it possible to reduce external component size and to implement full space efficient power management solutions.

Features

- 8 DC/DC (34704A) or 5 DC/DC (34704B) switching regulators with up to ±2% output voltage accuracy
- Dynamic voltage scaling on all regulators.
- Selectable output voltage or current regulation on REG8
- I^2C programmability
- Output undervoltage and overvoltage detection for each regulator
- Overcurrent limit detection and short-circuit protection for each regulator
- Thermal limit detection for each regulator, except REG7
- Integrated compensation for REG1, REG3, REG6, and REG8
- 5.0 µA maximum shutdown current (All regulators are off, 5.5 V VIN)
- True cutoff on all of the boost and buck-boost regulators

ORDERING INFORMATION		
Device	**Temperature Range (T_A)**	**Package**
MC34704AEP/R2	-20 °C to 85 °C	56 QFN EP
MC34704BEP/R2		



* Available only in 34704A device

Figure 1. 34704 Simplified Application Diagram

DEVICE VARIATIONS

Table 1. Device Variations

Orderable Part Number	No. of Regulators	Regulator Number
MC34704AEP/R2	8	Reg 1 - 8
MC34704BEP/R2	5	Reg 2, 3, 4, 5, 8

INTERNAL BLOCK DIAGRAM

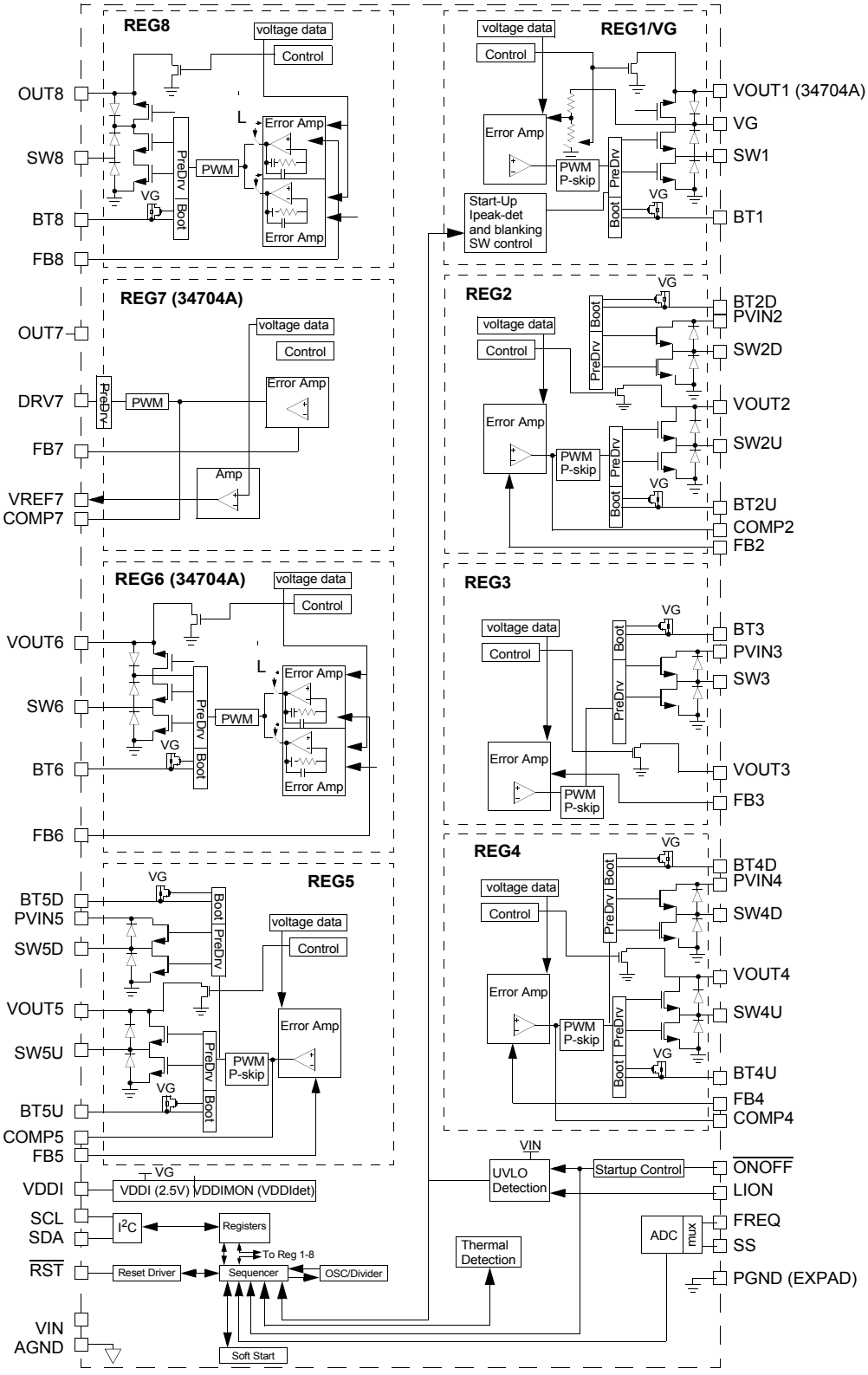


Figure 2. 34704 Internal Block Diagram

PIN CONNECTIONS

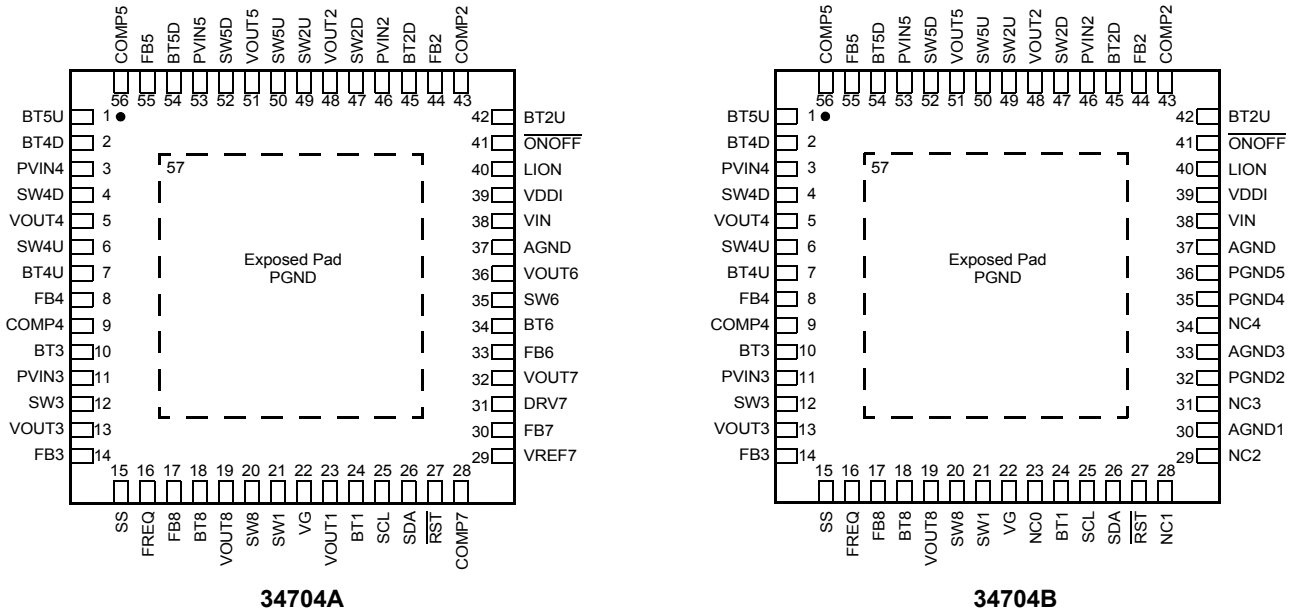


Figure 3. 34704 Pin Connections

Table 2. 34704 Pin Definitions

A functional description of each pin can be found in the Functional Pin Description section beginning on page 17.

Pin Number	Device	Pin Name	Pin Function	Formal Name	Definition
1	A/B	BT5U	Passive	REG5 Boost Stage bootstrap capacitor input pin	Connect a 1.0 μF capacitor between this pin and SW5U pin to enhance the gate of the Switch Power MOSFET.
2	A/B	BT4D	Passive	REG4 Buck Stage bootstrap capacitor input pin	Connect a 0.01 μF capacitor between this pin and SW4D pin to enhance the gate of the Switch Power MOSFET.
3	A/B	PVIN4	Power	REG4 power supply input voltage	This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG4 operation. Use a 10uf decoupling capacitor for better performance.
4	A/B	SW4D	Input/Output	REG4 Buck Stage switching node	The inductor is connected between this pin and the SW4U pin.
5	A/B	VOUT4	Output	REG4 regulated output voltage pin	Connect this pin to the load and to the output filter as close to the pin as possible.
6	A/B	SW4U	Input/Output	REG4 Boost Stage switching node	The inductor is connected between this pin and the SW4D pin.
7	A/B	BT4U	Passive	REG4 Boost Stage bootstrap capacitor input pin	Connect a 0.01 μF capacitor between this pin and SW4U pin to enhance the gate of the Switch Power MOSFET.
8	A/B	FB4	Input	REG4 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
9	A/B	COMP4	Passive	REG4 compensation network connection	REG4 compensation network connection.
10	A/B	BT3	Passive	REG3 bootstrap capacitor input pin	Connect a 0.01 μF capacitor between this pin and SW3 pin to enhance the gate of the Switch Power MOSFET.

Table 2. 34704 Pin Definitions (continued)

A functional description of each pin can be found in the Functional Pin Description section beginning on page 17.

Pin Number	Device	Pin Name	Pin Function	Formal Name	Definition
11	A/B	PVIN3	Power	REG3 power supply input voltage	This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG3 operation. Use a 10uf decoupling capacitor for better performance.
12	A/B	SW3	Output	REG3 switching node	The inductor is connected between this pin and the regulated REG3 output.
13	A/B	VOUT3	Output	REG3 output voltage return pin	This is the discharge path of REG3 output voltage.
14	A/B	FB3	Input	REG3 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
15	A/B	SS	Input	Soft start time	The soft start time for all regulators can be adjusted by connecting this pin to an external resistor divider between VDDI and AGND pins.
16	A/B	FREQ	Input	Oscillator frequency	The oscillator frequency can be adjusted by connecting this pin to an external resistor divider between VDDI and AGND pins. This pin sets F_{SW1} value.
17	A/B	FB8	Input	REG8 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
18	A/B	BT8	Passive	REG8 bootstrap capacitor input pin	Connect a 0.01 μF capacitor between this pin and SW8 pin to enhance the gate of the Synchronous Power MOSFET.
19	A/B	VOUT8	Output	REG8 regulated output voltage pin	Connect this pin directly to the load directly and to the output filter as close to the pin as possible.
20	A/B	SW8	Output	REG8 switching node	The inductor is connected between this pin and the VIN pin.
21	A/B	SW1	Output	REG1 switching node	The inductor is connected between this pin and the VIN Pin.
22	A/B	VG	Passive	REG1 regulated output voltage before the cutoff switch	REG1 regulated output voltage before the cut-off switch. This supplies the internal circuits and the gate drive
23[(1)]	A	VOUT1	Output	REG1 regulated output voltage pin.	Connect this pin directly to the load directly and to the output filter as close to the pin as possible.
	B	NC0	No Connect	-	Pin 23 is not connected.
24	A/B	BT1	Passive	REG1 bootstrap capacitor input pin	Connect a 1.0 μF capacitor between this pin and SW1 pin to enhance the gate of the Switch Power MOSFET.
25	A/B	SCL	Input/Output	I^2C serial interface clock input	I^2C serial interface clock input.
26	A/B	SDA	Input/Output	I^2C serial interface data input	I^2C serial interface data input.
27	A/B	$\overline{RST}$	Open Drain	Power reset output signal (Microprocessor Reset)	This is an open drain output and must be pulled up by an external resistor to a supply voltage like V_{IN}.
28	A	COMP7	Passive	REG7 compensation network connection	REG7 compensation network connection.
	B	NC1	No Connect	-	Pin 28 is not connected
29	A	VREF7	Output	REG7 resistor feedback network reference voltage	Connect this pin to the bottom of the feedback resistor divider.
	B	NC2	No Connect	-	Pin 29 is not connected

Table 2. 34704 Pin Definitions (continued)

A functional description of each pin can be found in the Functional Pin Description section beginning on page 17.

Pin Number	Device	Pin Name	Pin Function	Formal Name	Definition
30	A	FB7	Input	REG7 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
	B	AGND1	-	-	Pin 30 is connected to AGND
31	A	DRV7	Output	REG7 external Power MOSFET gate drive	REG7 external Power MOSFET gate drive.
	B	NC3	No Connect	-	Pin 31 is not connected
32	A	VOUT7	Output	REG7 output voltage return pin.	This is the discharge path of REG7 output voltage.
	B	PGND1	-	-	Pin 32 is connected to PGND
33	A	FB6	Input	REG6 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
	B	AGND2	-	-	Pin 33 is connected to AGND
34	A	BT6	Passive	REG6 bootstrap capacitor input pin.	Connect a 0.01 μF capacitor between this pin and SW6 pin to enhance the gate of the Synchronous Power MOSFET.
	B	NC4	No Connect	-	Pin 34 is not connected
35	A	SW6	Output	REG6 switching node	The inductor is connected between this pin and the VIN pin.
	B	PGND2	-	-	Pin 35 is connected to PGND
36	A	VOUT6	Output	REG6 regulated output voltage pin	Connect this pin directly to the load directly and to the output filter as close to the pin as possible.
	B	PGND3	-	-	Pin 36 is connected to PGND
37	A/B	AGND	Ground	Analog ground of the IC	Analog ground of the IC.
38	A/B	VIN	Power	Battery voltage connection	Input decoupling /filtering is required for the device to operate properly.
39	A/B	VDDI	Output	Internal supply voltage	Connect a 1.0 μF low ESR decoupling filter capacitor between this pin and GND.
40	A/B	LION	Input	Battery Detection	Always pull this pin High with a 470kohm Resistor to indicate Input power is present.
41	A/B	$\overline{\text{ONOFF}}$	Input	Dual function IC turn On/ Off	This is a hardware enable/disable for the 34704A/B. It can be connected to a mechanical switch to turn the power On or Off.
42	A/B	BT2U	Passive	REG2 Boost Stage bootstrap capacitor input pin	Connect a 1.0 μF capacitor between this pin and SW2U pin to enhance the gate of the Switch Power MOSFET.
43	A/B	COMP2	Passive	REG2 compensation network connection	REG2 compensation network connection.
44	A/B	FB2	Input	REG2 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
45	A/B	BT2D	Passive	REG2 Buck Stage bootstrap capacitor input pin	Connect a 1.0 μF capacitor between this pin and SW2D pin to enhance the gate of the Switch Power MOSFET.
46	A/B	PVIN2	Power	REG2 power supply input voltage	This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG2 operation. Use a 10uf decoupling capacitor for better performance

Table 2. 34704 Pin Definitions (continued)

A functional description of each pin can be found in the Functional Pin Description section beginning on page 17.

Pin Number	Device	Pin Name	Pin Function	Formal Name	Definition
47	A/B	SW2D	Input/Output	REG2 Buck Stage switching node	The inductor is connected between this pin and the SW2U pin.
48	A/B	VOUT2	Output	REG2 regulated output voltage pin	Connect this pin to the load and to the output filter as close to the pin as possible.
49	A/B	SW2U	Input/Output	REG2 Boost Stage switching node	The inductor is connected between this pin and the SW2D pin.
50	A/B	SW5U	Input/Output	REG5 Boost Stage switching node	The inductor is connected between this pin and the SW5D pin.
51	A/B	VOUT5	Output	REG5 regulated output voltage pin	Connect this pin to the load and to the output filter as close to the pin as possible.
52	A/B	SW5D	Input/Output	REG5 Buck Stage switching node	The inductor is connected between this pin and the SW5U pin.
53	A/B	PVIN5	Power	REG5 power supply input voltage	This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG5 operation. Use a 10uf decoupling capacitor for better performance
54	A/B	BT5D	Passive	REG5 Buck Stage bootstrap capacitor input pin	Connect a 1.0 μF capacitor between this pin and SW5D pin to enhance the gate of the Switch Power MOSFET.
55	A/B	FB5	Input	REG5 voltage feedback input for voltage regulation/programming	Connect the feedback resistor divider to this pin.
56	A/B	COMP5	Passive	REG5 compensation network connection	REG5 compensation network connection.
Exposed Pad	A/B	PGND	Ground	Power Ground Connection for all of the regulators except REG7	Power Ground Connection for all of the regulators except REG7. This pad is provided to enhance thermal performance.

Notes

1. If regulator 1 is not used, leave pin 23 Unconnected, All other components should be used to provide VG to the system
2. If regulators 5, 6, 7 and 8 are not used, connect the corresponding pins as follows: FB, SW and VOUT nodes: tied to GND; BT, COMP and PVIN pins: Not connected; DRV and VREF nodes (REG7 only): Not connected
3. REG 2,3 and 4 should always be populated.

ELECTRICAL CHARACTERISTICS

MAXIMUM RATINGS

Table 3. Maximum Ratings

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Ratings	Symbol	Value	Unit
ELECTRICAL RATINGS			
Battery Input Supply Voltage (VIN) Pin	V_{IN}	-0.3 to 6.0	V
PVINx, $\overline{RST}$, $\overline{ONOFF}$, LION, DRV7[8], VG, SCL, SDA and VOUT1-5 Pins		-0.3 to 6.0	
VDDI, COMPx, FBx, VREF7[8], FREQ, and SS Pins		-0.3 to 3.0	
SW1-5 Pins	V_{SW-LOW}	-1.0 to 6.0	V
SW8, SW6[8] Pins	$V_{SW-HIGH}$	-1.0 to 27	V
BTx Pins (Referenced to switch node)	V_{BT}-V_{SW}	-0.3 to 6.0	V
BTx Pins to GND	V_{BT}	-0.3 to 27	V
VOUT8, VOUT6[8] Pins	$V_{OUT-HIGH}$	-0.3 to 27	V
VOUT7 Pin[8]	$V_{OUT-NEG}$	-10.0 to 0.3	V
Continuous Output Current			mA
REG1[8]		500	
REG2,5		500	
REG3		550	
REG4		300	
REG6,7[8]		60	
REG8		30	
ESD Voltage			V
Human Body Model	V_{ESD1}	±1000	
Charge Device Model	V_{ESD2}	±500	
THERMAL RATINGS			
Maximum Junction Temperature	$T_{J(MAX)}$	+150	°C
Storage Temperature	T_{STG}	-65 to +150	°C
Maximum Power Dissipation (T_A = 85°C)	PD	2.5	W
THERMAL RESISTANCE[7]			
Thermal Resistance			°C/W
Junction to Ambient	$R_{\Theta JA}$	26	
Junction to Board	$R_{\Theta JB}$	10	
Peak Package Reflow Temperature During Reflow[5],[6]	T_{PPRT}	Note 6	°C

Notes

4. ESD testing is performed in accordance with the Human Body Model (HBM) (C_{ZAP} = 100 pF, R_{ZAP} = 1500 Ω), and the Charge Device Model (CDM), Robotic (C_{ZAP} = 4.0 pF).
5. Pin soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause malfunction or permanent damage to the device.
6. Freescale's Package Reflow capability meets Pb-free requirements for JEDEC standard J-STD-020C. For Peak Package Reflow Temperature and Moisture Sensitivity Levels (MSL), Go to www.freescale.com, search by part number [e.g. remove prefixes/suffixes and enter the core ID to view all orderable parts. (i.e. MC33xxxD enter 33xxx), and review parametrics.
7. Thermal Resistance is based on a four-layer board (2s2p)
8. Available only on the 34704A

STATIC ELECTRICAL CHARACTERISTICS

Table 4. Static Electrical Characteristics

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
POWER INPUT					
Input Supply Voltage Typical Range	V_{IN}	2.7	-	5.5	V
Input DC Supply Current[9] VIN Pin Only All regulators are ON, no load; V_{IN} = 3.6 V, FSW =1.0 MHz Regulators 1 - 5 On, Reg 6, 7 and 8 Off; V_{IN} = 3.6 V, FSW = 1.0 MHz	I_{IN}	 - - -	 - 86 32	 - - -	mA
Input DC Shutdown Supply Current[9] (Shutdown, All regulators are OFF and V_{IN} = 5.5V) This includes any pin connected to the battery	I_{OFF}	-	-	5.0	µA
Rising UVLO Threshold	$UVLO_R$	-	-	3.0	V
Falling UVLO Threshold	$UVLO_F$	-	-	2.7	V
$\overline{RST}$					
$\overline{RST}$ Low Level Output Voltage I_{OL} = 1.0 mA	V_{RST-OL}	-	-	0.4	V
$\overline{RST}$ Leakage Current, Off-state @ 25°C	$I_{RST-LKG}$	-	-	1.0	µA
Current Limit Monitoring					
Over and Short-circuit Current Limit Accuracy	-	-20	-	20	%
REGULATOR 1 & VG					
VG Output Voltage	V_{VG}	-	5.0	-	V
REG1 Output Voltage[10]	V_{OUT}	-	5.0	-	V
Output Accuracy	-	-4.0	-	4.0	%
Line/Load Regulation[9]	$REG_{LN/LD}$	-1.0	-	1.0	%
Dynamic Voltage Scaling Range	V_{DYN}	-10	-	10	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Continuous Output Current[9]	I_{OUT}	-	100	500	mA
Overcurrent Limit (Detected in Low-side FET)	I_{LIM_ION}	-	2.7	-	A
Short-circuit Current Limit (Detected in the Blocking FET)	I_{SHORT_ION}	-	4.0	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)^-SW}$	-	100	-	mΩ
N-CH Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)^-SY}$	-	150	-	mΩ
N-CH Shutdown Power MOSFET $R_{DS(on)}$	$R_{DS(on)^-SH}$	-	100	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)^-DIS}$	-	70	-	Ω
Thermal Shutdown Threshold[9]	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis[9]	T_{SD-HYS}	-	25	-	°C
SW1 Leakage Current (Off State) @ 25°C	I_{SW1_LKG}	-	-	1.0	µA
Peak Current Detection Threshold at Power Up[9]	I_{PEAK}	-	300	-	mA

Notes:
9. Guaranteed by Design
10. Available only on the 34704A

Table 4. Static Electrical Characteristics (continued)

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
REGULATOR 2					
Output Voltage Range	V_{OUT}	0.6	3.3	3.6	V
Output Accuracy	-	-2.0	-	2.0	%
Line/Load Regulation(11)	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600(12)	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-17.5	-	17.5	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Continuous Output Current(11)	I_{OUT}	-	200	500	mA
Overcurrent Limit (Detected in buck high-side FET)	I_{LIM_ION}	-	1.4	-	A
Short-circuit Current Limit (Detected in buck high-side FET)	I_{SHORT_ION}	-	2.1	-	A
Battery Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Buck Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SW}$	-	120	-	mΩ
N-CH Buck Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SY}$	-	1000	-	mΩ
N-CH Boost Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SW}$	-	120	-	mΩ
N-CH Boost Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SY}$	-	120	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)\_DIS}$	-	70	-	Ω
Thermal Shutdown Threshold(11)	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis(11)	T_{SD-HYS}	-	25	-	°C
PVIN2 Leakage Current (Off State) @25°C	I_{PVIN2G_LKG}	-	-	1.0	µA
SW2D Leakage Current (Off State) @25°C	I_{SW2D_LKG}	-	-	1.0	µA
SW2U Leakage Current (Off State) @25°C	I_{SW2U_LKG}	-	-	1.0	µA
REGULATOR 3					
Output Voltage Range	V_{OUT}	0.6	1.2	1.8	V
Output Accuracy	-	-4.0	-	4.0	%
Line/Load Regulation(11)	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600(12)	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-17.5	-	17.5	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Continuous Output Current(11)	I_{OUT}	-	150	550	mA
Overcurrent Limit (Detected in buck high-side FET)	I_{LIM_ION}	-	1.0	-	A
Short-circuit Current Limit (Detected in buck high-side FET)	I_{SHORT_ION}	-	1.5	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SW}$	-	500	-	mΩ
N-CH Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SY}$	-	500	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)\_DIS}$	-	70	-	Ω
Thermal Shutdown Threshold (11)	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis(11)	T_{SD-HYS}	-	25	-	°C
PVIN3 Leakage Current (Off State) @25°C	I_{PVIN3_LKG}	-	-	1.0	µA
SW3 Leakage Current (Off State) @25°C	I_{SW3_LKG}	-	-	1.0	µA

Notes:
11. Guaranteed by Design
12. V_{FB} is 0.6V when the part is powered up and no DVS is changed. DVS is achieved by modifying V_{FB} reference.

Table 4. Static Electrical Characteristics (continued)

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
REGULATOR 4					
Output Voltage Range	V_{OUT}	0.6	1.8	3.6	V
Output Accuracy	-	-2.0	-	2.0	%
Line/Load Regulation[13]	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600[14]	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-10	-	10	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	1.0	-	%
Continuous Output Current[13]	I_{OUT}	-	100	300	mA
Overcurrent Limit (Detected in buck high-side FET)	I_{LIM_ION}	-	1.5	-	A
Short-circuit Current Limit (Detected in buck high-side FET)	I_{SHORT_ION}	-	2.25	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Buck Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SW}$	-	200	-	mΩ
N-CH Buck Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SY}$	-	600	-	mΩ
N-CH Boost Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SW}$	-	200	-	mΩ
N-CH Boost Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SY}$	-	600	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)\text{-}DIS}$	-	70	-	Ω
Thermal Shutdown Threshold[13]	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis[13]	$T_{SD\text{-}HYS}$	-	25	-	°C
PVIN4 Leakage Current (Off State) @25°C	I_{PVIN4_LKG}	-	-	1.0	μA
SW4D Leakage Current (Off State) @25°C	I_{SW4D_LKG}	-	-	1.0	μA
SW4U Leakage Current (Off State) @25°C	I_{SW4U_LKG}	-	-	1.0	μA
REGULATOR 5					
Output Voltage Range	V_{OUT}	0.6	3.3	3.6	V
Output Accuracy	-	-2.0	-	2.0	%
Line/Load Regulation[13]	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600[14]	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-17.5	-	17.5	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Continuous Output Current[13]	I_{OUT}	-	150	500	mA
Overcurrent Limit (Detected in buck high-side FET)	I_{LIM_ION}	-	1.4	-	A
Short-circuit Current Limit (Detected in buck high-side FET)	I_{SHORT_ION}	-	2.1	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Buck Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SW}$	-	120	-	mΩ
N-CH Buck Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SY}$	-	1000	-	mΩ
N-CH Boost Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SW}$	-	120	-	mΩ
N-CH Boost Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}SY}$	-	120	-	mΩ
Discharge MOSFET $R_{DS(on)}$	$R_{DS(on)\text{-}DIS}$	-	70	-	Ω
Thermal Shutdown Threshold[13]	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis[13]	$T_{SD\text{-}HYS}$	-	25	-	°C

Notes:
13. Guaranteed by Design
14. V_{FB} is 0.6V when the part is powered up and no DVS is changed. DVS is achieved by modifying V_{FB} reference.

Table 4. Static Electrical Characteristics (continued)

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
PVIN5 Leakage Current (Off State) @25°C	I_{PVIN5_LKG}	-	-	1.0	μA
SW5D Leakage Current (Off State) @25°C	I_{SW5D_LKG}	-	-	1.0	μA
SW5U Leakage Current (Off State) @25°C	I_{SW5U_LKG}	-	-	1.0	μA
REGULATOR 6(16)					
Output Voltage Range	V_{OUT}	5.0	15	15	V
Output Accuracy	-	-4.0	-	4.0	%
Line/Load Regulation(15)	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600(17)	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-10	-	10	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Continuous Output Current(15)	I_{OUT}	-	50	60	mA
Overcurrent Limit (Detected in low-side FET)	I_{LIM_ION}	-	3.0	-	A
Short-circuit Current Limit (Detected in the Blocking FET)	I_{SHORT_ION}	-	4.5	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SW}$	-	200	-	mΩ
N-CH Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SY}$	-	600	-	mΩ
N-CH Shutdown Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SH}$	-	200	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)\_DIS}$	-	70	-	Ω
Thermal Shutdown Threshold(15)	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis(15)	T_{SD-HYS}	-	25	-	°C
SW6 Leakage Current (Off State) @25°C	I_{SW6_LKG}	-	-	1.0	μA
REGULATOR 7(16)					
Output Voltage Range	V_{OUT}	-5.0	-7.0	-9.0	V
Output Accuracy	-	-2.0	-	2.0	%
Line/Load Regulation(15)	$REG_{LN/LD}$	-1.0	-	1.0	%
Feedback Reference Voltage	V_{FB}	-	0.600(17)	-	V
Continuous Output Current(15)	I_{OUT}	-	50	60	mA
Discharge MOSFET $R_{DS(on)}$	$R_{DS(on)\_DIS}$	-	55	-	Ω
Gate Drive Voltage High Level (@ -50 mA, V_{IN}=3.6V)	V_{IN}-V_{OH}	-	0.8	1.4	V
Gate Drive Voltage Low Level (@ 50 mA, V_{IN}=3.6V)	V_{OL}	-	1.1	1.8	V
VREF7 Output Voltage	V_{REF7}	-	1.5	-	V
VREF7 Voltage Accuracy	-	1.43	-	1.57	V
VREF7 Output Load Regulation (10 μA to 1.0 mA)	REG_{LD}	1.43	-	1.57	V

Notes
15. Guaranteed by Design
16. Available only on the 34704A
17. V_{FB} is 0.6V when the part is powered up and no DVS is changed. DVS is achieved by modifying V_{FB} reference.

Table 4. Static Electrical Characteristics (continued)

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
REGULATOR 8					
Output Voltage Range	V_{OUT}	5.0[19]	15	15	V
Output Accuracy	-	-4.0	-	4.0	%
Feedback Reference Voltage	V_{FB}	-	0.600[20]	-	V
Feedback Reference Voltage on current regulation mode	V_{FB}	-	0.230[21]	-	V
Dynamic Voltage Scaling Range	V_{DYN}	-10	-	10	%
Dynamic Voltage Scaling Step Size	V_{DYN_STEP}	-	2.5	-	%
Line/Load Regulation[18]	$REG_{LN/LD}$	-1.0	-	1.0	%
Continuous Output Current[18]	I_{OUT}	-	15	30	mA
Overcurrent Limit (Detected in low-side FET)	I_{LIM_ION}	-	1.0	-	A
Short-circuit Current Limit (Detected in the Blocking FET)	I_{SHORT_ION}	-	1.5	-	A
Overcurrent Limit Accuracy	-	-20	-	20	%
N-CH Switch Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SW}$	-	450	-	mΩ
N-CH Synch. Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SY}$	-	1000	-	mΩ
N-CH Shutdown Power MOSFET $R_{DS(on)}$	$R_{DS(on)\_SH}$	-	450	-	mΩ
Discharge MOSFET $R_{DS(ON)}$	$R_{DS(on)\_DIS}$	-	70	-	Ω
Thermal Shutdown Threshold[18]	T_{SD}	-	170	-	°C
Thermal Shutdown Hysteresis[18]	T_{SD-HYS}	-	25	-	°C
SW8 Leakage Current (Off State) @25°C	I_{SW8_LKG}	-	-	1.0	μA

Notes

18. Guaranteed by Design
19. When Battery voltage is higher than 5.0V and VOUT8 is 5.0V, a polarization diode is necessary to achieve accurate output voltage. See Component Calculation on page 39 for further details.
20. V_{FB} is 0.6V when the part is powered up and no DVS is changed. DVS is achieved by modifying V_{FB} reference.
21. When in Current regulation mode, the Voltage reference is set to 0.230mV to set the maximum current, and it is internally decreased to achieve a factor of the maximum current passing through the LED string

DYNAMIC ELECTRICAL CHARACTERISTICS

Table 5. Dynamic Electrical Characteristics

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
I²C COMMUNICATION					
Device Physical Address (7 bit Address)		-	$54	-	
Maximum **I²C** Speed		-	-	400	kHz
FREQ					
Selectable Switching Frequency 1	f_{SW1}	750	-	2000	kHz
Selectable Switching Frequency 2	f_{SW2}	250	-	1000	kHz
Selectable Switching Frequency Step Size	f_{STEP}	-	250	-	kHz
Switching Frequency Accuracy		-10	-	10	%
Retry Timeout Period[23]	$t_{TIMEOUT}$	-	10	-	ms
CURRENT LIMIT MONITORING					
Overcurrent Limit Timer[23]	t_{LIMIT}	-	10	-	ms
Retry Timeout Period[23]	t_{RETRY}	-	10	-	ms
OUTPUT OVERVOLTAGE/UNDERVOLTAGE MONITORING					
Undervoltage Threshold (Response A)	V_{UV-R}	-	-20	-	%
Overvoltage Threshold (Response A)	V_{OV-R}	-	20	-	%
Undervoltage Threshold (Response B)	V_{UV-R}	-	-20	-	%
Overvoltage Threshold (Response B)	V_{OV-R}	-	20	-	%
Filter Delay Timer[23]	t_{FILTER}	-	20	-	µs
$\overline{RST}$					
$\overline{RST}$ Reset Delay[23]	$t_{RST-DELAY}$	-	10		ms
REGULATOR 1 & VG					
Operating Frequency[22], [23]	f_{SW1}	750	-	1500	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
Constant Time Off Value[23]	t_{OFF}	-	1.0	-	µs
Low-side Timeout[23]	$t_{TIMEOUT}$	-	15	-	µs
REGULATOR 2					
Operating Frequency[23]	f_{SW1}	750	-	2000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz

Notes

22. When REG1 is used, the maximum f_{SW1} Frequency programed with external components should be 1500 kHz
23. Guaranteed by design.

Table 5. Dynamic Electrical Characteristics

Characteristics noted under conditions 2.7 V ≤ V_{IN} ≤ 5.5 V, -20°C ≤ T_A ≤ 85 °C, GND = 0 V, unless otherwise noted. Typical values noted reflect the approximate parameter means at T_A = 25 °C under nominal conditions, unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
REGULATOR 3					
Operating Frequency	f_{SW1}	750	-	2000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
REGULATOR 4					
Operating Frequency	f_{SW1}	750	-	2000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
REGULATOR 5					
Operating Frequency	f_{SW1}	750	-	2000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
REGULATOR 6					
Operating Frequency	f_{SW2}	250	-	1000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
REGULATOR 7					
Operating Frequency Selections	f_{SW2}	250	-	1000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz
REGULATOR 8					
Operating Frequency	f_{SW2}	250	-	1000	kHz
Operating Frequency Selection Step Size	f_{STEP}	-	250	-	kHz

FUNCTIONAL DESCRIPTION

INTRODUCTION

The 34704 is an multi-channel power management IC (PMIC) meant to address power management needs for various multimedia applications microprocessors in various configurations with a target overall efficiency of > 80% at typical loads.

The 34704 accepts an input voltage from various sources:

- 1 cell Li-Ion/Polymer (2.7 to 4.2 V)
- 5.0 V USB supply or AC wall adapter

The different channels are:

REGULATOR	REGULATOR TYPE	V_{OUT} TYP (V)	I_{OUT} TYP (MA)	I_{OUT} MAX (MA)	TARGET APPLICATION
REG1[25]	Synchronous Boost	5.0	100	500	+5.0 V 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[25]	Synchronous Boost	15.0	20	60	REF+
REG7[25]	Inverter Boost	-7.0	20	60	REF -
REG8	Synchronous Boost	15.0	15	30	Backlight Display

Notes

24. Synchronous Buck-Boost: These regulators can work as pure BUCK regulator when the output voltage is lower than the input voltage; and work as pure BOOST regulator when the input voltage is lower than the output voltage. Compensation should be done for the worst case scenario, which is in most of the cases when the device is working as a boost converter, after compensating for this scenario it is recommended to verify the buck operation to assure stability in the whole operating range.
25. Available only on the 34704A

REG1, REG3, REG6, and REG8 use internal compensation, while REG2, REG4, REG5, and REG7 use external compensation.

The switching frequency of all regulators except REG6, 7, & 8 can be selected through the FREQ pin between 750 kHz and 2.0 MHz in 250 kHz steps. The high frequency operation is meant to minimize the size of external components while lower operating frequencies will allow for higher efficiency. REG7 is limited to operate at a lower frequency to minimize switching noise induced by driving the external switching MOSFET, but also can operate at the 1.0 MHz value with proper board layout. REG 6, 7, and 8 switching frequency can be selected between 250 kHz and 1.0 MHz in 250 kHz steps through I^2C.

For all regulators and at lower loads, a pulse skipping mode is implemented to maintain high efficiency.

Note that pulse skipping occurs when the regulator enters into discontinuous conduction mode (DCM) at very light loads, however transitions between DCM and CCM may result in noisy switching nodes, therefore it is recommended to design the regulators to work in CCM all the time. Pulse skipping function is not guaranteed by circuit implementation. The 34704 uses 4 different phases of switching for all regulators except REG6, 7, and 8, to spread out the current draw by the individual converters from the input supply over time, to reduce the peak input current demand. This allows for better EMI performance and reduction in the input filter requirements.

Each regulator except REG1 uses an external feedback resistor divider to set the output voltage. All output voltages can be adjusted dynamically (Dynamic Voltage Scaling) on the fly through an I²C serial interface. All converters, except REG1, utilize automatic soft-start by ramping the reference voltage to the error amplifier to prevent sudden change in duty cycle and output current/voltage at power up. REG1 (VG) will limit the inrush current by implementing a peak current detect and a constant off time.

The 34704 is equipped with a dual function Power On/Off pin ($\overline{\text{ONOFF}}$). This pin can be controlled by a mechanical switch to turn the device on or off. Pressing and releasing the mechanical switch turns the 34704 on while pressing and holding the switch for a time period (programmable through I^2C) turns the 34704 off. Enable/disable control is also granted through I^2C for groups of regulators and the whole IC.

FUNCTIONAL PIN DESCRIPTION

REG5 BOOST STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT5U)

Connect a 1.0 μF capacitor between this pin and SW5U pin to enhance the gate of the Switch Power MOSFET.

REG4 BUCK STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT4D)

Connect a 0.01 μF capacitor between this pin and SW4D pin to enhance the gate of the Switch Power MOSFET.

REG4 POWER SUPPLY INPUT VOLTAGE (PVIN4)

This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG4 operation.

REG4 BUCK STAGE SWITCHING NODE (SW4D)

The inductor is connected between this pin and the SW4U pin.

REG4 REGULATED OUTPUT VOLTAGE PIN (VOUT4)

Connect this pin to the load and to the output filter as close to the pin as possible.

REG4 BOOST STAGE SWITCHING NODE (SW4U)

The inductor is connected between this pin and the SW4D pin.

REG4 BOOST STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT4U)

Connect a 0.01 μF capacitor between this pin and SW4U pin to enhance the gate of the Switch Power MOSFET.

REG4 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB4)

Connect the feedback resistor divider to this pin.

REG4 COMPENSATION NETWORK CONNECTION (COMP4)

REG4 compensation network connection.

REG3 BOOTSTRAP CAPACITOR INPUT PIN (BT3)

Connect a 0.01 μF capacitor between this pin and SW3 pin to enhance the gate of the Switch Power MOSFET.

REG3 POWER SUPPLY INPUT VOLTAGE (PVIN3)

This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG3 operation.

REG3 SWITCHING NODE (SW3)

The inductor is connected between this pin and the regulated REG3 output.

REG3 OUTPUT VOLTAGE RETURN PIN (VOUT3)

This is the discharge path of REG3 output voltage.

REG3 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB3)

Connect the feedback resistor divider to this pin.

SOFT START TIME (SS)

The soft start time for all regulators can be adjusted by connecting this pin to an external resistor divider between VDDI and AGND pins.

OSCILLATOR FREQUENCY (FREQ)

The oscillator frequency can be adjusted by connecting this pin to an external resistor divider between VDDI and AGND pins. This pin sets F_{SW1} value.

REG8 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB8)

Connect the feedback resistor divider to this pin, when voltage mode control is used. When current mode control is used, connect this pin between the LED string and an I_{SET} resistor to GND to force the operating current. Refer to Figure 10 and Figure 11. Exclude the components not used.

REG8 BOOTSTRAP CAPACITOR INPUT PIN (BT8)

Connect a 0.01 μF capacitor between this pin and SW8 pin to enhance the gate of the Synchronous Power MOSFET.

REG8 REGULATED OUTPUT VOLTAGE PIN (VOUT8)

Connect this pin directly to the load directly and to the output filter as close to the pin as possible.

REG8 SWITCHING NODE (SW8)

The inductor is connected between this pin and VIN pin.

REG1 SWITCHING NODE (SW1)

The inductor is connected between this pin and VIN pin.

REG1 REGULATED OUTPUT VOLTAGE BEFORE THE CUT-OFF SWITCH (VG)

REG1 regulated output voltage before the cutoff switch. This supplies the internal circuits and the gate drive.

REG1 REGULATED OUTPUT VOLTAGE PIN (VOUT1) (34704A ONLY)

Connect this pin directly to the load directly and to the output filter as close to the pin as possible.

REG1 BOOTSTRAP CAPACITOR INPUT PIN (BT1)

Connect a 1.0 μF capacitor between this pin and SW1 pin to enhance the gate of the Switch Power MOSFET.

I²C SERIAL INTERFACE CLOCK INPUT (SCL)

I²C serial interface clock input.

I²C SERIAL INTERFACE DATA INPUT (SDA)

I²C serial interface data input

POWER RESET OUTPUT SIGNAL (MICROPROCESSOR RESET) ($\overline{\text{RST}}$)

This is an open drain output and must be pulled up by an external resistor to a supply voltage like V_{IN}.

REG7 COMPENSATION NETWORK CONNECTION (COMP7)

REG7 compensation network connection.

REG7 RESISTOR FEEDBACK NETWORK REFERENCE VOLTAGE (VREF7) (34704A ONLY)

Connect this pin to the bottom of the feedback resistor divider.

REG7 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB7) (34704A ONLY)

Connect the feedback resistor divider to this pin.

REG7 EXTERNAL POWER MOSFET GATE DRIVE (DRV7) (34704A ONLY)

REG7 external Power MOSFET gate drive.

REG7 OUTPUT VOLTAGE RETURN PIN (VOUT7) (34704A ONLY)

This is the discharge path of REG7 output voltage.

REG6 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB6) (34704A ONLY)

Connect the feedback resistor divider to this pin.

REG6 BOOTSTRAP CAPACITOR INPUT PIN (BT6) (34704A ONLY)

Connect a 0.01 μF capacitor between this pin and SW6 pin to enhance the gate of the Synchronous Power MOSFET.

REG6 SWITCHING NODE (SW6) (34704A ONLY)

The inductor is connected between this pin and the VIN pin.

REG6 REGULATED OUTPUT VOLTAGE PIN (VOUT6) (34704A ONLY)

Connect this pin directly to the load directly and to the output filter as close to the pin as possible.

ANALOG GROUND (AGND)

Analog ground of the IC.

BATTERY VOLTAGE CONNECTION (VIN)

Input decoupling /filtering is required for the device to operate properly.

INTERNAL SUPPLY VOLTAGE (VDDI)

Connect a 1.0 μF low ESR decoupling filter capacitor between this pin and GND.

BATTERY DETECTION (LION)

Pull this pin high to VIN to indicate a connection to a Li-Ion battery.

DUAL FUNCTION IC TURN ON/OFF ($\overline{\text{ONOFF}}$)

This is a hardware enable/disable for the 34704. It can be connected to a mechanical switch to turn the power On or Off.

REG2 BOOST STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT2U)

Connect a 1.0 μF capacitor between this pin and SW2U pin to enhance the gate of the Switch Power MOSFET.

REG2 COMPENSATION NETWORK CONNECTION (COMP2)

REG2 compensation network connection.

REG2 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB2)

Connect the feedback resistor divider to this pin.

REG2 BUCK STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT2D)

Connect a 1.0 μF capacitor between this pin and SW2D pin to enhance the gate of the Switch Power MOSFET.

REG2 POWER SUPPLY INPUT VOLTAGE (PVIN2)

This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG2 operation.

REG2 BUCK STAGE SWITCHING NODE (SW2D)

The inductor is connected between this pin and the SW2U pin.

REG2 REGULATED OUTPUT VOLTAGE PIN (VOUT2)

Connect this pin to the load and to the output filter as close to the pin as possible.

REG2 BOOST STAGE SWITCHING NODE (SW2U)

The inductor is connected between this pin and the SW2D pin.

REG5 BOOST STAGE SWITCHING NODE (SW5U)

The inductor is connected between this pin and the SW5D pin.

REG5 REGULATED OUTPUT VOLTAGE PIN (VOUT5)

Connect this pin to the load and to the output filter as close to the pin as possible.

REG5 BUCK STAGE SWITCHING NODE (SW5D)

The inductor is connected between this pin and the SW5U pin.

REG5 POWER SUPPLY INPUT VOLTAGE (PVIN5)

This is the connection to the drain of the high-side switch FET. Input decoupling /filtering is required for proper REG5 operation.

REG5 BUCK STAGE BOOTSTRAP CAPACITOR INPUT PIN (BT5D)

Connect a 1.0 μF capacitor between this pin and SW5D pin to enhance the gate of the Switch Power MOSFET.

REG5 VOLTAGE FEEDBACK INPUT FOR VOLTAGE REGULATION/PROGRAMMING (FB5)

Connect the feedback resistor divider to this pin.

REG5 COMPENSATION NETWORK CONNECTION (COMP5)

REG5 compensation network connection.

POWER GROUND CONNECTION FOR ALL OF THE REGULATORS EXCEPT REG7 (PGND)

Power Ground Connection for all of the regulators except REG7.

FUNCTIONAL INTERNAL BLOCK DESCRIPTION

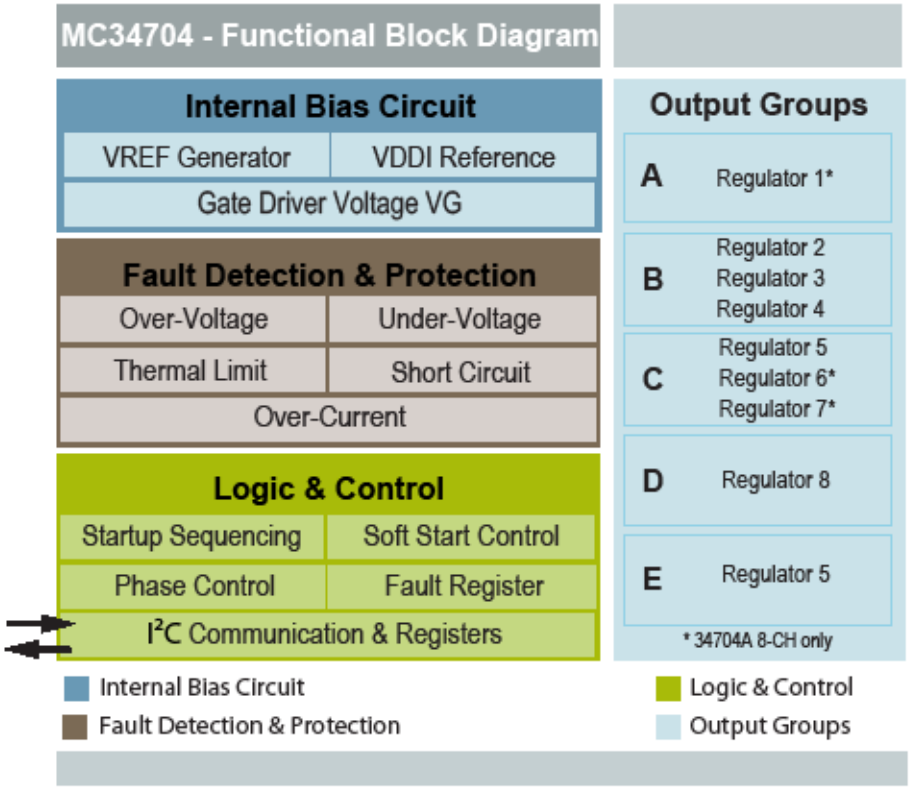


Figure 4. MC34704 Functional Internal Block Diagram

INTERNAL BIAS CIRCUIT

Gate Driver Voltage (VG)

REG1/VG is the main regulator of the 34704 IC and will be used to supply internal circuitry and voltage biases through the VG output. It also provides the gate drive voltage for the rest of the regulators and itself.

See Power-Up Sequence on page 28 for more details on how REG1 is a critical part of powering up the 34704. Based on this, REG1 will need extra circuitry to help it boot up until its output voltage is high enough that it can supply internal circuitry for the main control loop to take over.

REG1 VG starts up in peak current detect PFM mode and REG1 VG output starts rising. When the appropriate internal circuitry is alive and the switching frequency F_{SW1} is selected, the PWM control of REG1 can take over.

VREF Generator - Internal Reference

Each one of the regulators in the 34704 uses a DAC which is controlled by the I^2C interface to generate a dynamic VREF voltage for setting the output voltage on each regulator.

VDDI Reference Voltage

The 34704 uses the internal VG voltage to provide a precise low current 2.5 V voltage that is meant to serve as reference voltage to derive the FREQ and SS voltage needed to set the switching frequency 1 (FSW1) and the soft start, respectively.

FAULT DETECTION AND PROTECTION

Thermal Limit Detection

There is a thermal sensor for each regulator except REG7. All regulators of the corresponding group will shutdown if at least one of them reaches the thermal limit. If either REG2, REG3 or REG4 reaches its thermal limit, the whole part will shutdown immediately.

Overcurrent & Short-circuit Monitoring

The current limit circuitry has two levels of current limiting:

- A soft overcurrent limit (overcurrent limit): If the peak current reaches the typical overcurrent limit, the switcher will start a cycle-by-cycle operation to limit the current and a 10 ms current limit timer starts. The switcher will stay in this mode of operation until the part regains normal

operation, or shuts down after a failure to regain normal operation.

- A hard overcurrent limit (short-circuit limit) that is higher than the cycle by cycle limit at which the device reacts by shutting down the output immediately. This is necessary to prevent damage in case of a short-circuit. After that, only GrpB will attempt a one time retry after a time-out period of 10 ms and will go through a new soft start cycle

Output Overvoltage/Undervoltage Monitoring

In the case of an output overvoltage/undervoltage, the user has two options that can be programmed through the I^2C interface:

Response A: The output will switch off automatically and the 34704 would alert the processor through I^2C that such an event happened.

Response B: The output will not switch off. Rather the 34704 communicates to the processor that an overvoltage/undervoltage condition has occurred and waits for the processor decision to either shutoff or not; in the mean time the control loop will try to fix itself.

NOTE: If Response A is set on any of the regulators from GrpB, and a OV/UV event occurs in the corresponding regulator, the complete device will shutdown and try to restart as long as the OV/UV is no longer present. This will also set the RST signal low until REG2, 3 and 4 are on regulation.

LOGIC AND CONTROL

Startup Sequencing

At power up, the VG regulator starts ramping up in peak detect mode. Meanwhile, VDDI is tracking VG until it reaches regulation and releases a POR signal that enables the internal circuitry and reads the FREQ and SS configuration to ramp up REG2, REG3 and REG4, that serve as the MPU main power supplies. Once the MPU is up, I^2C communication is available to enable or disable GrpA, GrpC, GrpD and GrpE. An extra sequence can be configured for REG5, REG6 and REG7, changing the order in which they ramp up when enabled. See Power-Up Sequence on page 28.

Soft Start Control

During power up the 34704 reads the SS terminal to configure a default soft start timing for all regulators when these are enabled. Soft start for REG5 to REG8 can be changed via I^2C at any time after power up has successfully completed.

Phase Control

REG1 to REG5 use the main Switching frequency FSW1, which is configured through the FREQ terminal at power up. FSW1 uses 4 different phases of switching (clock is 80 degrees out of phase) to spread out the current draw by the individual converters from the input supply over time to reduce the peak input current demand. The remaining regulators use FSW2 which can be programmed at any time via I^2C after a successful power up sequence.

Fault Register

The 34704 has a dedicate fault register accessible via I^2C which indicate which regulator is detecting a fault situation. In addition to this, each channel has its own fault register which indicates the type of fault detected in that regulator.

I^2C communication and Registers

The 34704 can communicate using a standard I^2C, communication protocol or an accurate I^2C protocol. During the first one, the device processes the given command as soon as it has received it. During the accurate data communication, the device requires that each read/write command be sent twice to validate the data. The 34704 provides a user accessible register map that allows various general IC configurations as well as independent control of each regulator, including fault flag registers and all configurable features for each regulator.

OUTPUT GROUPS - REGULATORS

The 34704 is divided in 5 different groups which are arranged as follows:

- GrpA: Includes REG1[26] (VOUT1)
- GrpB: Includes REG2, REG3, and REG4
- GrpC: Includes REG5, REG6[26], and REG7[26]
- GrpD: Includes REG8
- GrpE: This is a special group. It includes REG5 when GrpC/E power sequencing option#1 is chosen

Turning on/off each group would cause all contained regulators to turn on/off.

Notes
26. Only on 34704A

REGUALATOR OVERVIEW WITH EFFICIENCY ANALYSIS

REG1 (34704A Only)

REG1 is a synchronous boost PWM voltage-mode control DC/DC regulator available only in the 34704A. Even though REG1 is a synchronous regulator, it is recommended to have a diode connected externally across its synchronous MOSFET. When the battery voltage is above REG1's output (>5.0 V) as the case might be when connected to the USB supply or wall adaptor, the REG1 power MOSFETs will be tri-stated and the voltage on the output will be Battery minus the diode drop. This will help maintain REG1's output to a maximum of 5.2 V and not allow it to drift all the way to 5.5 V.

The switcher will operate in DCM at very light loads to allow pulse skipping.

On the 34704A, when the appropriate command is received from the processor to turn on VOUT1, then the isolation FET of REG1 would turn on gradually to avoid any inrush current out of VG and to ramp the VOUT1 voltage in a controlled manner.

REG1 VOUT1 will be discharged every time GrpA is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW1}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NHV_HC) as its output stage
- It offers load disconnect from the input battery when the output is off (True Cutoff)
- The output is ±4% accuracy
- Output voltage is set to 5.0 V by means of an internal resistor divider
- The output can be adjusted up or down at 2.5% for a total of 10% on each direction allowing Dynamic Voltage Scaling
- Uses a bootstrap network with an internal diode to power its synchronous MOSFET
- All gate drive circuits are supplied from REG1's own VG output.
- Uses integrated compensation
- The output is monitored for undervoltage and overvoltage conditions
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The VG output is always active as long as:

- The IC is not in an undervoltage lockout AND
- No shutdown signal through the $\overline{\text{ONOFF}}$ pin is present AND
- There is no ALLOFF shutdown command through the I^2C interface AND
- No faults exist that would cause the 34704 to shutdown

The VOUT1 output will be active when:

- VG output is available AND
- There is no GrpA shutdown command through the I^2C interface AND
- No faults exist that would cause the VOUT1 to shut down

REG2

This is a 4-switch synchronous buck-boost PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG2 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT2 will be discharged every time the regulator is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW1}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NHV_HC) as its output stage
- The output is ±2% accuracy
- Output voltage is adjustable by means of an external resistor divider
- The output can be adjusted up or down at 2.5% steps for a total of +17.5% to -20.0% on each direction allowing Dynamic Voltage Scaling
- Uses bootstrap networks with an internal diode to power its high-side MOSFETs
- All gate drive circuits are supplied from VG
- Uses external compensation
- The output is monitored for undervoltage and overvoltage conditions
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpB shutdown command through the I^2C interface AND
- No faults exist that would cause GrpB to shut down

REG3

This is a synchronous buck PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG3 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT3 will be discharged every time the regulator is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW1}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NHV_HC) as its output stage
- The output is ±4% accuracy
- Output voltage is adjustable by means of an external resistor divider
- The output can be adjusted up or down at 2.5% steps to achieve from +17.5% to -20.0% on each direction allowing Dynamic Voltage Scaling using the I^2C DVS register.
- An extra fine voltage scaling in 0.5% steps helps to adjust down the output voltage as low as 40%.
- Uses a bootstrap network with an internal diode to power its switch MOSFET
- All gate drive circuits are supplied from VG.
- Uses integrated compensation.
- The output is monitored for undervoltage and overvoltage conditions
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpB shutdown command through the I^2C interface AND
- No faults exist that would cause GrpB to shut down

REG4

This is a 4-switch synchronous buck-boost PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG4 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT4 will be discharged every time the regulator is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW1}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NHV_HC) as its output stage
- The output is ±2% accuracy
- Output voltage is adjustable by means of an external resistor divider
- The output can be adjusted up or down at 2.5% steps for a total of +17.5% to -20.0% on each direction allowing Dynamic Voltage Scaling.
- Uses bootstrap networks with an internal diode to power its high-side MOSFETs
- All gate drive circuits are supplied from VG.
- Uses external compensation
- The output is monitored for undervoltage and overvoltage conditions
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpB shutdown command through the I^2C interface AND
- No faults exist that would cause GrpB to shut down

REG5

This is a 4-switch synchronous buck-boost PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 on for more details on when REG5 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT5 will be discharged every time the regulator is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW1}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NHV_HC) as its output stage
- The output is ±2% accuracy
- Output voltage is adjustable by means of an external resistor divider
- The output can be adjusted up or down at 2.5% steps for a total of +17.5% to -20.0% on each direction allowing Dynamic Voltage Scaling.
- Uses bootstrap networks with an internal diodes to power its high-side MOSFETs
- All gate drive circuits are supplied from VG.
- Uses external compensation
- The output is monitored for undervoltage and overvoltage conditions

- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpC (OR GrpE) shutdown command through the I^2C interface AND
- No faults exist that would cause GrpC (OR GrpE) to shut down

REG6 (Only 34704A)

This is a synchronous boost PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG6 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT6 will be discharged every time the regulator is shutting down and it will be held low by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW2}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NVHV_LC) as its output stage
- It offers load disconnect from the input battery when the output is off (True Cut-Off)
- The output is ±4% accuracy
- Output voltage is adjustable by means of an internal resistor divider
- The output can be adjusted up or down at 2.5% steps for a total of 10% on each direction allowing Dynamic Voltage Scaling
- Uses a bootstrap network with an internal diode to power its synchronous MOSFET
- All gate drive circuits are supplied from VG.
- Uses integrated compensation.
- The output is monitored for undervoltage and overvoltage conditions
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpC shutdown command through the I^2C interface AND
- No faults exist that would cause GrpC to shut down

REG7 (Only 34704A)

This is a none-synchronous buck-boost inverting PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG7 is powered up in the sequence.

The switcher will operate in DCM at very light loads to allow pulse skipping.

VOUT7 will be discharged every time the regulator is shutting down and it will be held high to ground by the discharge FET as long as possible.

Characteristics

- It powers up directly from the battery
- Operates at a switching frequency equals to F_{SW2}
- Drives an external P-channel power MOSFET
- The output is ±2% accuracy
- Output voltage is adjustable by means of an external resistor divider
- The output can be adjusted up or down at 2.5% steps for a total of 10% on each direction allowing Dynamic Voltage Scaling.
- All gate drive circuits are supplied from V_G
- Uses external compensation, the type is up to the designer
- The output is monitored for undervoltage and overvoltage conditions

Operation Modes

The switcher will be active when:

- VG is in regulation AND
- There is no GrpC shutdown command through the I^2C interface AND
- No faults exist that would cause GrpC to shut down

REG8

This is a synchronous boost PWM voltage-mode control DC/DC regulator.

See Power-Up Sequence on page 28 for more details on when REG8 is powered up in the sequence.

VOUT8 will be discharged every time the regulator is shutting down and it will be held to ground by the discharge FET as long as possible.

This regulator offers either voltage regulation for organic LEDs or current regulation for LCD backlighting LEDs. It provides either voltage or current feedback for these purposes through the same feedback pin.

The regulator cannot drive only 1LED with a forward voltage drop of less than the battery input voltage.

The processor would set the REG8 register through I^2C before enabling REG8 to indicate if voltage regulation or current regulation will be used.

Characteristics

- It powers up directly from the battery

- Operates at a switching frequency equals to F_{SW2}
- Drives integrated low $R_{DS(on)}$ N-channel power MOSFETs (NVHV_LC) as its output stage
- It offers load disconnect from the input battery when the output is off (True Cut-Off)
- The output is ±4% accuracy
- Output voltage is adjustable by means of an external resistor divider when in voltage regulation mode
- A 240 mV current limit comparator will be used to program/sense the voltage drop across the current setting resistor at the bottom of the LED string connected to the REG8 output when the current regulation mode is selected. This will be used to program the maximum current flowing and will regulate it
- The output can be adjusted up or down at 2.5% steps for a total of 10% on each direction allowing Dynamic Voltage Scaling
- Maximum output current is adjustable by means of an external resistor connected to the FB8 pin and then the output current can be scaled down from the set maximum in 16 steps through I^2C interface
- Uses a bootstrap network with an internal diode to power its synchronous MOSFET
- All gate drive circuits are supplied from VG.
- Uses integrated compensation
- The output is monitored for overcurrent and short-circuit conditions
- The regulator is monitored for overtemperature conditions
- The output is monitored for undervoltage and overvoltage conditions

Operation Modes

The switchers will be active when:

- VG is in regulation AND
- There is no GrpD shutdown command through the I^2C interface AND
- No faults exist that would cause GrpD to shut down

OVERALL EFFICIENCY ANALYSIS

In battery applications, it is highly recommended to power every single regulator directly from the battery to obtain full output capability:

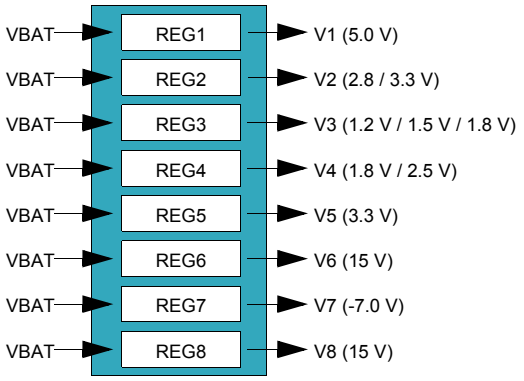


Figure 5. Overall Efficiency Analysis

Efficiency analysis includes the following losses:

- MOSFET Conduction Losses
- MOSFET Switching Losses (Except for REG7 due to external MOSFET and board layout dependence)
- MOSFET Gate Charging Losses
- MOSFET Deadtime Losses
- External Diode Losses (Only for REG7)
- Inductor Winding DC Losses
- Inductor Core Losses (Assumed to be 20% of DC Losses as a rule of thumb)
- Output AC Losses

Efficiency Analysis

In this configuration, all of the regulators are supplied or powered directly with 3.6 V nominal, battery voltage.

Efficiency was calculated using the maximum allowed frequency of 1.5 MHz and 1.0 MHz for F_{SW1} and F_{SW2}, respectively, in this configuration. As a result, the following numbers are valid for worst case operation conditions.

The following table shows the detailed analysis for each regulator with V2 at 3.3 V, V3 at 1.2 V, and V4 at 1.8 V.