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MB39C502/503/504

High Efficiency Step Down DC/DC Controller Datasheet

Description

MB39C502 is a single output step down DC/DC controller using external FETs. It achieves the high efficiency with “Enhanced Low Power Mode (LPM) Operation” in light load. In Enhanced LPM, this controller operates that the quiescent current is reduced only 30µA and the switching frequency is fallen by extending on time. These operations enable to improve the efficiency in light load. Internal compensation circuit with current mode architecture and internal boost switch allow reducing the BOM parts and the component area.

Features

- High Efficiency with Enhanced LPM Operation
- Automatic Transition for PFM/PWM
- Enhanced LPM Operation Transferred by SLP_N Assertion
- Over Current Alerting
- Reference Voltage Accuracy: ±1%
- Output Voltage Range : 0.7V to 2.0V (MB39C502)
: 2.4V to 3.5V (MB39C503)
: fixed 5V (MB39C504)
- VIN Input Voltage Range : 4.0V to 25V (MB39C502/C503)
: 5.4V to 25V (MB39C504)
- VDD Input Voltage Range: 4.5V to 5.5V (MB39C502/C503)
- Internal 5V LDO with Switchover (MB39C504)
- Fixed Frequency Emulated On-Time Control: 800kHz
- Current Mode Architecture with Internal Compensation Circuit
- Internal Boost Switch
- Fixed 700µs Soft Start Time without Load Dependence
- Internal Discharge FET
- Power Good Monitor
- Enhanced Protection Functions: OVP, UVP, ILIM
- Thermal Shutdown
- Small 3mm × 3mm × 0.75mm QFN16 Package

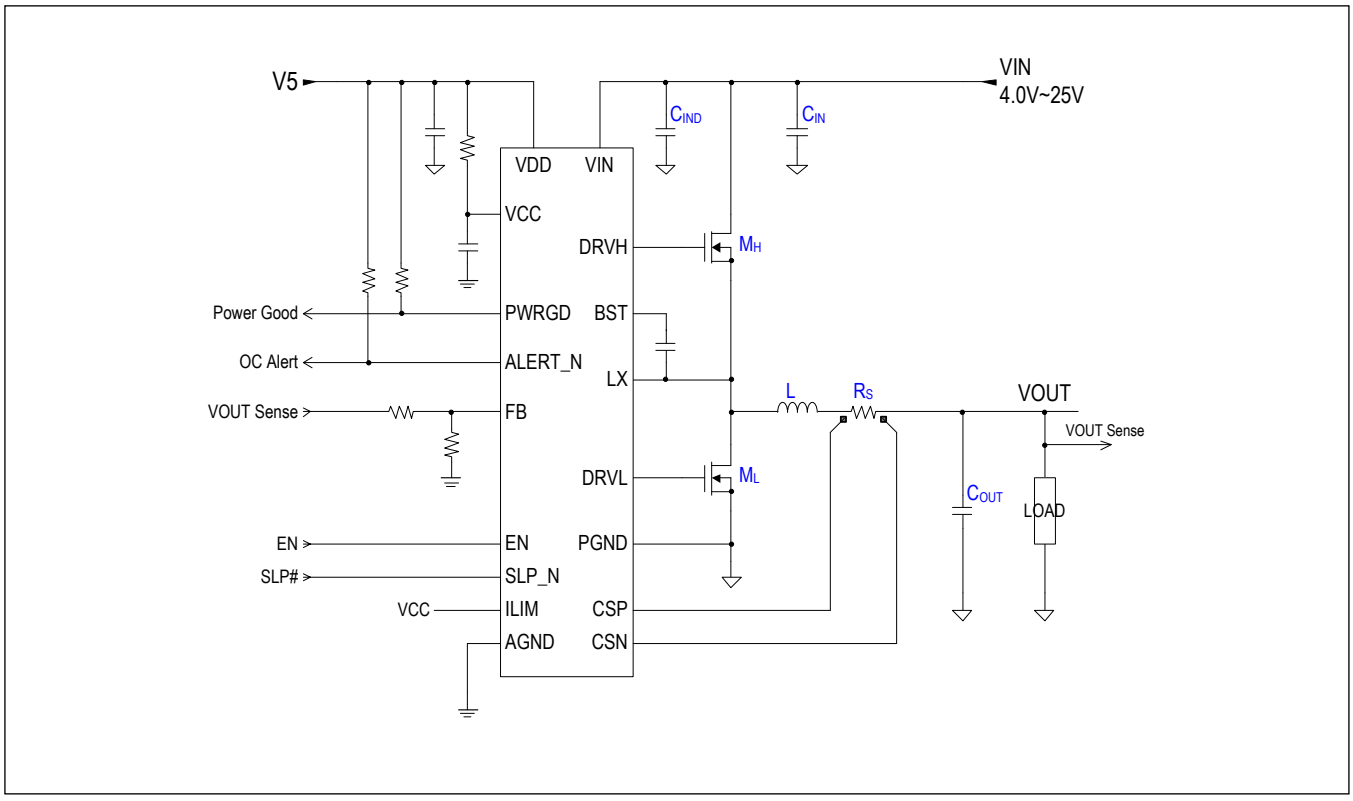
Applications

- Point of Load VR for Note PC
- General Purpose Step Down Regulator

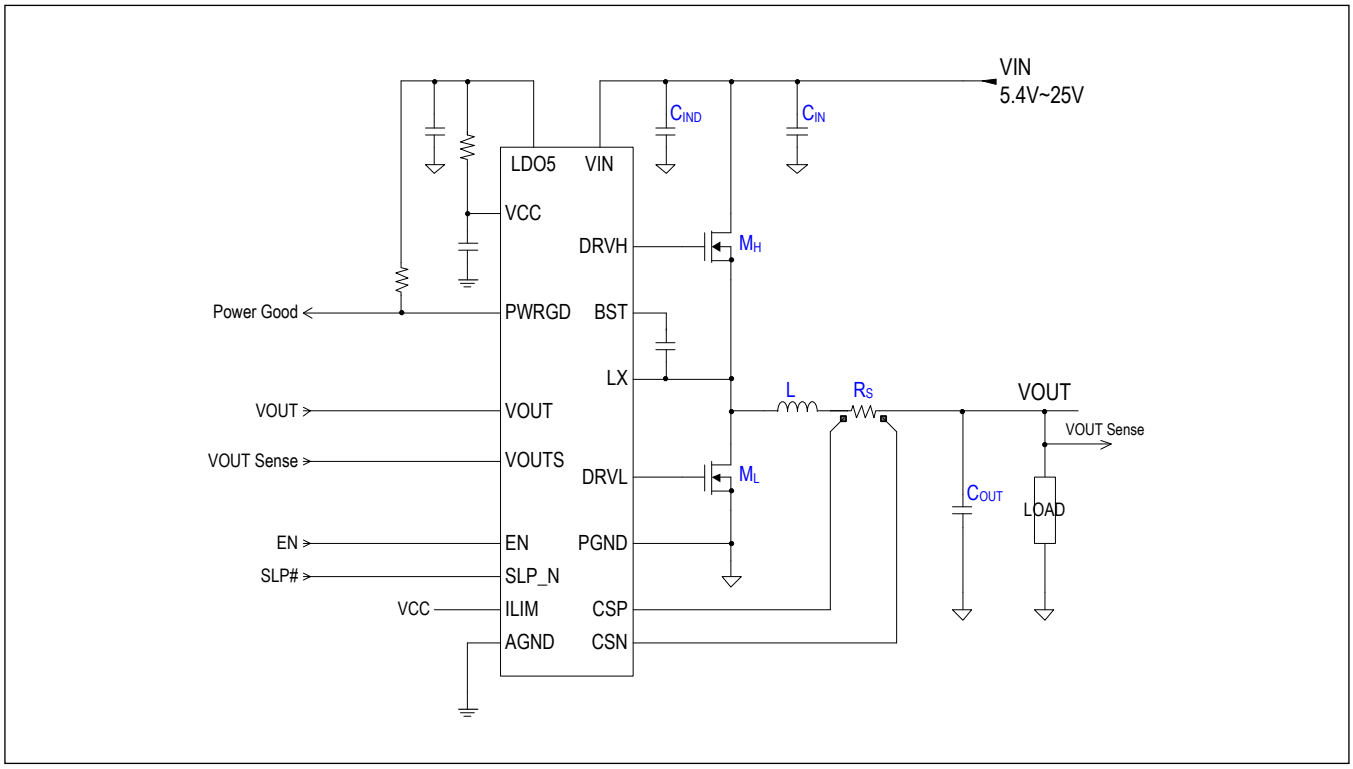
Contents

1. Typical Application

(MB39C502/C503)

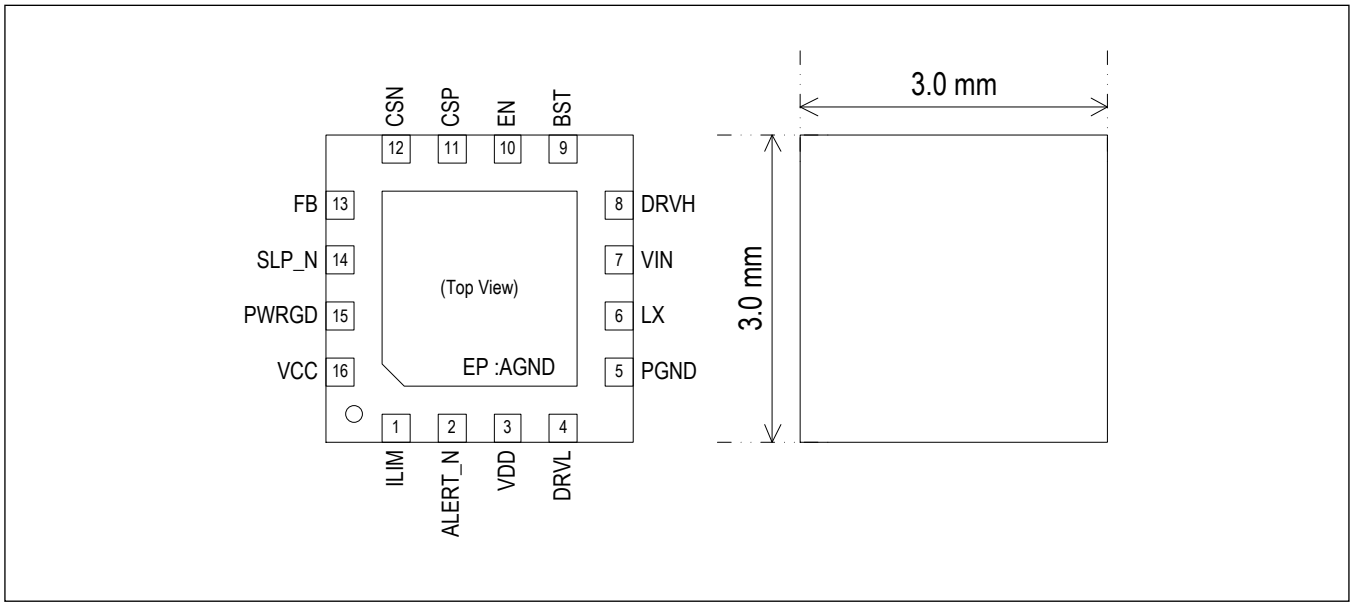


(MB39C504)

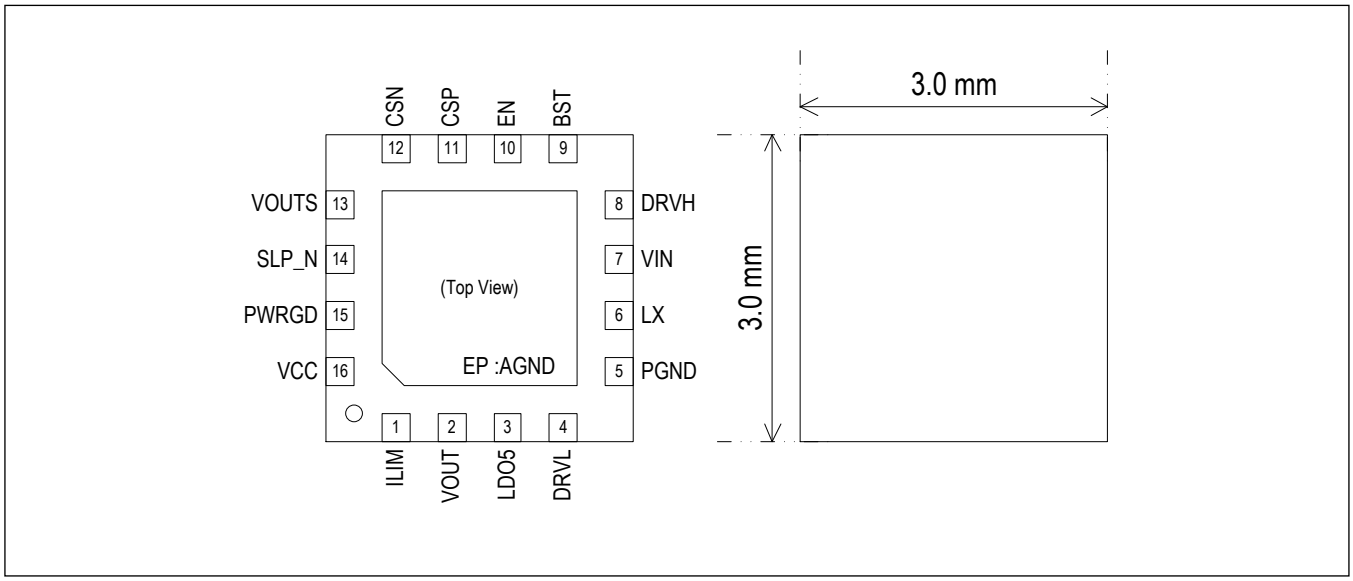


2. Pin Configuration

(MB39C502/C503)



(MB39C504)


CSN
CSP
EN
BST
12
11
10
9
VOUTS 13
SLP_N 14
PWRGD 15
VCC 16
8 DRVH
7 VIN
6 LX
5 PGND
(Top View)
EP :AGND
1
2
3
4
ILIM
VOUT
LDO5
DRVL
3.0 mm
3.0 mm

3. Pin Configuration

(MB39C502/C503)

Pin Number	Pin Name	I/O	Description
1	ILIM(*1)	I	Connect to VCC terminal.
2	ALERT_N	O	Open drain output terminal with over current alerting.
3	VDD	I	Power supply voltage input terminal of switching FET gate driver.
4	DRVL	O	Low side switching FET gate driver output terminal.
5	PGND	-	Power ground.
6	LX	-	Inductor and high side switching FET source connection terminal.
7	VIN	I	Power supply of switching regulator input terminal.
8	DRVH	O	High side switching FET gate driver output terminal.
9	BST	I	Boost capacitor connection terminal.
10	EN	I	Enable input of PWM controller. When turning on, apply greater than 0.65V and less than 5.5V. When turning off, apply less than 0.25V.
11	CSP	I	Current sensing positive input terminal.
12	CSN	I	Current sensing negative input terminal.
13	FB	I	Feedback voltage input of switching regulator.
14	SLP_N	I	Low power mode signal input terminal. Transferred to low power mode by connecting to “L” level
15	PWRGD	O	Open drain output terminal with power good.
16	VCC	I	Power supply voltage input terminal of PWM controller.
EP	AGND	-	Analog ground.

*1: ILIM terminal should be fixed to connect to VCC terminal.

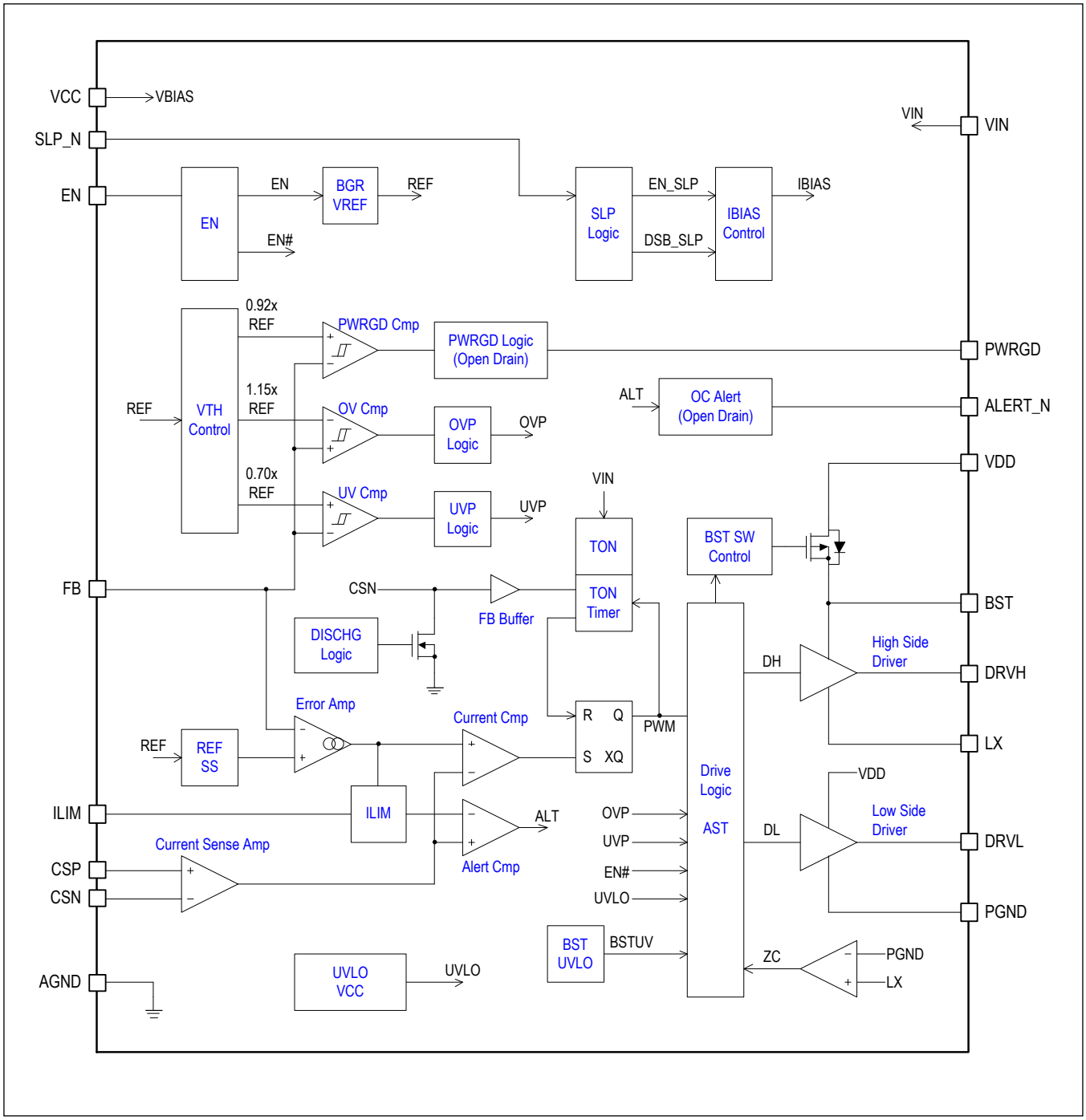
(MB39C504)

Pin Number	Pin Name	I/O	Description
1	ILIM(*1)	I	Connect to VCC terminal whenever.
2	VOUT	I	DCDC output voltage input for switchover.
3	LDO5	O	5V LDO output terminal.
4	DRVL	O	Low side switching FET gate driver output terminal.
5	PGND	-	Power ground.
6	LX	-	Inductor and high side switching FET source connection terminal.
7	VIN	I	Power supply of switching regulator input terminal.
8	DRVH	O	High side switching FET gate driver output terminal.
9	BST	I	Boost capacitor connection terminal.
10	EN	I	Enable input of PWM controller. When turning on, apply greater than 2.5V and less than 25V. When turning off, apply less than 0.6V.
11	CSP	I	Current sensing positive input terminal.
12	CSN	I	Current sensing negative input terminal.
13	VOUTS	I	DCDC output voltage input terminal.
14	SLP_N	I	Low power mode signal input terminal. Transferred to low power mode by connecting to “L” level
15	PWRGD	O	Open drain output terminal with power good.
16	VCC	I	Power supply voltage input terminal of PWM controller.
EP	AGND	-	Analog ground.

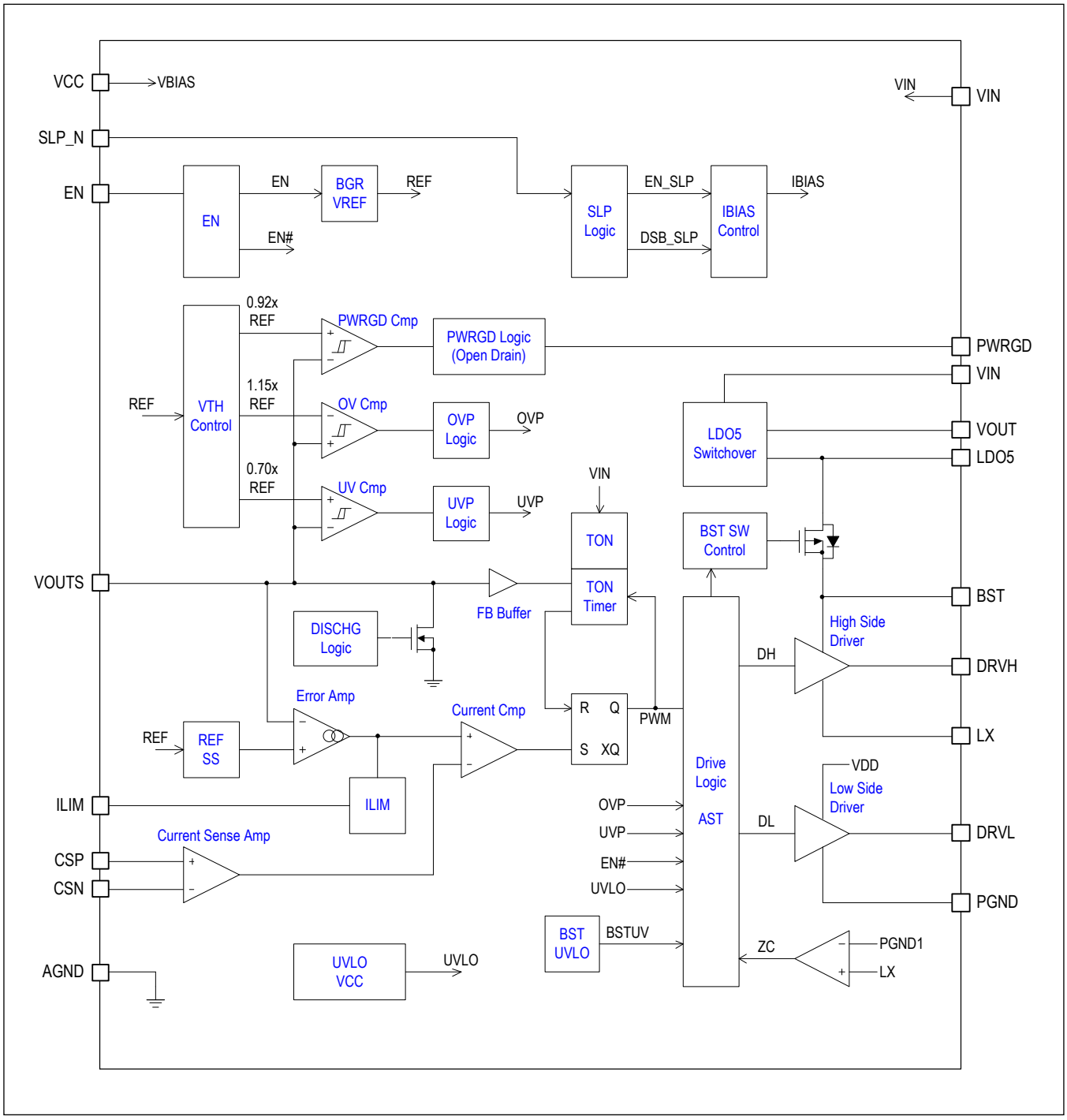
*1: ILIM terminal should be fixed to connect to VCC terminal.

4. Block Diagram

(MB39C502/C503)



(MB39C504)


VCC
VBIAS
SLP_N
EN
EN
EN#
BGR
VREF
REF
SLP
Logic
EN_SLP
DSB_SLP
IBIAS
Control
IBIAS
VIN
VIN
0.92x
REF
PWRGD Cmp
PWRGD Logic
(Open Drain)
PWRGD
VIN
REF
VTH
Control
1.15x
REF
OV Cmp
OVP
Logic
OVP
LDO5
Switchover
VOUT
LDO5
0.70x
REF
UV Cmp
UVP
Logic
UVP
VIN
TON
BST SW
Control
VOUTS
TON
Timer
FB Buffer
BST
DISCHG
Logic
High Side
Driver
DH
DRVH
Error Amp
Current Cmp
R Q
S XQ
PWM
LX
REF
REF
SS
Drive
Logic
AST
VDD
Low Side
Driver
ILIM
ILIM
OVP
UVP
EN#
UVLO
DL
DRVL
Current Sense Amp
CSP
CSN
PGND
BST
UVLO
BSTUV
ZC
PGND1
LX
AGND
UVLO
VCC
UVLO

5. Absolute Maximum Rating

(MB39C502/C503/C504)

Parameter	Symbol	Condition	Rating		Unit
			Min	Max	
Power supply voltage	V_{VIN}	VIN input voltage	–0.3	+28	V
	V_{VCC}	VCC input voltage	–0.3	+6.5	V
	V_{VDD}	VDD input voltage (MB39C502/C503)	–0.3	+6.5	V
	V_{VOUT}	VOUT input voltage (MB39C504)	–0.3	+6.5	V
Terminal voltage	V_{BST}	BST bias voltage	–0.3	+34.5	V
	V_{LX}	LX switching voltage	–2	+28	V
	V_{FB}	FB input voltage (MB39C502/C503)	–0.3	V_{VCC} +0.3	V
	V_{VOUTS}	VOUTS input voltage	–0.3	+6.5	V
	V_{INPUT}	ILIM input voltage	–0.3	V_{VCC} +0.3	V
	V_{CS}	CSP, CSN input voltage	–0.3	+6.5	V
	V_{EN}	EN input voltage (MB39C502/C503)	–0.3	+6.5	V
		EN input voltage (MB39C504)	–0.3	+28	V
	V_{SLP}	SLP_N input voltage	–0.3	+6.5	V
	V_{NOD}	PWRGD, ALERT_N bias voltage	–0.3	+6.5	V
Difference voltage	V_{BST-LX}	BST–LX difference voltage	–0.3	+6.5	V
	$V_{BST-VDD}$	BST–VDD difference voltage (MB39C502/C503)	-	+28	V
	$V_{BST-LDO5}$	BST–VOUT, LDO5 difference voltage (MB39C504)	-	+28	V
	V_{GND}	AGND–PGND difference voltage	–0.3	+0.3	V
	$V_{CSP-CSN}$	CSP–CSN difference voltage	–0.3	+0.3	V
Output current	I_{DRV}	DRVH, DRVL DC current	–60	+60	mA
	I_{NOD}	PWRGD	-	+2	mA
	I_{ALERT}	ALERT_N sink current (MB39C502/C503)	-	+2	mA
Power dissipation	P_D	Ta ≤ ±25°C	-	2100(*1)	mW
Storage temperature	T_{STG}	-	–55	+125	°C

*1: When the IC is mounted on 10cm × 10cm four-layer square epoxy board. IC is mounted on a four-layer epoxy board, which terminal bias, and the IC's thermal pad is connected to the epoxy board.

WARNING

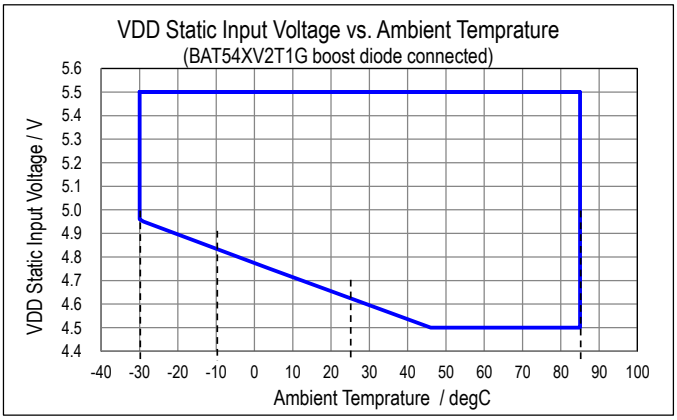
- *Semiconductor devices can be permanently damaged by application of stress (voltage, current, temperature, etc.) in excess of absolute maximum ratings. Do not exceed these ratings.*

6. Recommended Operating Conditions

(MB39C502/C503/C504)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
Power supply voltage	V_{VIN}	VIN input voltage (MB39C502/C503)	4.0	-	25	V
	V_{VIN}	VIN input voltage (MB39C504)	5.4	-	25	V
	V_{VCC}	VCC input voltage	4.5	-	5.5	V
	V_{VDD}	VDD input voltage (MB39C502)	4.5(*1)	-	5.5	V
	V_{VDD}	VDD input voltage (MB39C503)	4.5	-	5.5	V
	V_{LDO5}	VOUT input voltage (MB39C504)	4.5	-	5.5	V
Terminal voltage	V_{BST}	BST bias voltage	0	-	30.5	V
	V_{LX}	LX switching voltage	–1	-	25	V
	V_{INPUT}	FB, ILIM input voltage (MB39C502/C503)	0	-	V_{VCC}	V
	V_{INPUT}	ILIM input voltage (MB39C504)	0	-	V_{VCC}	V
	V_{CS}	CSP, CSN input voltage (MB39C502)	0	-	2.0	V
	V_{CS}	CSP, CSN input voltage (MB39C503)	0	-	3.5	V
	V_{CS}	CSP, CSN, VOUTS input voltage (MB39C504)	0	-	5.5	V
	V_{EN}	EN, SLP_N input voltage (MB39C502/C503)	0	-	5.5	V
	V_{EN}	EN input voltage (MB39C504)	0	-	25	V
	V_{SLP}	SLP_N input voltage (MB39C504)	0	-	5.5	V
	V_{NOD}	PWRGD, ALERT_N bias voltage (MB39C502/C503)	0	-	5.5	V
	V_{NOD}	PWRGD bias voltage (MB39C504)	0	-	5.5	V
Difference voltage	V_{BST-LX}	BST–LX difference voltage	0	-	5.5	V
	$V_{BST-VDD}$	BST–VDD difference voltage (MB39C502/C503)	-	-	25	V
	$V_{BST-LDO5}$	BST–VOUT, LDO5 difference voltage (MB39C504)	-	-	25	V
	V_{GND}	AGND–PGND difference voltage	–0.05	-	0.05	V
	$V_{CSP-CSN}$	CSP–CSN difference voltage	0	-	35	mV
Output current	I_{DRV}	DRVH, DRVL DC current	–45	-	45	mA
	I_{NOD}	PWRGD, ALERT_N sink current	-	-	1	mA
BST capacitor	C_{BST}	Connect BST to LX capacitor	-	0.47	-	µF
VCC capacitor	C_{VCC}	Connect VCC to AGND capacitor	-	1.0	-	µF
VDD capacitor	C_{VDD}	Connect VDD to PGND capacitor (MB39C502/C503)	-	4.7	-	µF
LDO5 capacitor	C_{LDO5}	Connect LDO5 to PGND capacitor(MB39C504)	-	4.7	-	µF
Operating ambient temperature	T_A	Ambient temperature	–30	-	85	°C

*1: This VDD minimum input voltage indicates dynamic input range below 1ms. Refer to figure (next page) about the static VDD minimum input voltage.



WARNING

- *The recommended operating conditions are required in order to ensure the normal operation of the semiconductor device. All of the device's electrical characteristics are warranted when the device is operated within these ranges.*
- *Always use semiconductor devices within their recommended operating condition ranges.*
- *Operation outside these ranges may adversely affect reliability and could result in device failure.*
- *No warranty is made with respect to use, conditions, or combinations not represented on the data sheet. Users considering application outside the listed conditions are advised to contact their representatives beforehand.*

7. Electrical Characteristics

(MB39C502)

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
REFERENCE VOLTAGE						
Internal reference voltage	V_{REF}	This voltage is compared to feedback voltage. Ta = 25°C	0.693	0.700	0.707	V
		Ta = –10°C to 85°C	0.686	-	0.714	V
FB input current	I_{FB}	VFB = 1.0V	–0.1	-	0.1	µA
ENABLE, SLP_N						
Enable condition	V_{EN}	Enable voltage range	0.65	-	5.5	V
	V_{DSB}	Disable voltage range	0	-	0.25	V
EN input current	I_{EN}	V_{EN} = 5.0V	-	0	0.1	µA
SLP_N enable condition	V_{SLPDSB}	LPM disable voltage range	0.65	-	5.5	V
	V_{SLPEN}	LPM enable voltage range	0	-	0.35	V
SLP_N input current	I_{SLP_N}	V_{SLP_N} = 5.0V	-	0	0.1	µA
SUPPLY CURRENT						
VDD supply current	I_{VDDPWM}	VDD, VCC input current at PWM operating. T_A = 25°C	-	380	760	µA
	I_{VDDPFM}	VDD, VCC input current at idle state in PFM operation. Static 0A inductor current. T_A = 25°C	-	180	360	µA
	I_{VDDLPM}	VDD, VCC input current at idle state in LPM operation. Static 0A inductor current. T_A = 25°C	-	30	60	µA
VDD shutdown current	I_{VDDSDN}	VDD, VCC input current at V_{EN} = 0V	-	0.1	1.0	µA
VIN supply current	I_{VIN}	V_{VIN} = 25V	-	10	15	µA
VIN shutdown current	I_{VINSDN}	VIN input current at V_{EN} = 0V	-	0.1	1.0	µA
UNDER VOLTAGE LOCKOUT						
VCC UVLO threshold	V_{UVLO}	UVLO release voltage	3.99	4.14	4.29	V
	V_{HYS}	Hysteresis	0.005	0.070	0.200	V
SOFT START, DISCHARGE						
Period of power on reset	t_{POR}	From enable ON to the switching initiating.	200	-	1000	µs
Ramp up time	t_{SS}	From the switching initiating after enable ON to the output voltage reaches 95%.	598	665	732	µs
Discharge resistance	R_{DISCHG}	VOUT = 0.2V, discharge enable.	50	100	200	Ω
Discharge ends voltage	V_{DISCHG}	V_{CSN} voltage.	0.07	0.10	0.13	V

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C502)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
ON TIMER						
On time	t_{ON}	V_{VIN} = 7.4V, V_{CSN} = 1.2V	193	210	227	ns
Minimum on time	t_{MINON}	V_{VIN} = 7.4V, V_{CSN} = 0.2V	80	120	-	ns
Minimum off time	t_{MINOFF}		-	200	400	ns
CURRENTLIMITATION						
Current limitation threshold	V_{ILIMIT}	CSP–CSN difference voltage at ILIM connects to VCC.	19.0	24.0	29.0	mV
ILIM input current	I_{ILIM}	V_{ILIM} = 5.0V	-	0	0.1	µA
CSP, CSN input current	I_{CS}	V_{CS} = 1.2V	–5.0	–2.0	-	µA
OVER AND UNDER VOLTAGE PROTECTION						
Over voltage threshold ratio	RT_{OV}	For target output voltage. At output voltage increasing.	110	115	125	%
Propagation delay of OV	t_{OV}	-	4	10	25	µs
Under voltage threshold ratio	RT_{UV}	For target output voltage. At output voltage decreasing.	65	70	75	%
Propagation delay of UV	t_{UV}	-	40	100	200	µs
POWER GOOD MONITOR						
Power good threshold ratio	RT_{PG}	For target output voltage. At output voltage increasing.	86	92	98	%
Hysteresis Ratio	RT_{HYS}	-	3	5	7	%
Propagation delay	t_{PG}	Power good	20	50	200	µs
	t_{PB}	Power bad	4	10	25	µs
PWRGD leak current	I_{LKPG}	V_{PWRGD} = 5.5V	-	0	1	µA
PWRGD output voltage “L” level	V_{OLPG}	I_{PWRGD} = 1mA sink	-	0.05	0.10	V
THERMAL SHUT DOWN						
Shut down temperature	T_{TSDH}	Shut down temperature.	-	150(*1)	-	°C
	T_{TSDL}	Exited temperature from thermal shut down state.	-	125(*1)	-	°C
OVER CURRENT ALERTING						
Over current alerting threshold ratio	RT_{ALT}	For target current limitation. At output current increasing.	78	85	92	%
Propagation delay	t_{ALTON}	On alerting assertion	20	50	200	µs
	t_{ALTOFF}	On alerting de-assertion	3	10	25	µs
ALERT_N leak current	I_{LKALT}	V_{ALERT_N} = 5.5V	-	0	1	µA
ALERT_N output voltage “L” level	V_{OLALT}	I_{ALERT_N} = 1mA sink	-	0.05	0.10	V

*1: No production tested, ensure by design.

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C502)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
DRIVER						
High side on resistance	R_{HOH}	At 100mA current sourcing	-	3(*1)	-	Ω
	R_{HOL}	At 100mA current sinking	-	1(*1)	-	Ω
Low side on resistance	R_{LOH}	At 100mA current sourcing	-	4(*1)	-	Ω
	R_{LOL}	At 100mA current sinking	-	0.75(*1)	-	Ω
High side source current	I_{SRCH}	V_{DRVH} = 2.5V	-	0.7(*1)	-	A
High side sink current	I_{SINKH}	V_{DRVH} = 2.5V	-	1.1(*1)	-	A
Low side source current	I_{SRCL}	V_{DRVL} = 2.5V	-	0.5(*1)	-	A
Low side sink current	I_{SINKL}	V_{DRVL} = 2.5V	-	1.7(*1)	-	A
Dead time	t_{DEAD}	From DRVH turn off to DRVL turn on. And reverse it.	10	20	-	ns
BOOST SWITCH						
Boost switch on resistance	R_{BST}	I_{BST} = 10mA	-	30	50	Ω
BST leak current	I_{LKBST}	V_{BST} = 30V	-	0.1	1.0	µA

*1: No production tested, ensure by design.

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C503)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
REFERENCE VOLTAGE						
Internal reference voltage	V_{REF}	This voltage is compared to feedback voltage. Ta = 25°C	0.99	1.00	1.01	V
		Ta = –10°C to 85°C	0.98	-	1.02	V
FB input current	I_{FB}	VFB = 1.0V	–0.1	-	0.1	µA
ENABLE, SLP_N						
Enable condition	V_{EN}	Enable voltage range	0.65	-	5.5	V
	V_{DSB}	Disable voltage range	0	-	0.25	V
EN input current	I_{EN}	V_{EN} = 5.0V	-	0	0.1	µA
SLP_N enable condition	V_{SLPDSB}	LPM disable voltage range	0.65	-	5.5	V
	V_{SLPEN}	LPM enable voltage range	0	-	0.35	V
SLP_N input current	I_{SLP_N}	V_{SLP_N} = 5.0V	-	0	0.1	µA
SUPPLY CURRENT						
VDD supply current	I_{VDDPWM}	VDD, VCC input current at PWM operating. T_A = 25°C	-	380	760	µA
	I_{VDDPFM}	VDD, VCC input current at idle state in PFM operation. Static 0A inductor current. T_A = 25°C	-	180	360	µA
	I_{VDDLPM}	VDD, VCC input current at idle state in LPM operation. Static 0A inductor current. T_A = 25°C	-	30	60	µA
VDD shutdown current	I_{VDDSDN}	VDD, VCC input current at V_{EN} = 0V	-	0.1	1.0	µA
VIN supply current	I_{VIN}	V_{VIN} = 25V	-	10	15	µA
VIN shutdown current	I_{VINSDN}	VIN input current at V_{EN} = 0V	-	0.1	1.0	µA
UNDER VOLTAGE LOCKOUT						
VCC UVLO threshold	V_{UVLO}	UVLO release voltage	3.99	4.14	4.29	V
	V_{HYS}	Hysteresis	0.005	0.070	0.200	V
SOFT START, DISCHARGE						
Period of power on reset	t_{POR}	From enable ON to the switching initiating.	200	-	1000	µs
Ramp up time	t_{SS}	From the switching initiating after enable ON to the output voltage reaches 95%.	598	665	732	µs
Discharge resistance	R_{DISCHG}	VOUT = 0.2V, discharge enable.	50	100	200	Ω
Discharge ends voltage	V_{DISCHG}	V_{CSN} voltage.	0.07	0.10	0.13	V

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C503)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
ON TIMER						
On time	t_{ON}	V_{VIN} = 7.4V, V_{CSN} = 3.3V	529	575	621	ns
Minimum on time	t_{MINON}	V_{VIN} = 7.4V, V_{CSN} = 0.2V	100	200		ns
Minimum off time	t_{MINOFF}	-		90	180	ns
CURRENTLIMITATION						
Current limitation threshold	V_{ILIMIT}	CSP–CSN difference voltage at ILIM connects to VCC.	21.0	26.0	31.0	mV
ILIM input current	I_{ILIM}	V_{ILIM} = 5.0V	-	0	0.1	µA
CSP input current	I_{CSP}	V_{CSP} = 3.3V	-	2.0	5.0	µA
CSN input current	I_{CSN}	V_{CSP} = 3.3V	-	8.0	20.0	µA
OVER AND UNDER VOLTAGE PROTECTION						
Over voltage threshold ratio	RT_{OV}	For target output voltage. At output voltage increasing.	110	115	125	%
Propagation delay of OV	t_{OV}	-	4	10	25	µs
Under voltage threshold ratio	RT_{UV}	For target output voltage. At output voltage decreasing.	65	70	75	%
Propagation delay of UV	t_{UV}	-	40	100	200	µs
POWER GOOD MONITOR						
Power good threshold ratio	RT_{PG}	For target output voltage. At output voltage increasing.	86	92	98	%
Hysteresis Ratio	RT_{HYS}	-	3	5	7	%
Propagation delay	t_{PG}	Power good	20	50	200	µs
	t_{PB}	Power bad	4	10	25	µs
PWRGD leak current	I_{LKPG}	V_{PWRGD} = 5.5V	-	0	1	µA
PWRGD output voltage “L” level	V_{OLPG}	I_{PWRGD} = 1mA sink	-	0.05	0.10	V
THERMAL SHUT DOWN						
Shut down temperature	T_{TSDH}	Shut down temperature.	-	150(*1)	-	°C
	T_{TSDL}	Exited temperature from thermal shut down state.	-	125(*1)	-	°C
OVER CURRENT ALERTING						
Over current alerting threshold ratio	RT_{ALT}	For target current limitation. At output current increasing.	78	85	92	%
Propagation delay	t_{ALTON}	On alerting assertion	20	50	200	µs
	t_{ALTOFF}	On alerting de-assertion	3	10	25	µs
ALERT_N leak current	I_{LKALT}	V_{ALERT_N} = 5.5V	-	0	1	µA
ALERT_N output voltage “L” level	V_{OLALT}	I_{ALERT_N} = 1mA sink	-	0.05	0.10	V

*1: No production tested, ensure by design.

VIN = 7.4V, VDD, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C503)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
DRIVER						
High side on resistance	R_{HOH}	At 100mA current sourcing	-	3(*1)	-	Ω
	R_{HOL}	At 100mA current sinking	-	1(*1)	-	Ω
Low side on resistance	R_{LOH}	At 100mA current sourcing	-	4(*1)	-	Ω
	R_{LOL}	At 100mA current sinking	-	0.75(*1)	-	Ω
High side source current	I_{SRCH}	V_{DRVH} = 2.5V	-	0.7(*1)	-	A
High side sink current	I_{SINKH}	V_{DRVH} = 2.5V	-	1.1(*1)	-	A
Low side source current	I_{SRCL}	V_{DRVL} = 2.5V	-	0.5(*1)	-	A
Low side sink current	I_{SINKL}	V_{DRVL} = 2.5V	-	1.7(*1)	-	A
Dead time	t_{DEAD}	From DRVH turn off to DRVL turn on. And reverse it.	10	20	-	ns
BOOST SWITCH						
Boost switch on resistance	R_{BST}	I_{BST} = 10mA	-	30	50	Ω
BST leak current	I_{LKBST}	V_{BST} = 30V	-	0.1	1.0	µA

*1: No production tested, ensure by design.

VIN = 7.4V, VOUT, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C504)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
REFERENCE VOLTAGE						
Internal reference voltage	V_{REF}	This voltage is compared to feedback voltage. Ta = 25°C	4.95	5.00	5.05	V
		Ta = –10°C to 85°C	4.90	-	5.10	V
VOUTS input current	I_{VOUTS}	V_{VOUTS} = 5.0V	2.5	5.0	12.5	µA
ENABLE, SLP_N						
Enable condition	V_{EN}	Enable voltage range	2.5	-	25	V
	V_{DSB}	Disable voltage range	0	-	0.6	V
EN input current	I_{EN}	V_{EN} = 5.0V	-	0.5	1.2	µA
SLP_N enable condition	V_{SLPDSB}	LPM disable voltage range	0.65	-	5.5	V
	V_{SLPEN}	LPM enable voltage range	0	-	0.35	V
SLP_N input current	I_{SLP_N}	V_{SLP_N} = 5.0V	-	0	0.1	µA
SUPPLY CURRENT						
VOUT supply current	$I_{VOUTPWM}$	VOUT, VCC input current at PWM operating. T_A = 25°C	-	400	800	µA
	$I_{VOUTPFM}$	VOUT, VCC input current at idle state in PFM operation. Static 0A inductor current. T_A = 25°C	-	200	400	µA
	$I_{VOUTLPM}$	VOUT, VCC input current at idle state in LPM operation. Static 0A inductor current. T_A = 25°C	-	50	100	µA
VOUT shutdown current	$I_{VOUTSDN}$	VOUT, VCC input current at V_{EN} = 0V	-	0.1	1.0	µA
VIN supply current	I_{VIN}	V_{VIN} = 25V	-	20	30	µA
VIN shutdown current	I_{VINSDN}	VIN input current at V_{EN} = 0V	-	0.1	1.0	µA
UNDER VOLTAGE LOCKOUT						
VCC UVLO threshold	V_{UVLO}	UVLO release voltage	3.99	4.14	4.29	V
	V_{HYS}	Hysteresis	0.005	0.070	0.200	V
SOFT START, DISCHARGE						
Period of power on reset	t_{POR}	From enable ON to the switching initiating.	300	-	1400	µs
Ramp up time	t_{SS}	From the switching initiating after enable ON to the output voltage reaches 95%.	598	665	732	µs
Discharge resistance	R_{DISCHG}	VOUT = 0.2V, discharge enable.	50	100	200	Ω
Discharge ends voltage	V_{DISCHG}	V_{CSN} voltage.	0.07	0.10	0.13	V

VIN = 7.4V, VOUT, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C504)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
ON TIMER						
On time	t_{ON}	V_{VIN} = 7.4V, V_{VOUT} = 5.0V	802	872	942	ns
Minimum on time	t_{MINON}	V_{VIN} = 7.4V, V_{VOUT} = 0.2V	100	200	-	ns
Minimum off time	t_{MINOFF}	-	-	120	240	ns
CURRENTLIMITATION						
Current limitation threshold	V_{ILIMIT}	CSP–CSN difference voltage at ILIM connects to VCC.	21.0	26.0	31.0	mV
ILIM input current	I_{ILIM}	V_{ILIM} = 5.0V	-	0	0.1	µA
CSP input current	I_{CSP}	V_{CSP} = 5.0V	-	2.0	5.0	µA
CSN input current	I_{CSN}	V_{CSN} = 5.0V	-	8.0	20.0	µA
OVER AND UNDER VOLTAGE PROTECTION						
Over voltage threshold ratio	RT_{OV}	For target output voltage. At output voltage increasing.	110	115	125	%
Propagation delay of OV	t_{OV}	-	4	10	25	µs
Under voltage threshold ratio	RT_{UV}	For target output voltage. At output voltage decreasing.	65	70	75	%
Propagation delay of UV	t_{UV}	-	40	100	200	µs
POWER GOOD MONITOR						
Power good threshold ratio	RT_{PG}	For target output voltage. At output voltage increasing.	86	92	98	%
Hysteresis Ratio	RT_{HYS}	-	3	5	7	%
Propagation delay	t_{PG}	Power good	20	50	200	µs
	t_{PB}	Power bad	4	10	25	µs
PWRGD leak current	I_{LKPG}	V_{PWRGD} = 5.5V	-	0	1	µA
PWRGD output voltage “L” level	V_{OLPG}	I_{PWRGD} = 1mA sink	-	0.05	0.10	V
THERMAL SHUT DOWN						
Shut down temperature	T_{TSDH}	Shut down temperature.	-	150(*1)	-	°C
	T_{TSDL}	Exited temperature from thermal shut down state.	-	125(*1)	-	°C

*1: No production tested, ensure by design.

VIN = 7.4V, VOUT, BST and EN connect to 5V power supply, PGND, LX = 0V. T_A = –30°C to +85°C, unless otherwise noted.

(MB39C504)

Parameter	Symbol	Condition	Value			Unit
			Min	Typ	Max	
5V LDO						
Output voltage	V_{LDO5}	No switchover. VOUT input voltage < 4.4V	4.75	5.00	5.25	V
Output current	I_{LDO5}	No switchover. V_{VIN} = 5.4V	25	-	-	mA
Output short current	I_{LDO5S}	No switchover. V_{LDO5} = 0V	-	80	125	mA
Switchover voltage	V_{SWOVR}	VOUT voltage rising.	4.35	4.50	4.60	V
	V_{HYS}	Hysteresis voltage.	0.08	0.10	0.12	V
Startup time	t_{SLDO5}	LDO5 voltage reaches to 4.2V. C_{LDO5}, C_{VCC} = 1.0µF	100	150	400	µs
DRIVER						
High side on resistance	R_{HOH}	At 100mA current sourcing	-	3(*1)	-	Ω
	R_{HOL}	At 100mA current sinking	-	1(*1)	-	Ω
Low side on resistance	R_{LOH}	At 100mA current sourcing	-	4(*1)	-	Ω
	R_{LOL}	At 100mA current sinking	-	0.75(*1)	-	Ω
High side source current	I_{SRCH}	V_{DRVH} = 2.5V	-	0.7(*1)	-	A
High side sink current	I_{SINKH}	V_{DRVH} = 2.5V	-	1.1(*1)	-	A
Low side source current	I_{SRCL}	V_{DRVL} = 2.5V	-	0.5(*1)	-	A
Low side sink current	I_{SINKL}	V_{DRVL} = 2.5V	-	1.7(*1)	-	A
Dead time	t_{DEAD}	From DRVH turn off to DRVL turn on. And reverse it.	10	20	-	ns
BOOST SWITCH						
Boost switch on resistance	R_{BST}	I_{BST} = 10mA	-	30	50	Ω
BST leak current	I_{LKBST}	V_{BST} = 30V	-	0.1	1.0	µA

*1: No production tested, ensure by design.

8. Protections and Power Good function

8.1 Description

(MB39C502/C503/C504)

This PWM Control IC has some protection functions UVLO, OVP, UVP, ILIM, and TSD for the assumed various power system failures. Details of these protections are written as follows.

Under Voltage Lockout (UVLO)

The under voltage lockout (UVLO) protects ICs from malfunction and protects the system from destruction/deterioration, according to the reasons mentioned below.

- Transitional state when the voltage inputs to VCC (5V power supply) terminal.
- Momentary decrease

To prevent such a malfunction, this function detects a voltage drop of the 5V power supply, and stops IC operations. When the voltage of 5V power supply exceeds the threshold voltage of the under voltage lockout protection circuit, the system is restored.

Over Voltage Protection (OVP)

This function stops the output voltage when the output voltage has increased, and protects devices connected to the output. When the over voltage is detected, the controller is fixed that the high side switching FET is turned off and the low side switching FET is turned on with 10µs propagation delay. When the enable is reentered, this fixed state is released and beginning soft start.

Under Voltage Protection (UVP)

This function stops the output voltage when the output voltage has lowered, and protects devices connected to the output. When the under voltage is detected, the controller is fixed that the high side switching FET is turned off and the low side switching FET is turned off with 100µs propagation delay. When the enable is reentered, this fixed state is released and beginning soft start.

Over Current Limitation (ILIM)

This function limits the output current when it has increased, and protects devices connected to the output. This function detects the inductor valley current with current sense resister RSENSE. The differential voltage of the CSP-CSN terminals is amplified to x20 by internal current sense amplifier, and compared to the limit voltage of 480mV fixed at internal preset condition. Until the amplified voltage fall the limit voltage, the high side switching FET is held in the off state. After the voltage has fallen below the limit voltage, the high side switching FET is placed into the ON state. This limits the lower bound of the inductor current and also restricts the over current. As a result, it becomes operation that the output voltage droops.

Thermal Shutdown (TSD)

This function prevents the PWM Control IC from a thermal destruction. If the junction temperature reaches +150°C, the high side and low side switching FET are turned off. Then the discharge operation is carried out to discharge the output capacitor (The discharge operation continues until the state of the thermal shutdown released). If the junction temperature drops to +125°C, the soft start is automatically reactivated.

Power Good (PWRGD)

Power good flag is hoisted at PWRGD terminal (Open Drain) to “Hi-Z” level with 50µs propagation delay, when the output voltage becomes larger than 92% of the output setting voltage. It is related by the OVP protection written above. When the output voltage becomes lower than power good threshold level, the PWRGD terminal is changed to “L” level with 10µs propagation delay.

State Table of Protection Function

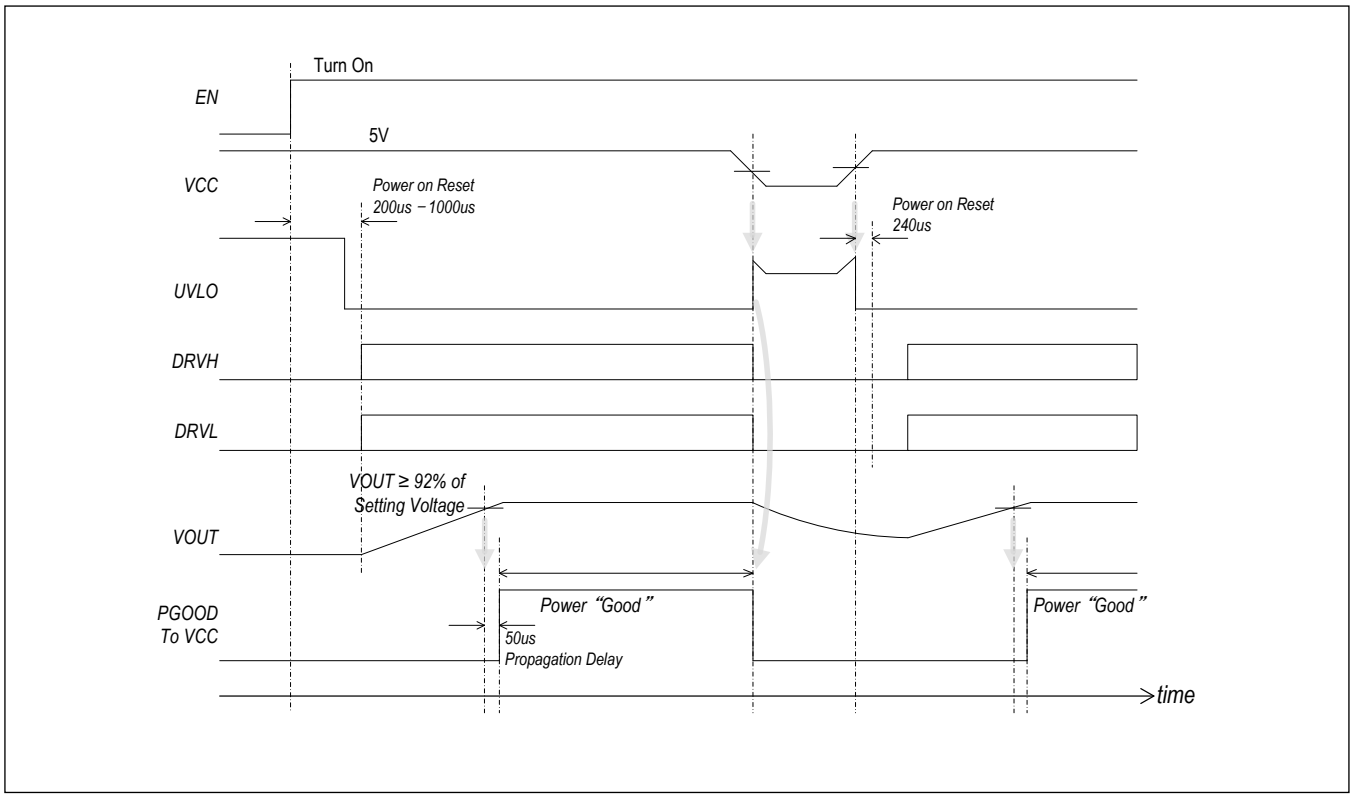
(MB39C502/C503/C504)

Protection Function	High Side FET	Low Side FET	Output state	Remarks
Under Voltage Lockout (UVLO)	OFF	OFF	OFF	After releasing UVLO, the System is an automatic restoration with soft start.
Over Voltage Protection (OVP)	OFF	ON	Latch OFF	Latch stall. It returns the System by enable reentry.
Under Voltage Protection (UVP)	OFF	OFF	Latch OFF	Latch stall. It returns the System by enable reentry.
Over Current Limitation (ILIM)	Switching	Switching	–	The output voltage is drooped with current limitation.
Thermal Shutdown (TSD)	OFF	OFF	OFF	After releasing TSD, the System is an automatic restoration with soft start.

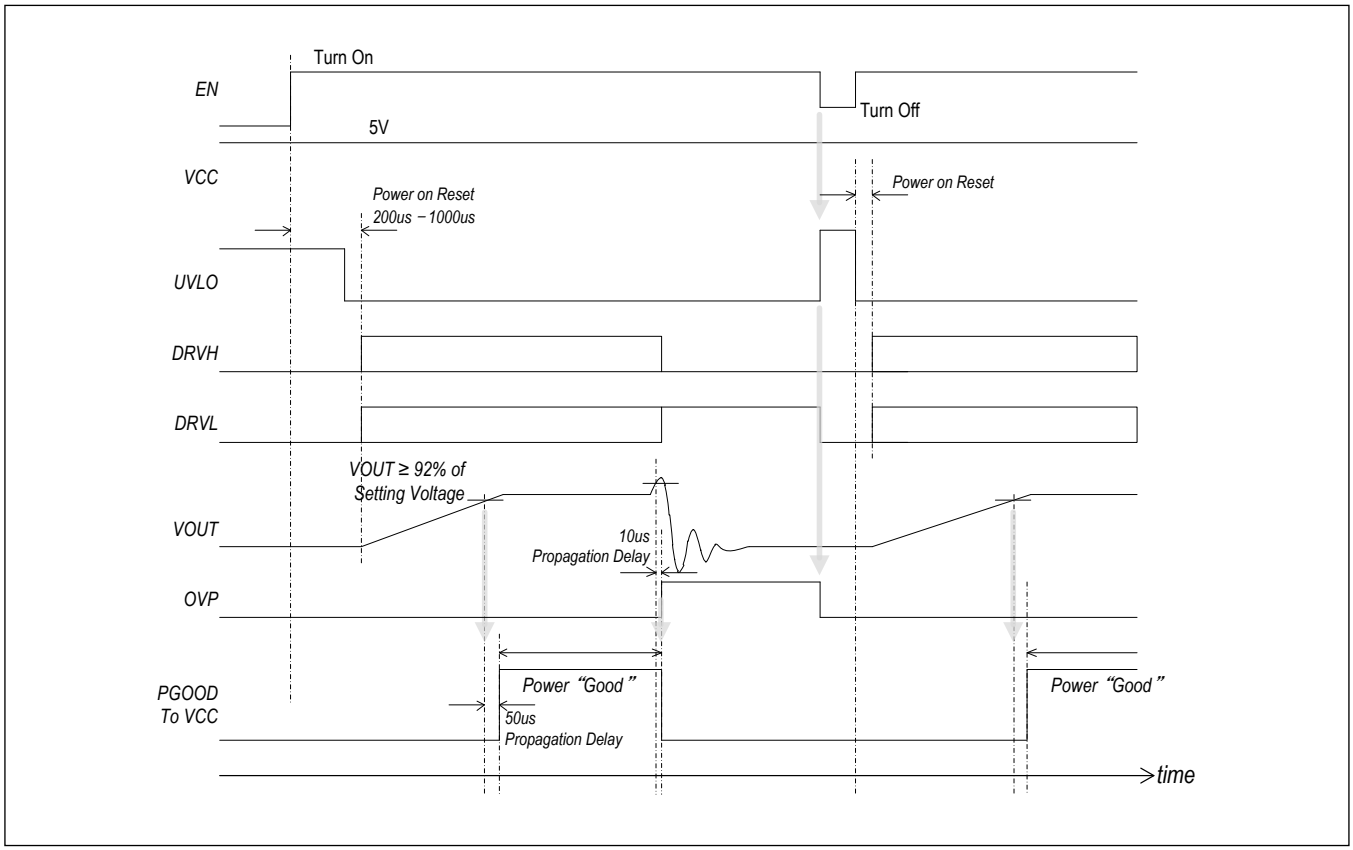
8.2 Timing Chart

(MB39C502/C503/C504)

Under Voltage Lockout Protection (UVLO)



Over Voltage Protection (OVP)



Under Voltage Protection (UVP)