MITSUMI

2A, 16V, Synchronous Step-down DCDC converter

MM4008

Overview

A step-down DC / DC converter for secondary car infotainment equipment. The high-precision oscillation frequency of 1.9MHz ± 5% avoids noise interference in the AM band, and the output MOSFET with low on-resistance operates with high efficiency.
The high-precision oscillation frequency of 1.9MHz ± 5% avoids noise interference in the AM band, and the output MOSFET with low on-resistance operates with high efficiency. In addition, high-precision overcurrent protection suppresses the size increase of the inductor in consideration of the worst case, and contributes to the miniaturization of the board as well as the built-in feedback resistor and phase compensation circuit. It is ideal as a power supply for loads of 1A to 2A where heat generation is a problem with conventional LDOs.

FEATURES

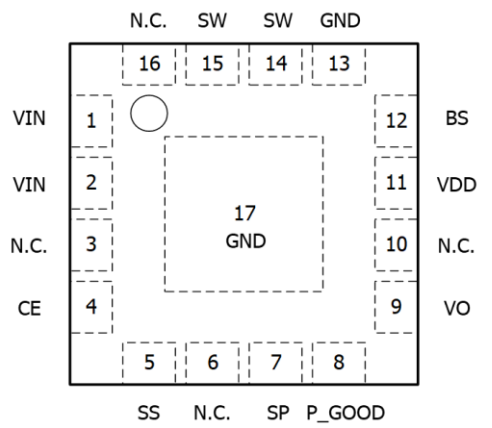
- Input Voltage range 4.5V-16V
- Output current 2A
- High-side, Low-side Internal FET Switch
  High side : 100mΩ typ. / Low side : 65mΩ typ.
- Overcurrent detection Space saving with high accuracy
- Suppression of output overvoltage by output mild recovery function
- High efficiency operation 12V input, 88% or more at 2A
- Noise reduction by spread spectrum function
- Built-in P_GOOD flag function

Package

- SQFN-16C 3.0 × 3.0 × 0.75 [mm]

■ Any products mentioned this leaflet are subject to any modification in their appearance and others for improvements without prior notification.
■ The details listed here are not a guarantee of the individual products at the time of ordering.
■ When using the products, you will be asked to check their specifications.

TERMINAL EXPLANATIONS

SQFN-16C	PIN No.	Name	Function
	1,2	VIN	Power supply pin. Input power supply voltage 4.5-16V. Place ceramic capacitors as close to the pins as possible.
	4	CE	Chip enable pin. Pull above 2.0V to enable, pull below 0.6V to disable. Please avoid use in the that is floating.
	5	SS	Soft-start time adjustable pin. Soft-start time can be set up by adjusting an external capacitor.
	7	SP	Spread spectrum modulation frequency setting pin. The modulation frequency can be set by adjusting the external capacitance. When not using the spread spectrum function, connect to GND.
	8	P_GOOD	Reset output pin. Open drain reset output pin. L signal is outputted when the abnormal operation is detected. In not using a P_GOOD pin, please connect to GND.
	9	VO	Output voltage feedback pin. When the output voltage is set to 5V or higher, power is supplied from the output to the internal circuit.
	11	VDD	Internal linear regulator output pin. The internal circuitry is powered from this voltage. Place ceramic capacitors as close to the pins as possible.
	12	BS	Bootstrap capacitor connection pin. The bootstrap capacitor 0.1μF is necessary between BS to SW to drive the high side switch.
	13	GND	Ground pin.
	14,15	SW	Inductor connection pin.
	17	GND	Ground terminal, thermal pad. Connect it to the ground to obtain the optimum electrical characteristics.
	3,6, 10,16	N.C.	No connection.

ABSOLUTE MAXIMUM RATINGS

(Ta=25°C and AGND standard, unless otherwise specified.)

ITEM	SYMBOL	MIN.	MAX.	UNIT
VIN supply voltage	V_{INMAX}	-0.3	18	V
SW pin voltage	V_{SWMAX}	-0.3	V_{IN}+0.3	V
BS pin voltage	V_{BSMAX}	V_{SW}-0.3	V_{SW}+5.5	V
VO pin voltage	V_{VOMAX}	-0.3	18	V
CE pin voltage	V_{CEMAX}	-0.3	5.5	V
SS pin voltage	V_{SSMAX}	-0.3	3	V
SP pin voltage	V_{SPMAX}	-0.3	3	V
VDD pin voltage	V_{VDDMAX}	-0.3	5.5	V
P_GOOD pin voltage	$V_{PGOODMAX}$	-0.3	5.5	V
Storage temperature	Tstg	-55	150	℃
Power dissipation *1	Pd	-	3.7	W

*1 Board conditions FR4, 6 layers, 80x80x1.6t mm, copper foil ratio 90%.

RECOMMENDED OPERATING CONDITIONS

ITEM	SYMBOL	MIN.	MAX.	UNIT
Operating Ambient temperature	Topr	-40	105	℃
Operating voltage	Vop	4.5	16	V

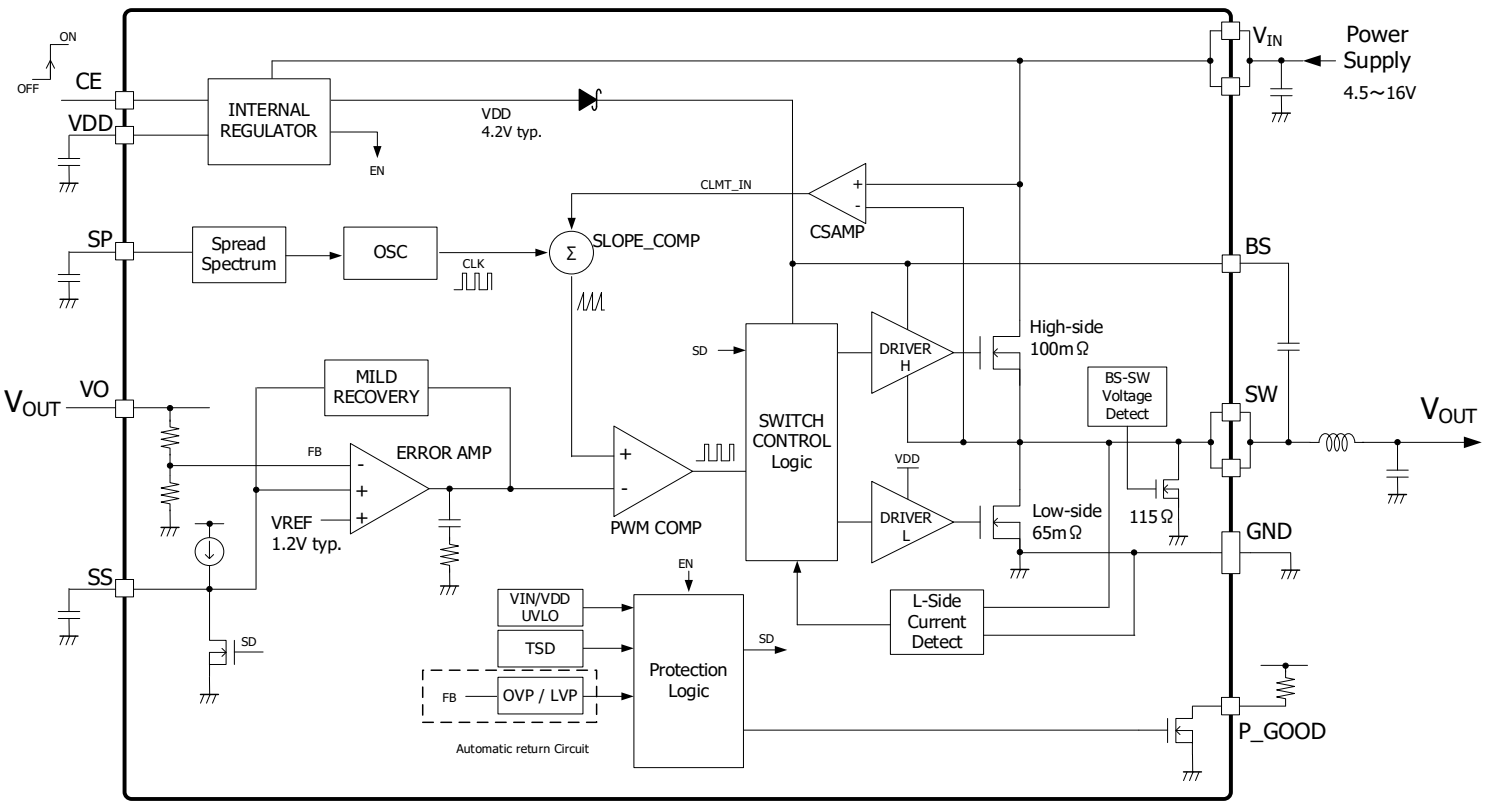
ELECTRICAL CHARACTERISTICS

(unless otherwise specified VIN=10V,CE=3V,Ta=25℃)

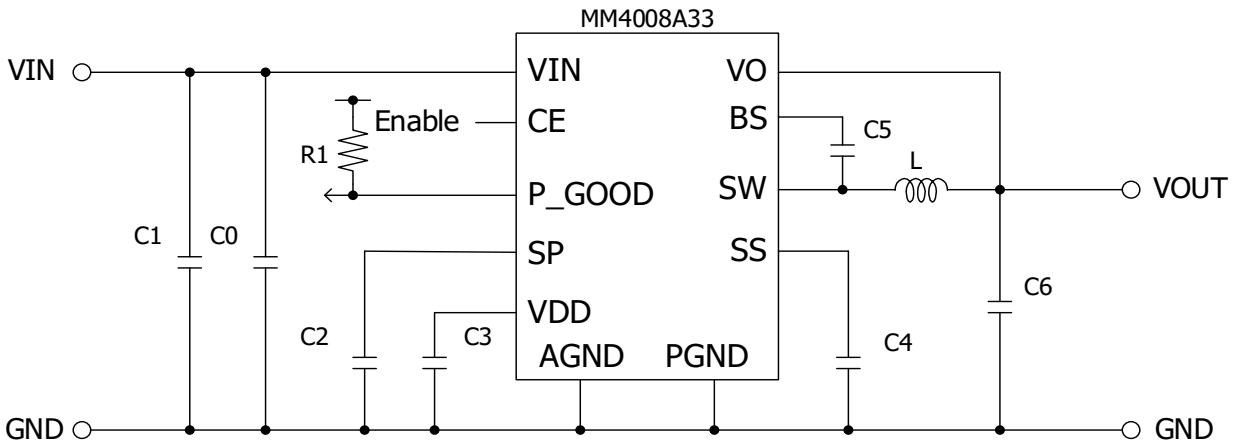
Parameter	Symbol	Conditions	MIN.	TYP.	MAX.	UNIT
Supply Current	I_{S1}	No switching	-	1.5	2.1	mA
Shutdown Current	I_{S2}	V_{CE}=0V,V_{IN}=16V	-	0.01	1.0	uA
VO pin Voltage	V_{OUT}	No Load	3.267	3.300	3.333	V
VO pin Voltage Temperature coefficient *2	-	Tj=-40 to 105°C	-50	-	50	ppm/°C
VO pin Input Current	I_{VO}	No switching	-	25	40	μA
High-side switch on-resistance *2	R_{ONH}	V_{GS}=4.2V	-	100	-	mΩ
Low-side switch on-resistance *2	R_{ONL}	V_{GS}=4.2V	-	65	-	mΩ
High-side switch leakage current	I_{LEAKH}	V_{CE}=V_{SW}=0V,V_{IN}=16V	-	0.01	1	μA
Low-side switch leakage current	I_{LEAKL}	V_{CE}=0V,V_{SW}=V_{BS}=16V	-	0.01	1	μA
Oscillation frequency	f_{SW}	SP=0V,Tj=-40 to 150°C *2	1.81	1.90	2.00	MHz
Minimum On Time	T_{ONMIN}		-	60	80	ns
Minimum Off Time	T_{OFFMIN}		-	80	100	ns
VDD Output Voltage	V_{VDD}		-	4.2	-	V
VIN UVLO detection voltage	V_{UVLO_VIN}	V_{IN}=high to low	3.8	4.0	4.2	V
VIN UVLO hysteresis voltage	ΔV_{UVLO_VIN}	V_{IN}=low to high	0.1	0.2	0.3	V
VDD UVLO detection voltage	V_{UVLO_VDD}	V_{VDD}=high to low	3.0	3.2	3.4	V
VDD UVLO hysteresis voltage	ΔV_{UVLO_VDD}	V_{VDD}=low to high	0.25	0.40	0.55	V
CE pin H threshold voltage	V_{CETH}		2.0	-	-	V
CE pin L threshold voltage	V_{CETL}		-	-	0.6	V
CE pin input current	I_{CE}	V_{CE}=3.3V	-	8	15	μA
OVP detection voltage	V_{OVP}	V_{VO}=low to high	110	115	120	%
OVP detection delay time *2	T_{DLY_OVP}		-	-	10	μs
OVP detection latch delay time	T_{LATCH_OVP}		0.7	1.0	1.3	ms
LVP detection voltage	V_{LVP}	V_{VO}=high to low	40	50	60	%
LVP detection latch delay time	T_{LATCH_LVP}		0.7	1.0	1.3	ms
Latch OFF Automatic return time	T_{R_DLY}		140	200	260	ms
High-side current limit *2	I_{LMTH}		3.3	3.5	3.7	A
Low-side current limit *2	I_{LMTL}		1.5	3.0	4.0	A
Thermal shutdown *4	TSD		-	170	-	℃
Thermal shutdown hysteresis *4	ΔTSD		-	30	-	℃
SS pin current	I_{SS}	V_{SS}=0.4V, V_{VO}=V_{OUT}*1.05	1.2	2.5	3.8	ms
Spread spectrum modulation frequency	f_{SS}	C_{SP}=2200pF	-	3	-	kHz
Spread Spectrum Modulation Frequency Range	-		-	20	-	%
SP pin current	I_{SP}	V_{SP}=1.1V	-	±4.0	-	μA
SW pin discharge resistance	R_{SW_DIS}		-	115	150	Ω
P_GOOD pin leakage current	I_{LEAK_PG}	V_{PGOOD}=5.5V	-	-	1	μA
P_GOOD pin sink current	I_{SINK_PG}	V_{PGOOD}=0.5V	1	2	-	mA

*2 Guaranteed by design, not tested.

BLOCK DIAGRAM



TYPICAL APPLICATION CIRCUIT



C0 - C8 Ceramic capacitor

Table1. Recommended external parts value.

L [μH]	R1 [kΩ]	C0 [μF]	C1 [μF]	C2 [pF]	C3 [μF]	C4 [μF]	C5 [μF]	C6 [μF]
2.2	10	0.1	10	2200	2.2	0.01	0.1	22

Soft start time calculation formula

$$T_{SS} = \frac{1.14 \times C4}{I_{SS}} + T_{DELAY} \quad [sec]$$

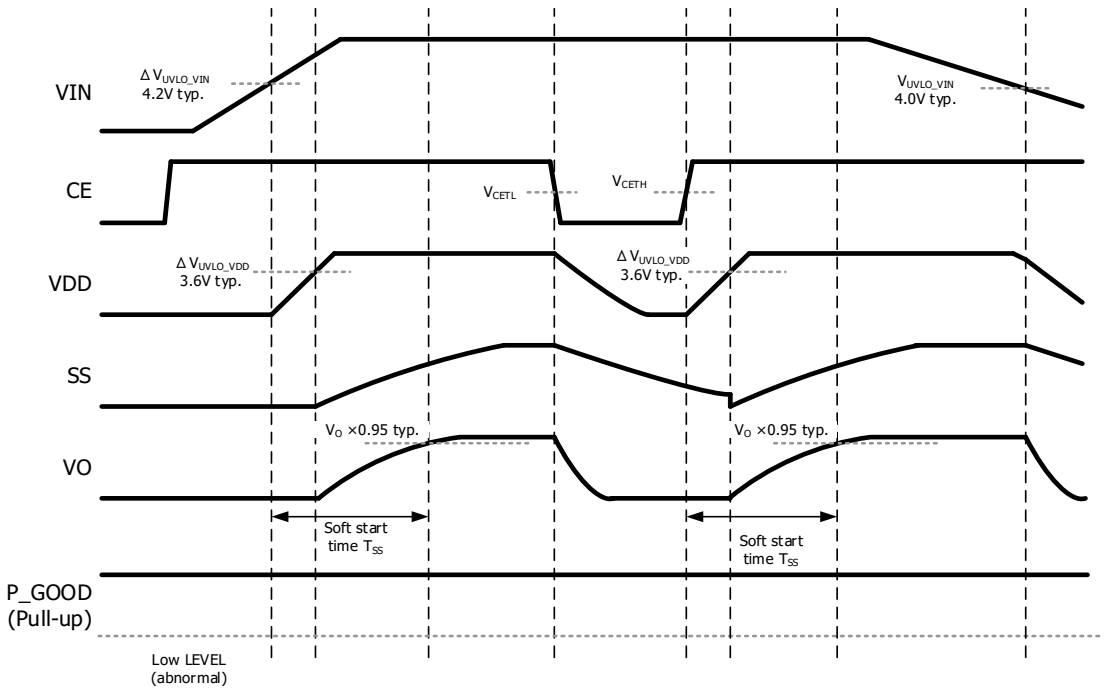
* T_{DELAY} : VDD start up delay time 100μs(typ)

Application hints

The output voltage is decided depending on the input voltage, Minimum on time, Maximum duty cycle.
Please decide the output condition in consideration of the above-mentioned characteristic.
There is a possibility that operation becomes unstable when the current rating of the coil is exceeded.
Please enlarge the current rating of the coil more than the output current.

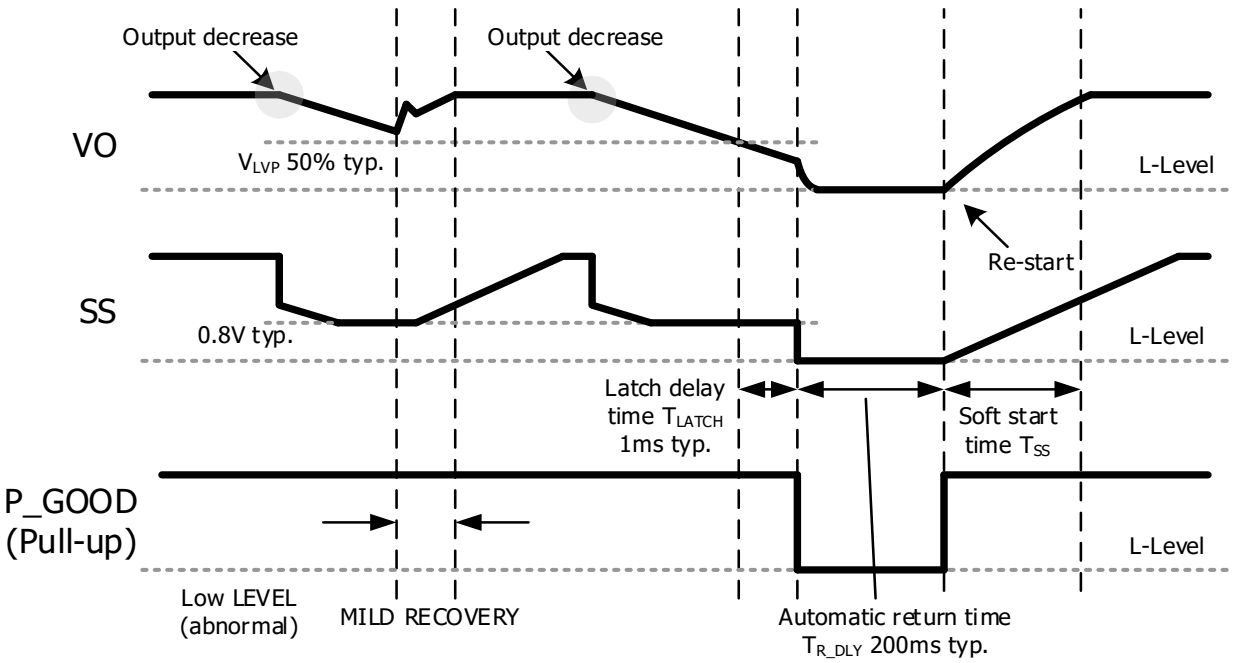
TIMMING CHART

Start-up/ Shut-down



Start-up condition is $V_{CE}>V_{CET}$ and $V_{IN}>V_{UVLO_VIN}$. Shut-down condition is $V_{CE}<V_{CET}$ or $V_{IN}<V_{UVLO_VIN}$.
Soft start time T_{SS} is from $V_{CE}>V_{CET}$ to time that V_{OUT} is up to reach 95% of the normal value.

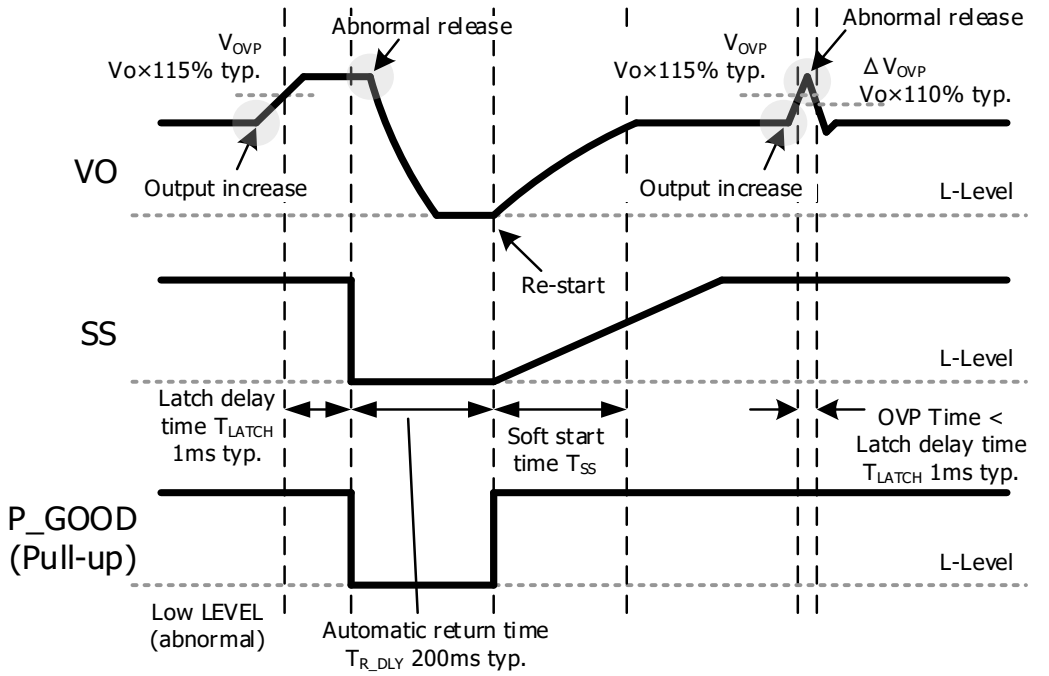
Low output voltage protection



When LVP are detected exceeding latch delay time T_{LATCH}, the IC is shutdown, P_GOOD is L-Output.
After 200ms, the IC will automatically return in soft-start operation.

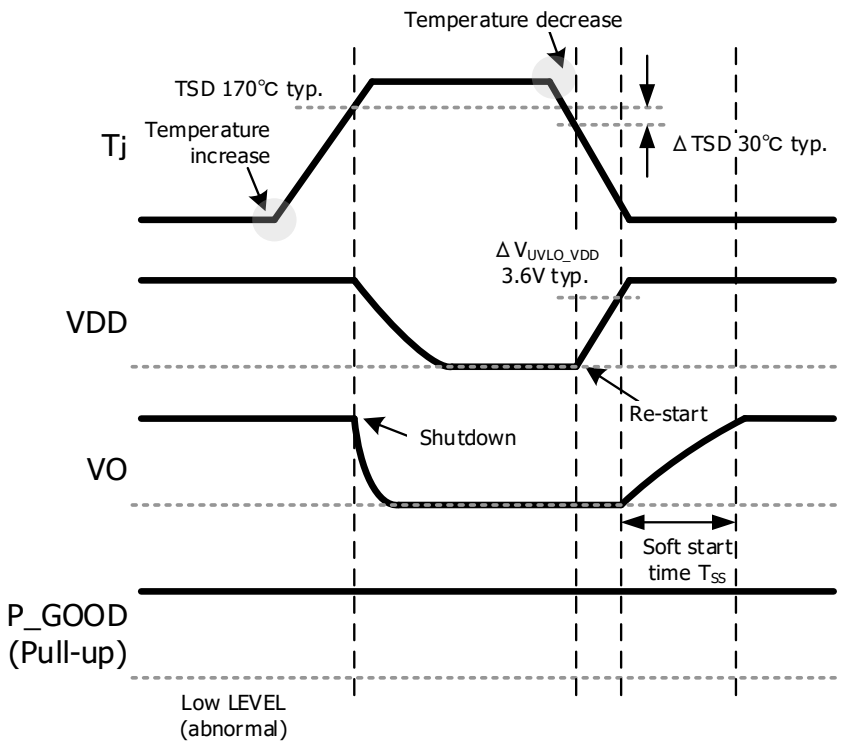
TIMMING CHART (CONTINUED)

Over output voltage protection



When OVP is detected, the IC stops switching. If OVP is detected exceeding latch delay time T_{LATCH}, the IC is shutdown, P_GOOD is L-Output. After 200ms, the IC will automatically return in soft-start operation.

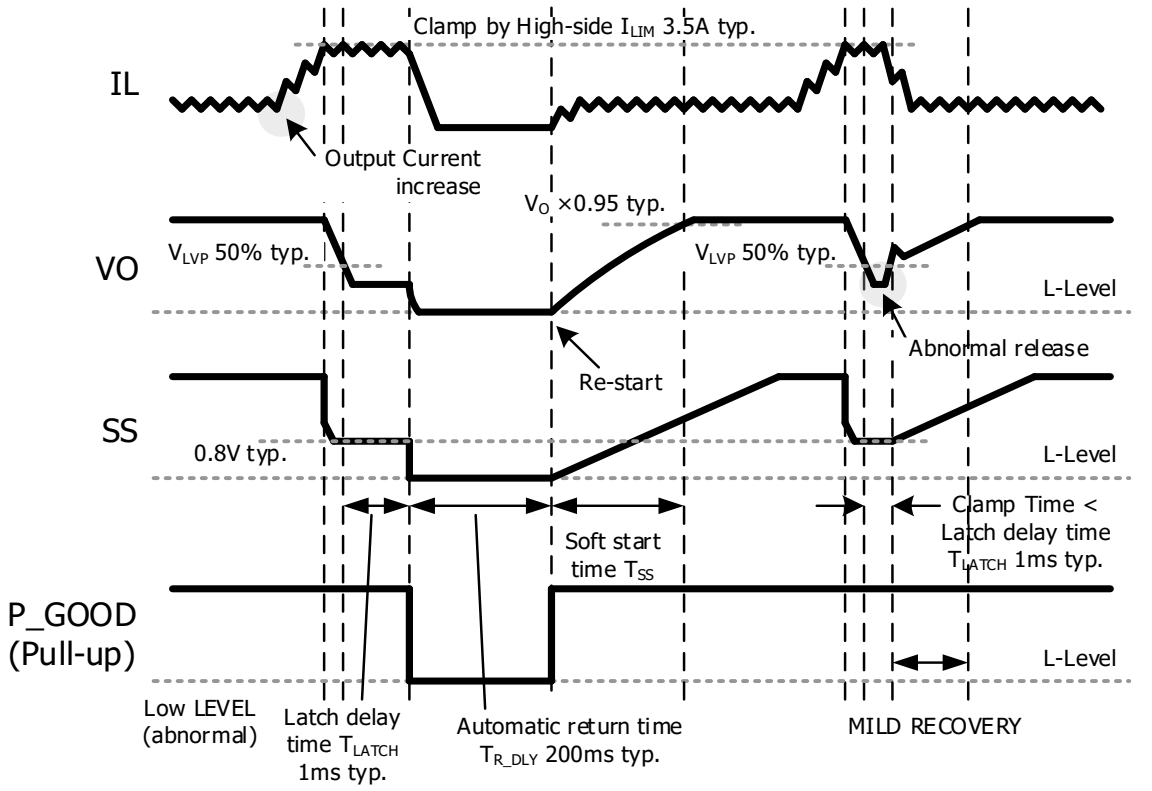
Thermal shutdown function



When the junction temperature (Tj) rises above 170 °C, VDD stops, and the IC shuts it down.
When the junction temperature (Tj) drops below 140 °C, the IC will restart.

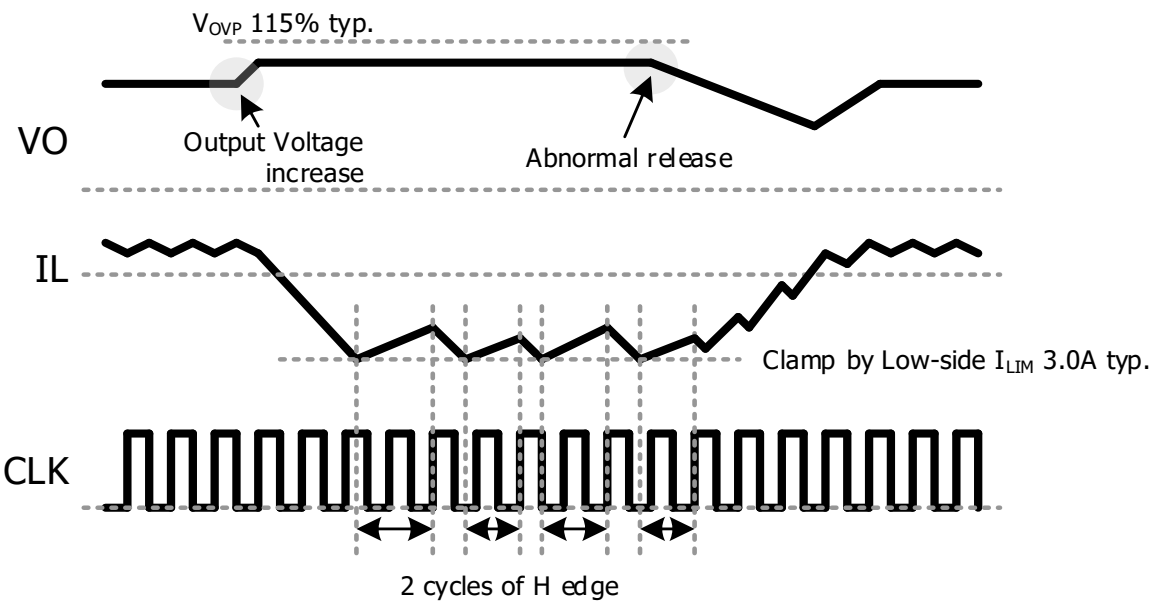
TIMMING CHART (CONTINUED)

High-side current limit function



The IC limits the current flowing through the high side Tr to 3.5A (typ.) or less.
If the output voltage drops due to current limitation, the mild recovery function will operate.

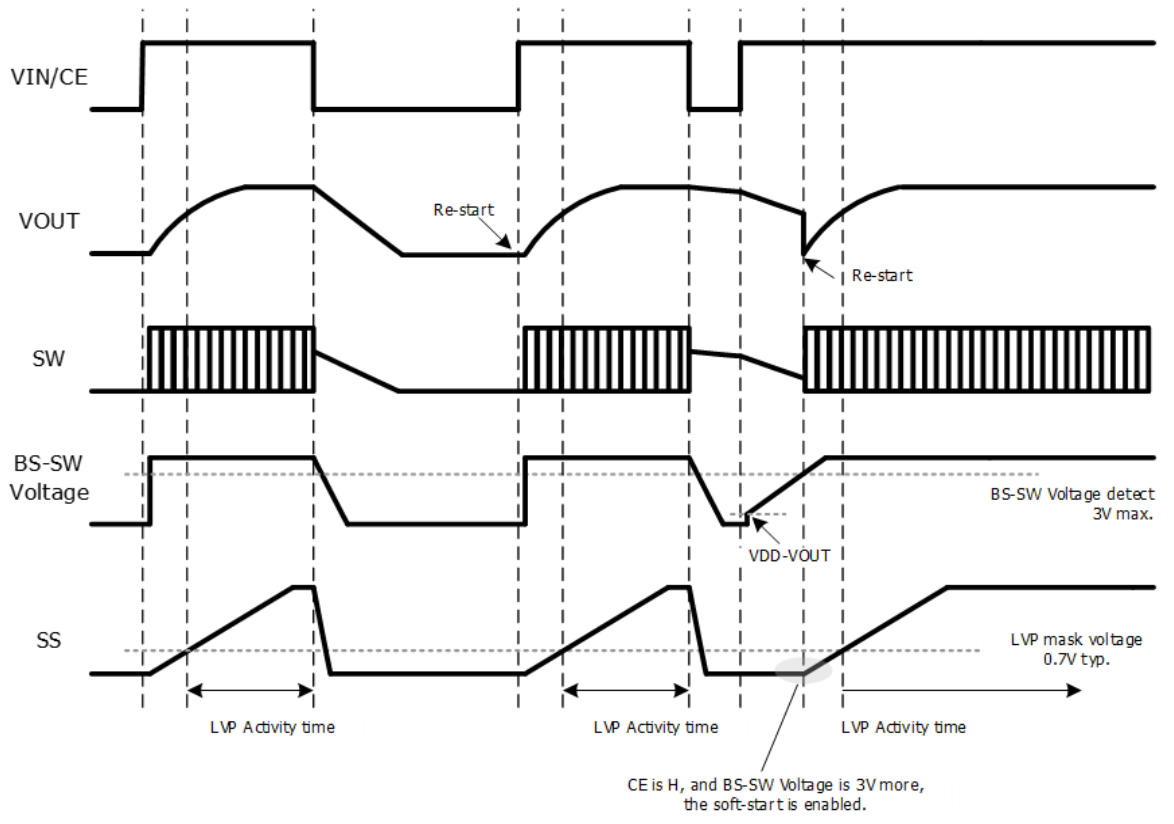
Low-side current limit function



The IC limits the current flowing through the low-side Tr to 3.0A(typ.) or less.
When the low-side current limit is detected, the IC keeps turning off the high-side and low-side Tr for two cycles of the oscillation frequency.
When the current falls below the specified value, it returns to normal switching operation.

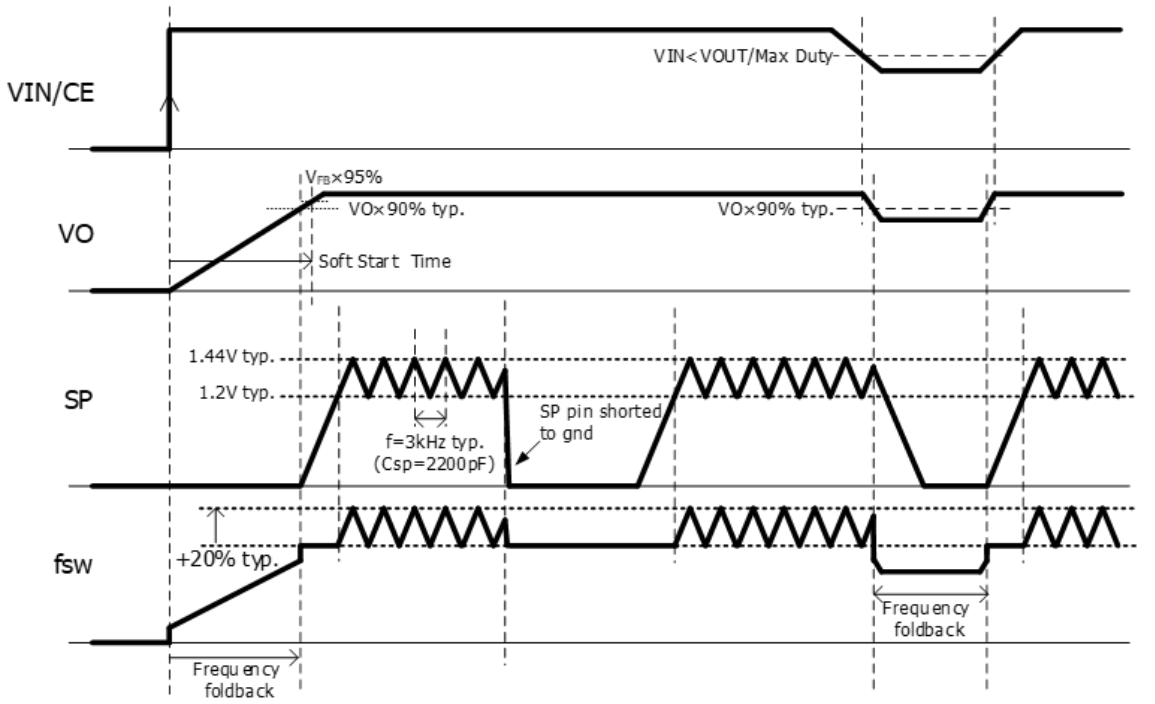
TIMMING CHART (CONTINUED)

Restart-up



In the case of Restart, please note for a change in the behavior of the start-up by the charge of V_{OUT}.
When the charge of the output remains, if BS-SW voltage is not reached to the detection voltage (3V max.) or more, the IC does not start the soft-start.

Spread spectrum function

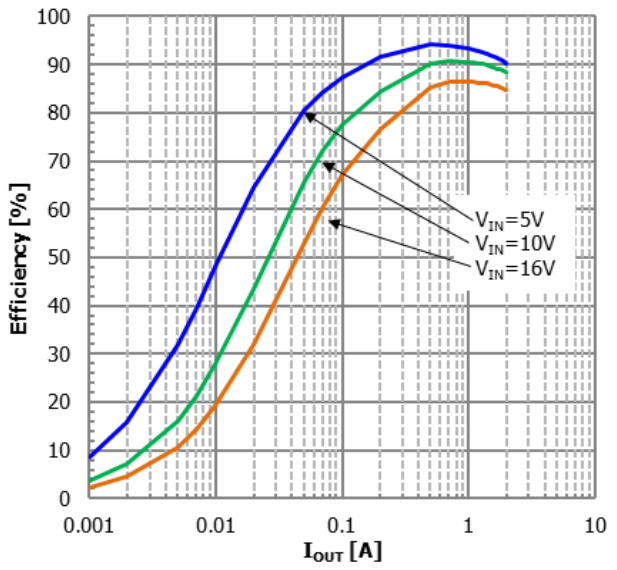


The start condition of the spread spectrum function is $V_O > V_O \times 90\%$. When VSP ≧ 1.2 V, the IC changes the oscillation frequency with + 20% triangular wave frequency modulation.

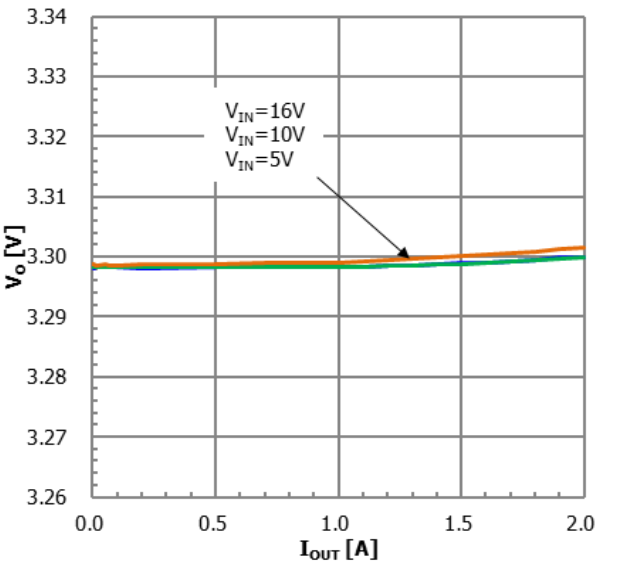
TYPICAL PERFORMANCE CHARACTERISTICS

(Unless otherwise specified, V_{IN}=10V, V_{CE}=3V, C_{SP}=2200pF, Ta=25℃)

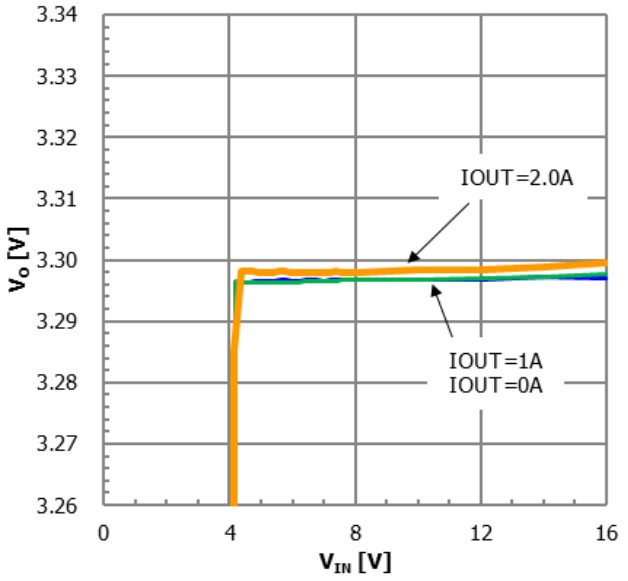
Efficiency



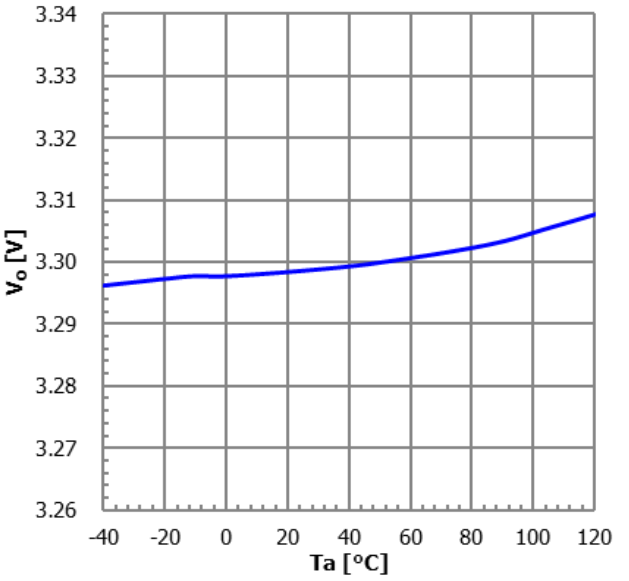
Load regulation



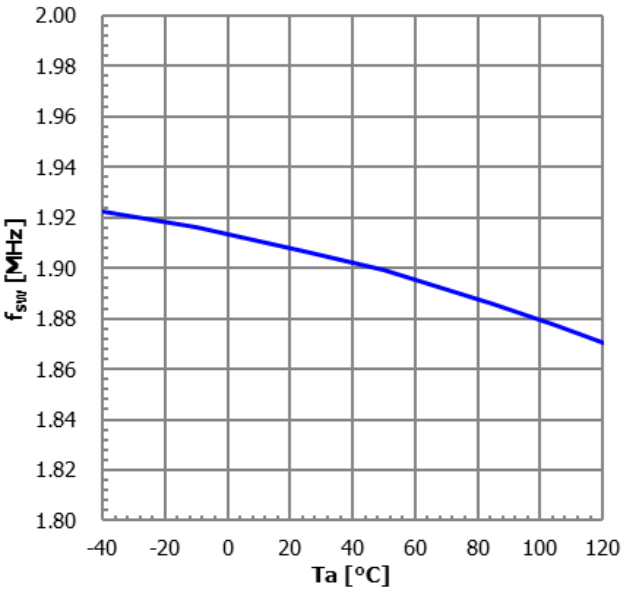
Line regulation



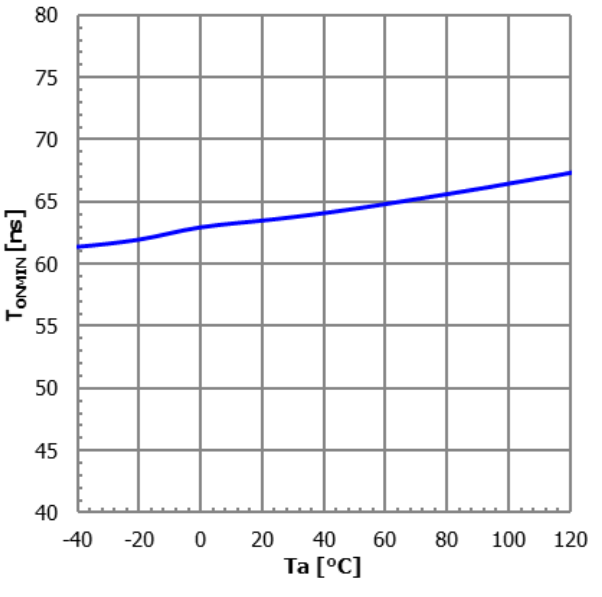
VO pin voltage vs Temperature



Oscillation frequency vs Temperature (SP=0V)



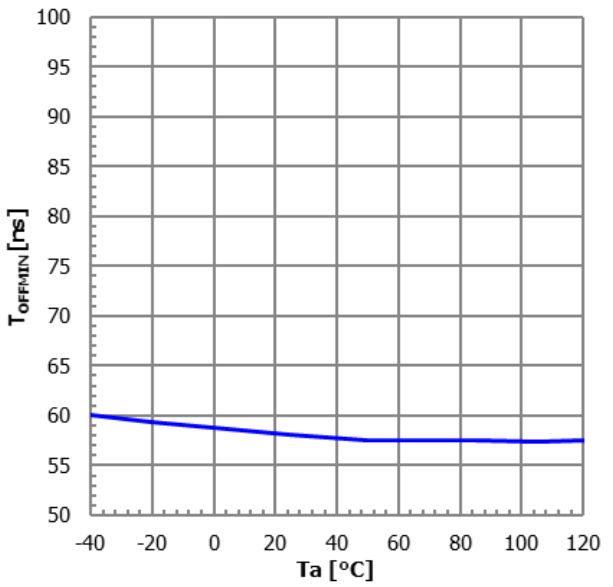
Minimum on time vs Temperature



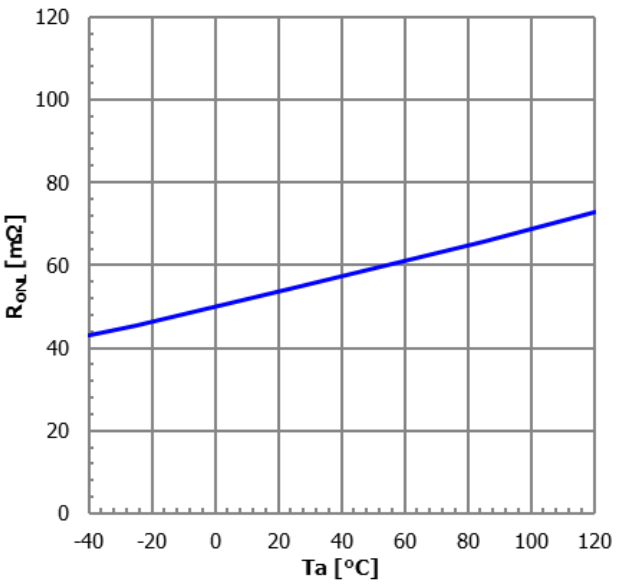
TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

(Unless otherwise specified, V_{IN}=10V, V_{CE}=3V, C_{SP}=2200pF, Ta=25℃)

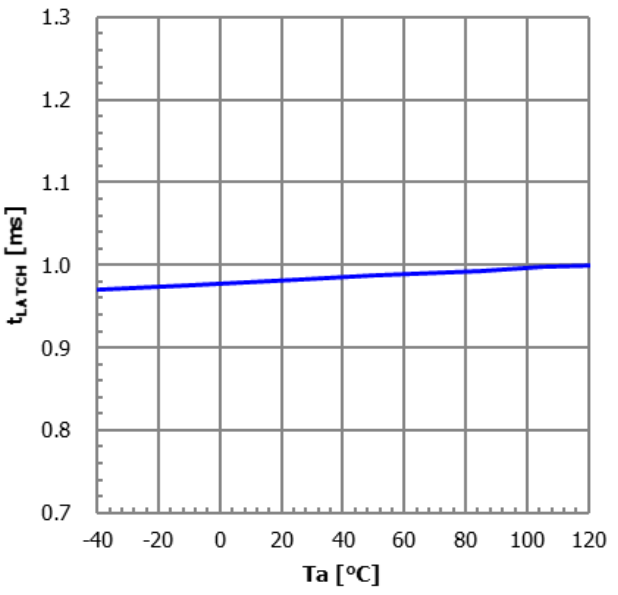
Minimum off time vs Temperature



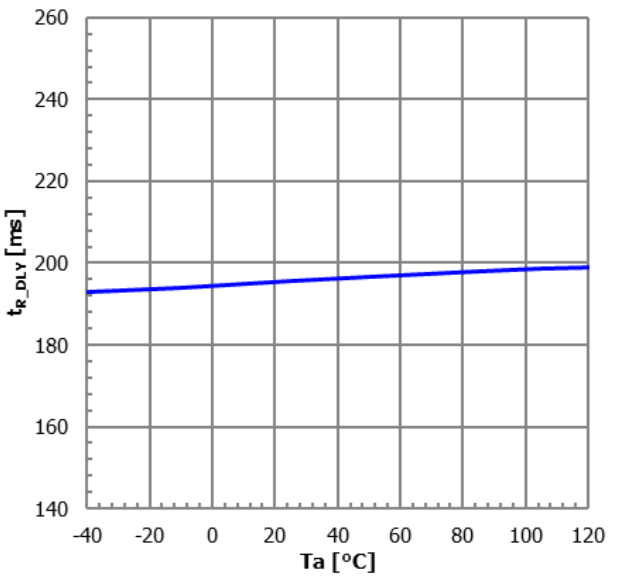
Low-side switch on-resistance vs Temperature



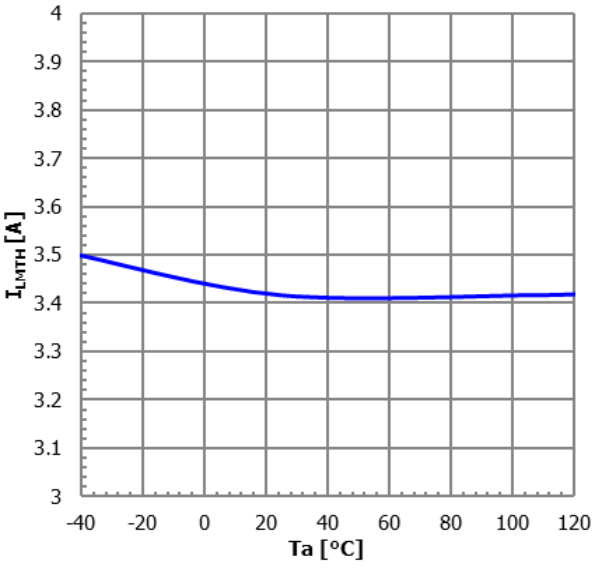
Latch delay time vs Temperature



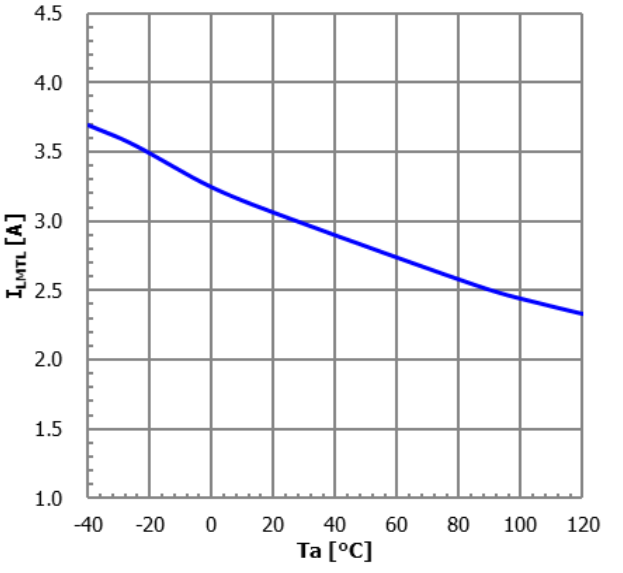
Latch OFF Automatic return time vs Temperature



High-side current limit vs Temperature



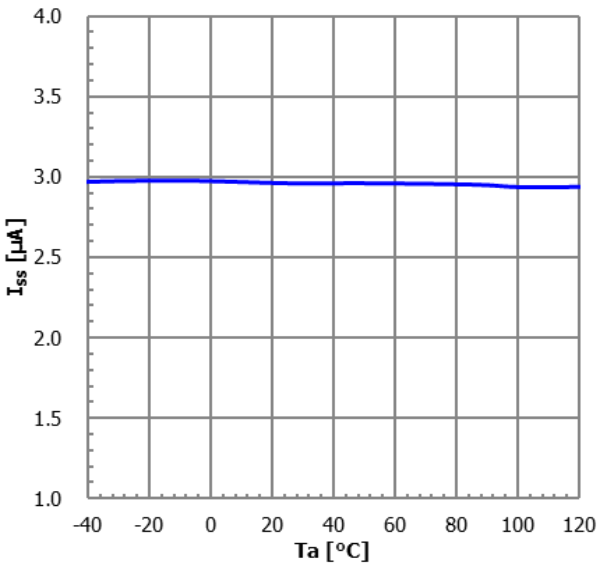
Low-side current limit vs Temperature



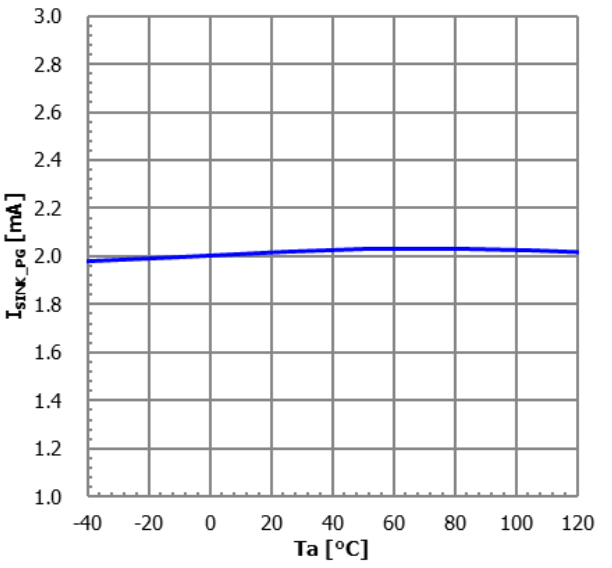
TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

(Unless otherwise specified, V_{IN}=10V, V_{CE}=3V, C_{SP}=2200pF, Ta=25℃)

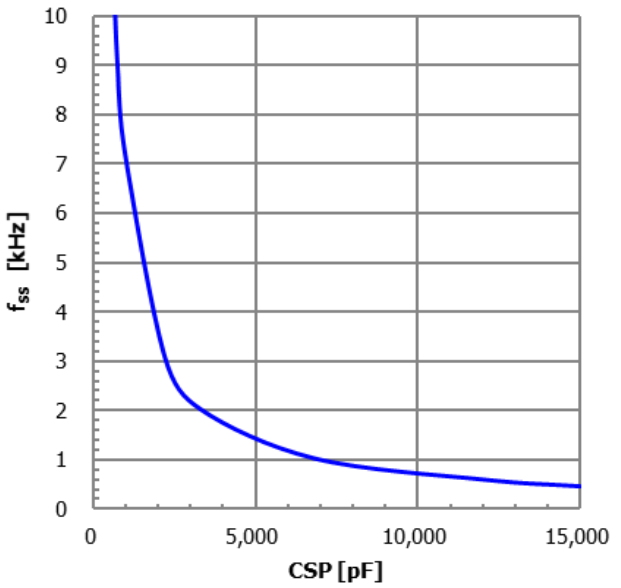
SS pin current vs Temperature



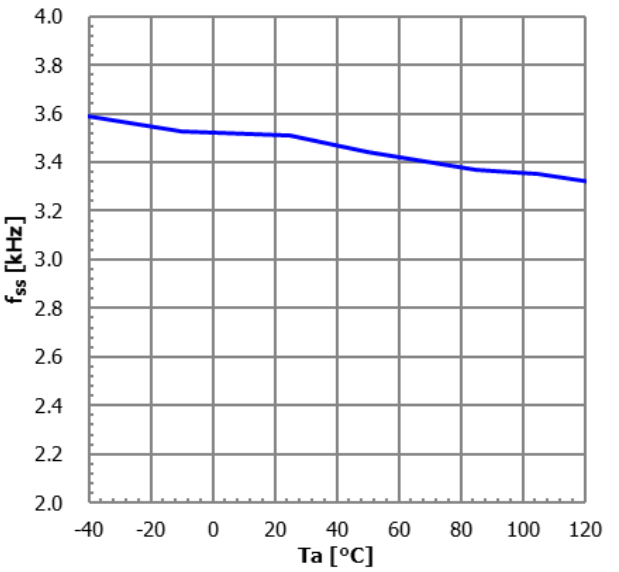
P_GOOD pin sink current vs Temperature



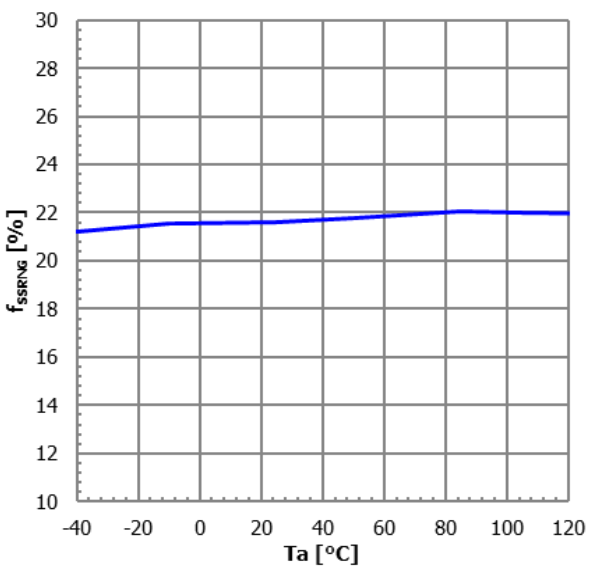
Modulation Frequency vs C_{SP}



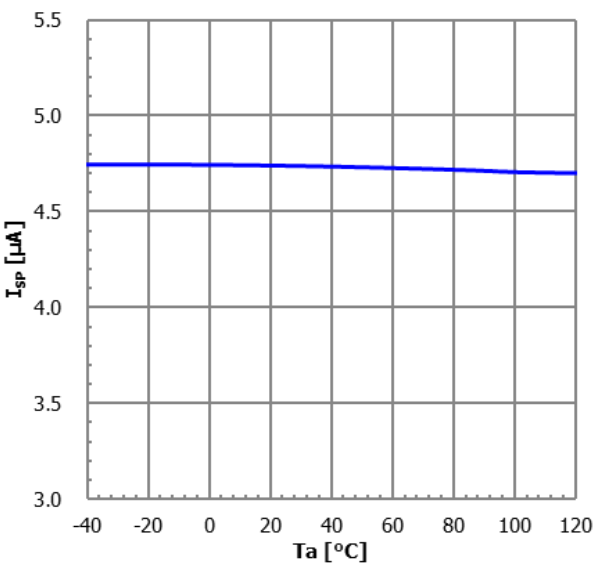
Modulation Frequency vs Temperature



Modulation Frequency Range vs Temperature



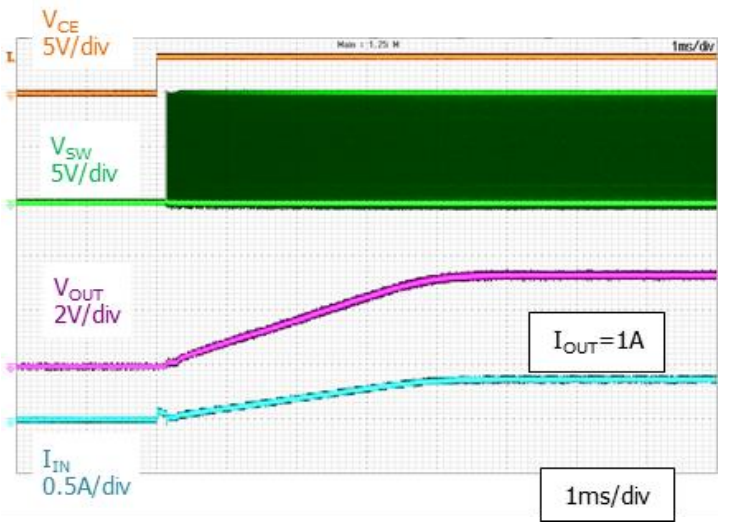
SP pin current vs Temperature



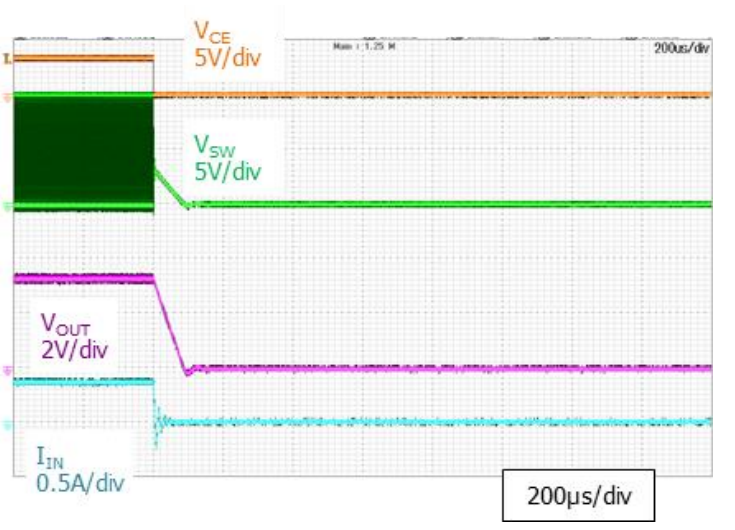
TYPICAL PERFORMANCE CHARACTERISTICS (CONTINUED)

(Unless otherwise specified, V_{IN}=10V, V_{CE}=3V, C_{SP}=2200pF, Ta=25℃)

Start-up



Shutdown



Load transient response

