2ch Synchronous Step-down DC/DC Converter + 1ch LDO + 2ch P-GOOD
Monolithic IC MM3558 Series

Outline

This IC is a compound power supply IC which built in Synchronous Step-down DC/DC converter 2ch, LDO1ch, and P-GOOD2ch.
The ripple of the input current is decreased so that the DC/DC converter of 2ch may work by the opposite phase, and a low noise is achieved. Because the output voltage can be set by external resistance, it is possible to use it according to various output conditions.

Features

1. Input Operating Voltage Range	3.0V~5.5V	
2. Shutdown Supply Current	0.1μA (Typ.)	
3. Temperature Range	−30~+85°C	
4. DC/DC converters		
Output Voltage	1.0V~PVIN	Accuracy ±2%
Maximum Output Current	1.5A / 1ch	
Oscillator Frequency	2MHz (Typ.)	
Output Voltage is changeable in external parts.		
Built-in start/stop sequence circuit.		
Output OverVoltage Protection function	0.72V (Typ.)	
Built-in SoftStart circuit	1.5ms (Typ.)	
Built-in OverCurrent detection timer	1.5ms (Typ.)	
5. LDO		
Output Voltage	3.3V	Accuracy ±1%
Dropout voltage	0.10V (Typ.)	
Current limit	40mA (Typ.)	
6. P-GOOD		
Input/Output Over Voltage/Low Voltage, Over Current, and Thermal detection.		

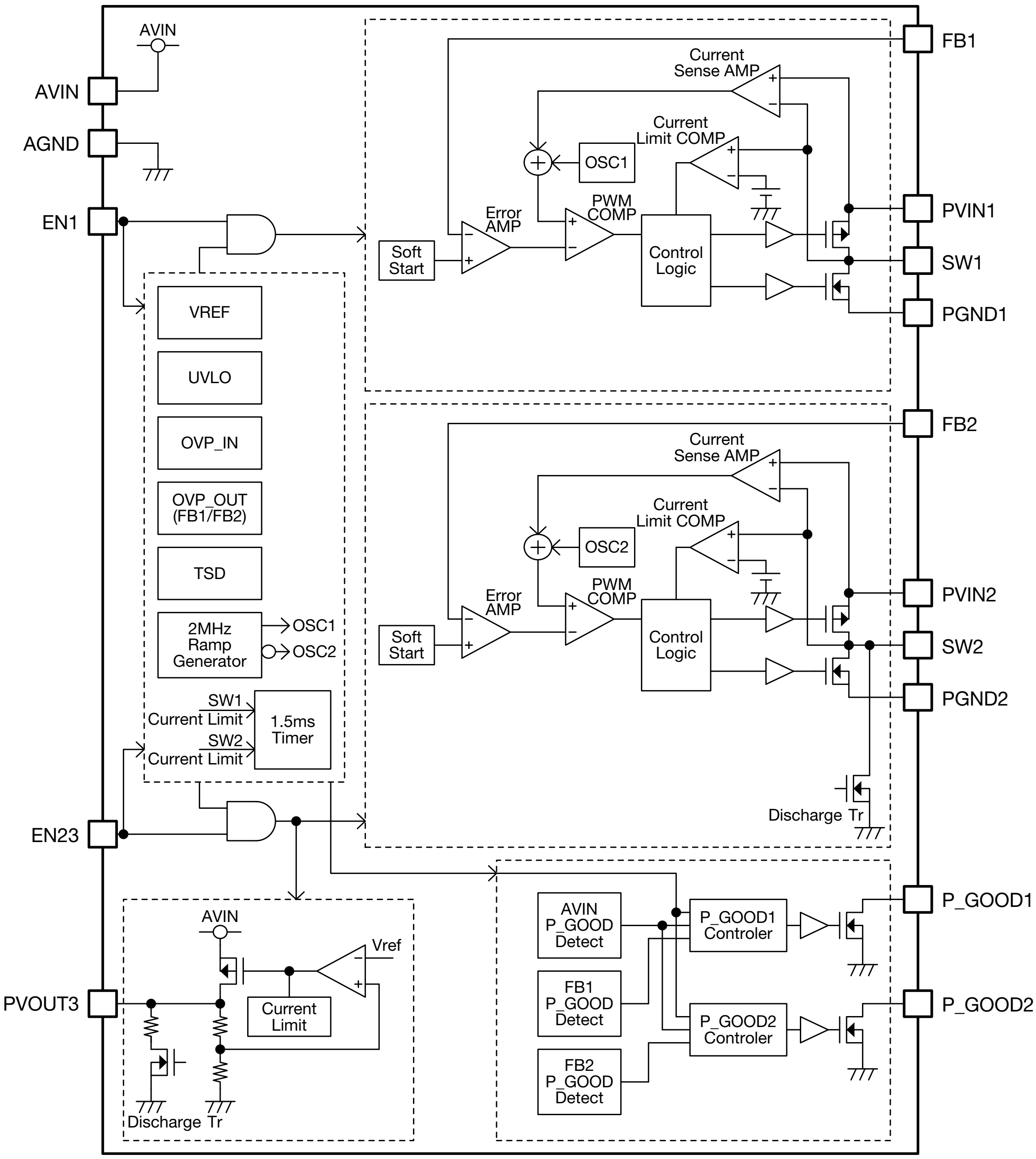
Package

SQFN-16A

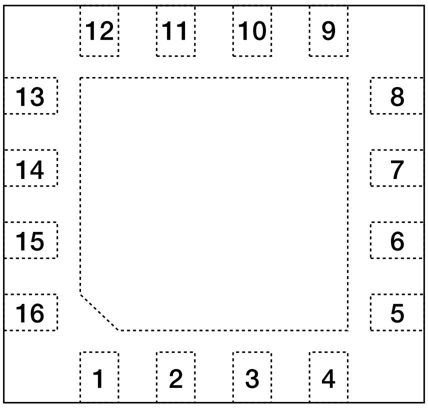
Applications

1. Printer
2. Composit device

Block Diagram



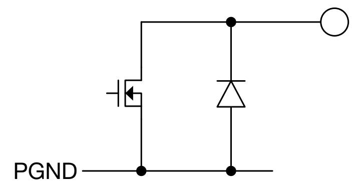
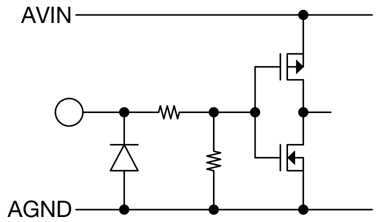
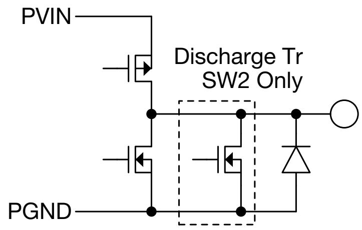
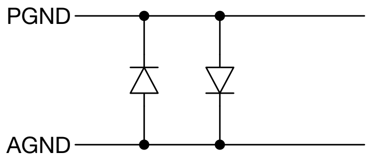
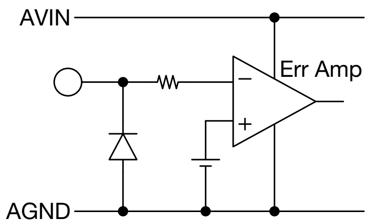
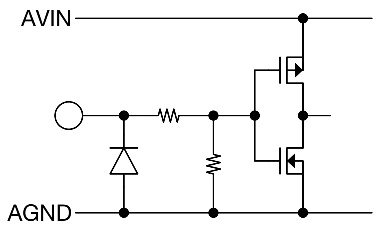
Pin Assignment

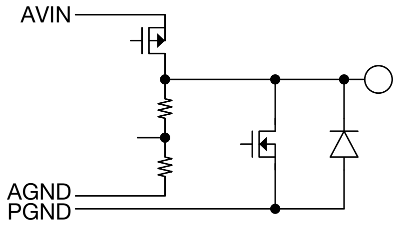
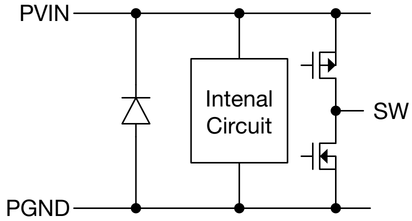
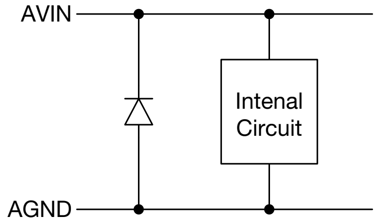


SQFN-16A
(TOP VIEW)

1	P_GOOD2	9	PGND2
2	EN1	10	SW2
3	SW1	11	EN23
4	PGND1	12	P_GOOD1
5	FB1	13	PVIN2
6	TP	14	AVIN
7	PVOUT3	15	AGND
8	FB2	16	PVIN1

Pin Description

Pin No.	Pin name	Pin description	Internal equivalent circuit diagram
1 12	P_GOOD2 P_GOOD1	Power Good output pin	
2 11	EN1 EN23	Enable pin for ON/OFF	
3 10	SW1 SW2	Power switched pin	
4 9 15	PGND1 PGND2 AGND	Ground pin	
5 8	FB1 FB2	DC/DC output voltage feedback pin	
6	TP	Test pin (Please connect with GND.)	

Pin No.	Pin name	Pin description	Internal equivalent circuit diagram
7	PVOUT3	Regulator output pin	
13 16	PVIN2 PVIN1	Power supply input pin	
14	AVIN	Power supply input pin	

Absolute Maximum Ratings (Except where noted otherwise Ta=25°C)

Item	Symbol	Ratings	Units
AVIN Voltage	V_{AVIN}	−0.3~+6.0	V
PVIN1 Voltage	V_{PVIN1}	−0.3~+6.0	V
PVIN2 Voltage	V_{PVIN2}	−0.3~+6.0	V
SW1 Voltage	V_{SW1}	−0.6~V_{PVIN1}+0.3	V
SW2 Voltage	V_{SW2}	−0.6~V_{PVIN2}+0.3	V
FB1 Voltage	V_{FB1}	−0.3~+6.0	V
FB2 Voltage	V_{FB2}	−0.3~+6.0	V
P_GOOD1 Voltage	V_{PG1}	−0.3~+6.0	V
P_GOOD2 Voltage	V_{PG2}	−0.3~+6.0	V
EN1 Voltage	V_{EN1}	−0.3~+6.0	V
EN23 Voltage	V_{EN23}	−0.3~+6.0	V
PVOUT3 Voltage	V_{PVO3}	−0.3~V_{AVIN}+0.3	V
SW1 Maximum Current	I_{SW1}	1.8	A
SW2 Maximum Current	I_{SW2}	1.8	A
P_GOOD1 Maximum Current	I_{PG1}	200	mA
P_GOOD2 Maximum Current	I_{PG2}	200	mA
PVOUT3 Maximum Current	I_{PVO3}	50	mA
Storage Temperature	T_{STG}	−55~+150	°C
Power Dissipation (Alone)	P_D	220 (Note1)	mW

Note1 : The values indicate reference values.

Recommended Operating Conditions (Except where noted otherwise Ta=25°C)

Item	Symbol	Ratings	Units
AVIN Voltage	V_{AVIN}	3.0~5.5	V
PVIN1 Voltage	V_{PVIN1}	3.0~5.5	V
PVIN2 Voltage	V_{PVIN2}	3.0~5.5	V
SW1 Current	I_{SW1}	0~1.5	A
SW2 Current	I_{SW2}	0~1.5	A
DC/DC Converter Output Voltage (Note2)	V_{DCO}	1.0~PVIN	V
PVOUT3 Current	I_{PVO3}	0~10	mA
Operating Temperature	T_{OPR}	−30~+85	°C
Junction Temperature (Note3)	T_J	150	°C

Note2 : There is a case to take operation from 1 to 2 when applying to the following condition in addition to the thing without the voltage difference between the input and the output.

- · Duty 90% or more
- · Hiside Tr ON resistance × load current > voltage difference between the input and the output

1) If Duty becomes 100%, the output voltage decreases depending on "Input voltage- Hiside Tr ON resistance × load current".
2) There is a case that becomes operation that the switching operates at a cycle different from the oscillatory frequency that looks like the abnormally oscillation.

Note3 : Please calculate TJ from ambient temperature TA and power consumption Preferring to the next expression.

TJ = TA + P × 62.2 °C/W

Thermal resistance 62.2 °C/W is a value when the substrate size mounts on two glass epoxy layer substrate of 90×90×1.6mm^3 (copper interconnect rate 90%).

Electrical Characteristics

(Except where noted otherwise AVIN=PVIN1=PVIN2=5.0V, EN1=EN23=5.0V, Ta=25°C)

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units	Measuring Circuit No.
Supply Current1 (DCDC1)	I_{DD1}	EN1=5V, EN23=0V FB1=0.65V		350	525	μA	2
Supply Current2 (DCDC2, PVOUT3)	I_{DD2}	EN1=0V, EN23=5V FB2=0.65V		400	600	μA	2
Supply Current (No switching)	I_{DD3}	FB1=FB2=0.55V PVOUT3=No Load		600	900	μA	2
Shutdown Current	I_{OFF}	EN1=EN23=0V		0.1	1.0	μA	2
VIN UVLO Detection Voltage	V_{UVLOD}	AVIN=4.5V→0V	2.45	2.55	2.65	V	2
VIN UVLO Release Voltage	V_{UVLOR}	AVIN=0V→4.5V	V_{UVLOD} +100	V_{UVLOD} +150	V_{UVLOD} +200	mV	2
OVP_IN Detection Voltage	V_{OVPID}	AVIN=5.0V→6.0V	5.6	5.8	6.0	V	2
OVP_IN Release Voltage	V_{OVPIR}	AVIN=6.0V→5.0V		V_{OVPID} −150		mV	2
OVP_OUT Detection Voltage	V_{OVPOD}	FB1(FB2)=0.6→0.8V	0.66	0.72	0.76	V	2
OVP_OUT Release Voltage	V_{OVPOR}	FB1(FB2)=0.8→0.6V		V_{OVPOD} −25		mV	2
EN1, EN23 pin "High" Input Voltage	V_{ENH}		AVIN/2			V	2
EN1, EN23 pin "Low" Input Voltage	V_{ENL}				0.5	V	2
EN1, EN23 Pin Input Current	I_{EN}	EN=6V		2		μA	2
Thermal Shutdown Detection	V_{THD}	No switching		150		°C	
Thermal Shutdown Release	V_{THR}	No switching		120		°C	
DC/DC converter							
FB1, 2 Voltage	V_{FBPWM}	VOUT=1.8V L=2.7μH, COUT=22μF	0.588	0.600	0.612	V	1
FB1, 2 Pin Current	I_{FB}	FB1=FB2=6V	−1.0		+1.0	μA	2
Oscillator Frequency	f_{OSC}		1.8	2.0	2.2	MHz	1
Hiside Tr Current Limit (Note4)	I_{LIMSW}		1.7		3.0	A	1
Hiside Tr ON Resistance	R_{SWH}	SW1(SW2)=100mA sink		0.3	0.6	Ω	2
Lowside Tr ON Resistance	R_{SWL}	SW1(SW2)=100mA source		0.25	0.5	Ω	2
Soft Start Time	t_{SS}	Time till it reaches to FB×0.9	0.5	1.5	2.5	ms	1
SW2 Pin Discharge Tr ON Resistance	R_{DSW2}	EN23=0V SW2=5.0V		100		Ω	2

Note4 : The parameter is guaranteed by design.

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units	Measuring Circuit No.
Regulator							
PVOUT3 Output Voltage 1	V_{VO31}	PVOUT3=No load	3.267	3.300	3.333	V	1
PVOUT3 Output Voltage 2	V_{VO32}	PVOUT3=10mA	3.252	3.300	3.333	V	1
Line Regulation	V_{LINE}	PVOUT3=1mA AVIN=3.4 to 5.5V		0.05	0.25	%/V	1
Load Regulation	V_{LOAD}	1mA≦PVOUT3≦10mA		5	15	mV	1
Dropout Voltage	V_{IO}	PVOUT3=10mA AVIN=3.1V		0.10	0.18	V	1
Ripple Rejection 1 (Note5)	RR1	PVOUT3=1mA f=1kHz		60		dB	
Ripple Rejection 2 (Note5)	RR2	PVOUT3=1mA f=10kHz		40		dB	
Output Short-circuit Current (Note5)	I_{LIM}	VPVO3=0V		40		mA	
PVOUT3 Discharge Tr ON Resistance PVOUT3	R_{DVO3}	EN23=0V PVOUT3=3.3V		1		kΩ	2
Power Good							
P_GOOD1, 2 Detection Voltage	V_{PGAD}	Monitor AVIN Voltage AVIN=2.8→0V		V_{UVLOD} +50		mV	2
P_GOOD1 Detection Voltage	V_{PGFB1D}	Monitor FB1 Voltage FB1=0.6→0V	0.46	0.50	0.54	V	2
P_GOOD2 Detection Voltage	V_{PGFB2D}	Monitor FB2 Voltage FB2=0.6→0V	0.46	0.50	0.54	V	2
P_GOOD1, P_GOOD2 Release Voltage	V_{PGAR}	Monitor AVIN Voltage AVIN=0→2.8V	V_{PGAD} +100	V_{PGAD} +150	V_{PGAD} +200	mV	2
P_GOOD1 Release Voltage	V_{PGFB1R}	Monitor FB1 Voltage FB1=0→0.8V	V_{PGFB1D} +10	V_{PGFB1D} +25	V_{PGFB1D} +40	mV	2
P_GOOD2 Release Voltage	V_{PGFB2R}	Monitor FB2 Voltage FB2=0→0.8V	V_{PGFB2D} +10	V_{PGFB2D} +25	V_{PGFB2D} +40	mV	2
P_GOOD1, 2 "L" Output Voltage	V_{PGOL}	FB1=FB2=0V P_GOOD1, 2=10mA		0.12	0.30	V	2
P_GOOD1, 2 Pin Sink Current (Note5, 6)	I_{PGSINK}	FB1=FB2=0V P_GOOD1, 2=5V	100	150		mA	2
P_GOOD1, 2 Pin Leakage Current	I_{PGLK}	FB1=FB2=0.65V P_GOOD1, 2=6V	−1.0		+1.0	µA	2

Note5 : The parameter is guaranteed by design.

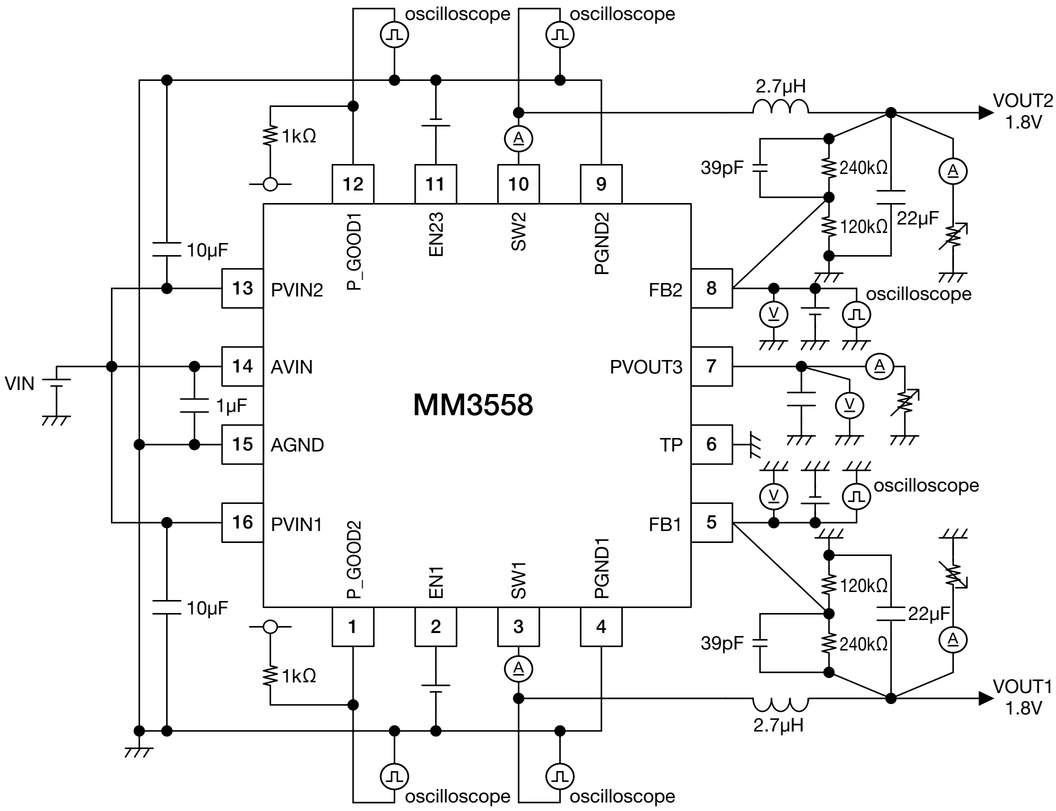
Note6 : Please use it under Power dissipation. It shows in 13.TYPICAL APPLICATION CIRCUIT about calculation method of Loss.

Item	Symbol	Measurement conditions	Min.	Typ.	Max.	Units	Measuring Circuit No.
Delay time							
Start / Stop Delay Time (Note7)	t_{STDLY}	EN1, 23=0V⇔3V EN1 : Ch1 enable EN23 : Ch2, LDO enable		10		us	2
P_GOOD Detection Blanking Time During SoftStart (Note7)	t_{DTDLY_SS}			5.5× t_{SS}	8.3× t_{SS}	ms	1
P_GOOD Detection Blanking Time (Note7)	t_{DTDLY}	AVIN=4.5V→V_{PGAD}, FB1(FB2)=0.6→V_{PGFB}		10		us	2
SW1, 2 Current Limit Timer Latch Time (Note7)	$t_{LIMSWDLY}$			1.5		ms	1

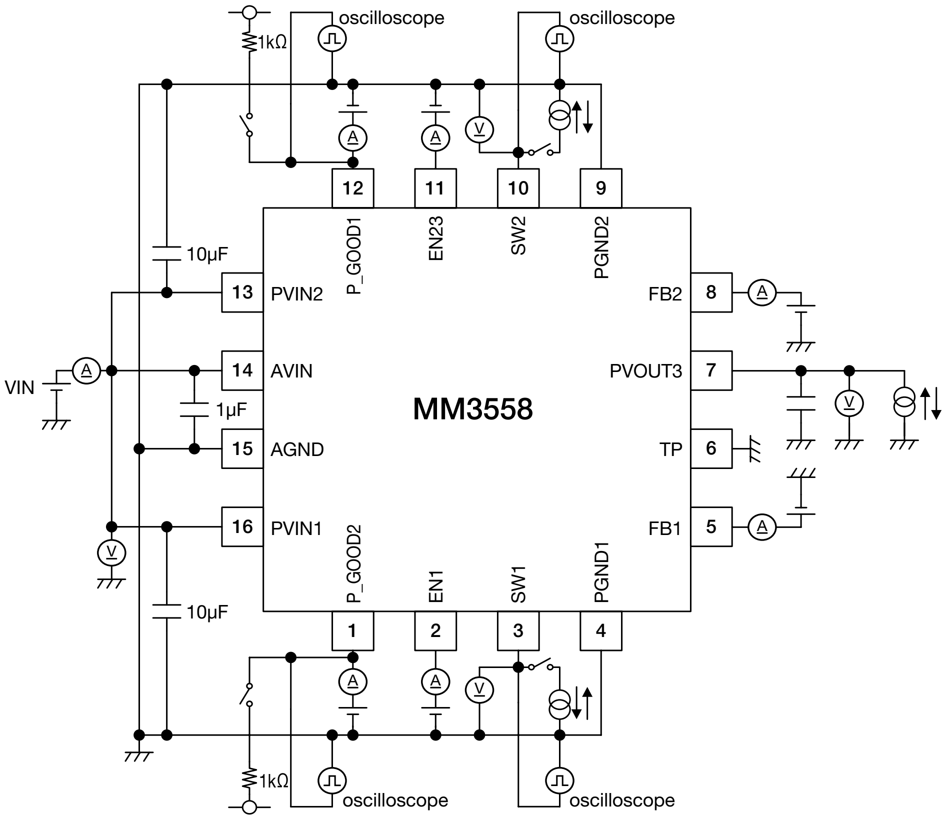
Note7 : The parameter is guaranteed by design.

Measuring Circuit

(1)

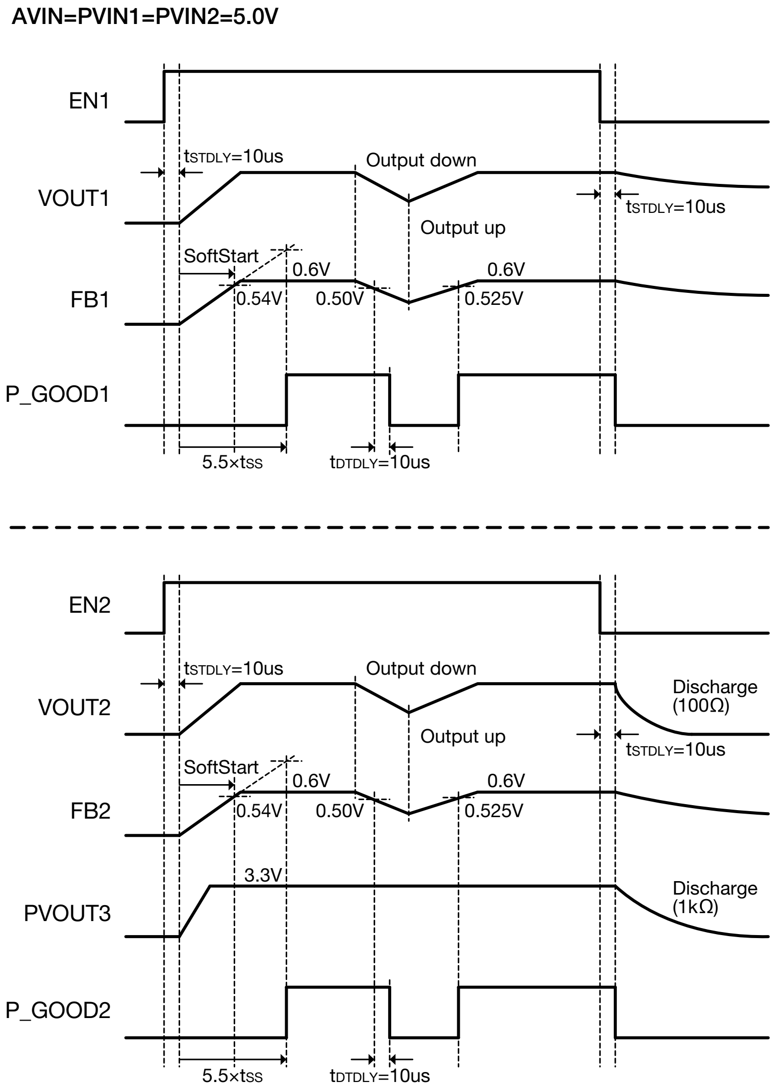


(2)



Timing Chart

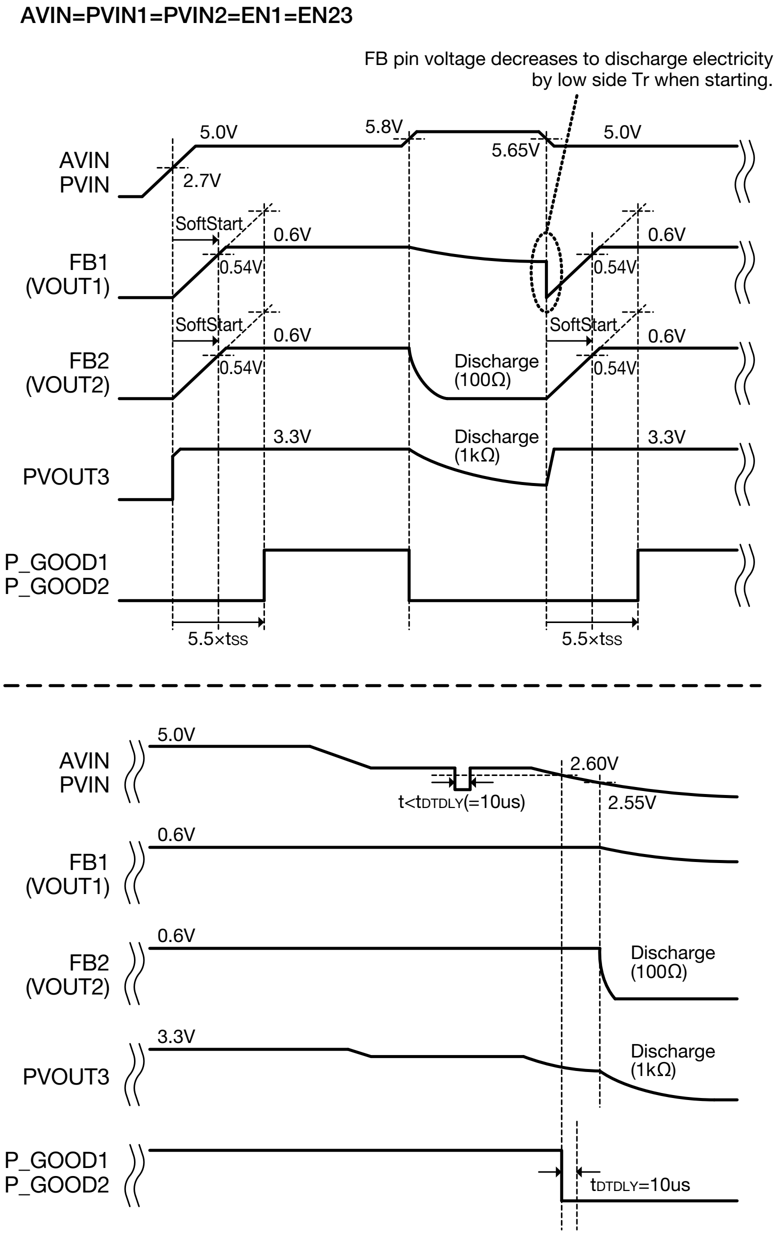
(1) Each output start, stop timing



The delay time (10us typ.) has been set for the input of enable terminal EN1 and EN23.
Therefore, IC-output doesn't response when a short signal of the cycle is input to an enable terminal at delay time.

(2) Protected operation

• UVLO detection, OVP_IN detection

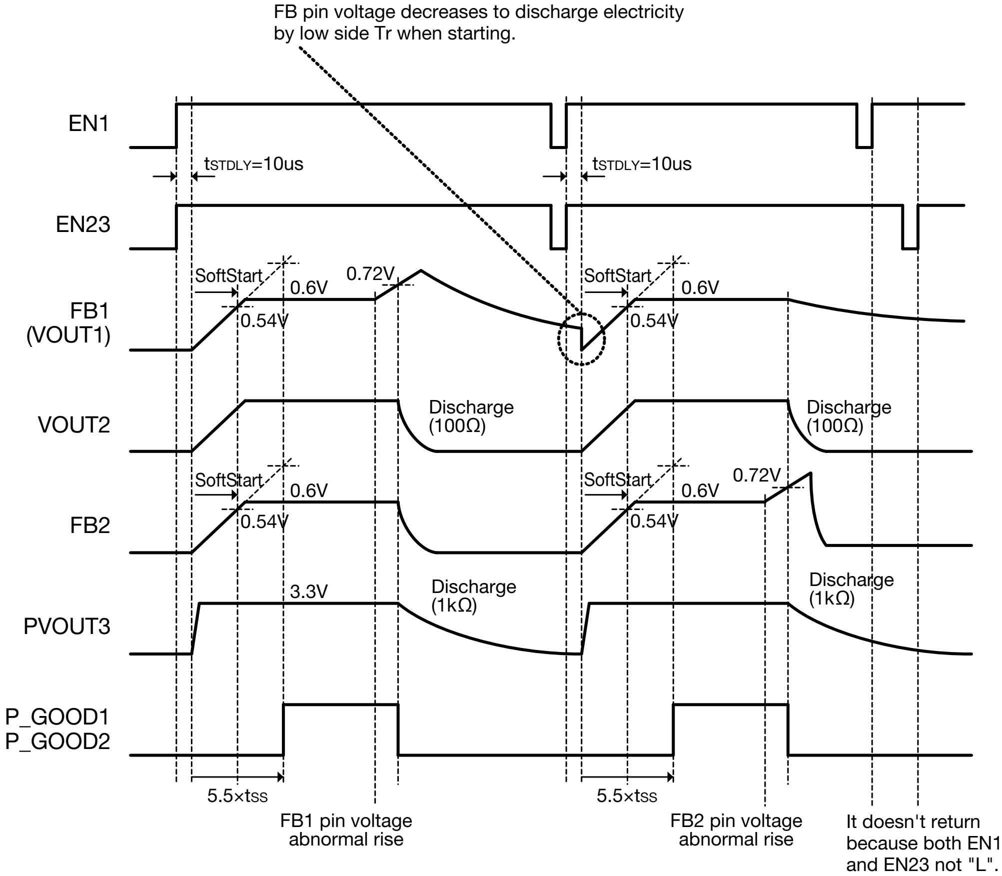


When AVIN rises and the input overvoltage is detected, VOUT1, 2, and PVOUT3 are turned off.
Operation can be returned by decreasing AVIN.

The P_GOOD changes to "L" in the condition of the AVIN≦P_GOOD detecting voltage (Monitor AVIN voltage) after delay time.
However, it doesn't respond for a signal of the cycle short following delay time.

• OVP_OUT detection

AVIN=PVIN1=PVIN2=5.0V

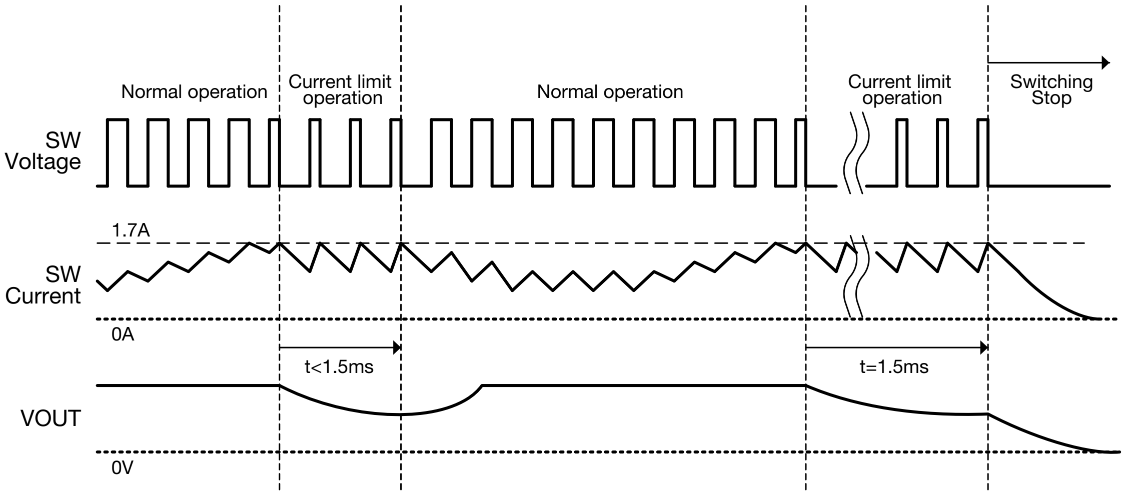


The output overvoltage protection circuit works when the DC/DC converter voltage of the FB pin exceeds 0.72V(TYP.), the switching of SW1 and SW2 stops, the PVOUT3 output is turned off, and the state is maintained.

It is necessary to decrease AVIN below VIN UVLO detection voltage so that the FB pin may release (FB1, FB2< 0.72V) when released and the state of the latch from the state of the output overvoltage or to make both EN1 and EN23 "L".

(3) Over current protection

• Over current protection for DC/DC converter



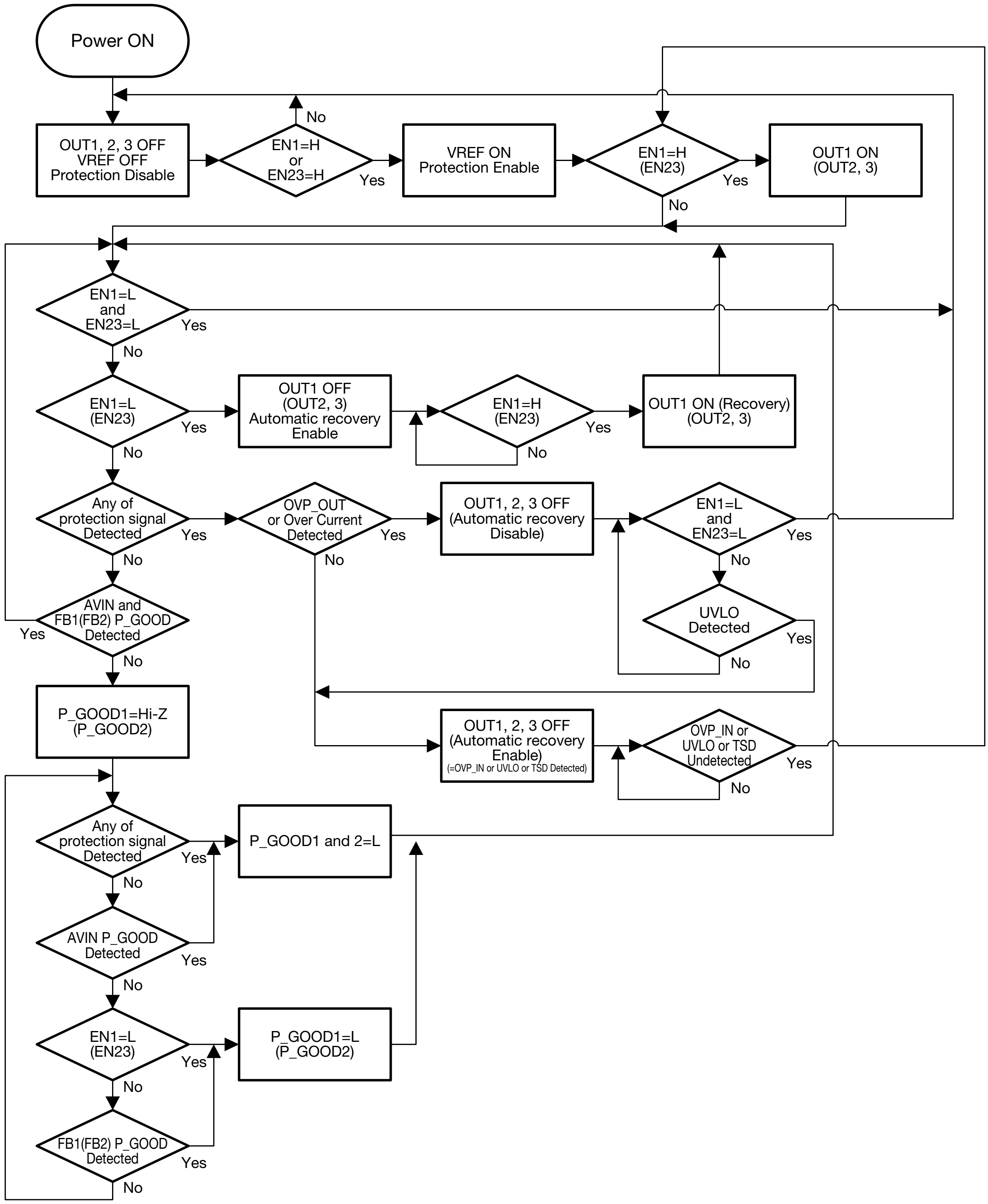
When a current limit is continuously detected between 1.5ms, the DC/DC converter maintains OFF state with the short-circuit protection circuit. And, both SW1 and SW2 switching are stopped, and the PVOUT3 output is turned off, too.

The output of the DC/DC converter and PVOUT3 returns by turning on both the re-turning on or EN1 and EN23 power supplies again.

• Over current protection for PVOUT3

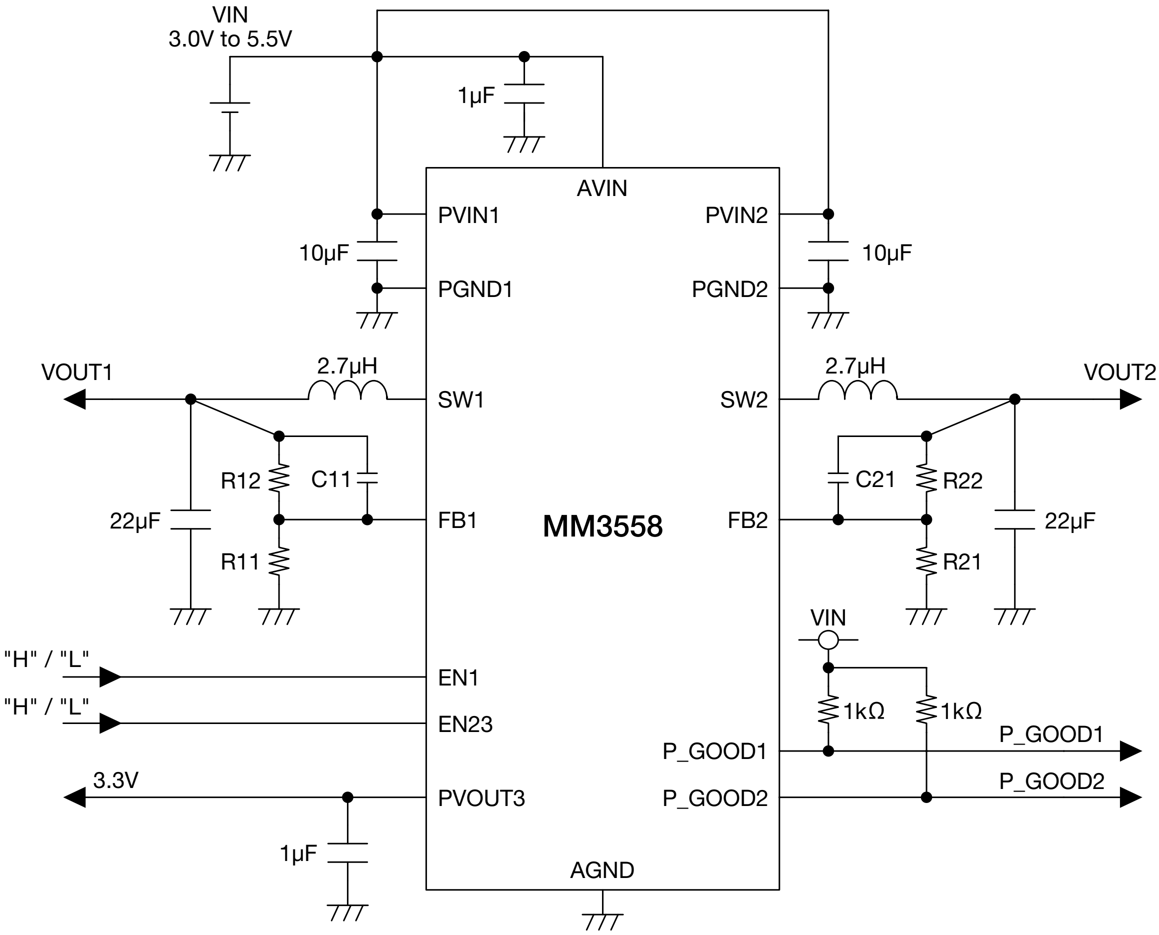
Even if over-current protection of PVOUT3 is effective, it does not have the influence on DC/DC converter operation. The output of PVOUT3 will also return, if over-current protection of PVOUT3 is canceled.

Flow Chart



Power ON
OUT1, 2, 3 OFF
VREF OFF
Protection Disable
EN1=H
or
EN23=H
No
Yes
VREF ON
Protection Enable
EN1=H
(EN23)
Yes
No
OUT1 ON
(OUT2, 3)
EN1=L
and
EN23=L
Yes
No
EN1=L
(EN23)
Yes
No
OUT1 OFF
(OUT2, 3)
Automatic recovery
Enable
EN1=H
(EN23)
Yes
No
OUT1 ON (Recovery)
(OUT2, 3)
Any of
protection signal
Detected
Yes
No
OVP_OUT
or Over Current
Detected
Yes
No
OUT1, 2, 3 OFF
(Automatic recovery
Disable)
EN1=L
and
EN23=L
Yes
No
UVLO
Detected
Yes
No
AVIN and
FB1(FB2) P_GOOD
Detected
Yes
No
P_GOOD1=Hi-Z
(P_GOOD2)
OUT1, 2, 3 OFF
(Automatic recovery
Enable)
(=OVP_IN or UVLO or TSD Detected)
OVP_IN or
UVLO or TSD
Undetected
Yes
No
Any of
protection signal
Detected
Yes
No
P_GOOD1 and 2=L
AVIN P_GOOD
Detected
Yes
No
EN1=L
(EN23)
Yes
No
P_GOOD1=L
(P_GOOD2)
FB1(FB2) P_GOOD
Detected
Yes
No

Application Circuit



Application notes

(1) Setting of output voltage

- The output voltage can be calculated by the following expressions.

  VOUT1=0.6×(1+R12/R11)
- Please set not to exceed R11+R12=1MΩ from the reason for stability.
- Please adjust for Zero points fz of the feedback loop to become 20kHz the value of C11 for the phase compensation. Zero points fz are calculated by the following expression.

  fz=1/(2×π×C11×R12)
- It becomes the best by adjusting fz according to the value of the usage, inductance, and the output capacity.
- Please set VOUT2 as well as VOUT1.

(2) When PVOUT3 is not used

- The capacitor of 1uF is recommended to be connected with the terminal even when PVOUT3 is not used.
- There is a possibility of connecting it with the problem of an increase of the supply current etc. when the terminal is opened or it is used while it is short-circuited in the power supply.

(3) About the calculation of IC loss

- The substrate size mounts on two glass epoxy layer substrate (90% of rate of copper interconnect) to which it is referring in Note3 of the RECOMMENDED OPERATING CONDITIONS is computed for an example.
- The power dissipation at 25°C to 150°C is computable with about 2.01 W from thermal resistance 62.2°C/W. For example, when carrying out the pull-up of the P_GOOD terminal to an external power supply, if it connects with 5V power supply directly, 150 mA (typ.) sink current will flow. As a loss of a P_GOOD terminal, P_{P_GOOD} = 5V x 150mA = 0.75W occur.
  When P_GOOD1 and 2 both sides are set as the same conditions, since 1.5W (typ.) loss occurs, it is the calculation which generates heat about 93.3°C.
  By element variation, temperature variation, other losses in a circuit, and thermal resistance by substrate conditions, since a loss/calorific value is changed, please set up the conditions of a P_GOOD terminal after fully examining a loss and calorific value by the set of use.

(4) About the output operation of 1.0V or less

- If an input-and-output voltage difference is large and ON Duty falls, it becomes impossible to take operation in the PWM mode stable like following figure A.
  The stability of input voltage of operation over 1.0V or less is shown in figure B.

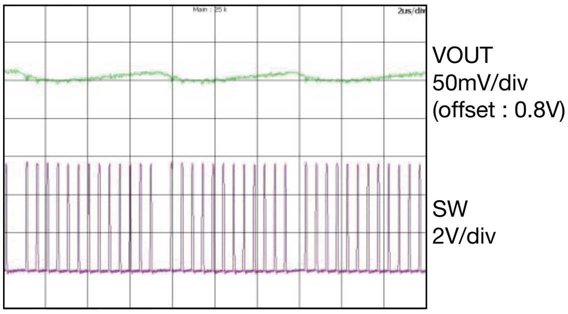


Figure.A Unstable operation waveform

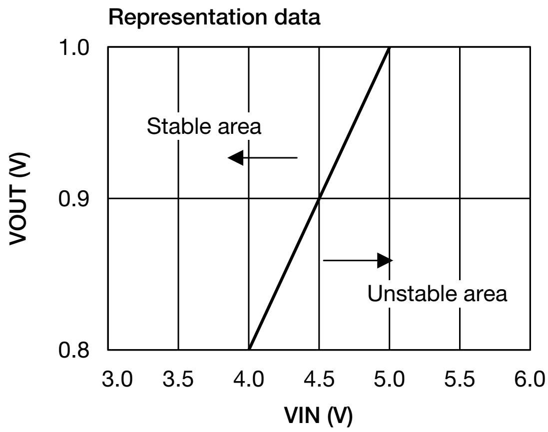
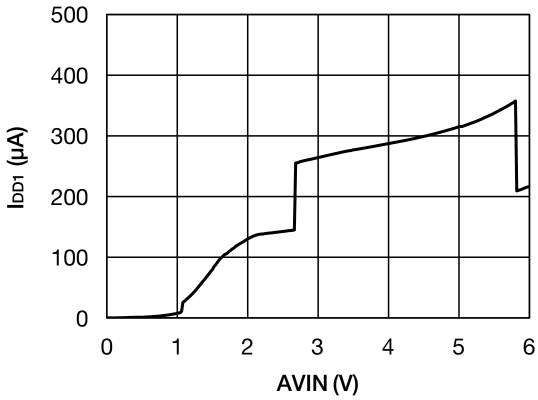


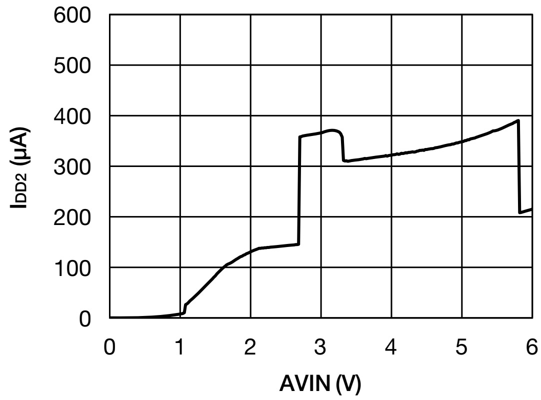
Figure.B 1V or less output vs VIN operation stability

Characteristics (Except where noted otherwise Ta=25°C)

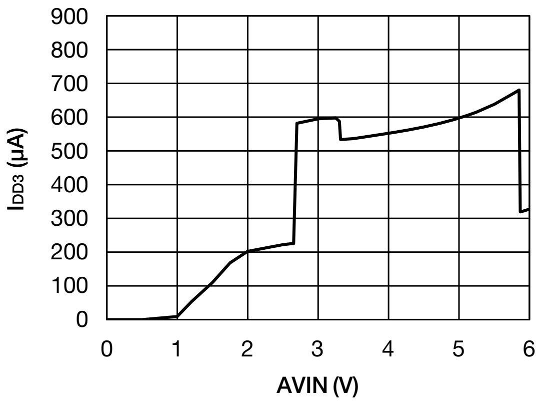
Supply Current 1
(EN23=0V, AVIN=PVIN1,2=0→6.0V)



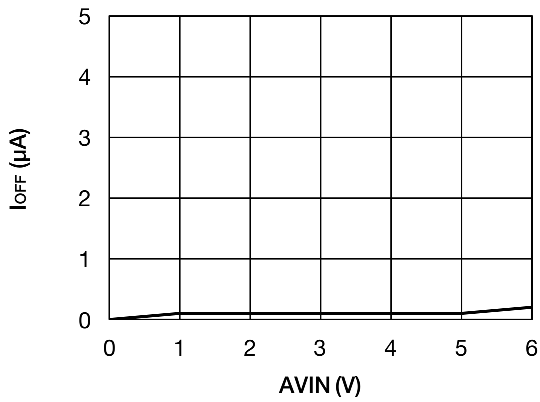
Supply Current 2
(EN1=0V, AVIN=PVIN1,2=0→6.0V)



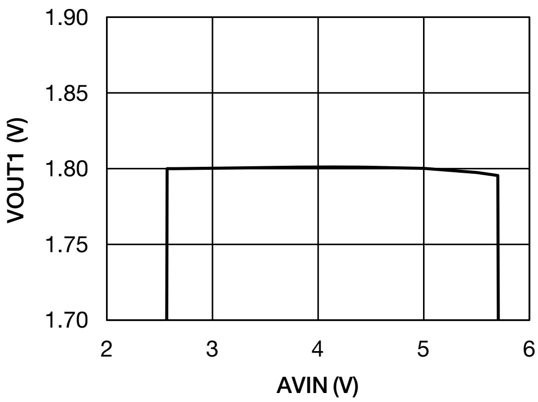
Supply Current
(EN1=EN23=5V, AVIN=PVIN1,2=0→6.0V)



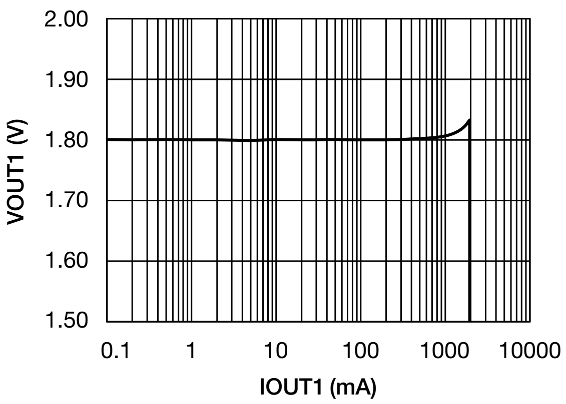
Shutdown Current
(EN1=EN23=0V, AVIN=PVIN1,2=0→6.0V)



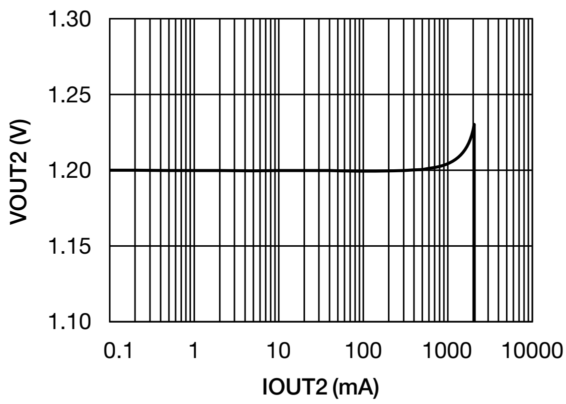
Line regulation VOUT1(1.8V)
(AVIN=PVIN1=0→6.0V)



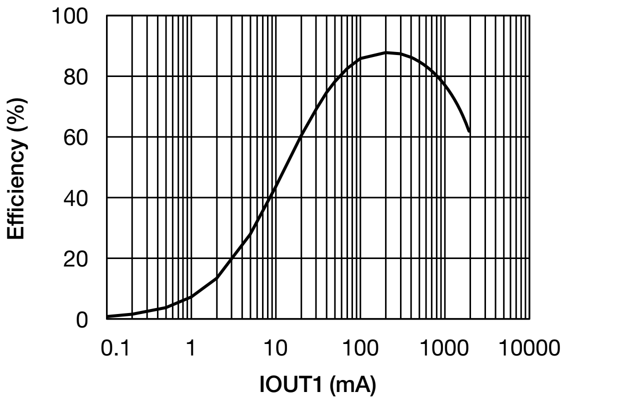
Load regulation VOUT1(1.8V)
(AVIN=PVIN1=5.0V, IOUT=0→2000mA)



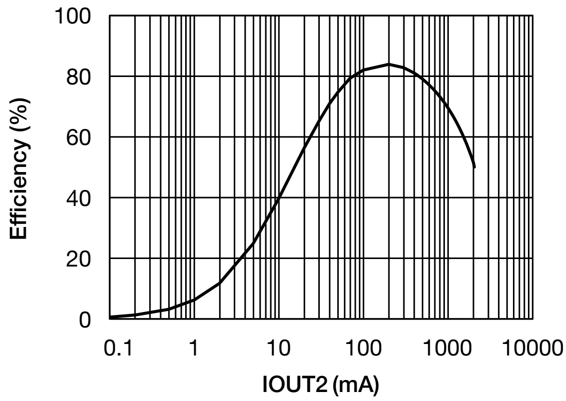
Load regulation VOUT2(1.2V)
(AVIN=PVIN2=5.0V, IOUT=0→2000mA)



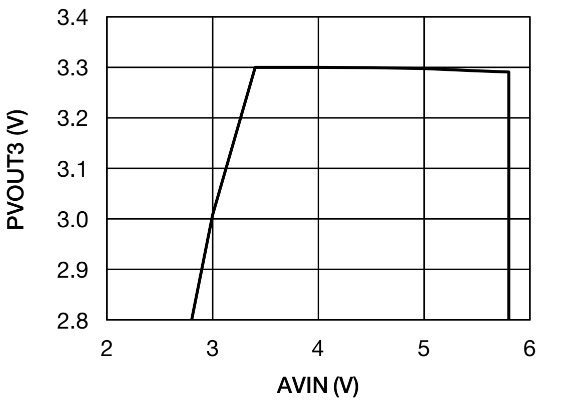
Efficiency VOUT1(1.8V)
(AVIN=PVIN1=5.0V,EN23=0,IOUT=0→2000mA)



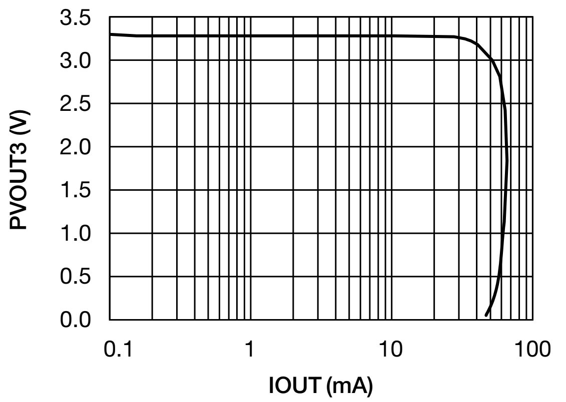
Efficiency VOUT2(1.2V)
(AVIN=PVIN2=5.0V,EN1=0,IOUT=0→2000mA)



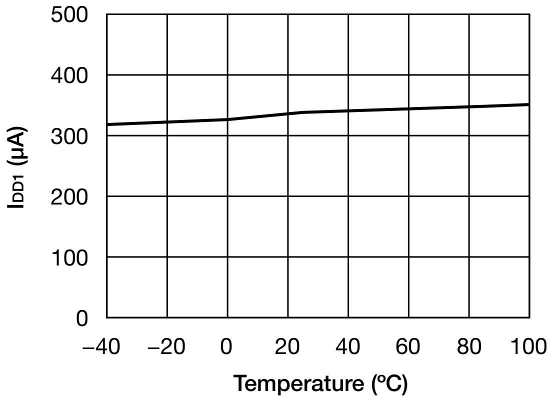
Line regulation PVOUT3
(AVIN=0→6.0V, IOUT=1mA)



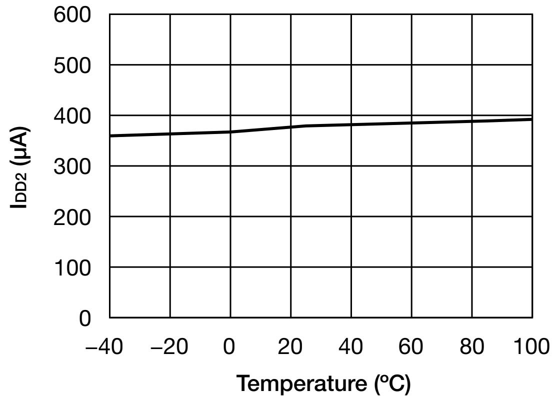
Load regulation PVOUT3
(AVIN=5.0V, IOUT=0→100mA)



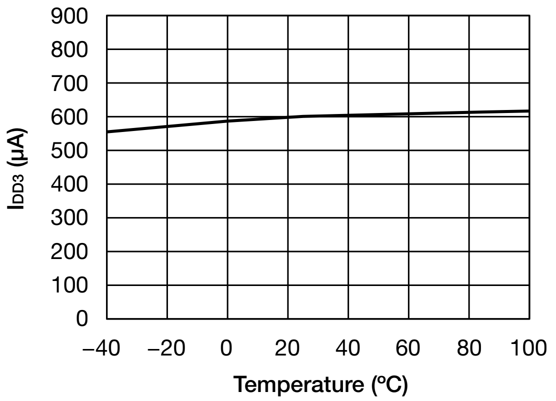
Supply current 1 - Temperature



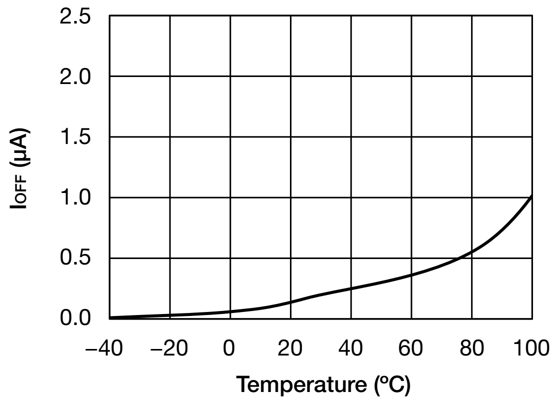
Supply current 2 - Temperature



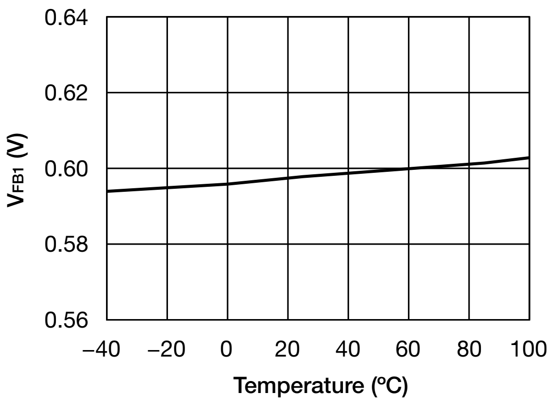
Supply current - Temperature



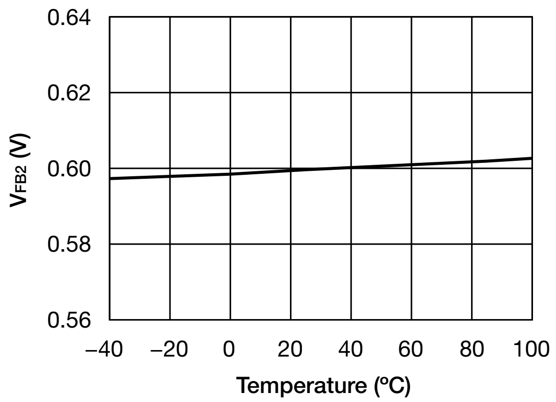
Shutdown current - Temperature



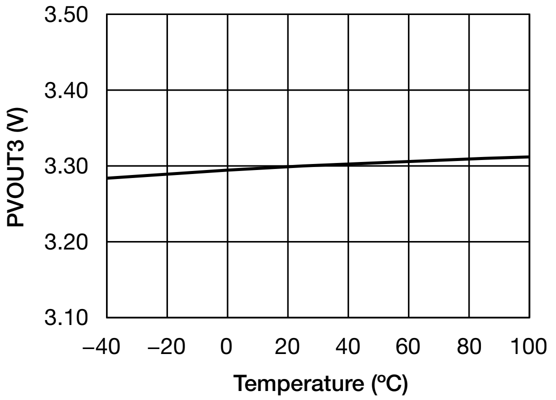
FB1 Voltage - Temperature (AVIN=PVIN1=5.0V, IOUT=300mA)



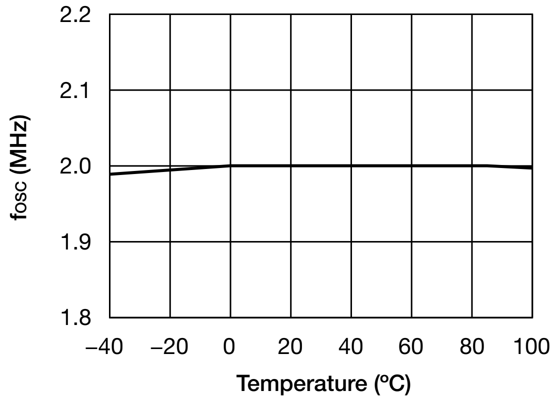
FB2 Voltage - Temperature (AVIN=PVIN1=5.0V, IOUT=300mA)



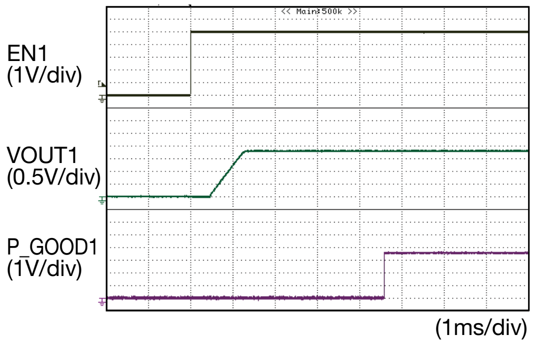
PVOUT3 - Temperature
(AVIN=5.0V, IOUT=No Load)



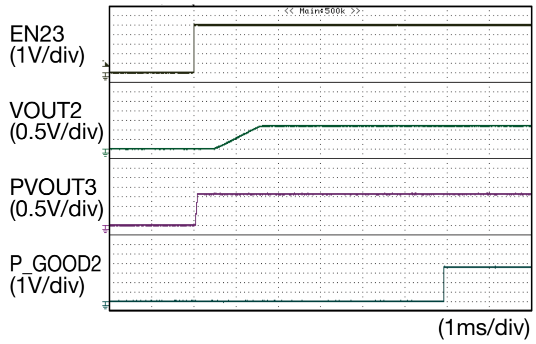
Oscillator Frequency - Temperature



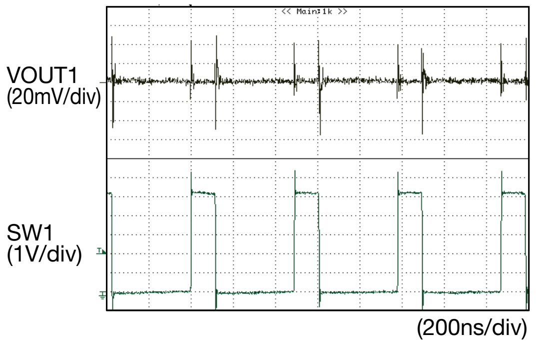
EN1 Start-Up
(AVIN=PVIN1=5.0V, EN1=0→5V)



EN23 Start-Up
(AVIN=PVIN2=5.0V, EN23=0→5V)

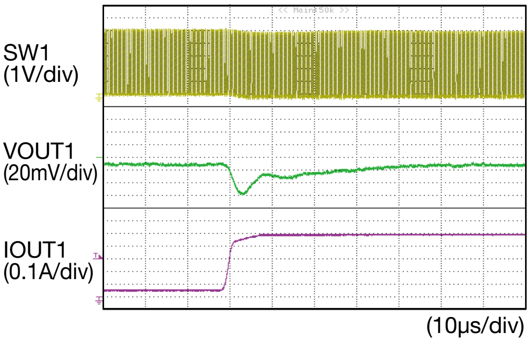


Switching Operation
(AVIN=PVIN1=5.0V)

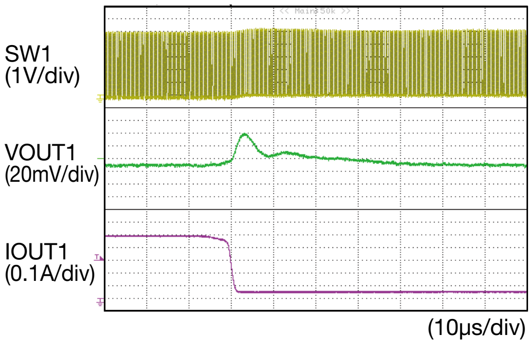


Load Transient Response

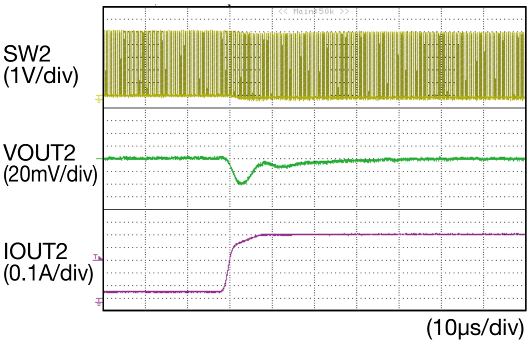
(AVIN=PVIN1=5.0V, VOUT1=1.8V, IOUT1=50mA→500mA)



(AVIN=PVIN1=5.0V, VOUT1=1.8V, IOUT1=500mA→50mA)



(AVIN=PVIN2=5.0V, VOUT2=1.2V, IOUT2=50mA→500mA)



(AVIN=PVIN2=5.0V, VOUT2=1.2V, IOUT2=500mA→50mA)