1ch Gate Driver Providing Galvanic Isolation

2500Vrms Isolation Voltage

BM60056FV-C

General Description

The BM60056FV-C is a gate driver with an isolation voltage of 2500Vrms, I/O delay time of 3.0μs, minimum input pulse width of 3.0μs. It incorporates the fault signal output function (FLT_UVLO, FLT_SC, FLT_OT), under voltage lockout (UVLO) function, short circuit protection (SCP) function, over temperature protection (OT) or over voltage protection (OV) function, over current protection (OC) function, soft turn off function, temperature or voltage monitoring function, active miller clamping function, switching controller function and output state feedback function.

Features

- AEC-Q100 Qualified*(Note 1)*
- Fault Signal Output Function
- Under Voltage Lockout Function
- Short Circuit Protection Function
- Pre-over Current Protection Function
- Over Current Protection Function
- Selectable Mode of Temperature Monitor Mode or Voltage Monitor Mode
- Over Temperature Protection (Temperature Monitor Mode)
- Over Voltage Protection (Voltage Monitor Mode)
- Temperature Compensation for OC and Pre-OC (Temperature Monitor Mode)
- Soft Turn Off Function for SCP and OC
- Pre-OC Turn Off Function
- Active Miller Clamping
- Selectable Turn Off Resistance
- Switching Regulator

(Note 1) Grade1

Key Specifications

- Isolation Voltage: 2500 Vrms (Max)
- Maximum Gate Drive Voltage: 24 V (Max)
- I/O Delay Time: 3.0 μs (Max)
- Minimum Input Pulse Width: 3.0 μs (Max)

Package

Package	W(Typ) x D(Typ) x H(Max)
SSOP-B28W	9.2mm x 10.4mm x 2.4mm

SSOP-B28W

Applications

- Automotive Isolated IGBT/MOSFET Inverter Gate Drive
- Automotive DC-DC Converter
- Industrial Inverters System
- UPS System

Typical Application Circuit

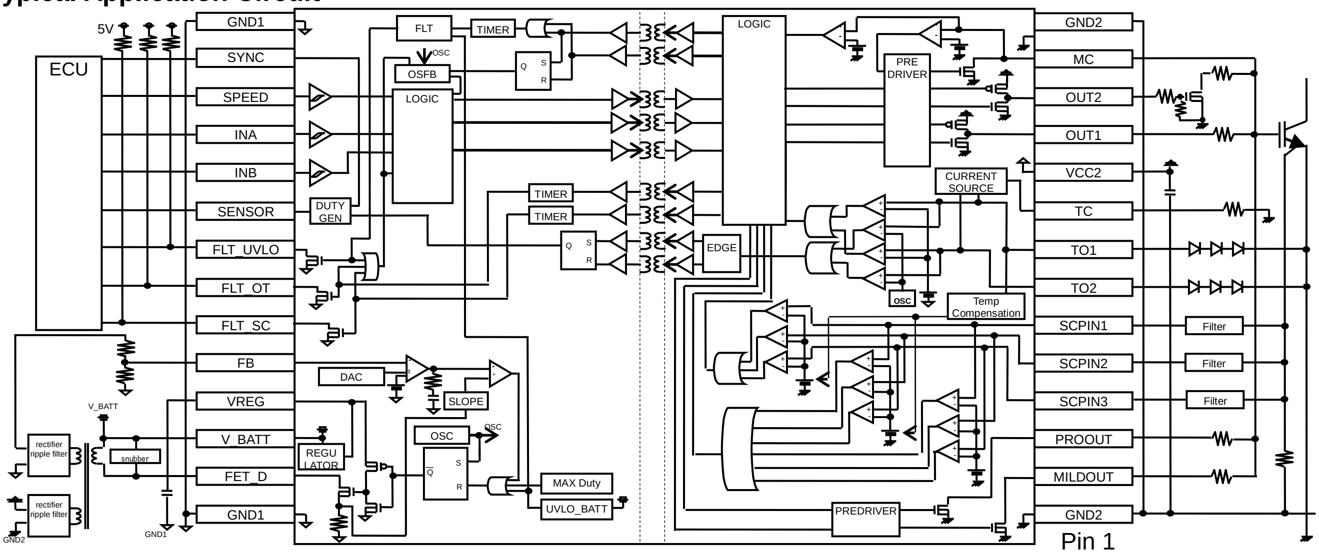


Figure 1. Typical Application Circuit

○Product structure : Silicon integrated circuit ○This product has no designed protection against radioactive rays

Contents

Recommended Range of External Constants

Pin Name	Symbol	Recommended Value			Unit
		Min	Typ	Max	
TC	R_{TC}	0.5	-	25	kΩ
V_BATT	C_{VBATT}	3	-	-	µF
VCC2	C_{VCC2}	0.4	-	-	µF
VREG	C_{VREG}	0.1	1	10	µF

Pin Configuration

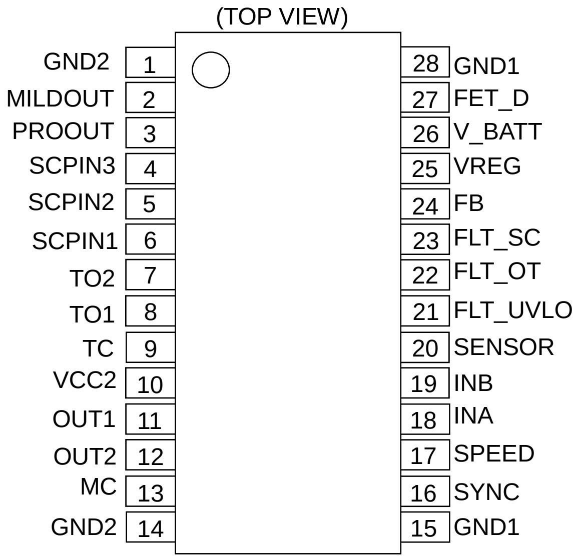


Figure 2. Pin Configuration

Pin Descriptions

Pin No.	Pin Name	Function
1	GND2	Output-side ground pin
2	MILDOUT	Pre-OC turn off pin
3	PROOUT	Soft turn off pin
4	SCPIN3	Short circuit detection pin 3
5	SCPIN2	Short circuit detection pin 2
6	SCPIN1	Short circuit detection pin 1
7	TO2	Constant current output pin/Sensor voltage input pin 2
8	TO1	Constant current output pin/Sensor voltage input pin 1
9	TC	Resistor connection pin for setting constant current source output/Mode selection input pin of temperature monitor or voltage monitor
10	VCC2	Output-side power supply pin
11	OUT1	Output pin 1
12	OUT2	Output pin 2
13	MC	Input and output pin for Miller Clamp
14	GND2	Output-side ground pin
15	GND1	Input-side ground pin
16	SYNC	Frequency synchronization input pin for temperature monitor
17	SPEED	Selectable gate resistance input pin
18	INA	Control input pin A
19	INB	Control input pin B
20	SENSOR	Temperature information output pin
21	FLT_UVLO	Fault (UVLO) output pin
22	FLT_OT	Fault (OT, OV) output pin
23	FLT_SC	Fault (SCP) output pin
24	FB	Error amplifier inverting input pin for switching controller
25	VREG	Power supply pin for drive MOS FET for switching controller
26	V_BATT	Main power supply pin
27	FET_D	Switching pin for switching controller
28	GND1	Input-side ground pin

Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Main Power Supply Voltage	$V_{BATTMAX}$	-0.3 to +40.0 (Note 2)	V
Output-side Supply Voltage	V_{CC2MAX}	-0.3 to +30.0 (Note 3)	V
INA Pin, INB Pin, SPEED Pin, SYNC Pin Input Voltage	V_{INMAX}	-0.3 to +7.0 (Note 2)	V
SENSOR Pin Output Current	I_{SENSOR}	10	mA
FLT_UVLO Pin, FLT_SC Pin, FLT_OT Pin Input Voltage	V_{FLTMAX}	-0.3 to +7.0 (Note 2)	V
FLT_UVLO Pin, FLT_SC Pin, FLT_OT Pin Output Current	I_{FLT}	10	mA
FB Pin Input Voltage	V_{FBMAX}	-0.3 to +7.0 (Note 2)	V
FET_D Pin Output Current	I_{FET_D}	2000	mA
SCPINx (x=1 to 3) Input Voltage	$V_{SCPINMAX}$	-0.3 to +6.0 (Note 3)	V
TC Input Voltage	V_{TCMAX}	-0.3 to +6.0 (Note 3)	V
TOx (x=1 to 2) Pin Input Voltage	V_{TOMAX}	-0.3 to V_{CC2} +0.3 (Note 3)	V
TOx (x=1 to 2) Pin Output Current	I_{TOMAX}	2	mA
Storage Temperature Range	Tstg	-55 to +150	°C
Maximum Junction Temperature	Tjmax	+150	°C

Caution 1: *Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.*

Caution 2: *Should by any chance the maximum junction temperature rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. In case of exceeding this absolute maximum rating, design a PCB with thermal resistance taken into consideration by increasing board size and copper area so as not to exceed the maximum junction temperature rating.*

(Note 2) Relative to GND1
(Note 3) Relative to GND2

Thermal Resistance(Note 4)

Parameter	Symbol	Thermal Resistance (Typ)		Unit
		1s(Note 6)	2s2p(Note 7)	
SSOP-B28W				
Junction to Ambient	θ_{JA}	112.9	64.4	°C/W
Junction to Top Characterization Parameter(Note 5)	Ψ_{JT}	34	23	°C/W

(Note 4) Based on JESD51-2A(Still-Air)
(Note 5) The thermal characterization parameter to report the difference between junction temperature and the temperature at the top center of the outside surface of the component package.
(Note 6) Using a PCB board based on JESD51-3.
(Note 7) Using a PCB board based on JESD51-7.

Layer Number of Measurement Board	Material	Board Size
Single	FR-4	114.3mm x 76.2mm x 1.57mmt

Top	
Copper Pattern	Thickness
Footprints and Traces	70µm

Layer Number of Measurement Board	Material	Board Size
4 Layers	FR-4	114.3mm x 76.2mm x 1.6mmt

Top		2 Internal Layers		Bottom	
Copper Pattern	Thickness	Copper Pattern	Thickness	Copper Pattern	Thickness
Footprints and Traces	70µm	74.2mm x 74.2mm	35µm	74.2mm x 74.2mm	70µm

Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit
Main Power Supply Voltage(Note 8)	V_{BATT}	6	30.0	V
Output-side Supply Voltage(Note 9)	V_{CC2}	14	24	V
SYNC Pin Input Frequency	f_{SYNC}	250	25k	Hz
TOx Pin Input Voltage(Note 9)	V_{TOx}	2.0	3.75	V
Operating Temperature	Topr	-40	+125	°C

(Note 8) GND1 reference
(Note 9) GND2 reference

Insulation Related Characteristics

Parameter	Symbol	Characteristic	Unit
Isolation Resistance (V_{IO}=500V)	R_S	$>10^9$	Ω
Isolation Withstand Voltage/1min	V_{ISO}	2500	Vrms
Isolation Test Voltage/1s	V_{ISO}	3000	Vrms

Electrical Characteristics

(Unless otherwise specified Ta=-40°C to +125°C, V_{BATT}=6V to 30V, V_{CC2}=14V to 24V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
General						
Main Power Supply Circuit Current 1	I_{BATT1}	2.5	6.5	11.0	mA	FET_D Pin switching operation, INA=INB=L
Main Power Supply Circuit Current 2	I_{BATT2}	2.3	6.2	10.8	mA	FET_D Pin No Switching, INA=INB=L
Output-side Circuit Current	I_{CC2}	2.0	3.6	5.2	mA	R_{TC}=10kΩ, OUT1=L
Switching Power Supply Controller						
VREG Output Voltage	V_{REG}	4.5	5.0	5.5	V	
FET_D ON-resistance	R_{ONDL}	0.2	0.5	1.2	Ω	I_{FET_D}=10mA
Oscillation Frequency	f_{OSC_SW}	160	200	240	kHz	
Soft-start Time	t_{SS}	-	-	50	ms	
FB Pin Threshold Voltage	V_{FB}	1.47	1.50	1.53	V	
FB Pin Input Current	I_{FB}	-0.8	0	+0.8	µA	
Over Voltage Detection Threshold	V_{OVTH}	1.60	1.65	1.70	V	
Under Voltage Detection Threshold	V_{UVTH}	1.23	1.30	1.37	V	
Over Voltage Detection Filtering Time	t_{OVFIL}	-	1.8	-	µs	
Under Voltage Detection Filtering Time	t_{UVFIL}	-	1.8	-	µs	
V_BATT UVLO OFF Voltage	$V_{UVLOBATTH}$	5.1	5.4	5.7	V	
V_BATT UVLO ON Voltage	$V_{UVLOBATTL}$	5.0	5.3	5.6	V	
VREG UVLO OFF Voltage	$V_{UVLOVREGH}$	-	4.25	-	V	
VREG UVLO ON Voltage	$V_{UVLOVREGL}$	-	4.15	-	V	
Maximum ON DUTY	D_{ONMAX}	-	85	-	%	
Protection Holding Time	$t_{DCDCRLS}$	20	40	60	ms	
Logic Block						
Logic High Level Input Voltage	V_{INH}	3.5	-	-	V	INA,INB,SPEED,SYNC
Logic Low Level Input Voltage	V_{INL}	-	-	1.5	V	INA,INB,SPEED,SYNC
Logic Pull-Down Resistance	R_{IND}	25	50	100	kΩ	INA,INB,SPEED,SYNC
Logic Input Filtering Time	t_{INFIL}	2.18	2.6	3.0	µs	INA,INB
Output						
OUT1 ON-resistance (Source-side)	R_{ONH}	0.9	1.8	3.6	Ω	I_{OUT1}=-40mA
OUT1 ON-resistance (Sink-side)	R_{ONL}	0.5	1.1	2.2	Ω	I_{OUT1}=40mA
OUT1 Maximum Current	I_{OUTMAX}	1.5	-	-	A	V_{CC2}=15V Guaranteed by design
OUT1 Output Voltage H	V_{OUTH}	-	-	V_{CC2} -8.4	V	I_{OUT1}=-1.5A Guaranteed by design
OUT1 Output Voltage L	V_{OUTL}	-	-	5.8	V	I_{OUT1}=1.5A Guaranteed by design
Turn ON Time	t_{PON}	2.18	2.6	3.0	µs	
Turn OFF Time	t_{POFF}	2.18	2.6	3.0	µs	
Propagation Distortion	t_{PDIST}	-0.3	0	0.3	µs	t_{POFF} - t_{PON}
Rise Time	t_{RISE}	-	30	50	ns	Load=1nF
Fall Time	t_{FALL}	-	30	50	ns	Load=1nF
OUT2 ON-resistance (Source-side)	R_{ON2H}	1.8	3.6	7.2	Ω	I_{OUT2}=-40mA
OUT2 ON-resistance (Sink-side)	R_{ON2L}	1.0	2.2	4.4	Ω	I_{OUT2}=40mA
OUT2 Maximum Current	$I_{OUT2MAX}$	0.5	-	-	A	V_{CC2}=15V Guaranteed by design
OUT2 Output Voltage H	V_{OUT2H}	-	-	V_{CC2} -4.3	V	I_{OUT2}=-0.5A Guaranteed by design
OUT2 Output Voltage L	V_{OUT2L}	-	-	3.0	V	I_{OUT2}=0.5A Guaranteed by design

Electrical Characteristics - continued
(Unless otherwise specified Ta=-40°C to +125°C, V_{BATT}=6V to 30V, V_{CC2}=14V to 24V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
OUT2 OFF Dead Time	t_{DTOFF2}	130	190	250	ns	
MC ON-resistance	R_{ONMC}	0.2	0.55	1.3	Ω	I_{MC}=40mA
MC Maximum Current	I_{MCTMAX}	5.0	-	-	A	V_{CC2}=15V Guaranteed by design
MC Output Voltage L	V_{MCL}	-	-	8.7	V	I_{MC}=5.0A Guaranteed by design
MC ON Threshold Voltage	V_{MCON}	2.7	3.0	3.3	V	
PROOUT ON-resistance	R_{ONPRO}	0.4	0.8	2.0	Ω	I_{PROOUT}=40mA
PROOUT Maximum Current	$I_{PROOUTMAX}$	1.0	-	-	A	V_{CC2}=15V Guaranteed by design
PROOUT Output Voltage L	$V_{PROOUTL}$	-	-	1.8	V	I_{PROOUT}=1.0A Guaranteed by design
MILDOUT ON-resistance	R_{ONMILD}	0.20	0.65	1.50	Ω	$I_{MILDOUT}$=40mA
MILDOUT Maximum Current	$I_{MILDOUTMAX}$	3.0	-	-	A	V_{CC2}=15V Guaranteed by design
MILDOUT Output Voltage L	$V_{MILDOUTL}$	-	-	7.3	V	$I_{MILDOUT}$=3.0A Guaranteed by design
Common Mode Transient Immunity	CM	100	-	-	kV/µs	Guaranteed by design
Temperature Monitor/Voltage Monitor						
TC High Level Input Voltage (Mode Selection)	V_{TCH}	1.3	-	-	V	
TC Pin Output Voltage	V_{TC}	0.975	1.000	1.025	V	
TOx Pin Output Current	I_{TO}	194	200	206	µA	V_{TC} < 1.3V (Temperature monitor mode) R_{TC}=5kΩ
SENSOR Output Duty Tolerance 1	$D_{SENSOR1}$	-2.1	0	+2.1	%	V_{TO1} = V_{TO2} ≤ 2.7V
SENSOR Output Duty Tolerance 2	$D_{SENSOR2}$	-3.0	0	+3.0	%	V_{TO1} = V_{TO2} > 2.7V
SENSOR Output Duty Tolerance 3	$D_{SENSOR3}$	-1.9	0	+1.9	%	V_{TO1} = V_{TO2} ≤ 3.1V Ta=25°C
SENSOR Output Duty (TOx Pin Open)	$D_{SENSORTOOPEN}$	-	0	-	%	TOx Pin Voltage > 9V
SENSOR Output Duty (TOx Pin = 0V)	$D_{SENSORTO0}$	87	90	93	%	TOx Pin Voltage = 0V
SENSOR Output Rising Edge Delay Time	$t_{DSENSOR}$	40	150	260	ns	
TOx Pin Disconnect Detection Voltage	V_{TOH}	7	8	9	V	
SENSOR ON-resistance (Source-side)	$R_{SENSORH}$	-	80	180	Ω	I_{SENSOR}=-5mA
SENSOR ON-resistance (Sink-side)	$R_{SENSORL}$	-	80	180	Ω	I_{SENSOR}=5mA
Protection Functions						
Output-side UVLO OFF Threshold Voltage	V_{UVLO2H}	11.5	12.5	13.5	V	
Output-side UVLO ON Threshold Voltage	V_{UVLO2L}	10.5	11.5	12.5	V	
Output-side UVLO Filtering Time	$t_{UVLO2FIL}$	1.6	2.2	2.8	µs	
Output-side UVLO Delay Time (OUT)	$t_{DUVLO2OUT}$	1.6	2.4	3.2	µs	
Output-side UVLO Delay Time (FLT_UVLO)	$t_{DUVLO2FLT}$	1.5	-	65	µs	

Electrical Characteristics - continued

(Unless otherwise specified Ta=-40°C to +125°C, V_{BATT}=6V to 30V, V_{CC2}=14V to 24V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Pre-over Current Detection Voltage 1	$V_{PREOCDET1}$	0.446	0.475	0.504	V	V_{TC} < 1.3V (Temperature monitor mode) V_{TO1}=2.5V
Pre-over Current Detection Voltage 2	$V_{PREOCDET2}$	0.337	0.359	0.381	V	V_{TC} < 1.3V (Temperature monitor mode) V_{TO1}=3.0V
Pre-over Current Detection Voltage 3	$V_{PREOCDET3}$	0.282	0.300	0.318	V	V_{TC} ≥ 1.3V (Voltage monitor mode)
Pre-over Current Detection Leading Edge Blanking	$t_{DPREOCLEB}$	1.00	1.12	1.24	µs	Guaranteed by design
Pre-over Current Detection Filtering Time	$t_{PREOCFIL}$	2.20	2.45	2.70	µs	
Over Current Detection Voltage1	V_{OCDET1}	0.587	0.625	0.663	V	V_{TC} < 1.3V (Temperature monitor mode) V_{TO1}=2.5V
Over Current Detection Voltage2	V_{OCDET2}	0.478	0.509	0.540	V	V_{TC} < 1.3V (Temperature monitor mode) V_{TO1}=3.0V
Over Current Detection Voltage3	V_{OCDET3}	0.470	0.500	0.530	V	V_{TC} ≥ 1.3V (Voltage monitor mode)
Over Current Detection Leading Edge Blanking	t_{DOCLEB}	1.00	1.12	1.24	µs	Guaranteed by design
Over Current Detection Filtering Time	t_{OCFIL}	2.20	2.45	2.70	µs	
Over Current Detection Delay Time (OUT)	t_{DOCOUT}	2.27	2.48	2.78	µs	OUT1=30kΩ pull down
Over Current Detection Delay Time (PROOUT)	$t_{DOCPROOUT}$	2.29	2.50	2.80	µs	PROOUT=30kΩ pull up
Over Current Detection Delay Time (FLT_SC)	t_{DOCFLT_SC}	2.33	2.54	2.84	µs	
Short Circuit Detection Voltage 1	$V_{SCPDET1}$	1.90	2.00	2.10	V	During Leading Edge Blanking of OC, Pre-OC
Short Circuit Detection Voltage 2	$V_{SCPDET2}$	0.95	1.00	1.05	V	After Leading Edge Blanking of OC, Pre-OC
Short Circuit Detection Filtering Time	t_{SCPFIL}	0.10	0.20	0.30	µs	
Short Circuit Detection Delay Time (OUT)	$t_{DSCPOUT}$	0.20	0.26	0.41	µs	OUT1=30kΩ pull down
Short Circuit Detection Delay Time (PROOUT)	$t_{DSCPPROOUT}$	0.20	0.26	0.41	µs	PROOUT=30kΩ pull up
Short Circuit Detection Delay Time (FLT_SC)	$t_{DSCPFLT\_SC}$	0.23	0.29	0.44	µs	
Over Temperature Detection Voltage(ON)	$V_{OTDETON}$	2.28	2.34	2.40	V	V_{TC} < 1.3V (Temperature monitor mode)
Over Temperature Detection Voltage(OFF)	$V_{OTDETOFF}$	2.36	2.43	2.50	V	V_{TC} < 1.3V (Temperature monitor mode)
Over Temperature Detection Delay time (OUT)	t_{DOTOUT}	2	10	30	µs	V_{TC} < 1.3V (Temperature monitor mode) OUT1=30kΩ Pull down
Over Temperature Detection Delay Time (FLT_OT)	t_{DOTFLT}	1	-	35	µs	V_{TC} < 1.3V (Temperature monitor mode)
Over Voltage Detection Voltage(ON)	$V_{OVDETON}$	2.97	3.05	3.13	V	V_{TC} ≥ 1.3V (Voltage monitor mode)
Over Voltage Detection Voltage(OFF)	$V_{OVDETOFF}$	2.78	2.85	2.92	V	V_{TC} ≥ 1.3V (Voltage monitor mode)
Over Voltage Detection Delay Time (FLT_OT)	t_{DOVFLT}	1	-	35	µs	V_{TC} ≥ 1.3V (Voltage monitor mode)
FLT_UVLO, FLT_SC, FLT_OT ON-resistance	R_{ONFLT}	-	30	80	Ω	I_{FLT}=5mA
Fault (SCP) Output Holding Time	t_{SCP_FLTRLS}	20	40	60	ms	

Typical Performance Curves

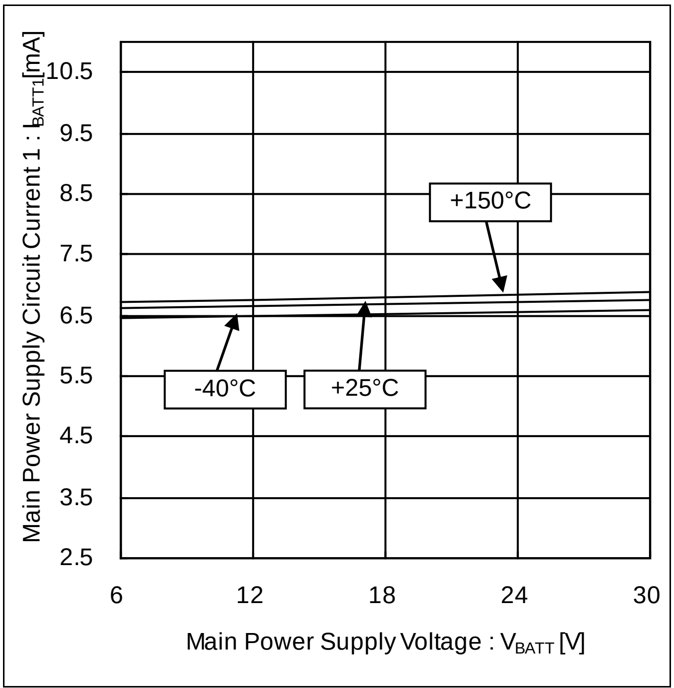


Figure 3. Main Power Supply Circuit Current 1 vs Main Power Supply Voltage

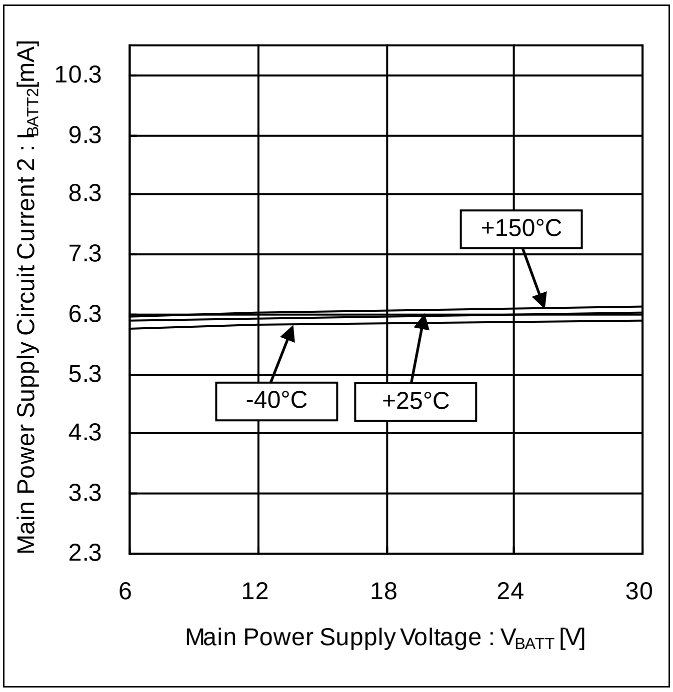


Figure 4. Main Power Supply Circuit Current 2 vs Main Power Supply Voltage

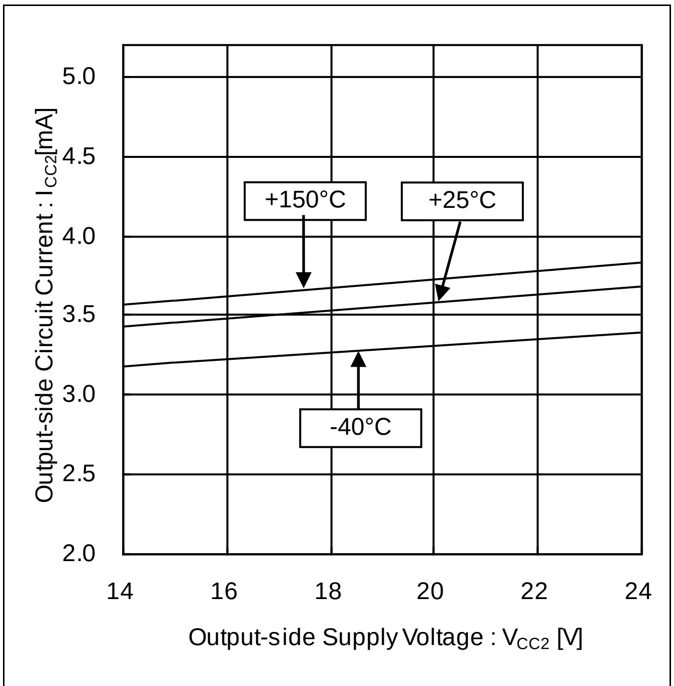


Figure 5. Output-side Circuit Current vs Output-side Supply Voltage

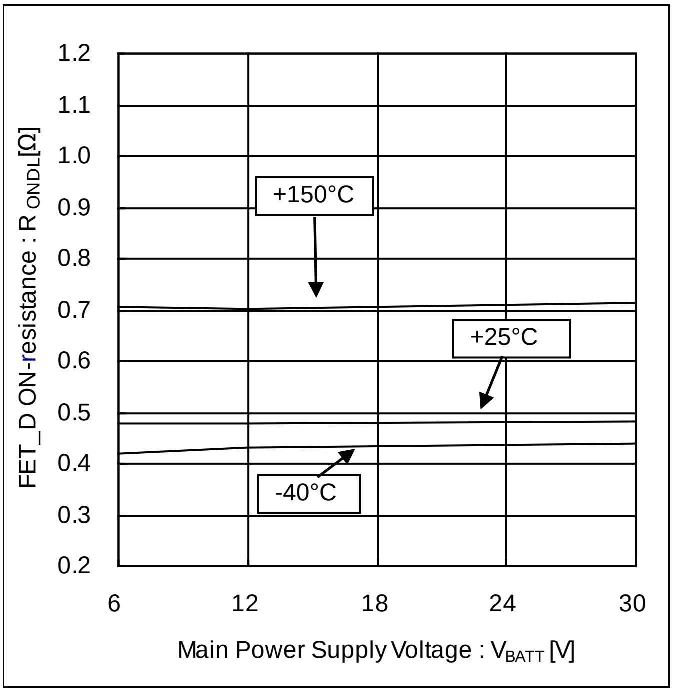


Figure 6. FET_D ON-resistance vs Main Power Supply Voltage

Typical Performance Curves - continued

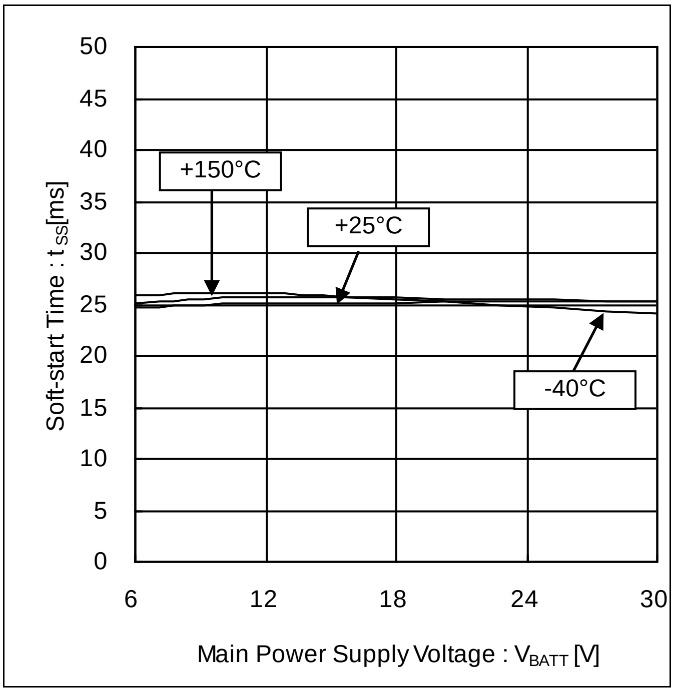


Figure 7. Soft-start Time vs Main Power Supply Voltage

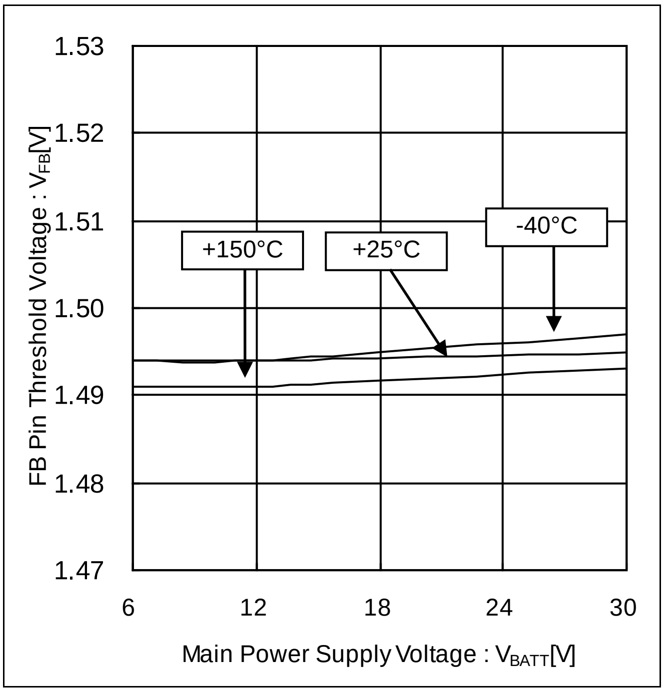


Figure 8. FB Pin Threshold Voltage vs Main Power Supply Voltage

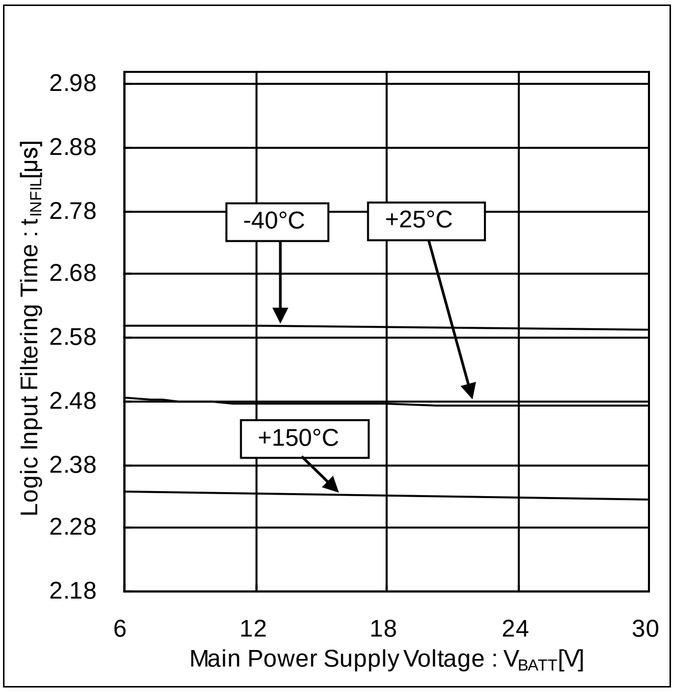


Figure 9. Logic Input Filtering Time vs Main Power Supply Voltage

Typical Performance Curves - continued

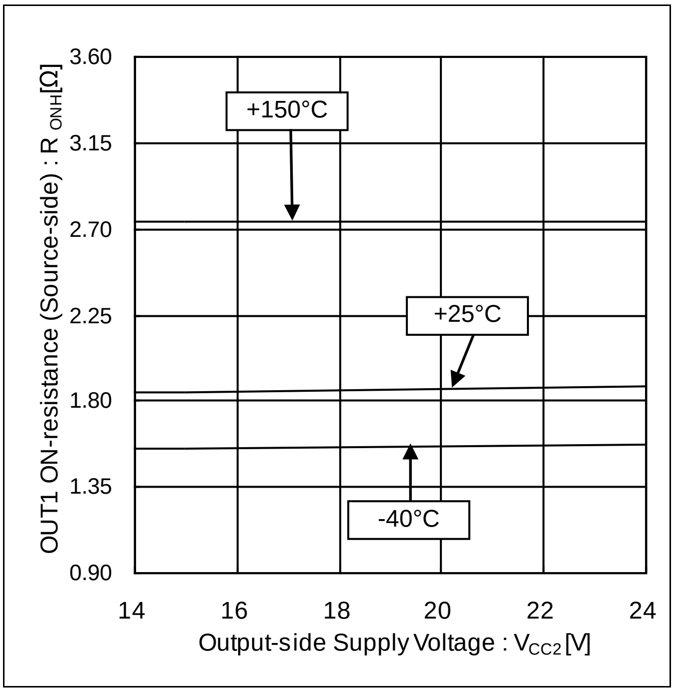


Figure 10. OUT1 ON-resistance (Source-side) vs Output-side Supply Voltage (I_{OUT1}=-40mA)

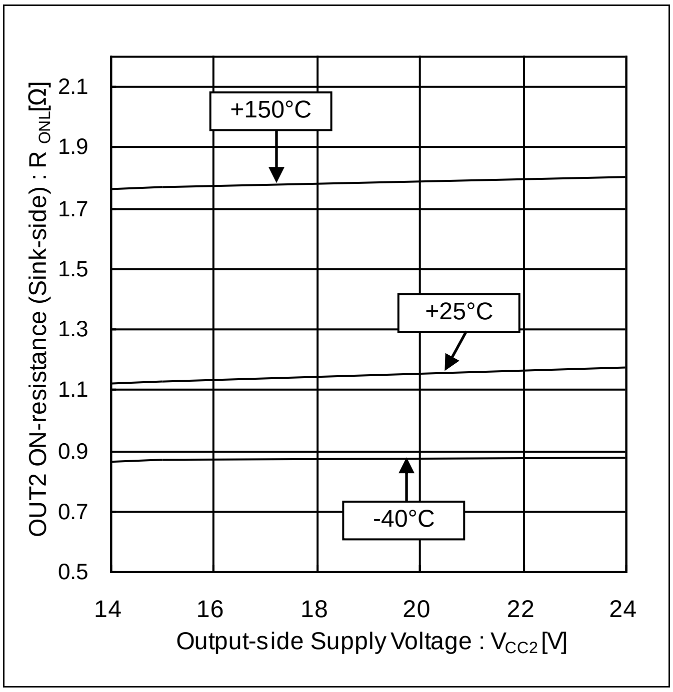


Figure 11. OUT2 ON-resistance (Sink-side) vs Output-side Supply Voltage (I_{OUT1}=40mA)

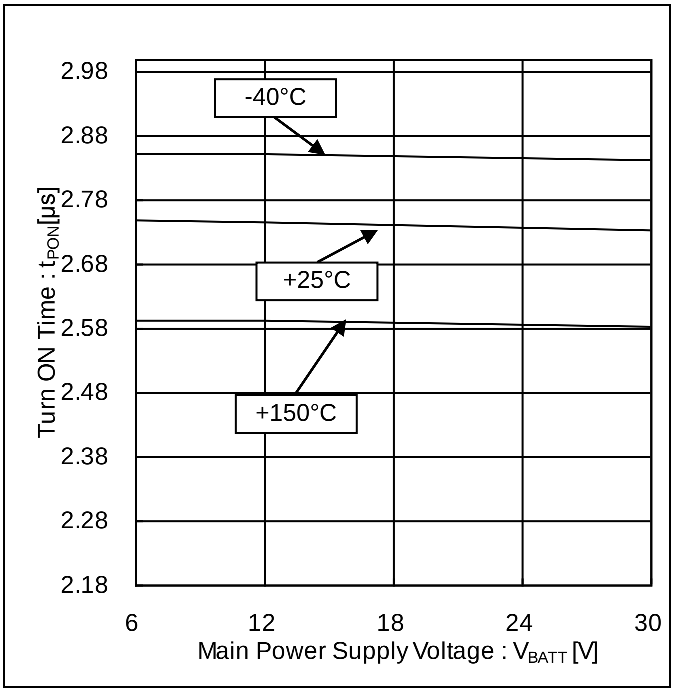


Figure 12. Turn ON Time vs Main Power Supply Voltage

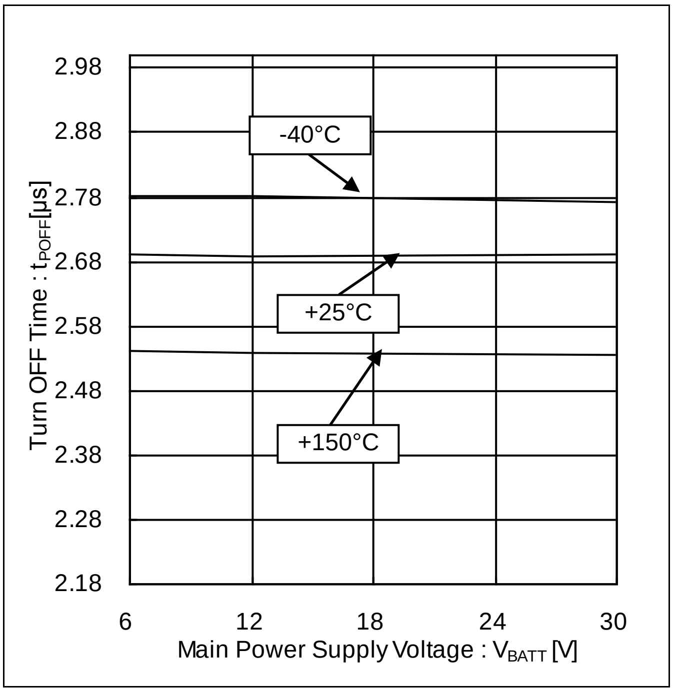


Figure 13. Turn OFF Time vs Main Power Supply Voltage

Typical Performance Curves - continued

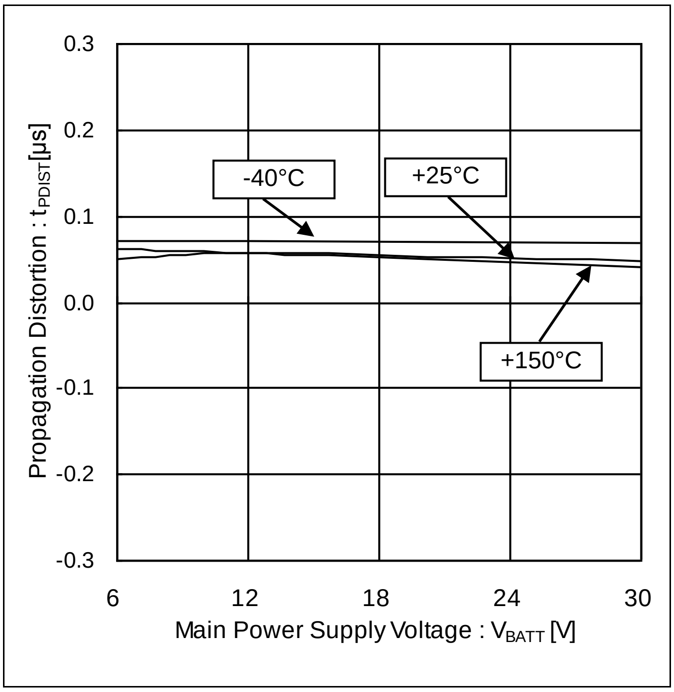


Figure 14. Propagation Distortion vs Main Power Supply Voltage

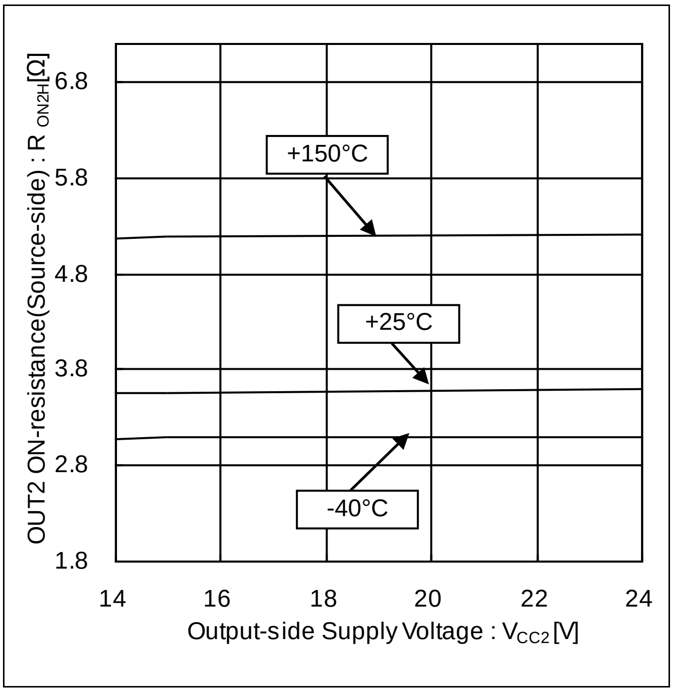


Figure 15. OUT2 ON-resistance (Source-side) vs Output-side Supply Voltage (I_{OUT2}=-40mA)

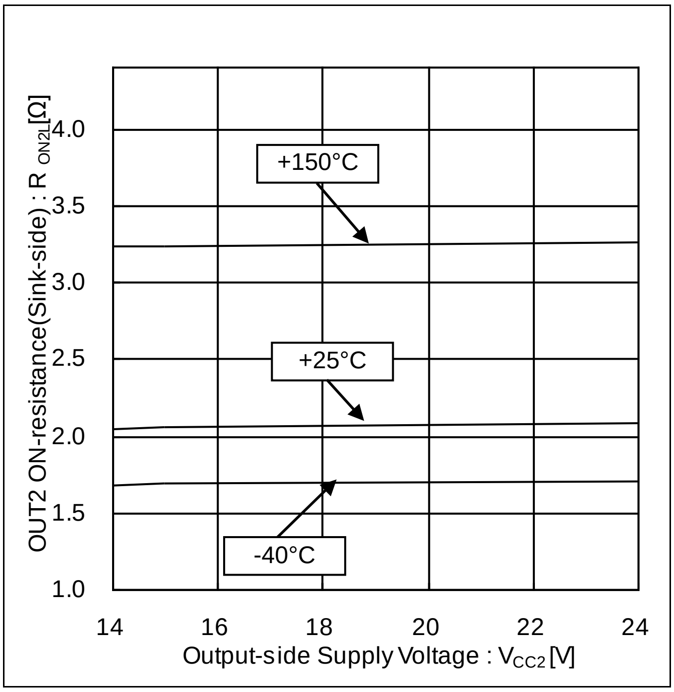


Figure 16. OUT2 ON-resistance (Sink-side) vs Output-side Supply Voltage (I_{OUT2}=40mA)

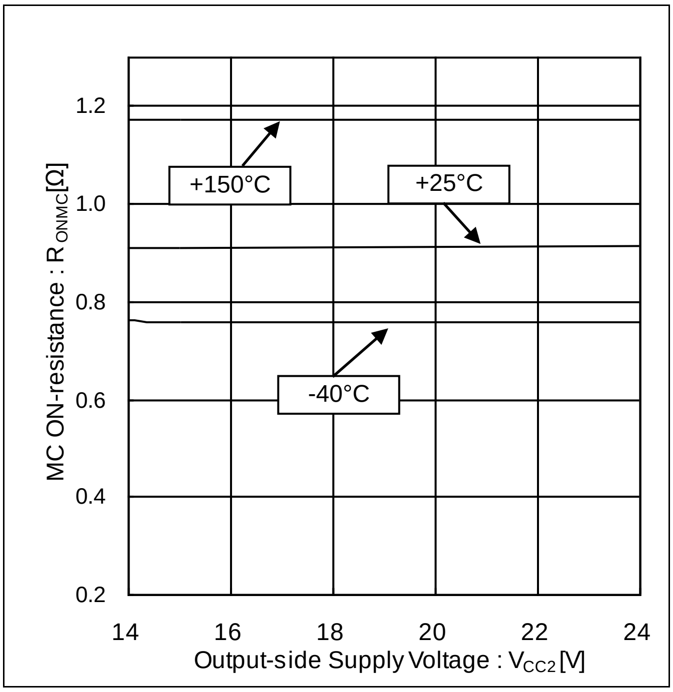


Figure 17. MC ON-resistance vs Output-side Supply Voltage (I_{MC}=40mA)

Typical Performance Curves - continued

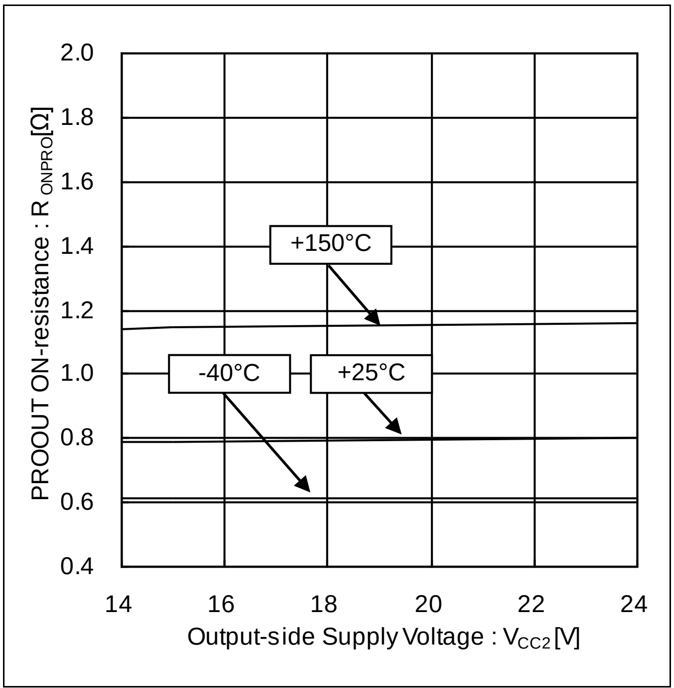


Figure 18. PROOUT ON-resistance vs Output-side Supply Voltage (I_{PROOUT}=40mA)

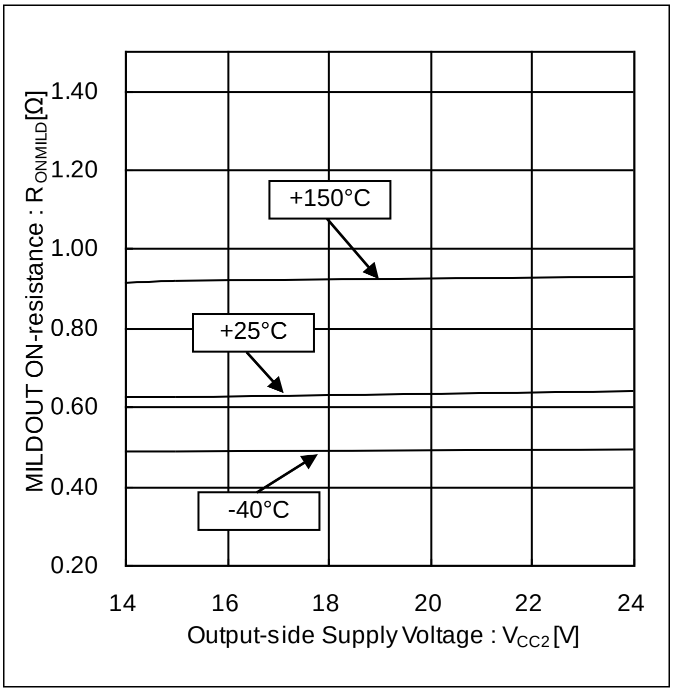


Figure 19. MILDOUT ON-resistance vs Output-side Supply Voltage ($I_{MILDOUT}$=40mA)

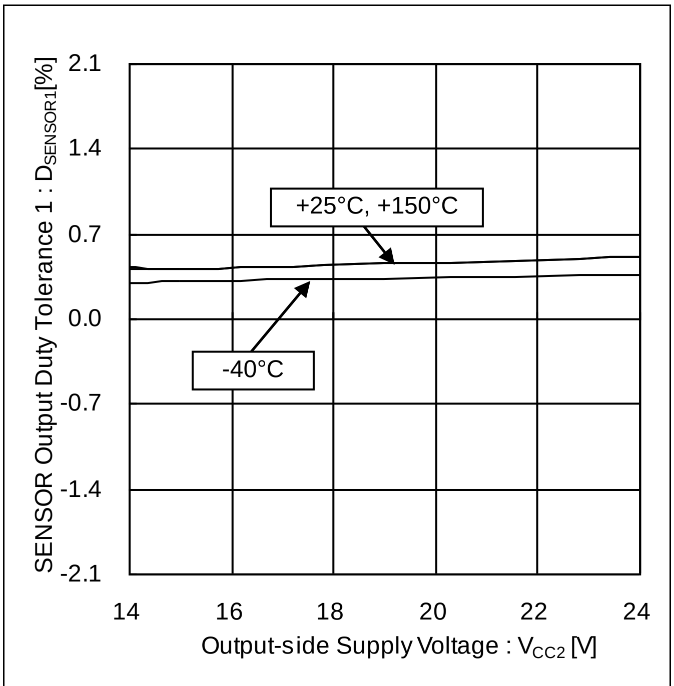


Figure 20. SENSOR Output Duty Tolerance 1 vs Output-side Supply Voltage (V_{TO1} = V_{TO2} ≤ 2.7V)

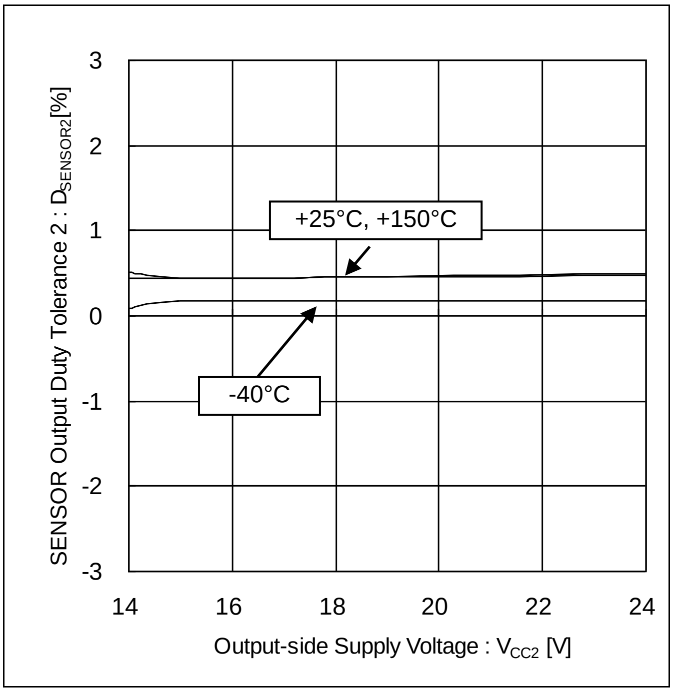


Figure 21. SENSOR Output Duty Tolerance 2 vs Output-side Supply Voltage (V_{TO1} = V_{TO2} > 2.7V)

Typical Performance Curves - continued

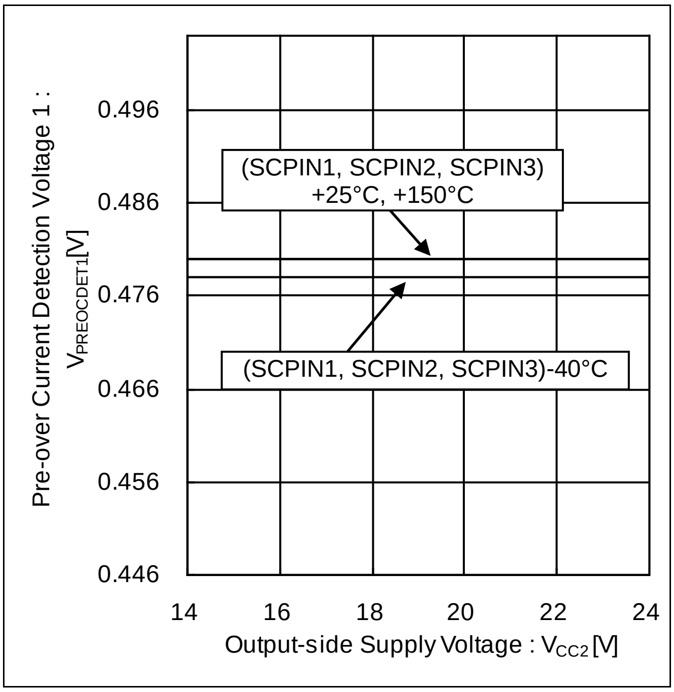


Figure 22. Pre-over Current Detection Voltage 1 vs Output-side Supply Voltage (V_{TC} < 1.3V (pull down, Temperature monitor mode) V_{TO1}=2.5V)

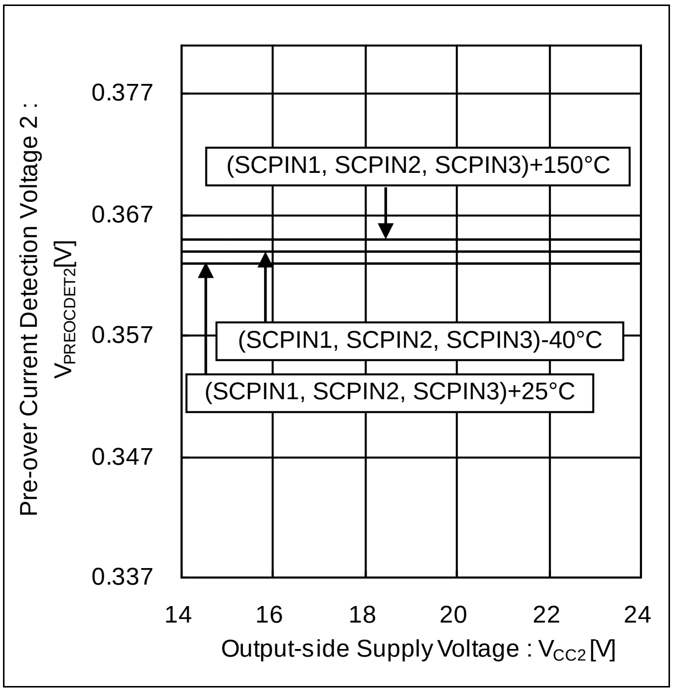


Figure 23. Pre-over Current Detection Voltage 2 vs Output-side Supply Voltage (V_{TC} < 1.3V (pull down, Temperature monitor mode) V_{TO1}=3.0V)

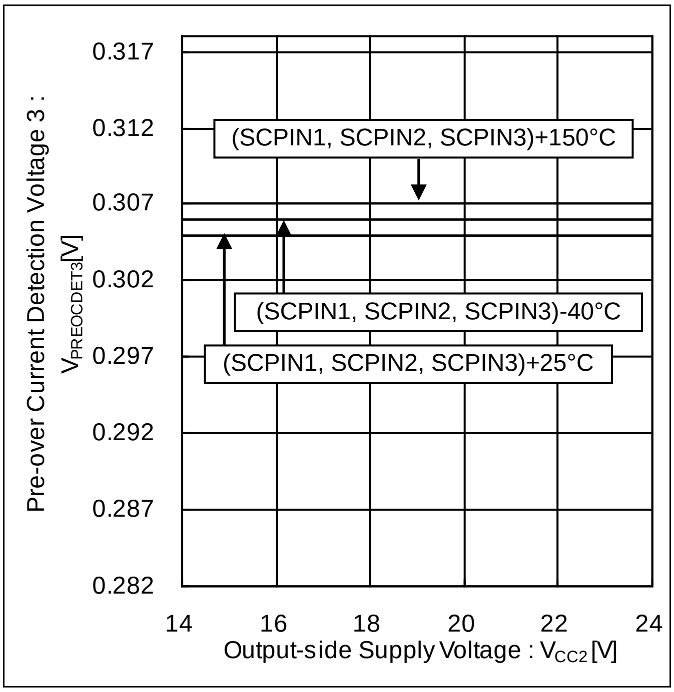


Figure 24. Pre-over Current Detection Voltage 3 vs Output-side Supply Voltage (V_{TC} ≥ 1.3V (Voltage monitor mode))

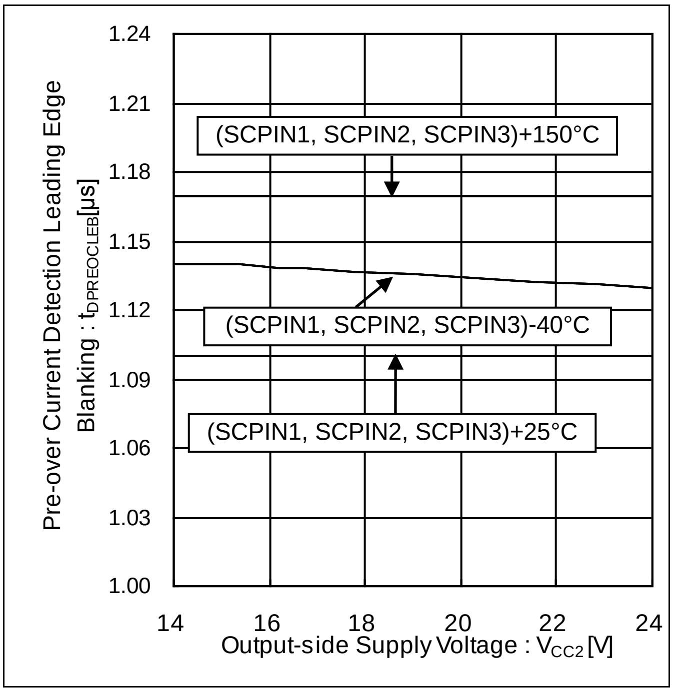


Figure 25. Pre-over Current Detection Leading Edge Blanking vs Output-side Supply Voltage

Typical Performance Curves - continued

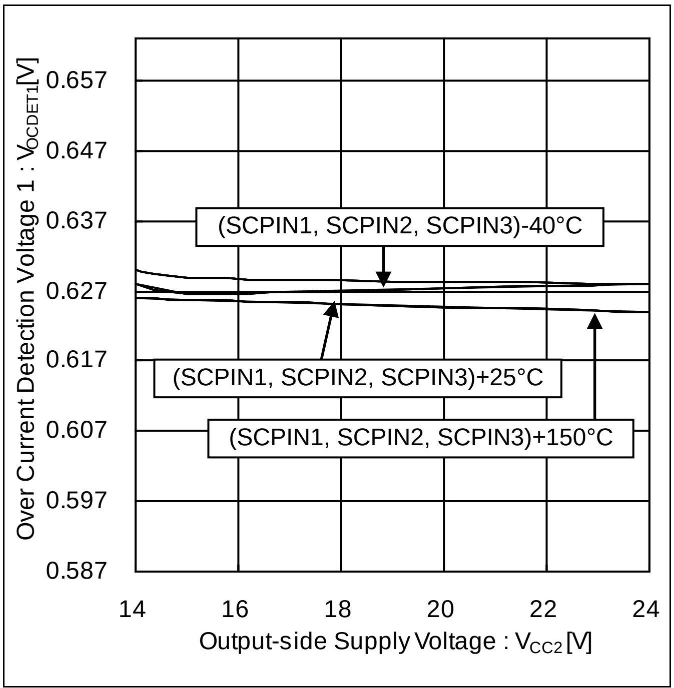


Figure 26. Over Current Detection Voltage 1 vs Output-side Supply Voltage (V_{TC} < 1.3V (pull down, Temperature monitor mode) V_{TO1}=2.5V)

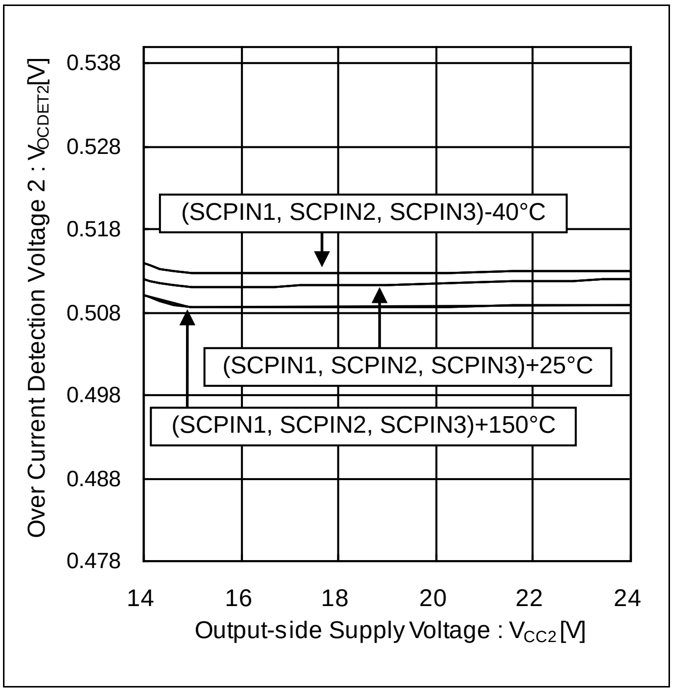


Figure 27. Over Current Detection Voltage 2 vs Output-side Supply Voltage (V_{TC} < 1.3V (pull down, Temperature monitor mode) V_{TO1}=3.0V)

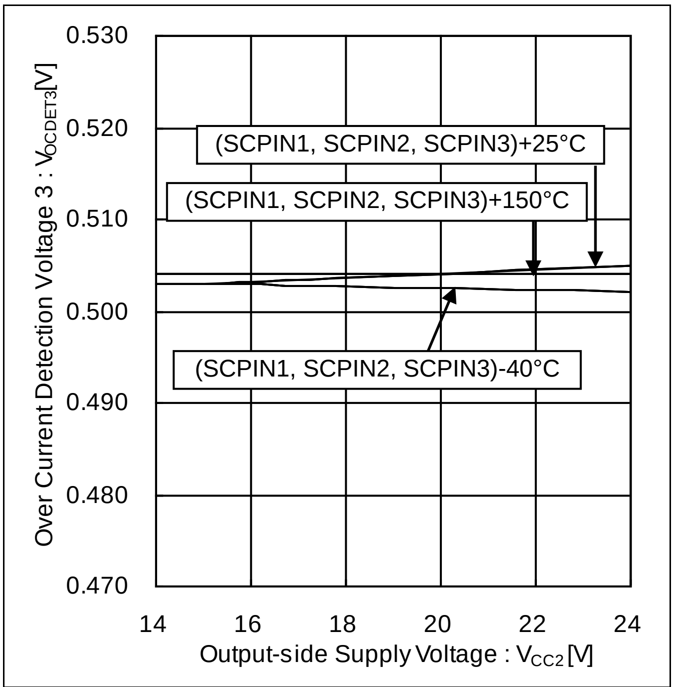


Figure 28. Over Current Detection Voltage 3 vs Output-side Supply Voltage (V_{TC} ≥ 1.3V (Voltage monitor mode))

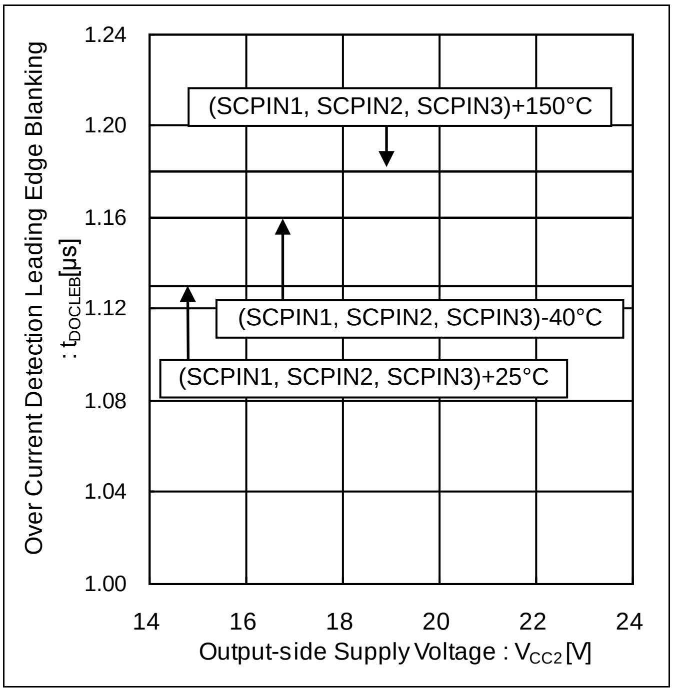


Figure 29. Over Current Detection Leading Edge Blanking vs Output-side Supply Voltage

Typical Performance Curves - continued

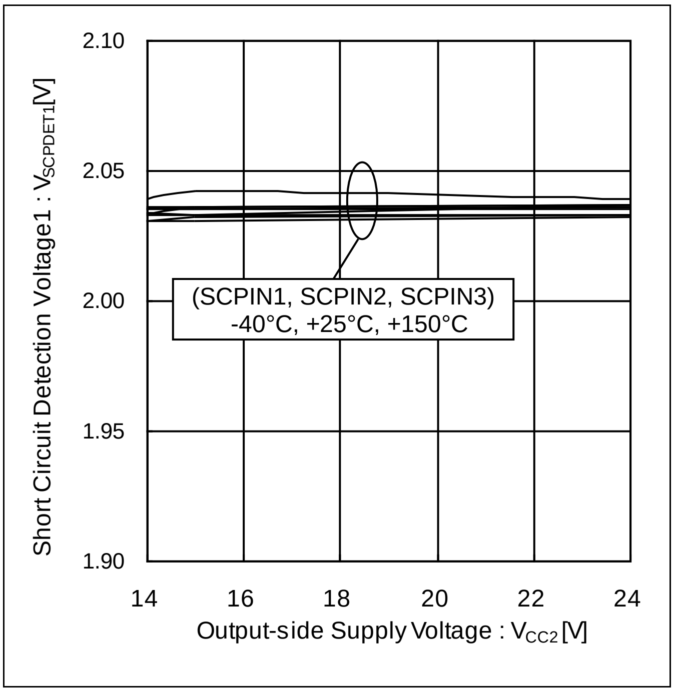


Figure 30. Short Circuit Detection Voltage1 vs
Output-side Supply Voltage
(During Leading Edge Blanking of OC, Pre-OC)

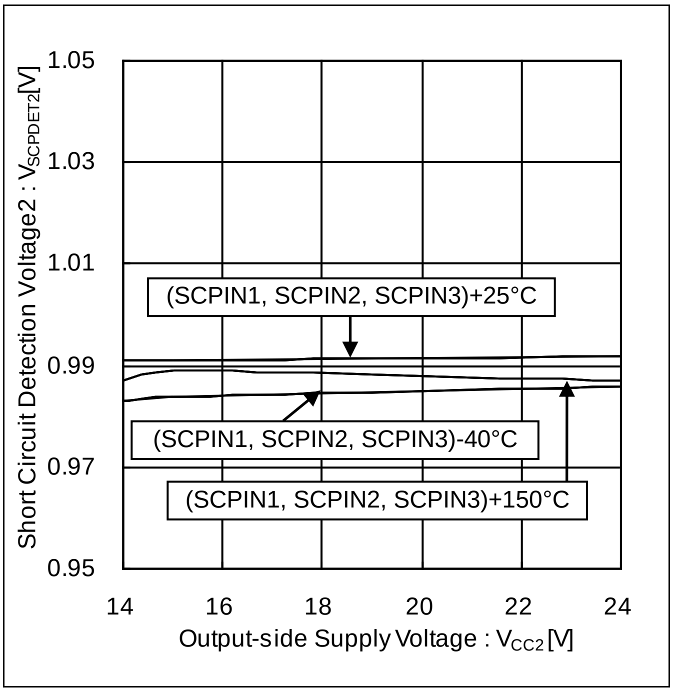


Figure 31. Short Circuit Detection Voltage2 vs
Output-side Supply Voltage
(After Leading Edge Blanking of OC, Pre-OC)

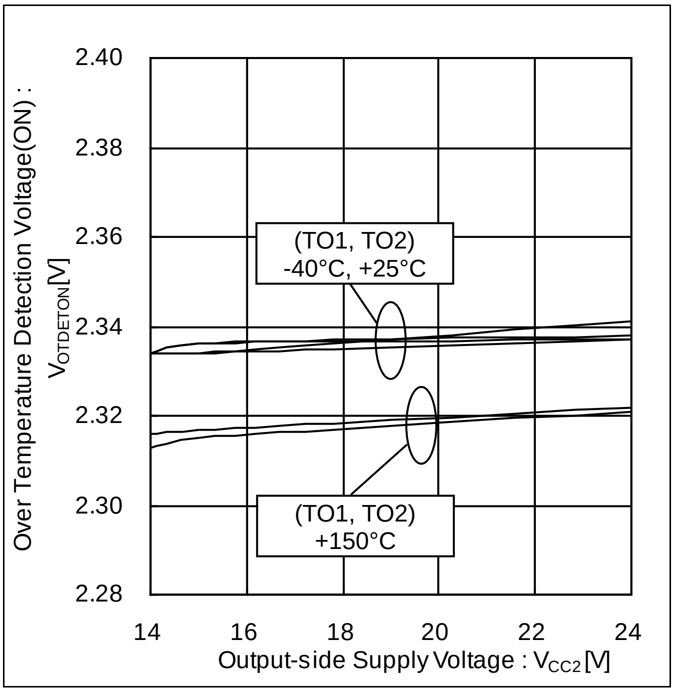


Figure 32. Over Temperature Detection Voltage (ON) vs
Output-side Supply Voltage
(V_{TC} < 1.3V (pull down, Temperature monitor mode))

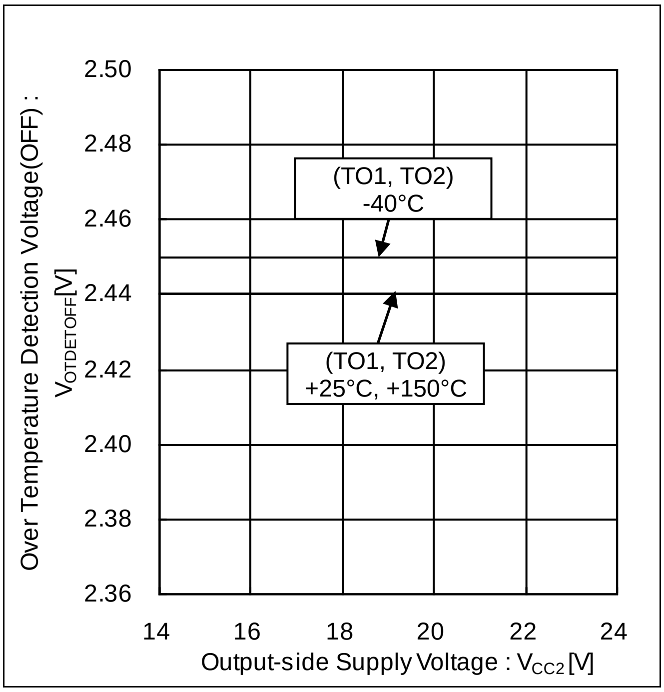


Figure 33. Over Temperature Detection Voltage (OFF) vs
Output-side Supply Voltage
(V_{TC} < 1.3V (pull down, Temperature monitor mode))

Typical Performance Curves - continued

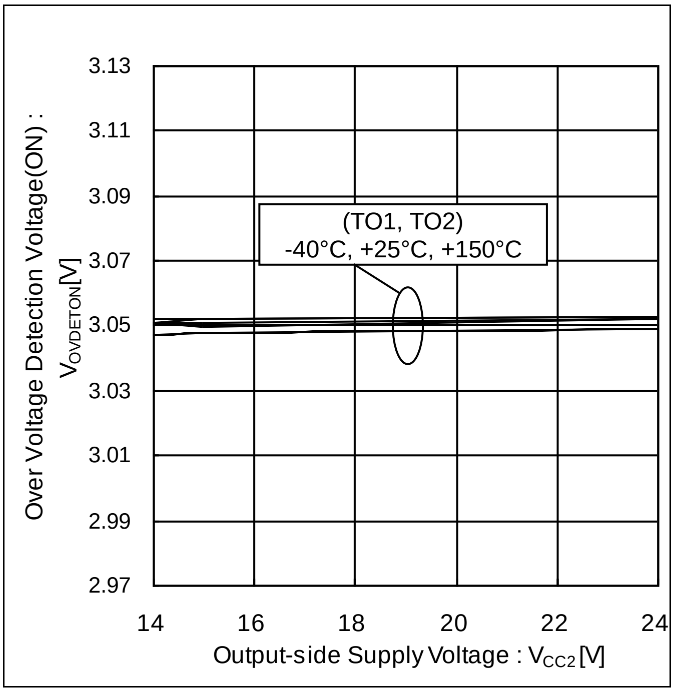


Figure 34. Over Voltage Detection Voltage (ON) vs Output-side Supply Voltage (V_{TC} ≥ 1.3V(Voltage monitor mode))

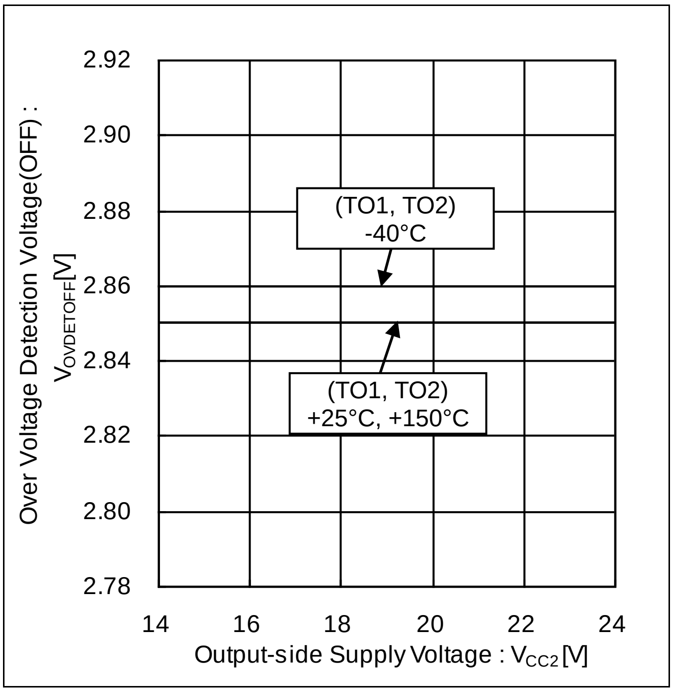


Figure 35. Over Voltage Detection Voltage (OFF) vs Output-side Supply Voltage (V_{TC} ≥ 1.3V(Voltage monitor mode))

Description of Pins and Cautions on Layout of Board

1. V_BATT (Main power supply pin)
   This is the main power supply pin. Connect a bypass capacitor between the V_BATT pin and the GND1 pin in order to suppress voltage variations.

2. GND1 (Input-side ground pin)
   The GND1 pin is a ground pin for the input-side.

3. VCC2 (Output-side positive power supply pin)
   The VCC2 pin is a positive power supply pin on the output side. To reduce voltage fluctuations due to the driving current of the internal transformer and output current, connect a bypass capacitor between the VCC2 and the GND2 pins.

4. GND2 (Output-side ground pin)
   The GND2 pin is a ground pin for the output-side. Connect the GND2 pin to the emitter / source of the output device.

5. INA (Control input pin A), INB (Control input pin B), SPEED (Selectable gate resistance pin)
   They are pins for determining the output logic.

SPEED	INA	INB	OUT1	OUT2
L	L	H	L	L
L	H	H	L	L
L	L	L	L	L
L	H	L	H	L
H	L	H	L	H
H	H	H	L	H
H	L	L	L	H
H	H	L	H	L

6. FLT_UVLO, FLT_SC, FLT_OT (Fault output pins)
   These pins have open drains that output fault signals when faults occur (i.e., when the under voltage lockout function (UVLO) or short circuit protection function (SCP) or over current protection function (OC) or over temperature protection (OT) is activated).

State	FLT_UVLO	FLT_SC	FLT_OT
While in normal operation	Hi-Z	Hi-Z	Hi-Z
V_BATT UVLO or VCC2 UVLO	L	Hi-Z	Hi-Z
SCP or OC	Hi-Z	L	Hi-Z
OT or OV or TOx Open	Hi-Z	Hi-Z	L

7. FB (Error amplifier inverting input pin for switching controller)
   This is a voltage feedback pin of the switching controller. This pin combine with voltage monitoring at over voltage protection function and under voltage protection function for switching controller. When over voltage or under voltage protection is activated, switching controller will be at OFF state (FET_D pin outputs Hi-Z). When the protection holding time ($t_{DCDCRLS}$) is completed, the protection function will be released. Under voltage function is not activated during soft-start.

8. VREG (Power supply pin for the driving MOS FET of the switching controller)
   This is the power supply pin for the driving MOSFET of the switching controller transformer drive. Be sure to connect a capacitor between the VREG pin and the GND1 pin even when the switching controller is not used, in order to prevent oscillation.

9. FET_D (MOS FET control pin for switching controller)
   This is a MOSFET control pin for the switching controller transformer drive. Leave it open when the switching controller is not used.

Description of Pins and Cautions on Layout of Board – continued

10. OUT1
    The OUT1 pin is a gate driving pin.

11. OUT2
    The OUT2 pin is a gate driving pin.

12. MC
    The MC pin is for preventing the increase in gate voltage due to the Miller current of the power device connected to the OUT1 pin. If the function is not used, short-circuit the MC pin to the GND2 pin.

13. PROOUT (Soft turn OFF pin)
    This pin is for soft turn OFF of output pin when short-circuit protection or over current protection is in action.

14. MILDOUT (Pre-OC turn OFF pin)
    This pin is for Pre-OC turn OFF of output pin when pre-over current protection is in action.

15. SCPINx (Short circuit current detection)
    This pin is used to detect current for short circuit current detection, over current detection and pre-over current detection. When the SCPINx (x=1 to 3) pin voltage is the $V_{SCPDETx}$ (x=1 to 2) or V_{OCDETx} (x=1 to 3) or $V_{PREOCDETx}$ (x=1 to 3) or more, the following table's function will be activated and this will make the IC function in an open state. To avoid such trouble, connect a resistor between the SCPINx pin and the GND2 pin or short the SCPINx pin to the GND2 pin when the SCP pin function is not used.
    The SCPINx pins are active only at OUT1=High.

Pin Name	Function	Threshold voltage	Filtering Time	IN	PROOUT	MILDOUT
SCPINx	Short circuit current detection	$V_{SCPDETx}$	t_{SCPFIL}	X	L	Hi-Z
	Over current detection	V_{OCDETx}	t_{DOCFIL}	X	L	Hi-Z
	Pre-over current detection	$V_{PREOCDETx}$	$t_{DPREOCFIL}$	H to L	Hi-Z	L

X : Don't care

16. TC (Resistor connection pin for setting constant current source output/Mode selection input pin of temperature monitor or voltage monitor)
    The TC pin is a resistor connection pin for setting the constant current output. If an arbitrary resistance value is connected between the TC pin and the GND2 pin, it is possible to set the constant current value output from the TOx pin.
    The TC pin is selectable function of temperature monitor or voltage monitor. When the TC pin voltage < V_{TCH} (1.3V min), temperature monitor function is activated. When the TC pin voltage ≥ V_{TCH} (1.3V min), the voltage monitor function is activated.

17. TOx (Constant current output/sensor voltage input pin)
    When temperature monitor function is activated (TC pin voltage < 1.3V), the TO1 pin and the TO2 pin are constant current output/voltage input pins. It can be used as a sensor input by connecting an element with arbitrary impedance between the TOx (x=1 to 2) pin and the GND2 pin. Furthermore, the TOx pin disconnect detection function is built-in.
    When voltage monitor function is activated (TC pin voltage ≥ 1.3V), the TO1 pin and the TO2 pin are voltage input pins.

TC Input Voltage	Function	TOx Constant Current output	TOx Input Voltage	State	IN	OUT1	FLT_OT	SENSOR
< 1.3V	Temperature Monitor	Enable	< $V_{OTDETON}$	OT	X	L	L	PWM
			> $V_{OTDETOFF}$	Normal	L	L	Hi-Z	PWM
					H	H	Hi-Z	PWM
			> V_{TOH}	TOx open	X	L	L	L
≥ 1.3V	Voltage Monitor	Disable	> $V_{OVDETON}$	OV	L	L	L	PWM
					H	H	L	PWM
			< $V_{OVDETOFF}$	Normal	L	L	Hi-Z	PWM
					H	H	Hi-Z	PWM
			> V_{TOH}	TOx open	X	L	L	L

18. SENSOR (Temperature information output pin)
    This is a pin which outputs the voltage of either the TO1 pin or the TO2 pin, whichever is lower, converted to duty cycle. The duty cycle is synchronized with the frequency of the SYNC pin.

19. SYNC (Frequency synchronization input pin for temperature monitor)
    This is a pin which inputs the frequency of the SENSOR pin. If the pin is not used, short the SYNC pin to the GND1 pin.

Description of Functions and Examples of Constant Setting

1. Fault Status Output

This function is used to output a fault signal from the FLT_UVLO pin when the under voltage lockout function (UVLO) is activated, the FLT_SC pin when the short circuit protection function (SCP) or over current protection (OC) is activated, and the FLT_OT pin when the over temperature protection (OT) or over voltage protection (OV) is activated.

The functions of SCP/OC is to hold the fault signal until fault output holding time (t_{SCP_FLTRLS}) is completed.

Status	FLT_SC pin
Normal	Hi-Z
SCP,OC	Low

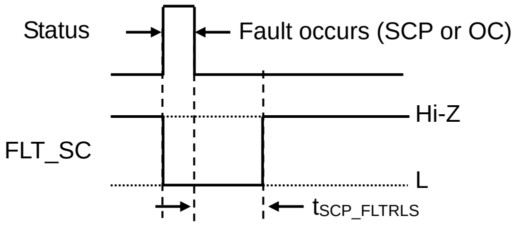


Figure 36. Fault Status Output Timing Chart (SCP or OC)

The UVLO function holds the fault signal until the V_BATT pin voltage goes high above $V_{UVLOVBATTH}$ or the VCC2 pin voltage goes high above V_{UVLO2H}.

Status	FLT_UVLO pin
Normal	Hi-Z
UVLO	Low

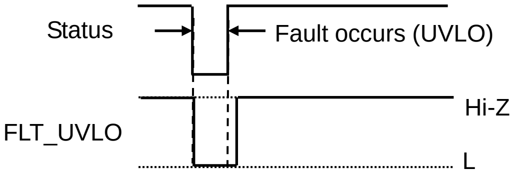


Figure 37. Fault Status Output Timing Chart (UVLO)

And the OT/OV function holds the fault signal until the TO pin voltage goes high above $V_{OTDETOFF}$ (temperature monitor mode) or until the TO pin voltage goes low below $V_{OVDETOFF}$ (voltage monitor mode).

Status	FLT_OT pin
Normal	Hi-Z
OT, OV, TOx Open	Low

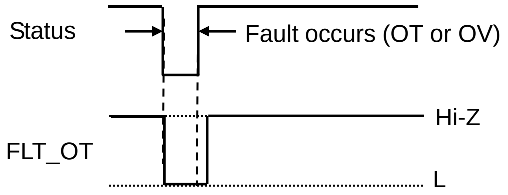


Figure 38. Fault Status Output Timing Chart (OT or OV)

Description of Functions and Examples of Constant Setting - continued

2. Under Voltage Lockout (UVLO) Function
   The BM60056FV-C incorporates the under voltage lockout (UVLO) function on V_BATT, VREG and VCC2. When the V_BATT pin voltage drops to $V_{UVLOBATTL}$, the VREG pin voltage drops to $V_{UVLOVREGL}$ or the VCC2 pin voltage drops to V_{UVLO2L}, the OUT1 turns off and the FLT_UVLO pin will both output the "Low" signal. When the V_BATT pin voltage rises to $V_{UVLOBATTH}$, the VREG pin voltage rises to $V_{UVLOVREGH}$ and the VCC2 pin voltage rises to V_{UVLO2H}, these pins will be reset. In addition, to prevent malfunction due to noise, mask time are set on low and high voltage sides. (IN= INA ∩ INB)

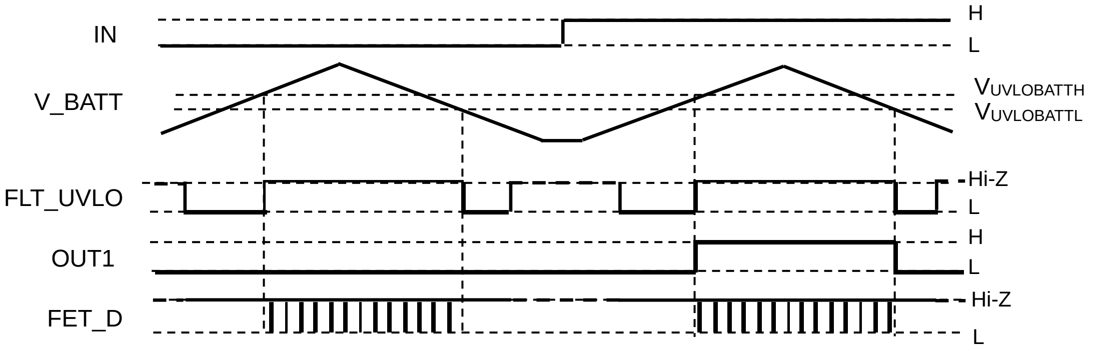


Figure 39. V_BATT UVLO Function Operation Timing Chart

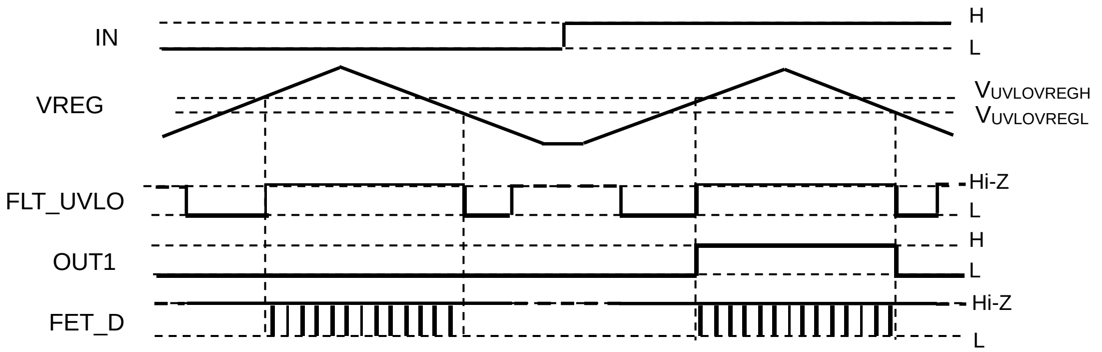


Figure 40. VREG UVLO Function Operation Timing Chart

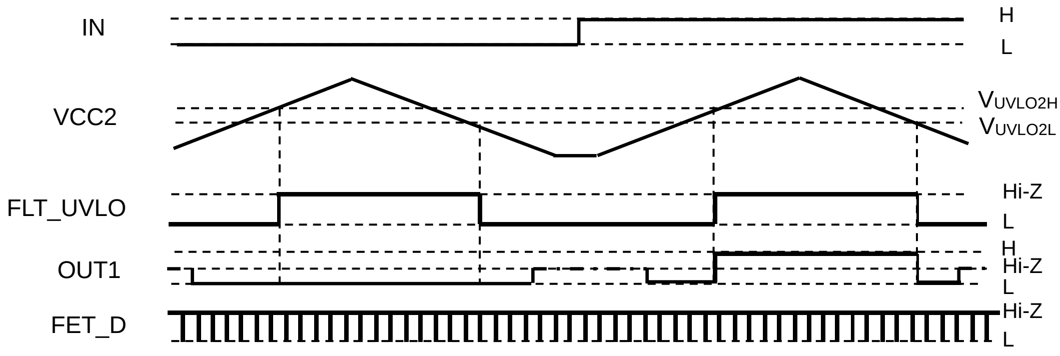


Figure 41. VCC2 UVLO Function Operation Timing Chart

2. Under Voltage Lockout (UVLO) Function - continued

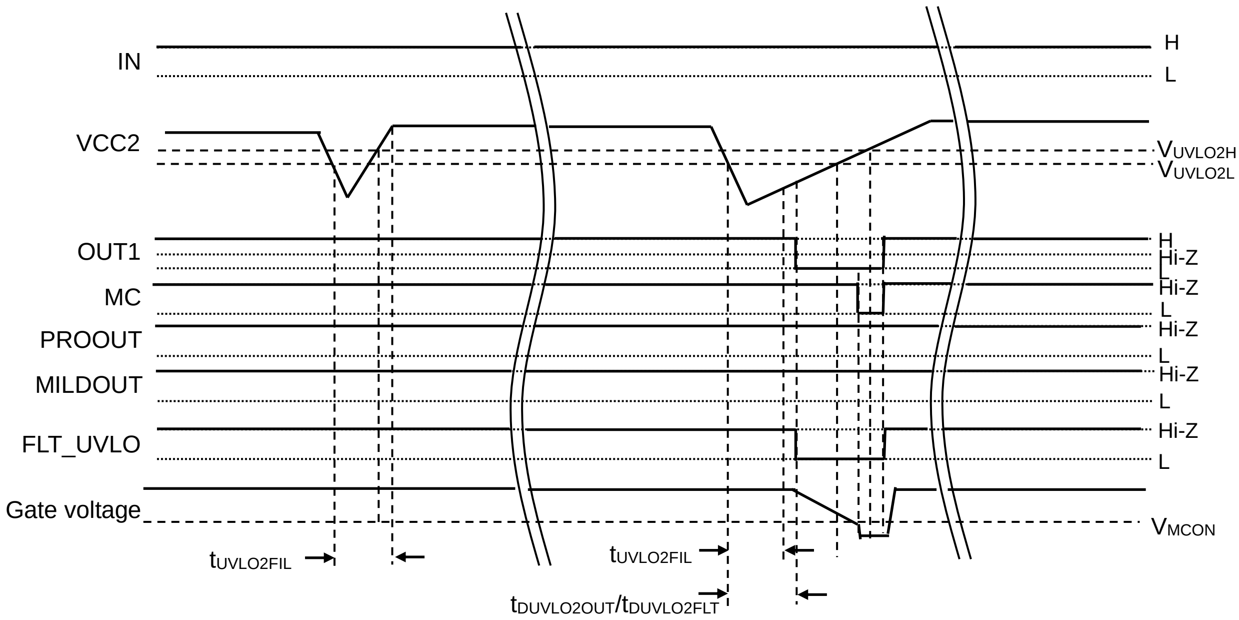


Figure 42. UVLO Operation Timing Chart (Normal Turn off)

Description of Functions and Examples of Constant Setting - continued

3. Short Circuit Protection (SCP) Function

When the SCPINx (x=1 to 3) pin voltage is the $V_{SCPDETx}$ (x=1 to 2) or more, the SCP function will be activated. When the SCP function is activated, soft turn off is activated.

When the SCP function is activated, the OUT1 pin voltage will be set to the "Hi-Z" level and the PROOUT pin voltage will be set to "Low" level first. Next, the MC pin voltage < V_{MCON}, internal MOS of the MC pin is turned ON (miller clamping) and the OUT1 pin will become Low.

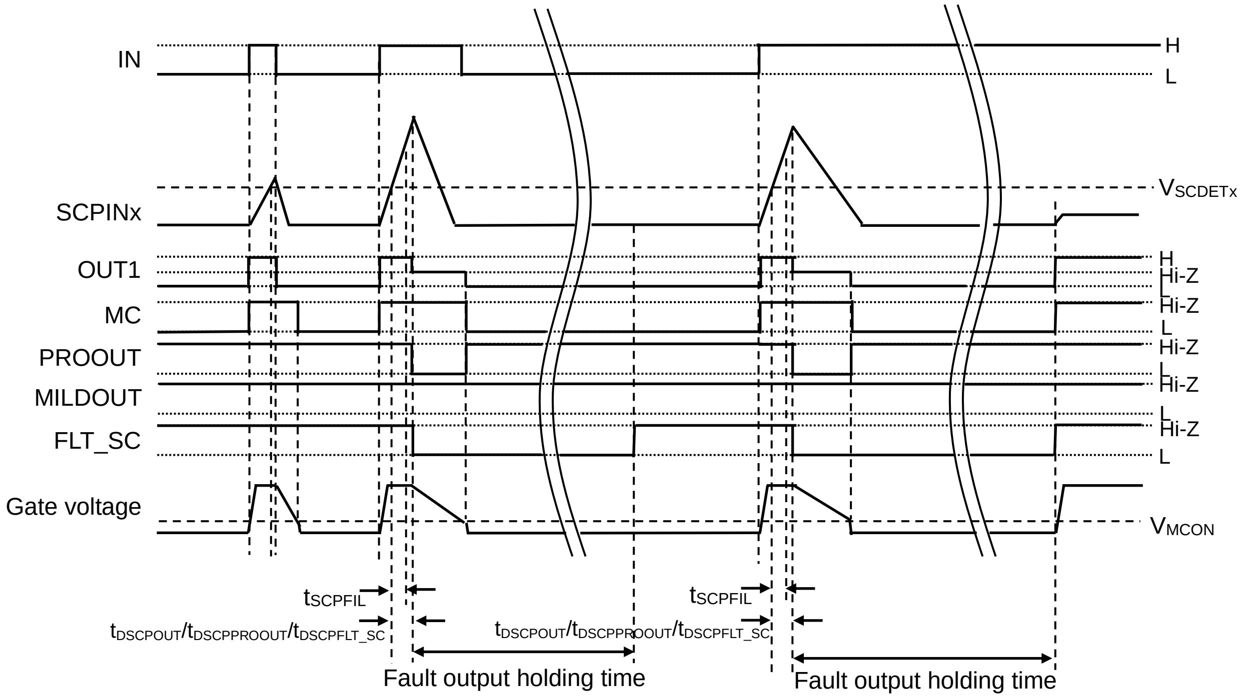


Figure 43. SCP Operation Timing Chart

4. Over Current Protection (OC) Function

When the SCPINx (x=1 to 3) pin voltage is the V_{OCDETx} (x=1 to 3) or more, the OC function will be activated. When the OC function is activated, soft turn off is activated.

When the OC function is activated, the OUT1 pin voltage will be set to the "Hi-Z" level and the PROOUT pin voltage will be set to "Low" level first. Next, the MC pin voltage < V_{MCON}, internal MOS of the MC pin is turned ON (miller clamping) and the OUT1 pin will become Low.

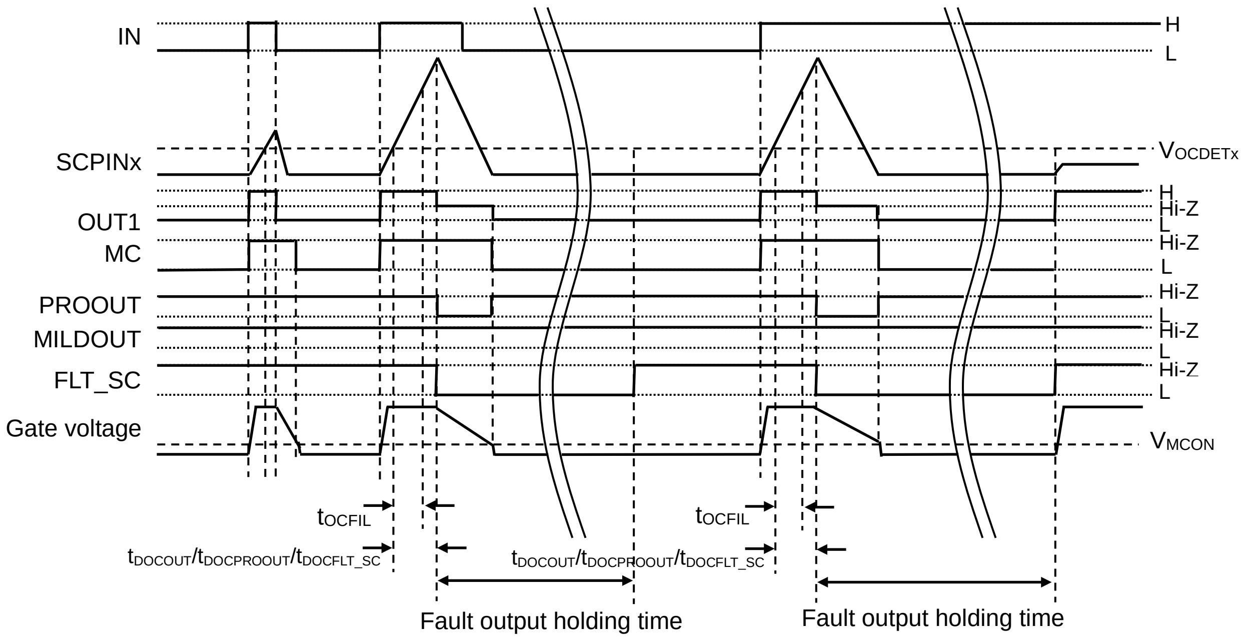


Figure 44. OC Operation Timing Chart

Description of Functions and Examples of Constant Setting - continued

5. Pre-over Circuit Detection (Pre-OC) Function

   When the SCPINx (x=1 to 3) pin voltage is the $V_{PREOCDETx}$ (x=1 to 3) or more, the Pre-OC function will be activated. When the Pre-OC function is activated, Pre-OC turn off is activated.

   When the Pre-OC function is activated and IN is High to Low, the OUT1 pin voltage will be set to the “Hi-Z” level and the MILDOUT pin voltage will go to the “Low” level first. Next, the MC pin voltage < V_{MCON}, internal MOS of the MC pin is turned ON (miller clamping) and the OUT1 pin become Low.

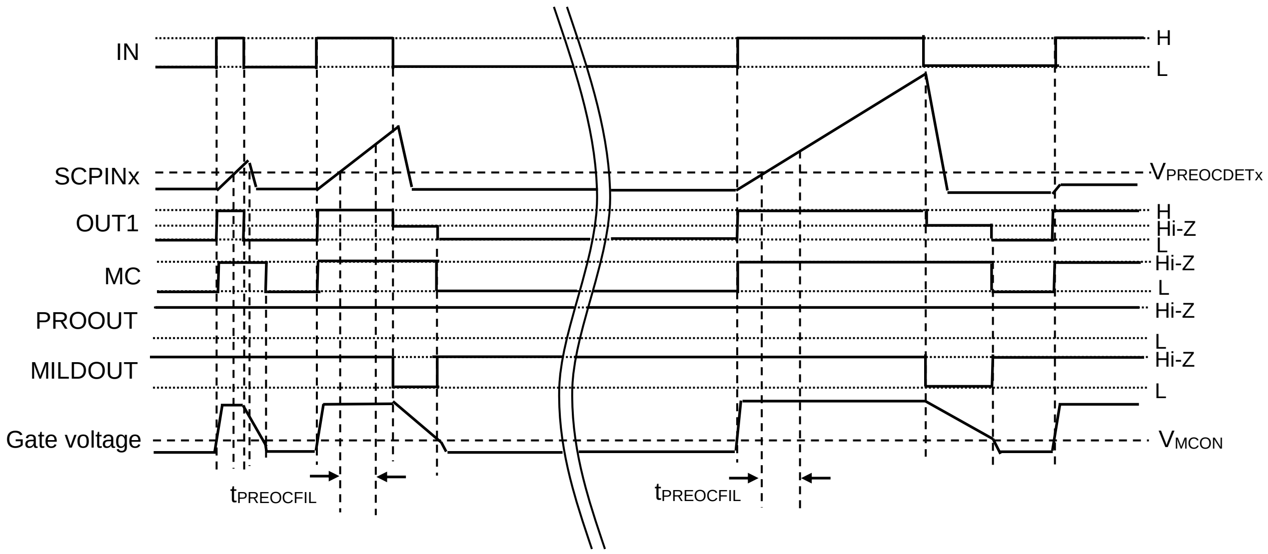


Figure 45. Pre-OC Operation Timing Chart

6. Leading Edge Blanking

   After the OUT1 is turned on, the OC function and the Pre-OC function remain disabled during leading edge blanking ($t_{DPREOCLEB}$/t_{DOCLEB}).

   During leading edge blanking, Short Circuit Detection Voltage is 2.0V(typ). After leading edge blanking, Short Circuit Detection Voltage is 1.0V(typ).

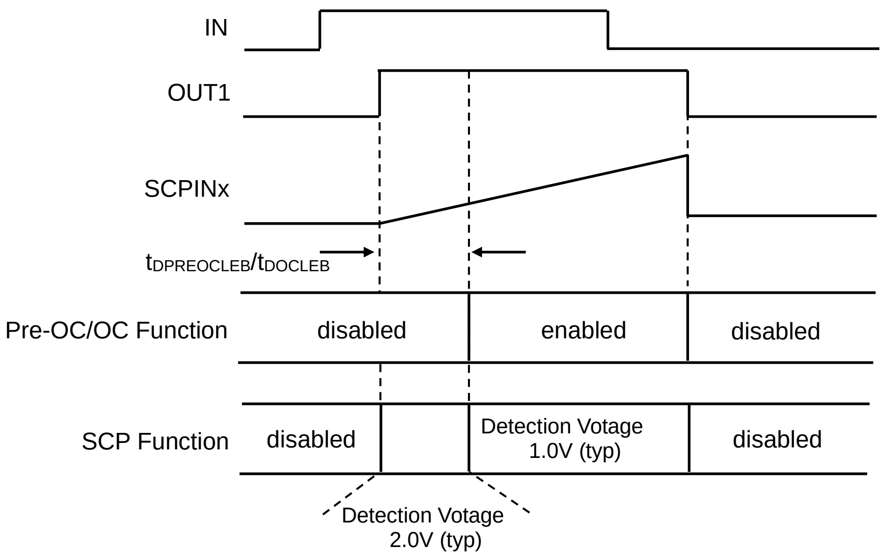


Figure 46. Leading Edge Blanking

Description of Functions and Examples of Constant Setting - continued

7. Temperature Compensation of OC and Pre-OC
   When temperature monitor function is activated (V_{TC} < 1.3V), the temperatures of OC and Pre-OC detection voltage (V_{OC} and V_{PREOC}) can be compensated in accordance with the TO1 pin voltage.
   When voltage monitor function is activated (V_{TC} ≥ 1.3V), OC and Pre-OC detection voltage are fixed.

   V_{TC} < 1.3V (Temperature monitor mode).

   $$V_{OC} = -0.231V_{TO1} + 1.202 \quad [V]$$
   $$V_{PREOC} = -0.231V_{TO1} + 1.052 \quad [V]$$

   V_{TC} ≥ 1.3V (Voltage monitor mode)

   $$V_{OC} = 0.5 \quad [V]$$
   $$V_{PREOC} = 0.3 \quad [V]$$

8. Selectable Gate Resistance
   Gate resistance is selected by the SPEED pin. The internal logic is defined at rising edge of INA when INB=Low or at falling edge of INB when INA=High

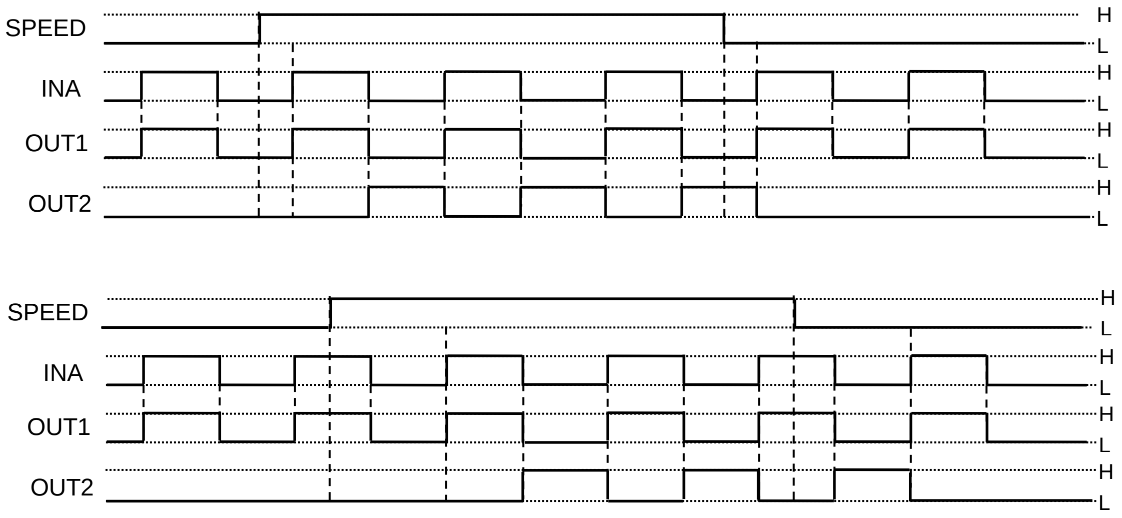


Figure 47. Gate Resistance Control

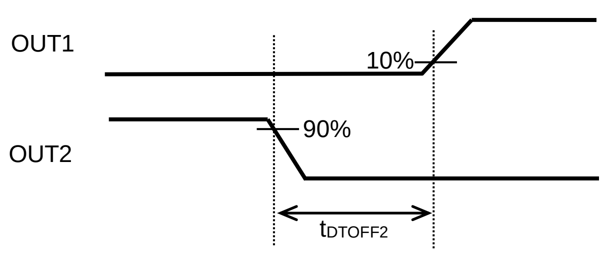


Figure 48. OUT2 OFF Dead Time

Description of Functions and Examples of Constant Setting - continued

9. Miller Clamping

When OUT1=Low and the MC pin voltage < V_{MCON}, internal MOS of the MC pin is turned ON, and Miller clamp function operates.

IN	MC pin input voltage	MC
L	Not more than V_{MCON}	L
H	X	Hi-Z

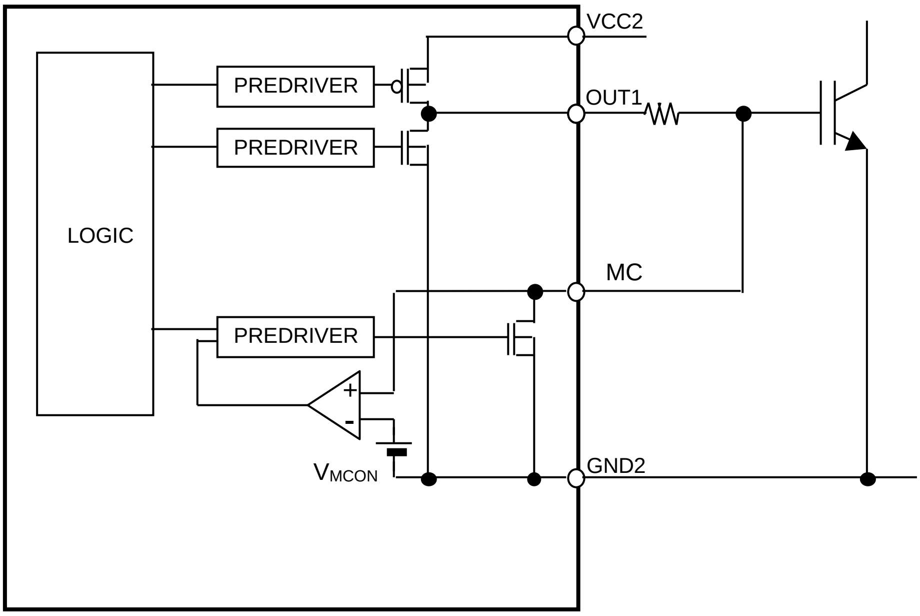


Figure 49. Block Diagram of Miller Clamp Function

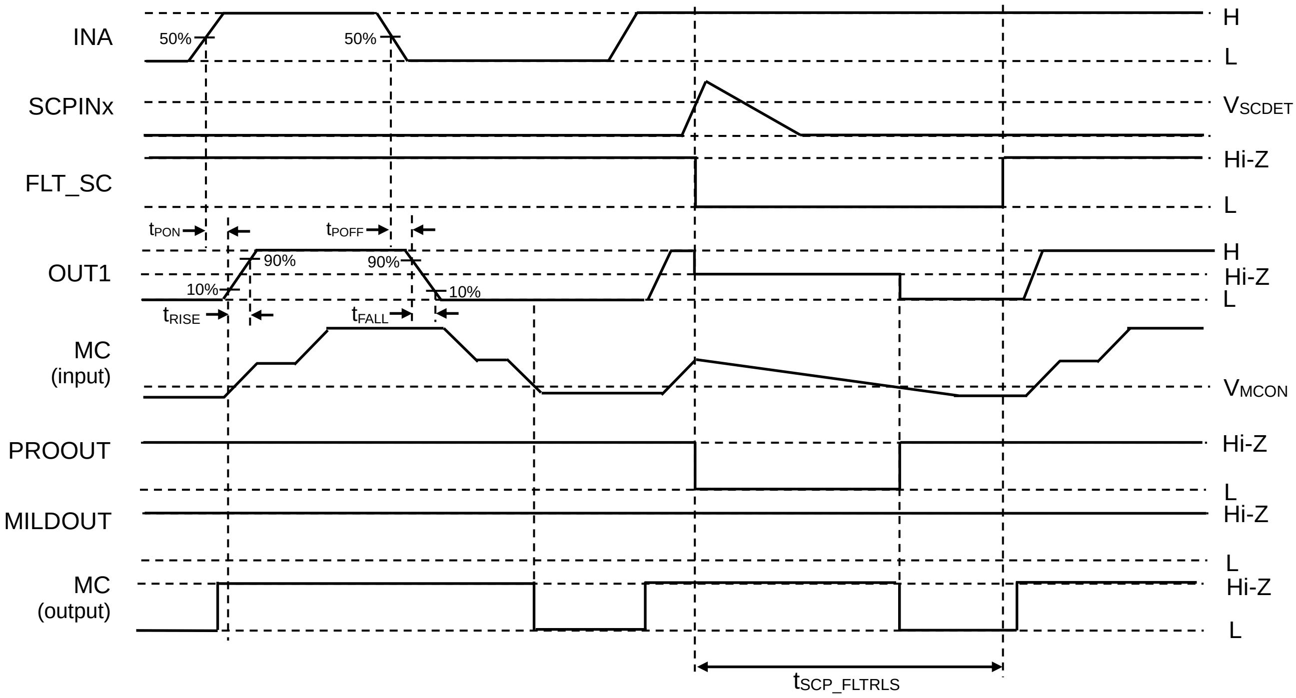


Figure 50. Timing Chart of Miller Clamp Function

Description of Functions and Examples of Constant Setting - continued

10. Temperature Monitor Function and Voltage Monitor Function

When TC pin voltage < 1.3V (pull down), constant current is supplied from the TOx pins from the built-in constant current circuit. This current value can be adjusted in accordance with the resistance value connected between the TC pin and the GND2 pin. Furthermore, the TO_X pin has voltage input function, and outputs signal of the TOx pin voltage converted to Duty synchronizing with SYNC frequency from the SENSOR pin. When voltage of either one of the TO_X pins is no less than disconnect detection voltage V_{TOH}, the SENSOR pin outputs Low. Therefore, when only one of the TO_X pins is used, connect a resistor between the other the TOx pins and the GND2 pin to keep pin voltage at no more than V_{TOH}.

$$\text{Constant current value} = V_{TC}/R_{TC}$$

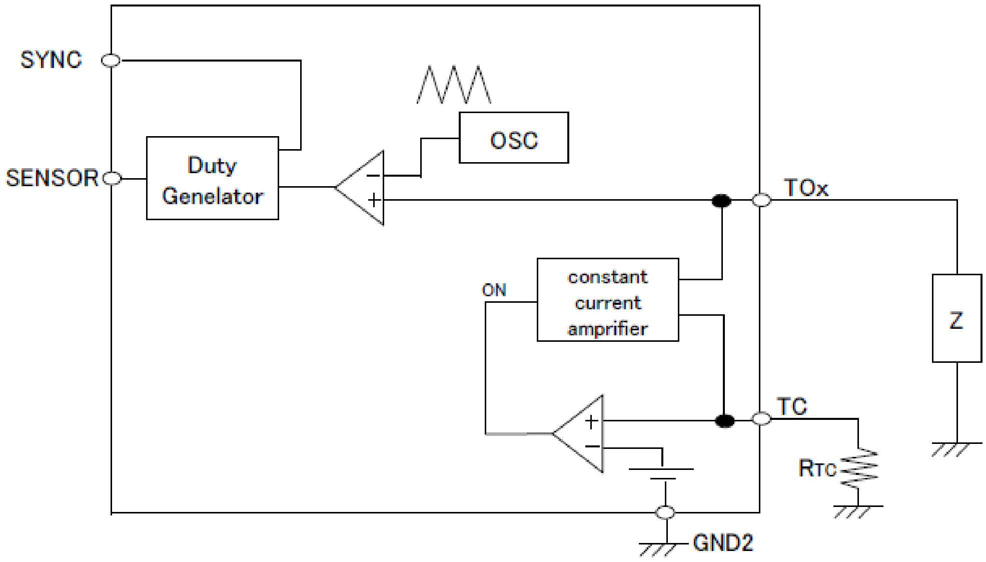


Figure 51. Block Diagram of Temperature Monitor Function

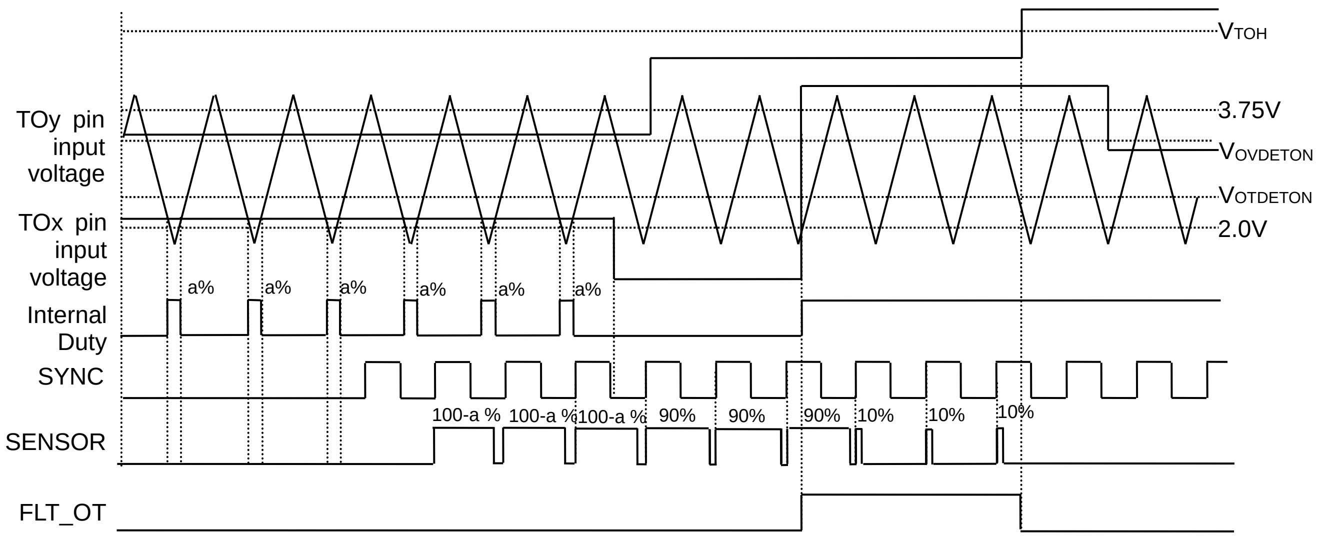


Figure 52. Timing Chart of Temperature Monitor Function

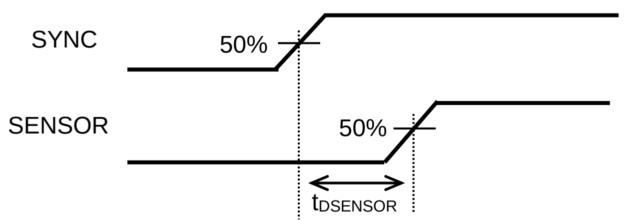


Figure 53. SENSOR Output Rising Edge Delay Time

10. Temperature Monitor Function and Voltage Monitor Function - continued
When TC pin voltage ≥ 1.3V, constant current from the TOx pins is turned off. The TOx pin voltage is converted to duty cycle synchronizing with SYNC frequency and is output from the SENSOR pin.
Please connect the TO1 pin and the TO2 pin.

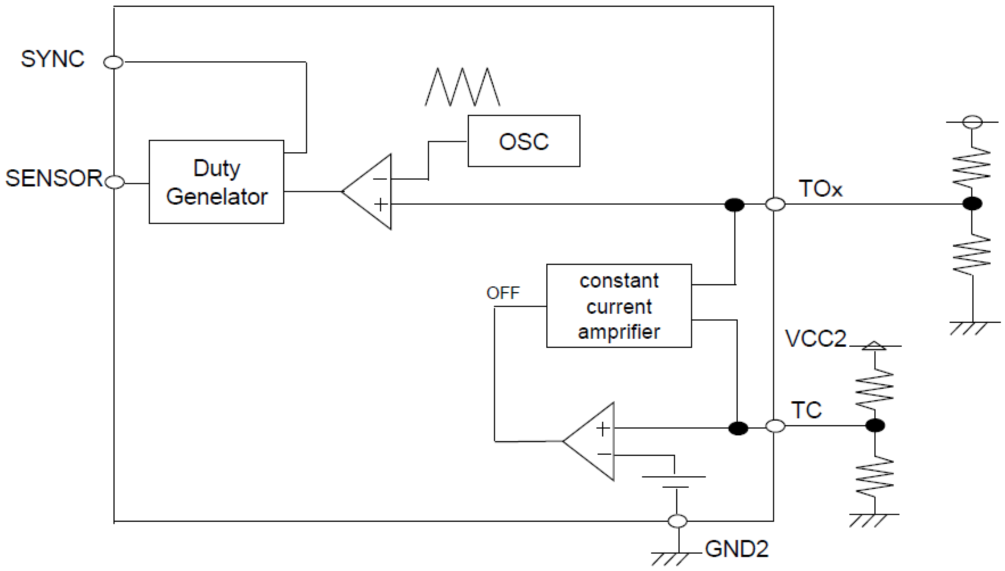


Figure 54. Block Diagram of Voltage Monitor Function

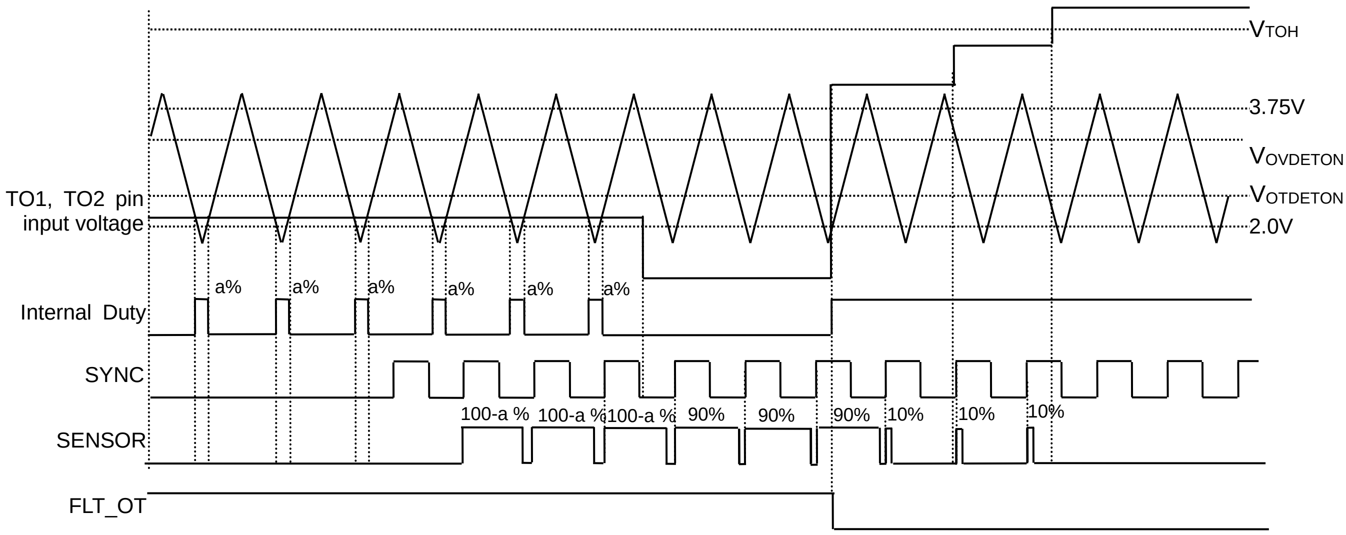


Figure 55. Timing Chart of Voltage Monitor Function

10. Temperature Monitor Function and Voltage Monitor Function - continued
The SENSOR duty is calculated according to the following calculating formula.

(2.0V < TOx < 3.75V)

$$SENSER\ Duty = -45.831 V_{TOX} + 182.11 \quad [\%]$$

(TOx ≤ 2.0V)

$$SENSER\ Duty = 90 \quad [\%]$$

(3.75V ≤ TOx)

$$SENSER\ Duty = 10 \quad [\%]$$

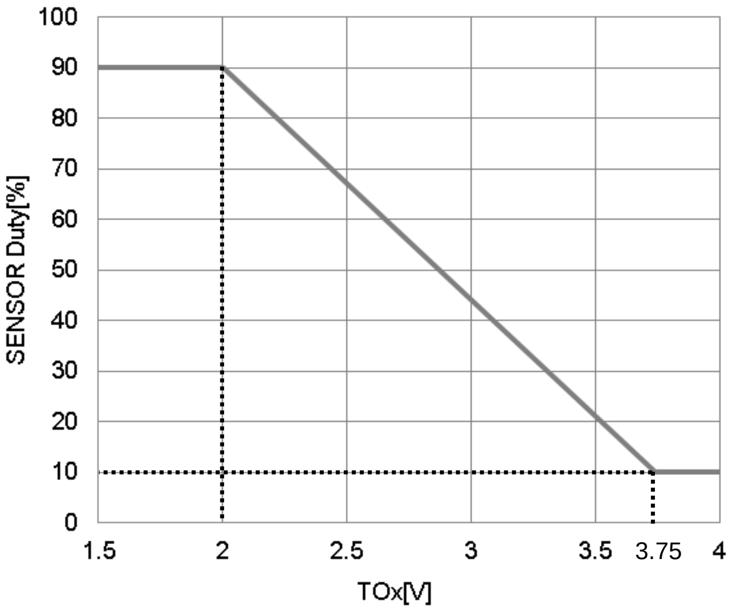


Figure 56. TOx Voltage vs SENSOR Duty

Description of Functions and Examples of Constant Setting – continued

11. Over Temperature Protection Function
    When the TOx pin voltage < $V_{OTDETON}$, OUT1 turns off and FLT_OT become Low. When the TOx pin voltage goes voltage high above $V_{OTDETOFF}$ the OT function will be released.

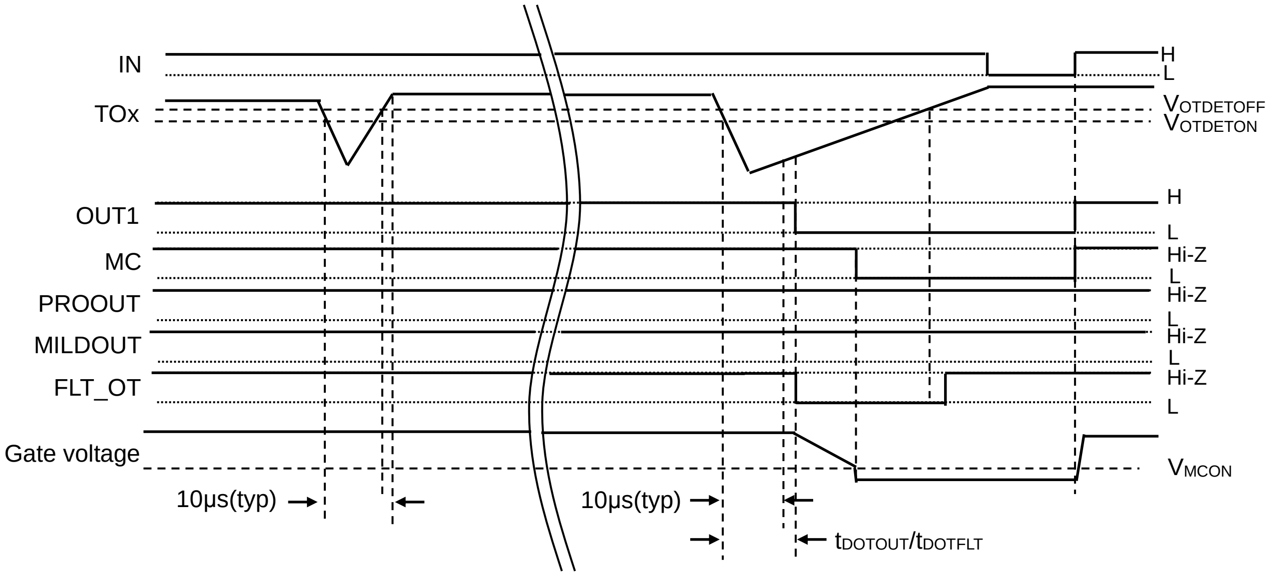


Figure 57. OT Operation Timing Chart

12. Over Voltage Protection Function
    When the TOx pin voltage > $V_{OVDETON}$, FLT_OT become Low. When the TOx pin voltage goes voltage high above $V_{OVDETOFF}$, the OV pin function will be released.

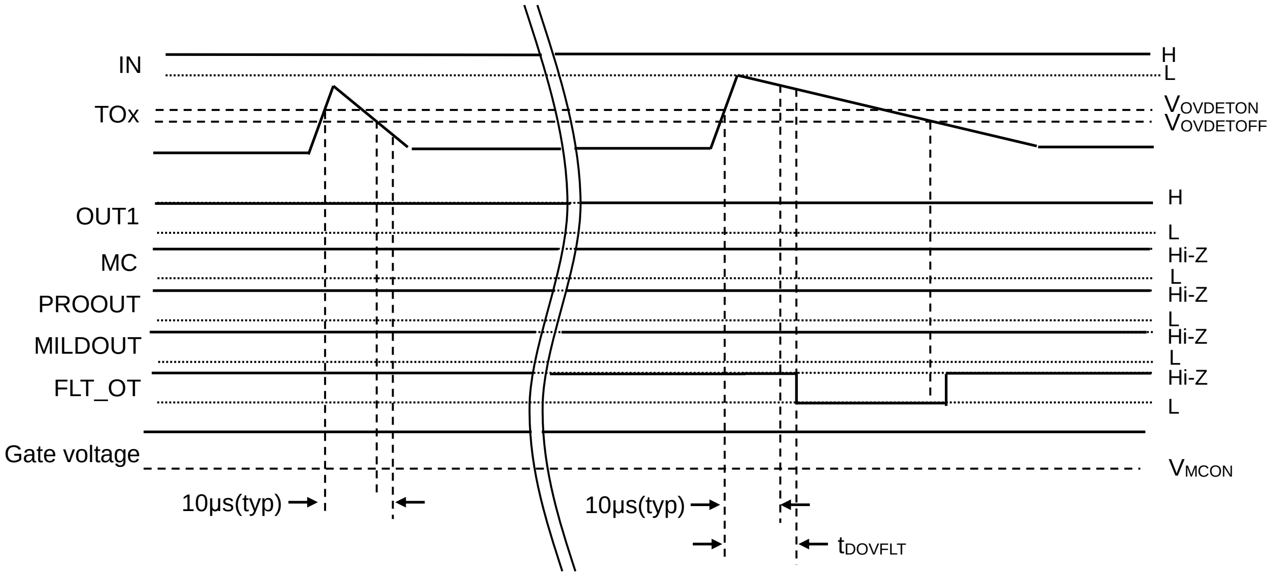


Figure 58. OV Operation Timing Chart

Description of Functions and Examples of Constant Setting – continued

13. Switching Controller

(1) Basic action

This IC has a switching power supply controller which repeats ON/OFF synchronizing with internal clock. When V_BATT voltage is supplied (V_BATT > $V_{UVLOBATTH}$), the FET_D pin starts switching by soft-start. Output voltage is determined by the following equation by external resistance and winding ratio "n" of flyback transformer (n= V_{OUT2} side winding number/V_{OUT1} side winding number)

$$V_{OUT2} = V_{FB} \times \{(R_1+R_2)/R_2\} \times n \quad [V]$$

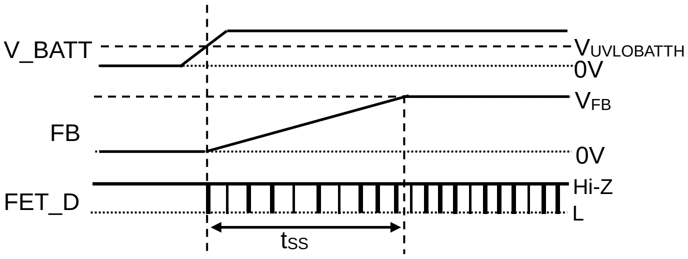


Figure 59. soft-start Timing Chart

(2) MAX DUTY

When, for example, output load is large, output is forcibly turned OFF by Maximum On Duty (D_{ONMAX}).

(3) Protection function

The switching controller has the over voltage protection (OVP) and the under voltage protection (UVP) as protection functions, and monitoring the FB pin voltage.

When the protection function is activated, switching controller will be OFF state. The protection holding time ($t_{DCDCRLS}$) is completed, the protection function will be released. Under voltage function is not activated during soft-start.

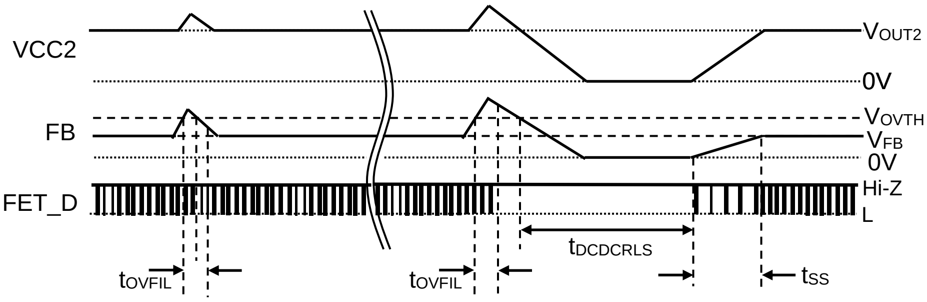


Figure 60. OVD Operation Timing Chart

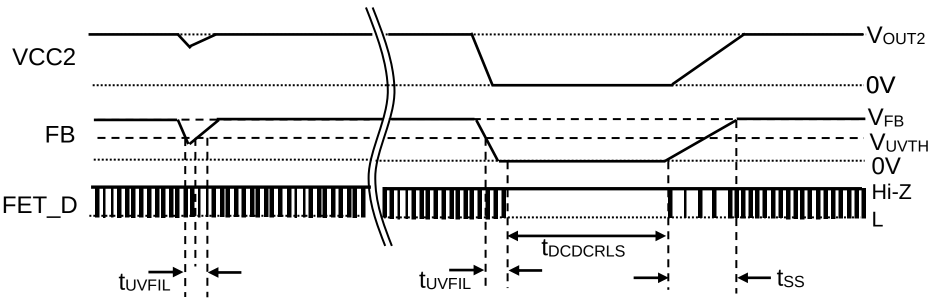


Figure 61. UVD Operation Timing Chart

(4) Pin conditions when the switching power supply controller is not used
Implement pin connection as shown below when switching power supply is not used.

Pin Number	Pin Name	Treatment Method
24	FB	Connect to VREG
25	VREG	Connect capacitor
26	V_BATT	Connect power supply
27	FET_D	No connection

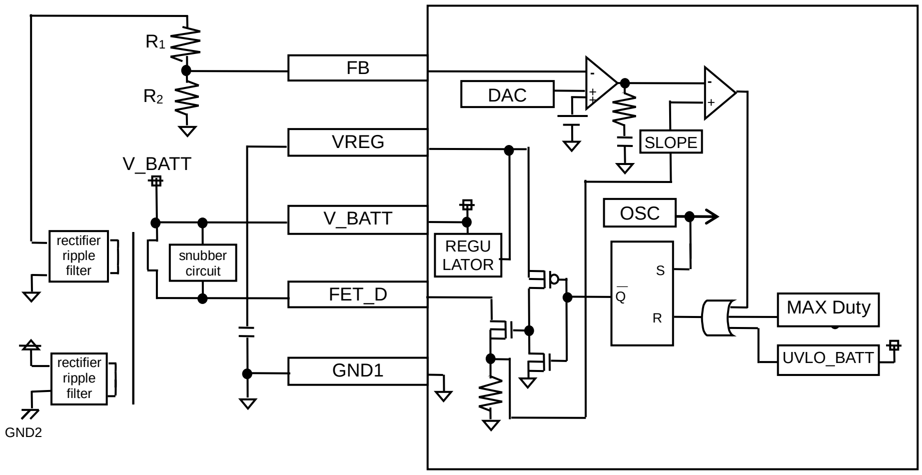


Figure 62. Block Diagram of Switching Controller

Description of Functions and Examples of Constant Setting - continued

14. I/O Condition Table

No.	Status	Input								Output							
		V_BATT	VCC2	TOx	SCPINx	SPEED	INB	INA	MC	OUT1	OUT2	MC	PROOUT	MILDOUT	FLT_UVLO	FLT_SC	FLT_OT
1	V_BATT UVLO	UVLO	〇	〇	L	L	X	X	H	L	L	Z	Z	Z	L	Z	Z
2		UVLO	〇	〇	L	L	X	X	L	L	L	L	Z	Z	L	Z	Z
3		UVLO	〇	〇	L	H	X	X	H	L	H	Z	Z	Z	L	Z	Z
4		UVLO	〇	〇	L	H	X	X	L	L	H	L	Z	Z	L	Z	Z
5	VCC2 UVLO	〇	UVLO	〇	L	X	X	X	H	L	L	Z	Z	Z	L	Z	Z
6		〇	UVLO	〇	L	X	X	X	L	L	L	L	Z	Z	L	Z	Z
7	OT	〇	〇	OT	L	X	X	X	H	L	L	Z	Z	Z	Z	Z	L
8		〇	〇	OT	L	X	X	X	L	L	L	L	Z	Z	Z	Z	L
9	OV	〇	〇	OV	L	L	L	L	H	L	L	Z	Z	Z	Z	Z	L
10		〇	〇	OV	L	L	L	L	L	L	L	L	Z	Z	Z	Z	L
11		〇	〇	OV	L	L	H	X	H	L	L	Z	Z	Z	Z	Z	L
12		〇	〇	OV	L	L	H	X	L	L	L	L	Z	Z	Z	Z	L
13		〇	〇	OV	L	L	L	H	H	H	L	Z	Z	Z	Z	Z	L
14		〇	〇	OV	L	L	L	H	L	H	L	Z	Z	Z	Z	Z	L
15		〇	〇	OV	L	H	L	L	H	L	H	Z	Z	Z	Z	Z	L
16		〇	〇	OV	L	H	L	L	L	L	H	L	Z	Z	Z	Z	L
17		〇	〇	OV	L	H	H	X	H	L	H	Z	Z	Z	Z	Z	L
18		〇	〇	OV	L	H	H	X	L	L	H	L	Z	Z	Z	Z	L
19		〇	〇	OV	L	H	L	H	H	H	L	Z	Z	Z	Z	Z	L
20		〇	〇	OV	L	H	L	H	L	H	L	Z	Z	Z	Z	Z	L
21	SCP	〇	〇	〇	SCP	X	L	H	H	Z	L	Z	L	Z	Z	L*	Z
22		〇	〇	〇	SCP	L	L	H	L	L	L	L	Z	Z	Z	L*	Z
23		〇	〇	〇	SCP	H	L	H	L	L	H	L	Z	Z	Z	L*	Z
24		〇	〇	〇	SCP	X	H	X	H	L	L	Z	Z	Z	Z	Z	Z
25		〇	〇	〇	SCP	X	H	X	L	L	L	L	Z	Z	Z	Z	Z
26	OC	〇	〇	〇	OC	X	L	H	H	Z	L	Z	L	Z	Z	L*	Z
27		〇	〇	〇	OC	L	L	H	L	L	L	L	Z	Z	Z	L*	Z
28		〇	〇	〇	OC	H	L	H	L	L	H	L	Z	Z	Z	L*	Z
29		〇	〇	〇	OC	X	H	X	H	L	L	Z	Z	Z	Z	Z	Z
30		〇	〇	〇	OC	X	H	X	L	L	L	L	Z	Z	Z	Z	Z

〇 : V_BATT, VCC2 > UVLO, TOx is normal, X: Don't care, Z: Hi-Z, L*: 40ms low pulse.

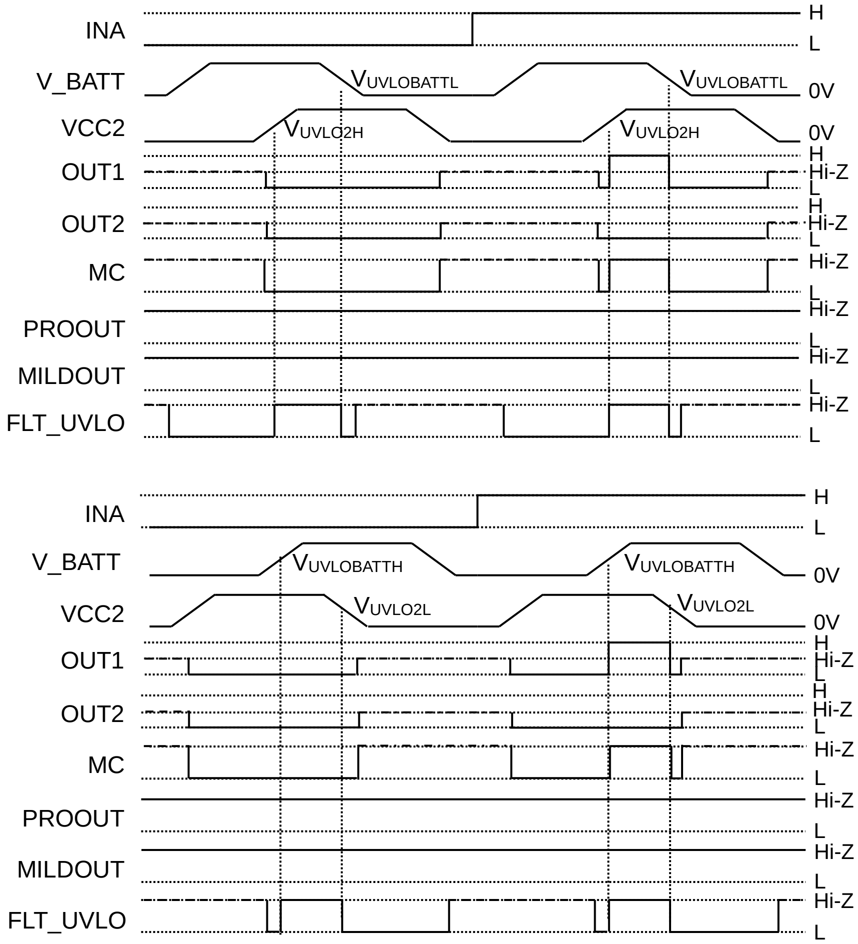
14. I/O Condition Table - continued

No.	Status	Input								Output							
		V_BATT	VCC2	TOx	SCPINx	SPEED	INB	INA	MC	OUT1	OUT2	MC	PROOUT	MILDOUT	FLT_UVLO	FLT_SC	FLT_OT
31	Pre-OC	○	○	○	Pre-OC	X	L	H	H	H	L	Z	Z	Z	Z	Z	Z
32		○	○	○	Pre-OC	X	L	H	L	H	L	Z	Z	Z	Z	Z	Z
33		○	○	○	Pre-OC	X	H	X	H	Z	L	Z	Z	L	Z	Z	Z
34		○	○	○	Pre-OC	L	H	X	L	L	L	L	Z	Z	Z	Z	Z
35		○	○	○	Pre-OC	H	H	X	L	L	H	L	Z	Z	Z	Z	Z
36	Normal	○	○	○	L	L	L	L	H	L	L	Z	Z	Z	Z	Z	Z
37		○	○	○	L	L	L	L	L	L	L	L	Z	Z	Z	Z	Z
38		○	○	○	L	L	H	X	H	L	L	Z	Z	Z	Z	Z	Z
39		○	○	○	L	L	H	X	L	L	L	L	Z	Z	Z	Z	Z
40		○	○	○	L	L	L	H	H	H	L	Z	Z	Z	Z	Z	Z
41		○	○	○	L	L	L	H	L	H	L	Z	Z	Z	Z	Z	Z
42		○	○	○	L	H	L	L	H	L	H	Z	Z	Z	Z	Z	Z
43		○	○	○	L	H	L	L	L	L	H	L	Z	Z	Z	Z	Z
44		○	○	○	L	H	H	X	H	L	H	Z	Z	Z	Z	Z	Z
45		○	○	○	L	H	H	X	L	L	H	L	Z	Z	Z	Z	Z
46		○	○	○	L	H	L	H	H	H	L	Z	Z	Z	Z	Z	Z
47		○	○	○	L	H	L	H	L	H	L	Z	Z	Z	Z	Z	Z

○ : V_BATT, VCC2 > UVLO, TOx is normal, X: Don't care, Z: Hi-Z, L*: 40ms low pulse.

Description of Functions and Examples of Constant Setting - continued

15. Power Supply Startup/Shutdown Sequence



-·-·-·-· : Since the VCC2 pin to the GND2 pin voltage is low and the output MOS does not turn ON, the output pins become Hi-Z conditions.

- - - - - - - : Since the V_BATT pin voltage is low and the FLT_UVLO output MOS does not turn ON, the output pins become Hi-Z conditions.

Figure 63. Power Supply Startup/Shutdown Sequence

Selection of Components Externally Connected

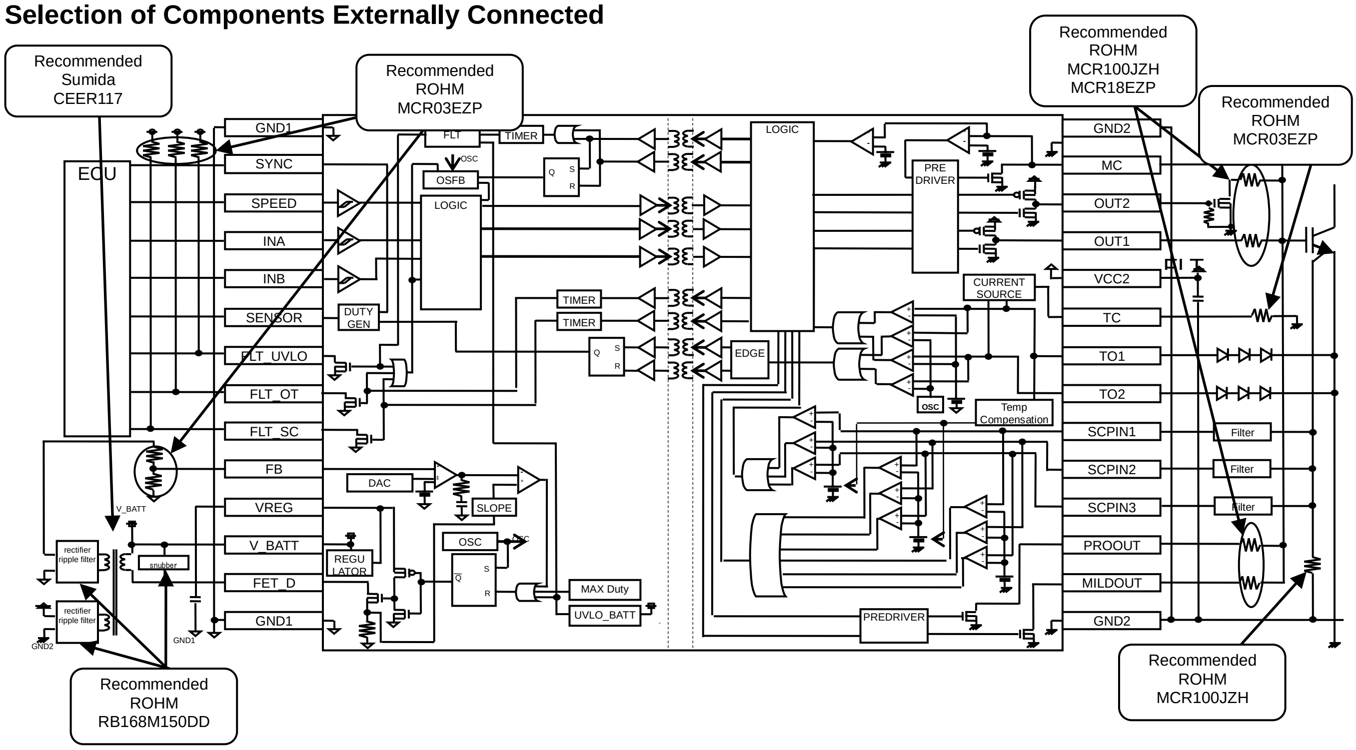


Figure 64. For Using Switching Power Supply Controller

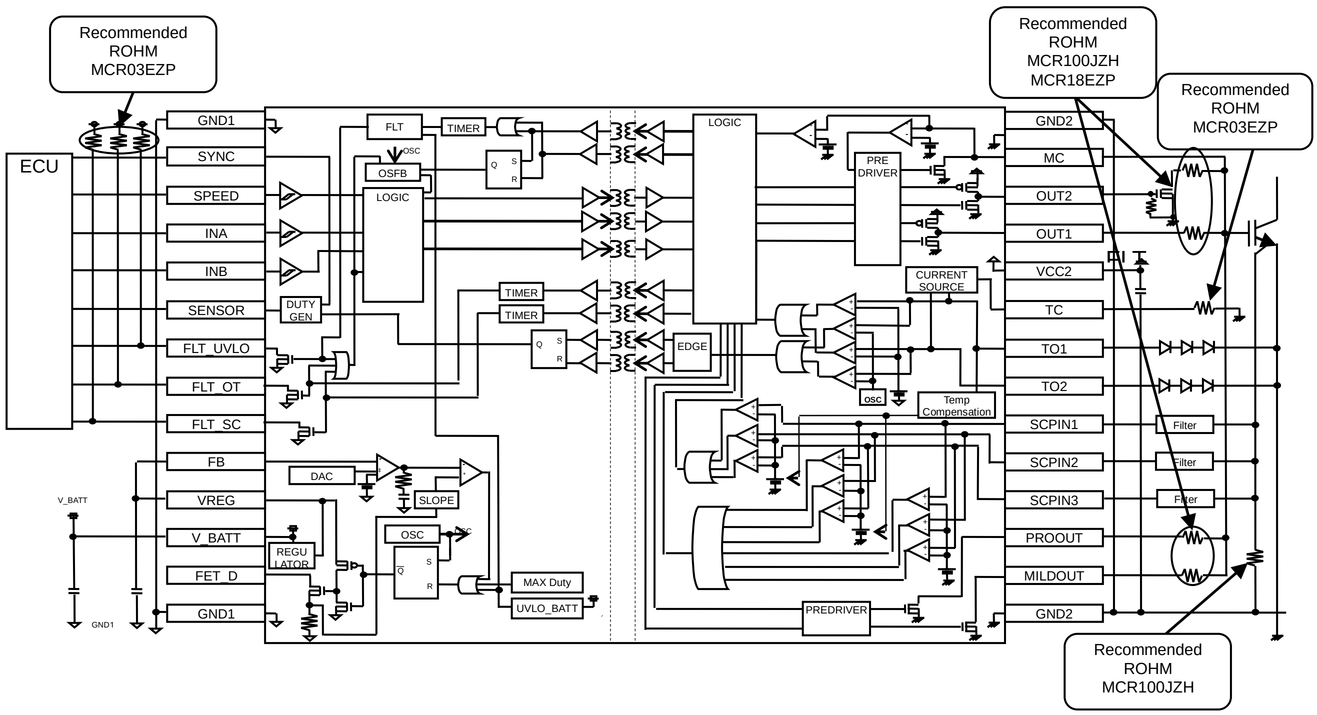
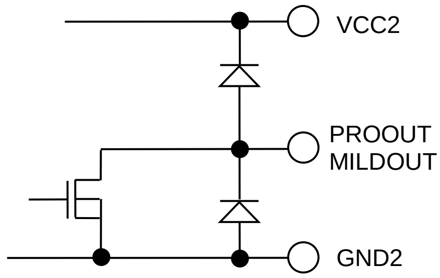
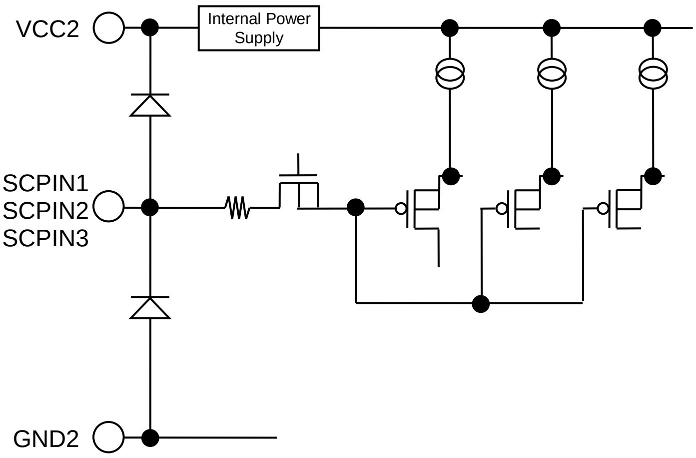
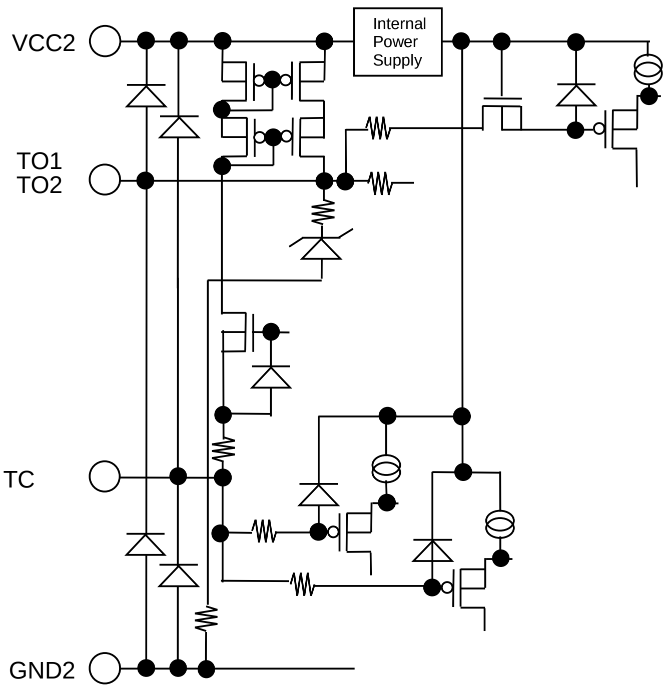
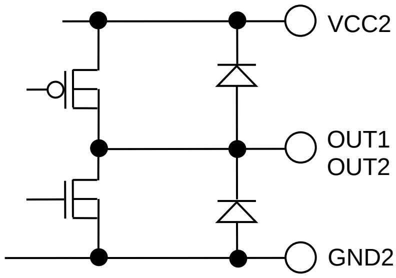
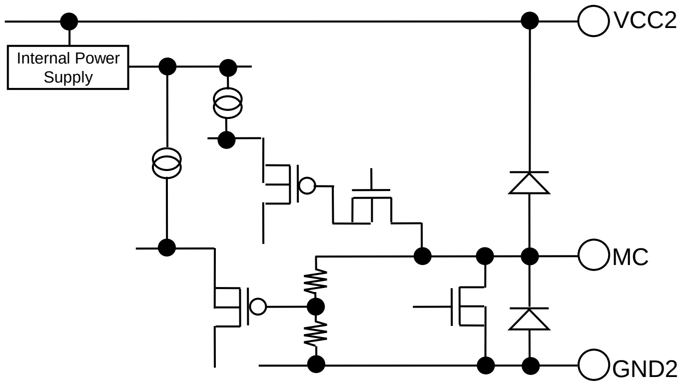
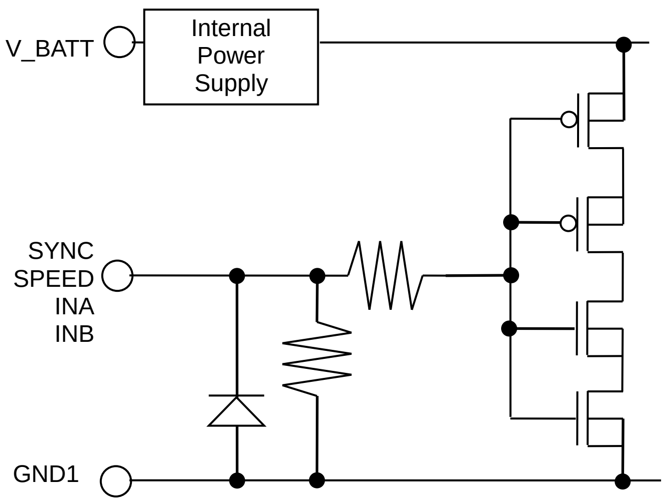
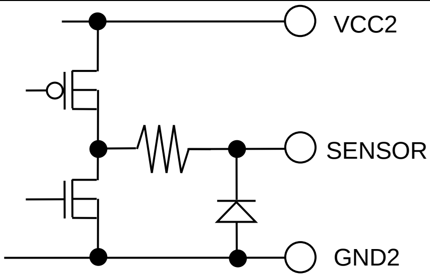


Figure 65. For Non-using Switching Power Supply Controller

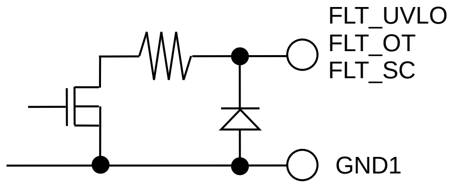
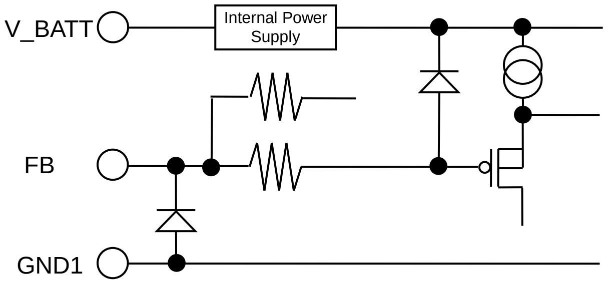
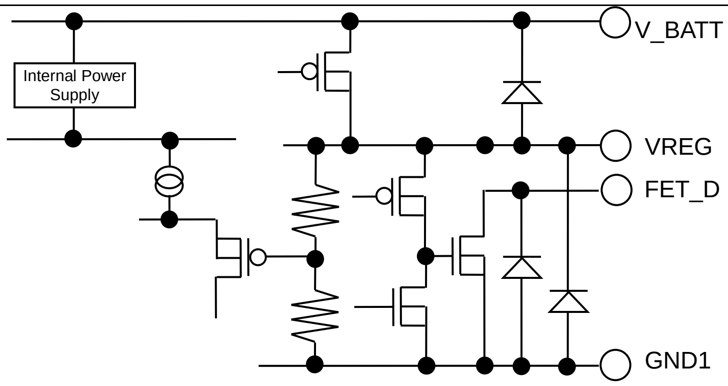
I/O Equivalence Circuit

Pin No.	Pin Name / Pin Function	Input Output Equivalent Circuit Diagram
2	MILDOUT	
	Pre-OC turn off pin	
3	PROOUT	
	Soft turn off pin	
4	SCPIN3	
	Short circuit detection pin 3	
5	SCPIN2	
	Short circuit detection pin 2	
6	SCPIN1	
	Short circuit detection pin 1	
7	TO2	
	Constant current output pin/ Sensor voltage input pin 2	
8	TO1	
	Constant current output pin/ Sensor voltage input pin 1	
9	TC	
	Resistor connection pin for setting constant current source output/ Mode selection input pin of temperature monitor or voltage monitor	

I/O Equivalent Circuit - continued

Pin No.	Pin Name / Pin Function	Input Output Equivalent Circuit Diagram
11	OUT1 / Output pin 1	
12	OUT2 / Output pin 2	(same as pin 11)
13	MC / Input and output pin for Miller Clamp	
16	SYNC / Frequency synchronization input pin for temperature monitor	
17	SPEED / Selectable gate resistance input pin	(same as pin 16)
18	INA / Control input pin A	(same as pin 16)
19	INB / Control input pin B	(same as pin 16)
20	SENSOR / Temperature information output pin	

I/O Equivalent Circuit - continued

<table>
<tr><td rowspan="2">Pin No.</td><td>Pin Name</td><td rowspan="2">Input Output Equivalent Circuit Diagram</td></tr>
<tr><td>Pin Function</td></tr>
<tr><td rowspan="2">21</td><td>FLT_UVLO</td><td rowspan="6"></td></tr>
<tr><td>Fault (UVLO) output pin</td></tr>
<tr><td rowspan="2">22</td><td>FLT_OT</td></tr>
<tr><td>Fault (OT,OV) output pin</td></tr>
<tr><td rowspan="2">23</td><td>FLT_SC</td></tr>
<tr><td>Fault (SCP) output pin</td></tr>
<tr><td rowspan="2">24</td><td>FB</td><td rowspan="2"></td></tr>
<tr><td>Error amplifier inverting input pin for switching controller</td></tr>
<tr><td rowspan="2">25</td><td>VREG</td><td rowspan="4"></td></tr>
<tr><td>Power supply pin for drive MOS FET for Switching controller</td></tr>
<tr><td rowspan="2">27</td><td>FET_D</td></tr>
<tr><td>Switching pin for switching controller</td></tr>
</table>

Operational Notes

1. **Reverse Connection of Power Supply**
Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

2. **Power Supply Lines**
Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

3. **Ground Voltage**
Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

4. **Ground Wiring Pattern**
When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

5. **Recommended Operating Conditions**
The function and operation of the IC are guaranteed within the range specified by the recommended operating conditions. The characteristic values are guaranteed only under the conditions of each item specified by the electrical characteristics.

6. **Inrush Current**
When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

7. **Operation Under Strong Electromagnetic Field**
Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

8. **Testing on Application Boards**
When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

9. **Inter-pin Short and Mounting Errors**
Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

10. **Unused Input Pins**
Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

Operational Notes – continued

11. Regarding the Input Pin of the IC

This IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When GND > Pin A and GND > Pin B, the P-N junction operates as a parasitic diode.
When GND > Pin B, the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

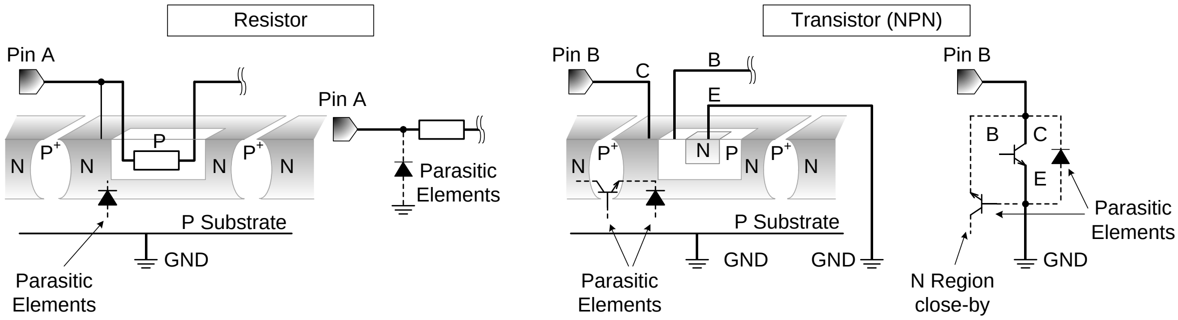


Figure 66. Example of IC Structure

12. Ceramic Capacitor

When using a ceramic capacitor, determine a capacitance value considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

13. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and the maximum junction temperature rating are all within the Area of Safe Operation (ASO).

Ordering Information

B M 6 0 0 5 6 F V - C E 2

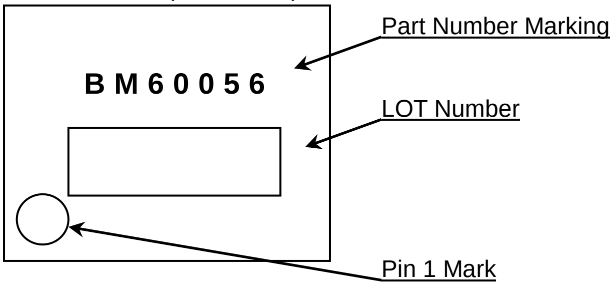
Part Number

Package
FV : SSOP-B28W

Product class
C : for Automotive applications
Packaging and forming specification
E2 : Embossed tape and reel
(SSOP-B28W)

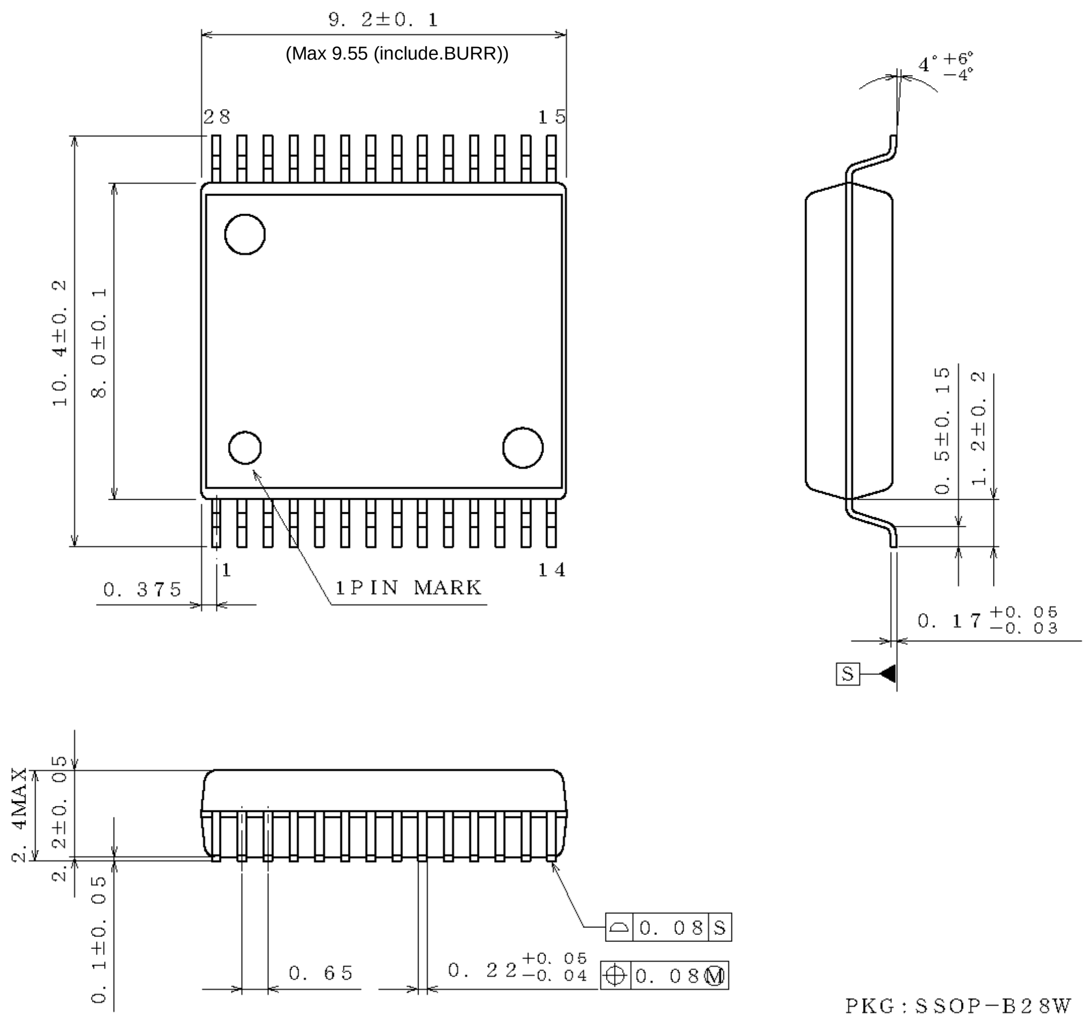
Marking Diagram

SSOP-B28W (TOP VIEW)



Physical Dimension and Packing Information

Package Name	SSOP-B28W

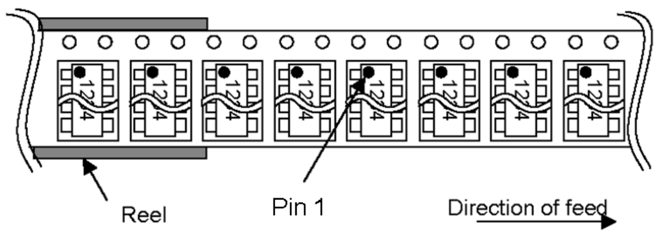


PKG : SSOP−B28W
Drawing No. ; EX072−5001

(UNIT : mm)

< Tape and Reel Information >

Tape	Embossed carrier tape
Quantity	1500pcs
Direction of feed	E2 The direction is the pin 1 of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand



Revision History

Date	Revision	Changes
20.Jun.2018	001	New Release

Notice

Precaution on using ROHM Products

1. If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment (Note 1), aircraft/spacecraft, nuclear power controllers, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

<table>
<tr><th>JAPAN</th><th>USA</th><th>EU</th><th>CHINA</th></tr>
<tr><td>CLASSⅢ</td><td rowspan="2">CLASSⅢ</td><td>CLASSⅡb</td><td rowspan="2">CLASSⅢ</td></tr>
<tr><td>CLASSⅣ</td><td>CLASSⅢ</td></tr>
</table>

2. ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
   [a] Installation of protection circuits or other protective devices to improve system safety
   [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure

3. Our Products are not designed under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc, prior to use, must be necessary:
   [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
   [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
   [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl_2, H_2S, NH_3, SO_2, and NO_2
   [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
   [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
   [f] Sealing or coating our Products with resin or other coating materials
   [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
   [h] Use of the Products in places subject to dew condensation

4. The Products are not subject to radiation-proof design.

5. Please verify and confirm characteristics of the final or mounted products in using the Products.

6. In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.

7. De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.

8. Confirm that operation temperature is within the specified range described in the product specification.

9. ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

Precaution for Mounting / Circuit board design

1. When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.

2. In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.

2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
   [a] the Products are exposed to sea winds or corrosive gases, including Cl2, H2S, NH3, SO2, and NO2
   [b] the temperature or humidity exceeds those recommended by ROHM
   [c] the Products are exposed to direct sunshine or condensation
   [d] the Products are exposed to high Electrostatic

2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.

3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.

4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

Precaution Regarding Intellectual Property Rights

1. All information and data including but not limited to application example contained in this document is for reference only. ROHM does not warrant that foregoing information or data will not infringe any intellectual property rights or any other rights of any third party regarding such information or data.
2. ROHM shall not have any obligations where the claims, actions or demands arising from the combination of the Products with other articles such as components, circuits, systems or external equipment (including software).
3. No license, expressly or implied, is granted hereby under any intellectual property rights or other rights of ROHM or any third parties with respect to the Products or the information contained in this document. Provided, however, that ROHM will not assert its intellectual property rights or other rights against you or your customers to the extent necessary to manufacture or sell products containing the Products, subject to the terms and conditions herein.

Other Precaution

1. This document may not be reprinted or reproduced, in whole or in part, without prior written consent of ROHM.
2. The Products may not be disassembled, converted, modified, reproduced or otherwise changed without prior written consent of ROHM.
3. In no event shall you use in any way whatsoever the Products and the related technical information contained in the Products or this document for any military purposes, including but not limited to, the development of mass-destruction weapons.
4. The proper names of companies or products described in this document are trademarks or registered trademarks of ROHM, its affiliated companies or third parties.

General Precaution

1. Before you use our Products, you are requested to carefully read this document and fully understand its contents. ROHM shall not be in any way responsible or liable for failure, malfunction or accident arising from the use of any ROHM's Products against warning, caution or note contained in this document.

2. All information contained in this document is current as of the issuing date and subject to change without any prior notice. Before purchasing or using ROHM's Products, please confirm the latest information with a ROHM sales representative.

3. The information contained in this document is provided on an "as is" basis and ROHM does not warrant that all information contained in this document is accurate and/or error-free. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties resulting from inaccuracy or errors of or concerning such information.