Datasheet

Boundary Conduction Mode

Power Factor Correction Controller IC Built-in 650 V GaN HEMT

BM3GF01MUV-LBZ BM3GF02MUV-LBZ

General Description

This is the product guarantees long time support in industrial market.
BM3GF01MUV-LB, BM3GF02MUV-LB incorporates the 650 V GaN HEMT and power factor correction converter (Power Factor Correction: PFC) that serve as switching devices to provide a compact, optimal system for all products that require power factor improvement.
Critical mode control is adopted for the PFC IC, and switching loss reduction and noise reduction are possible by zero current detection.
Built-in GaN HEMT contributes to miniaturization and high-efficiency.

Features

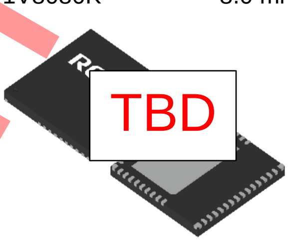
- Long Time Support Product for Industrial Applications.
- Built-in 650 V withstand Voltage GaN HEMT
- Built-in 650 V Startup Circuit
- Boundary Conduction Mode PFC
- Turn-off Slew Rate Adjusting Pin
- Built-in Low THD Circuit
- ON/OFF Control with PFCOFF Pin
- UVLO Function of VCC Pin
- ZCD by Auxiliary Winding
- Static OVP Function by VS Pin
- Error Amplifier Input Short Protection
- Soft Start
- Switching Frequency Limit Function

Key Specification

- Power Supply Voltage Range
  - VCC Pin: 10 V to 38 V
  - DRAIN Pin: 650 V (Max)
- Operating Current : 0.65 mA (Typ)
- Current when PFC OFF state: 100 µA (Typ)
- Operating Temperature Range : -40 °C to +105 °C
- ON Resistance
  - BM3GF01MUV-LB 150 mΩ
  - BM3GF02MUV-LB 70 mΩ

Package W(Typ) x D(Typ) x H(Max)

VQFN41V8080K 8.0 mm x 8.0 mm x 1.0 mm
Pitch 0.5 mm



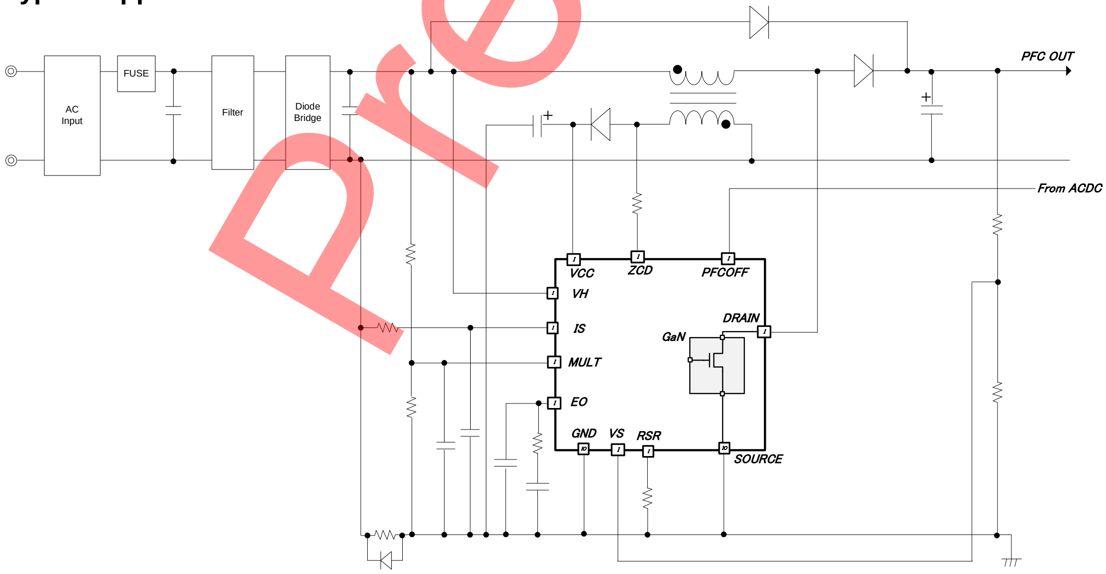
Lineup

Product Name	ON resistance
BM3GF01MUV-LBZ	150 mΩ
BM3GF02MUV-LBZ	70 mΩ

Applications

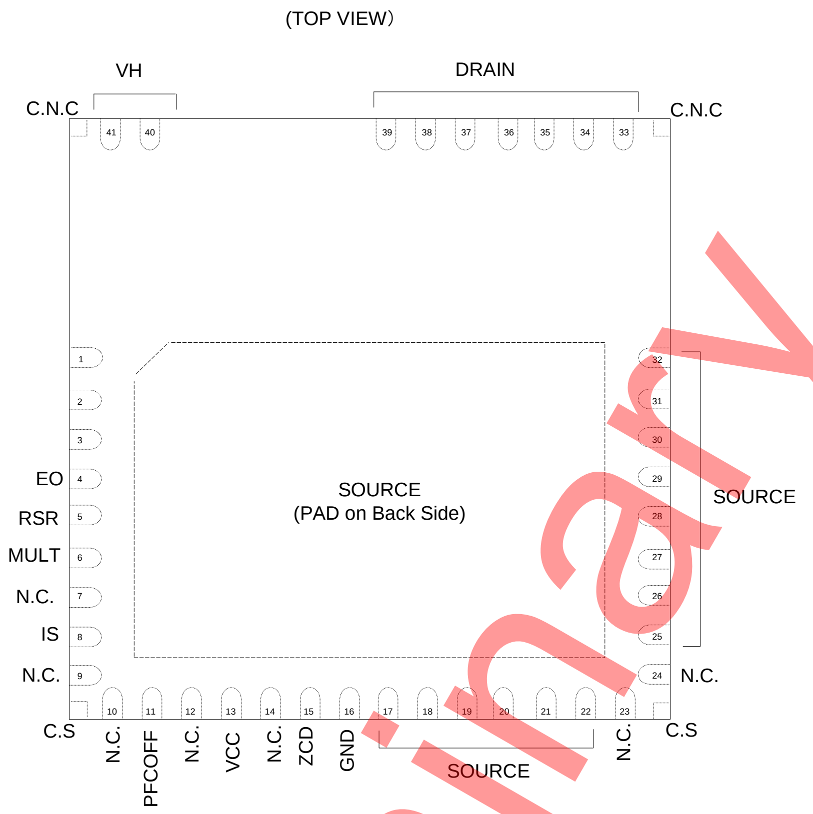
Industrial Equipment, AC Adapter etc.

Typical Application Circuit



〇Product structure : Silicon integrated circuit 〇This product has no designed protection against radioactive rays.

Pin Configuration

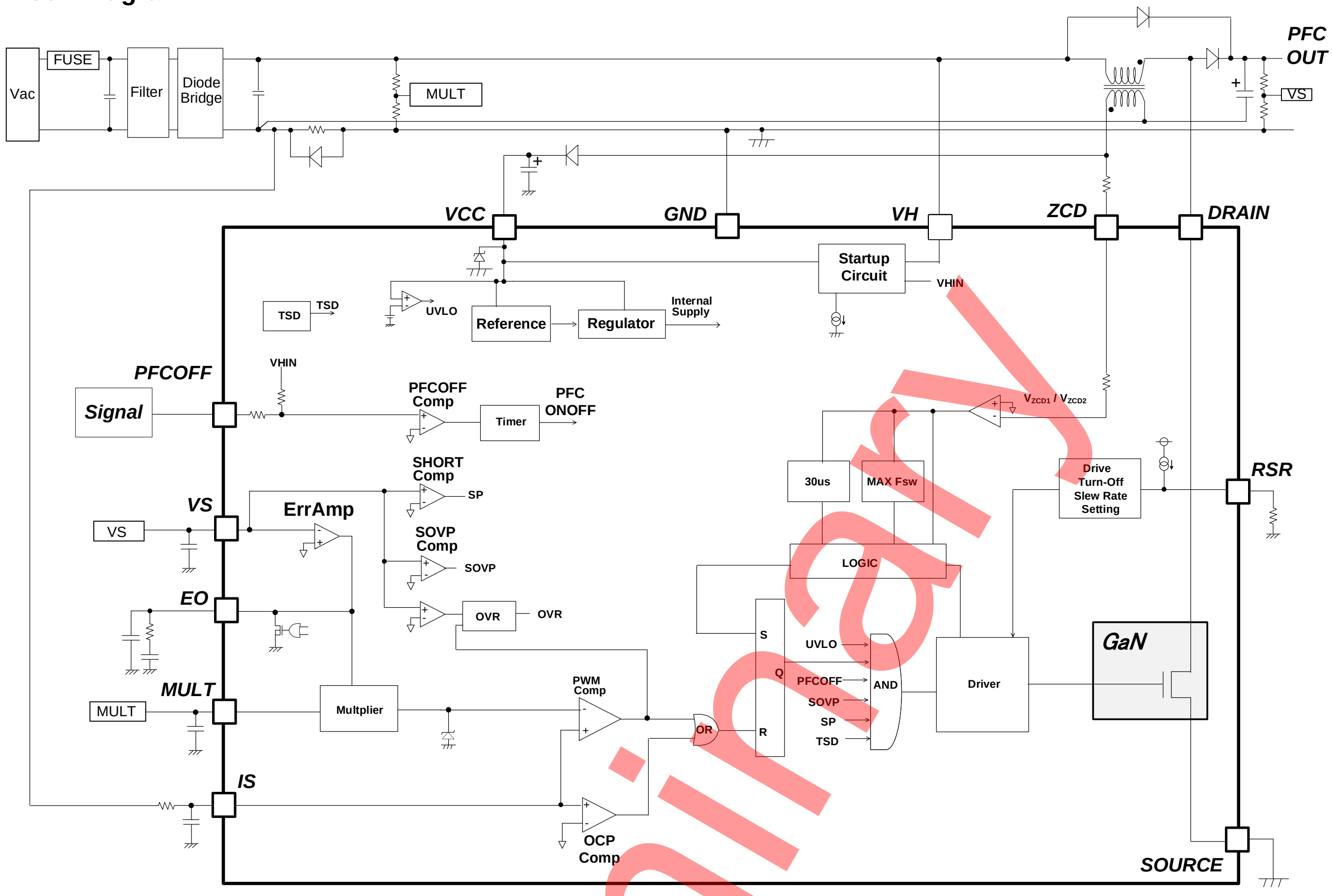


Pin Description

Pin No.	Pin Name	I/O	Function
1,2	SOURCE	I/O	GaN HEMT SOURCE pin
3	VS	I	Feedback input pin
4	EO	I/O	Error Amplifier Output pin
5	RSR	I	Turn-off slew rate adjusting pin
6	MULT	I	Multiplier Input pin
7	N.C.	-	Non connected
8	IS	I	Over current detection pin
9,10	N.C.	-	Non connected
11	PFCOFF	I	PFC ON/OFF setting pin
12	N.C.	-	Non connected
13	VCC	I	Power supply pin
14	N.C.	-	Non connected
15	ZCD	I	Zero Current detection pin
16	GND	-	GND pin
17 to 22	SOURCE	I/O	GaN HEMT SOURCE pin
23,24	N.C.	-	Non connected
25 to 32	SOURCE	I/O	GaN HEMT SOURCE pin
33 to 39	DRAIN	I	GaN HEMT DRAIN pin
40 to 41	VH	I	Starter circuit pin
-	C.S	-	Corner pin (Note 1) (Note 2)
-	C.N.C	-	Corner pin, unconnected (Note 2)

(Note 1) Internally connected to SOURCE pin.
(Note 2) Do not connect to other pins.

Block Diagram



Description of Blocks

1 Startup Circuit

This IC has a built-in startup circuit. It enables low standby power and high-speed startup.
The consumption current after startup is only OFF current I_{START3}.

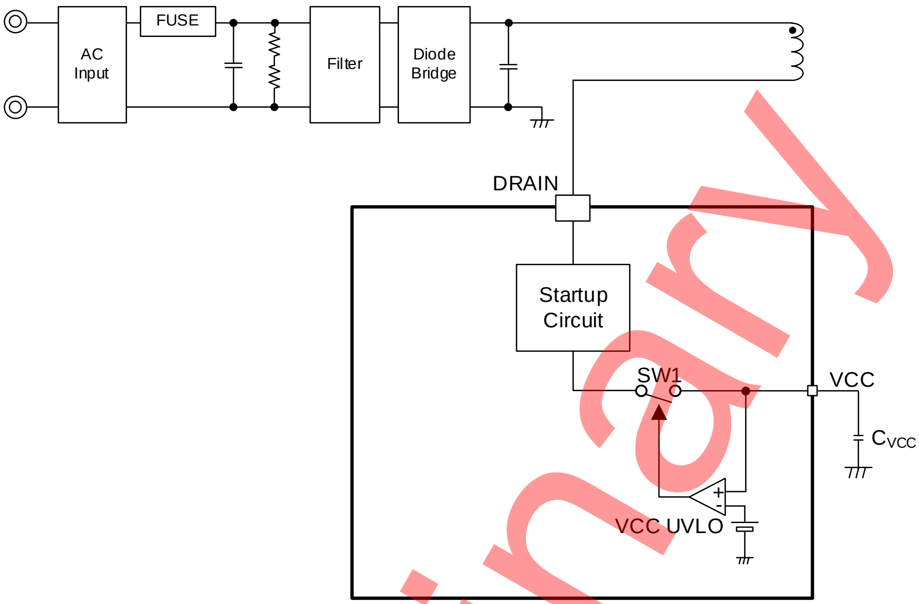


Figure 1. Block Diagram of Startup Circuit

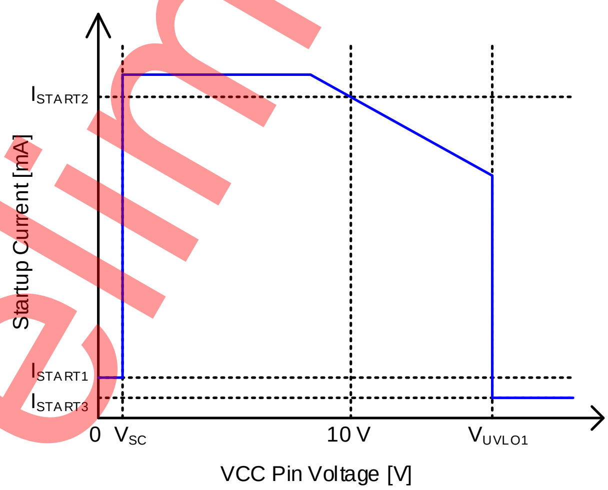


Figure 2. Startup Current vs VCC Pin Voltage

Description of Blocks - continue

2 VCC Pin Protective Function

This IC has a built-in the VCC pin undervoltage protective function VCC UVLO (Under Voltage Lock Out) and VCC recharge function that operates when the VCC pin voltage drops.

3 PFC: Power Factor Correction Section

The power factor improvement circuit is a voltage control method in the Boundary Conduction Mode.
The schematic operation schematic is shown in Figure 3, and the switching operation is shown in Figure 4.

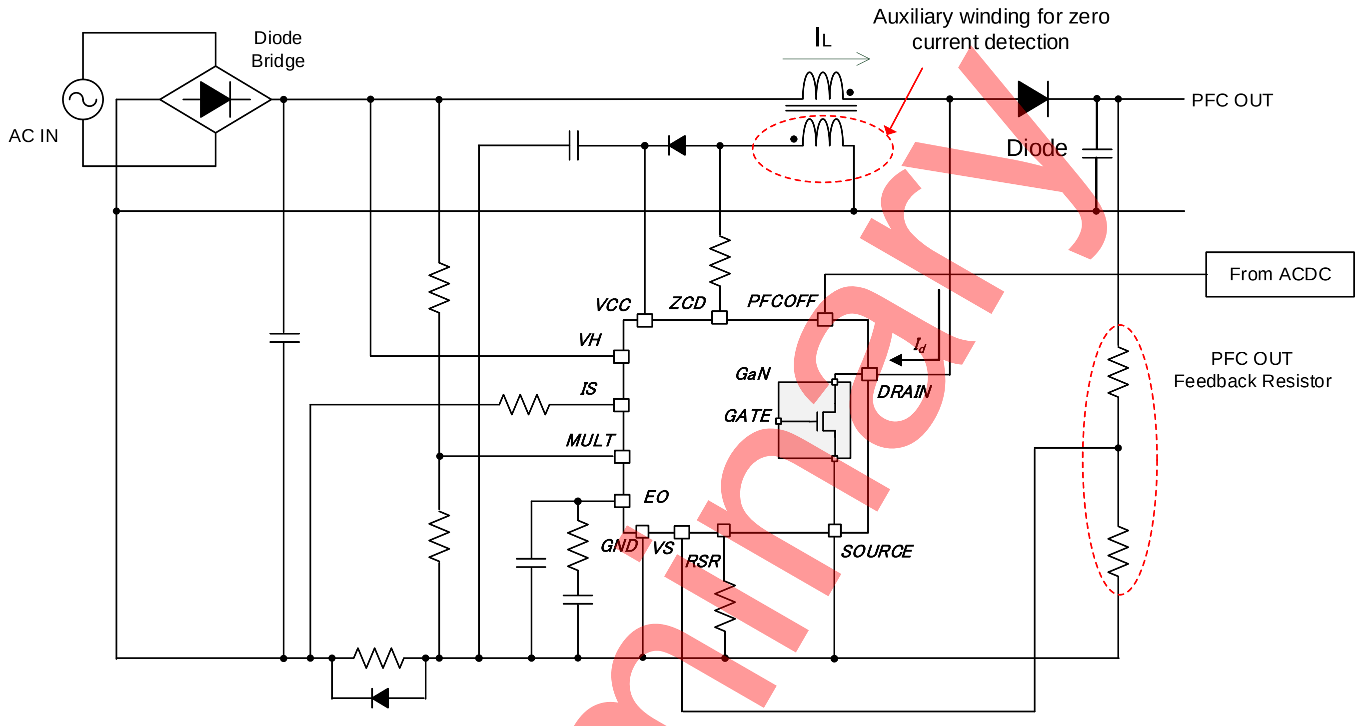


Figure 3. Operation Circuit Outline

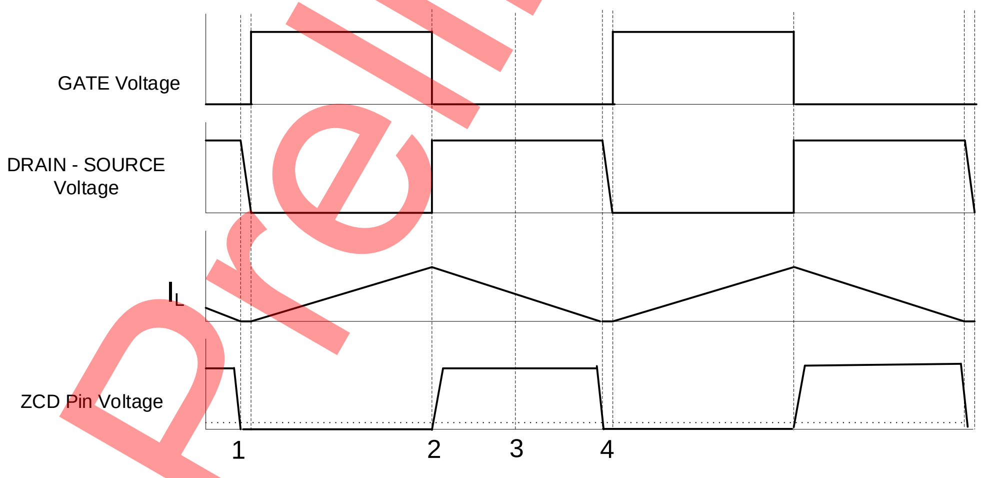


Figure 4. Switching Operation Timing Chart

Switching Operation
1. GaN HEMT is turned to ON and inductor current I_L increases.
2. The IC compares Multiplier output voltage with the generated signal from the IS pin voltage, GaN HEMT is turned to OFF when the generated signal voltage increases.
3. While GaN HEMT is turned to off, I_L is decreased to 0 A.
4. The ZCD pin detects the zero point of the I_L, and GaN HEMT is turned to ON.

Description of Blocks-continued

4 Regarding to ErrAMP

4.1 GmAMP

The VS pin monitors the resistor divided point of the output voltage. The ripple voltage of AC-frequency (50 Hz / 60 Hz) is overlapped on the VS pin. GmAMP removes this ripple voltage and controls the EO pin voltage level according to the error between the removed voltage and V_{AMP1}. When the EO pin voltage rises, the longer ON-time of the GaN. When the EO pin voltage drops below V_{BURST}, the switching operation stops. Therefore, the switching operation can be stopped by forcibly shorting the EO pin to GND from the outside.
Set the error amplifier constants so that the AC frequency does not appear in the EO pin. In doing so, be sure to check in the actual application.

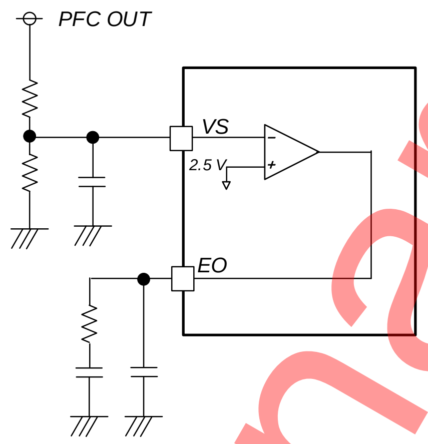


Figure 5. GmAMP Block Diagram

4.2 VS Short Protection Function

The VS pin has a short protection function. When the VS pin voltage < V_{SHORT} status continues for t_{VS_SH} or more, IC stops switching. Figure 6 shows the operation.

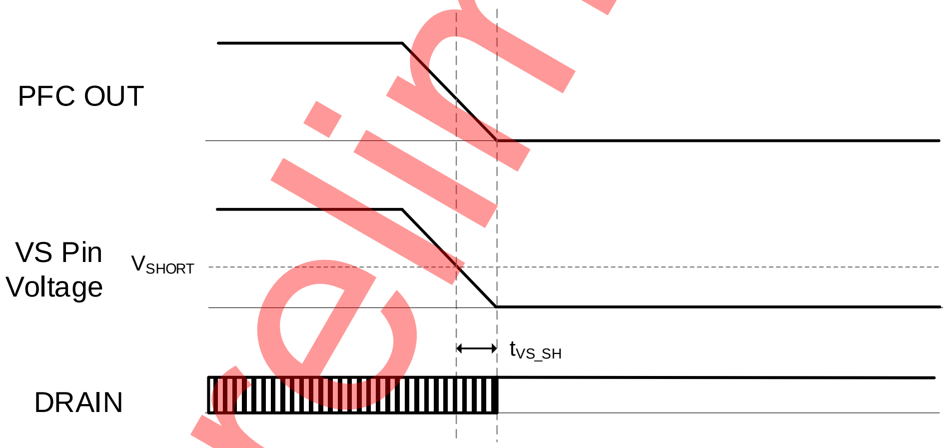


Figure 6. Operation of VS Short Protection

4 Regarding to ErrAMP-continued

4.3 VS Over Voltage Protection Function (SOVP)

When the VS pin voltage rises above V_{OVP1}, switching is stopped immediately. When the VS pin drops below V_{OVP2}, switching starts. Figure 7 shows the operation.

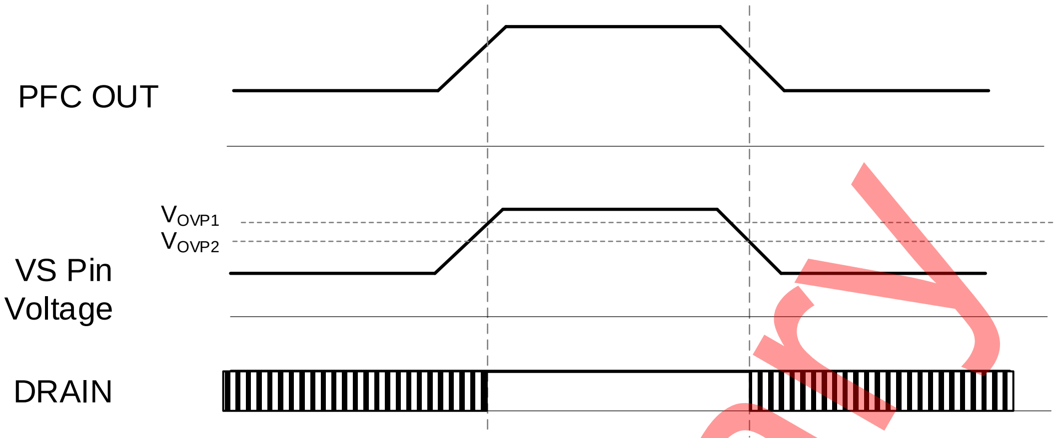


Figure 7. VS Over Voltage Protection Operation

4.4 Over-voltage Boost Reduction Function at Startup (OVR)

When the VS pin voltage rises to V_{OVR} (corresponding to-10 % of the output voltage) at startup, the EO voltage is forcibly discharged to V_{BURST}. When the EO pin voltage is low, the pulse width of DRAIN pin becomes narrower, which slows the rise of the output voltage and reduces the over boost at startup. This function is valid only once after VCC UVLO is released or after switching operation by the PFCOFF pin is started.

Description of Blocks-continued

5 ZCD Pin

The zero-current detection circuit is a function to detect a zero cross of the inductor current (Refer to Figure 8, 9). After the ZCD pin voltage is higher than V_{ZCD1}, when the ZCD pin voltage is lower than V_{ZCD2}, the GATE output is High to take delay time. If the ZCD pin voltage is less than V_{ZCD1}, the restart timer operation is operated.
In the operation, when the GATE voltage is turned to L and it takes $t_{REST,}$ The GATE voltage is turned to H (Refer to Figure 10).

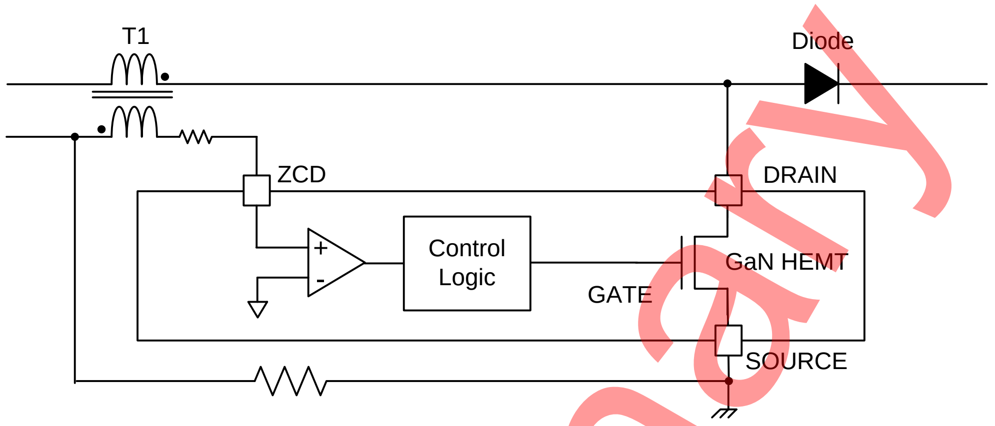


Figure 8. Zero Current Detection Circuit

Figure 9. Zero Current Detection operation

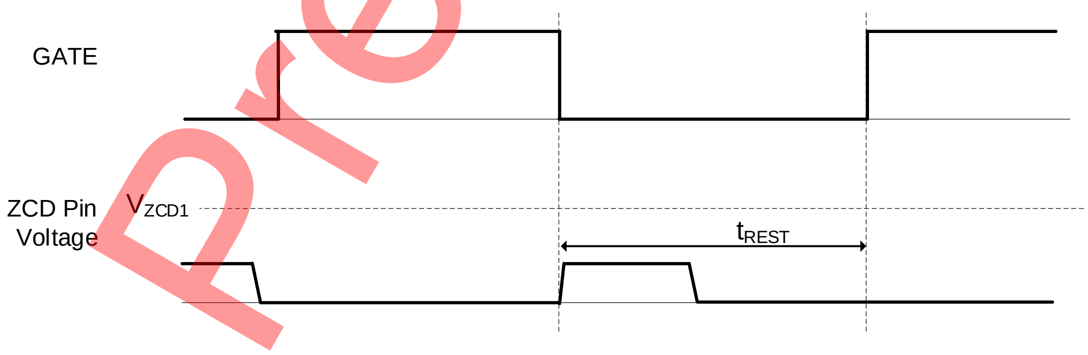


Figure 10. Restart Time operation

Description of Blocks-continued

6 MULTIPLIER

As shown in Figure 11, the DRAIN pin on time is determined by Multiplier out and V_{SOURCE}.
V_{SOURCE} can be expressed in the following formula.

$$V_{SOURCE} = K \times V_{MULT} \times (V_{EO} - V_{BURST})$$

K: MULTIPLIER GAIN
V_{MULT}: MULT pin voltage
V_{EO}: EO pin voltage
V_{BURST}: Burst voltage

AC voltage divider signal is input to MULT pin. This function improves the power factor by controlling the AC current along with the AC voltage.
When the SOURCE pin voltage = 0 V, the diode-bridge output voltage can be discharged more by increasing the ON-time. This improves the AC current distortion because current supplied from the diode-bridge is dischaged (Refer to Figure 11).

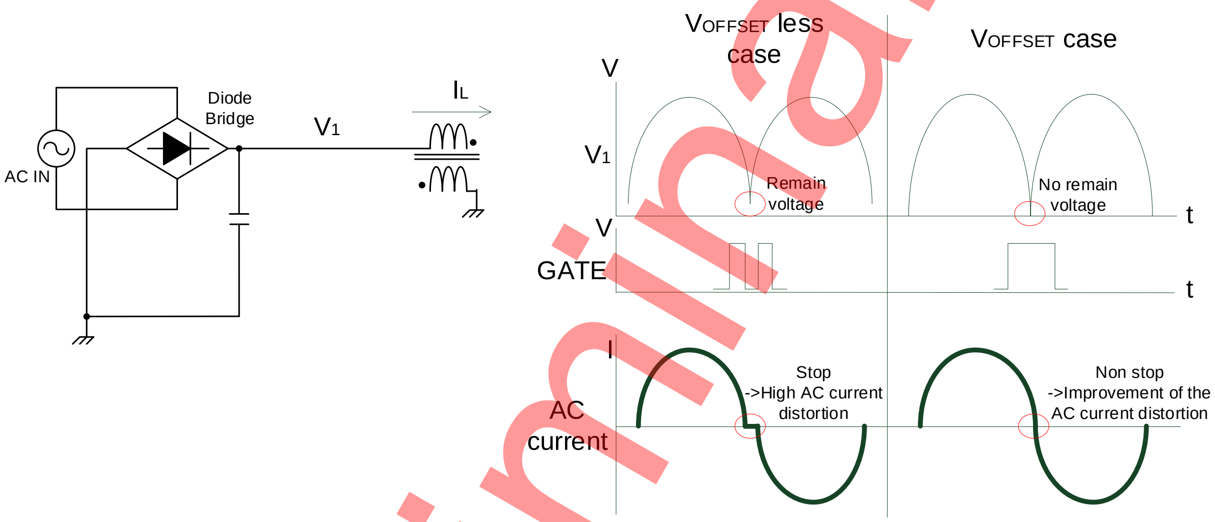


Figure 11. Improvement of the AC Current Distortion

Description of Blocks-continued

7 Over Current Protect Function

In the normal operation, turn-off is determined by the ON-time determined from the EO pin voltage and the MULT pin voltages.
However, when the IS pin voltage is less than V_{OCP}, over current protection is operated and the GATE is turned to L per pulse. This protection prevents over current to GaN HEMT.
Since the over current protection function is operated to limit the ON time, the PFC output voltage drops when PFC load is heavy and operate this protective function.

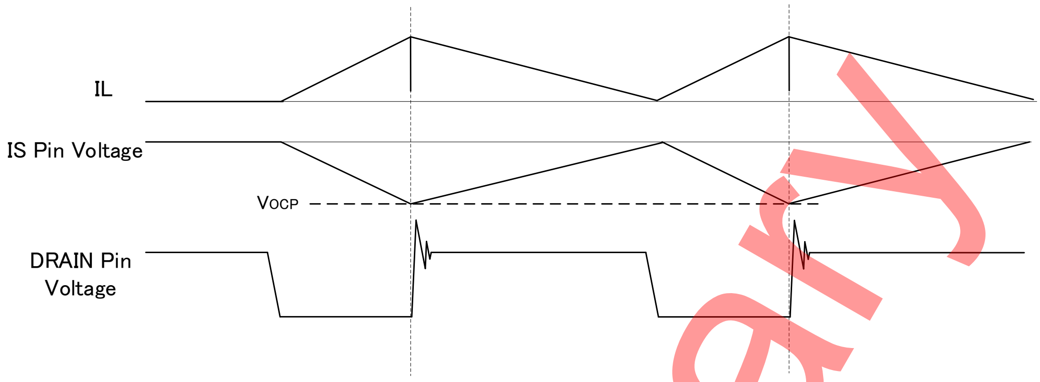


Figure 12. Current Limit operation

8 PFC ON/OFF Function

When the PFCOFF pin voltage is lower than V_{PFCOFF}, PFC is stopped after t_{PFCOFF} time. This function allows external control of PFC ON/OFF by connecting with ACDC power supply. It is possible to stop PFC operation in standby mode, etc., when PFC operation is not needed. It contributes to low standby power consumption. When PFC switches to ON, the IC has t_{PFCON} timer to prevent malfunctions due to noise.
Because the PFCOFF pin has an input pull-up resistor, PFCOFF pin voltage is equal to $V_{PFCOPEN}$ when the pin is open. If you do not use this function, open the PFCOFF pin.

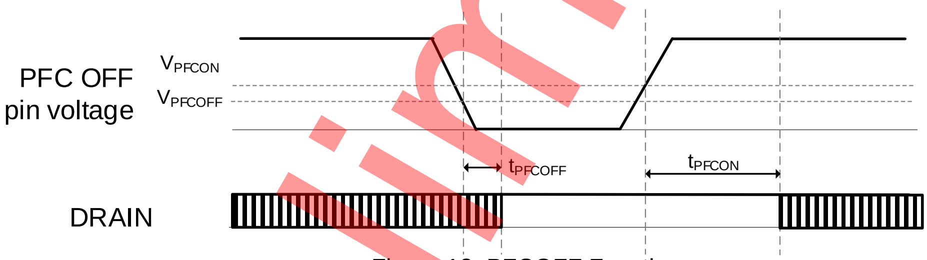


Figure 13. PFCOFF Function

9 Enhancement Mode GaN HEMT

This IC is built-in an enhancement mode (normally off) GaN device.
Compared to cascode topologies that connect depletion-mode (normally-on) GaN devices and Si MOSFET in series, enhancement-mode GaN devices have less parasitic inductance and switching loss introduced by the additional connection between the cascode-mode GaN devices and Si MOSFET. These characteristics provide better switching performance and are particularly noticeable in high-current applications.

Description of Blocks-continued

10 RSR Pin

The RSR pin is able to be adjusted GaN HEMT turn-off slew rate. Depending on the resistor connected to the RSR pin,
turn-off slew rate can be adjusted. The slew rate of turn ON is fixed.
The RSR pin resistor is needed to connect 10 kΩ or more.
The RSR pin also has a built-in short-circuit protection. Switching operation stops when the RSR pin voltage < V_{RSRSHT}.

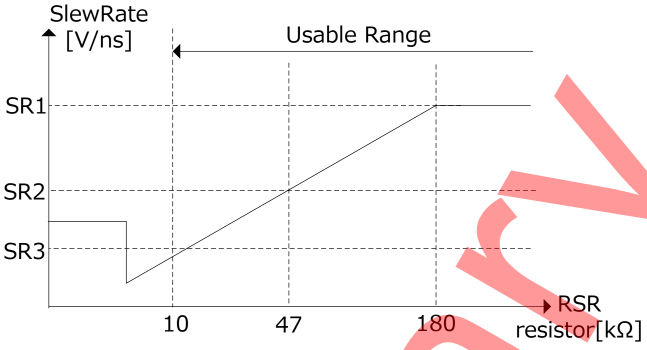


Figure14. Slew Rate characteristics

11 IS Pin Open Protection

If the SOURCE pin becomes OPEN, IC may be damaged.
To prevent to be damaged, this IC built in OPEN protection circuit（auto recovery protection）
Switching stops when the IS pin voltage < V_{ISOP}

Operation Mode of the Protection Circuit

Table 1 shows the operation modes of the protective functions.

Table 1. Operation Mode of Each Protective Circuit

Item	Content	Protective Action			
		Detection Method	Operation at Detection	How to Cancel	Operation at Release
VCC UVLO	VCC Pin Undervoltage Protection	VCC < V_{UVLO2} (when VCC falls)	Switching Stop EO Voltage Discharge	VCC > V_{UVLO1} (when VCC rises)	Start of Starting Operation
VCC Recharge	VCC Pin Recharge Function	VCC < V_{CHG1} (When VCC falls)	Start to charge VCC pin from DRAIN pin	VCC > V_{CHG2} (When VCC rises)	Stop to charge VCC pin from DRAIN pin
OCP	Overcurrent Protection Function	IS < V_{OCP} (at IS falls)	Switching Stop	IS > V_{OCP} (at IS rises)	Normal Operation
VS Short Protection	VS Pin Short Protection Function	VS < V_{SHORT} (when VS falls)	Switching stop EO voltage discharge	VS > V_{SHORT} (when VS rises)	Normal operation
VS Static OVP	VS Pin Overvoltage Protection Function	VS > V_{OVP1} (when VS rises)	Switching stop	VS < V_{OVP2} (when VS falls)	Normal operation
RSR Short Protection	RSR Pin Short Protection Function	RSR < V_{RSRSHT}	Switching stop EO voltage discharge	RSR > V_{RSRSHT}	Normal operation
IS Open Protection	IS Pin Open Protection Function	IS > V_{ISOP} (when IS rises)	Switching stop	IS < V_{ISOP} (when IS falls)	Normal operation

Absolute maximum rating (Ta = 25 °C)

Parameter	Symbol	Rating	Unit	Conditions
Maximum voltage 1	V_{MAX1A}	-0.3 to +650	V	DRAIN pin voltage, VH pin voltage
	V_{MAX1B}	-0.3 to +800	V	DRAIN pin voltage (t_{pulse} < 1 µs) (Note 1)
Maximum voltage 2	V_{MAX2}	-0.3 to +40	V	VCC pin
Maximum voltage 3	V_{MAX3}	-0.3 to +6.5	V	SOURCE pin, MULT pin, VS pin, EO pin, RSR pin, PFCOFF pin
Maximum voltage 4	V_{MAX4}	-4.0 to +0.3	V	IS pin
Maximum current 1 BM3GF01MUV	$I_{D1(RMS)}$	13.4	A	DRAIN pin RMS current
	$I_{D1(PULSE)}$	42.3	A	DRAIN pin pulse current (t_{pulse} < 1 µs) (Note 1)
Maximum current 2 BM3GF02MUV	$I_{D2(RMS)}$	20.9	A	DRAIN pin RMS current
	$I_{D2(PULSE)}$	66.1	A	DRAIN pin pulse current (t_{pulse} < 1 µs) (Note 1)
Maximum current 3	I_{ZCD1}	-3 to +3	mA	ZCD current
Maximum junction temperature	Tjmax	+150	°C	
Storage Temperature Range	Tstg	-55 to +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 1) Duty is less than 1%.

Thermal Resistance (Note 2)

Parameter	Symbol	Thermal Resistance (Typ) 1s (Note 4)	Thermal Resistance (Typ) 2s2p (Note 5)	Unit
VQFN41V8080K				
Junction to Ambient	θ_{JA}	T.B.D.	T.B.D.	°C/W
Junction to Top Characterization Parameter (Note 3)	Ψ_{JT}	T.B.D.	T.B.D.	°C/W

(Note 2) Based on JESD51-2A (Still-Air).
(Note 3) 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 4) Using a PCB board based on JESD51-3.
(Note 5) Using a PCB board based on JESD51-5, 7.

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

Top	
Copper Pattern	Thickness
Footprints and Traces	70 µm

Layer Number of Measurement Board	Material	Board Size	Thermal Via (Note 6) Pitch	Thermal Via (Note 6) Diameter
4 Layers	FR-4	114.3 mm x 76.2 mm x 1.6 mmt	1.20 mm	Φ0.30 mm

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

(Note 6) This thermal via connect with the copper pattern of layers 1,2, and 4. The placement and dimensions obey a land pattern.

Recommended operating conditions

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
Power Supply Voltage Range	VCC	10	15	38	V	VCC pin Voltage
Operating temperature	Topr	-40	+25	+105	°C	

Recommended external area (Ta = 25 °C)

Parameter	Symbol	Range	Unit
VCC pin Connecting Capacitance	C_{VCC}	10 to	µF
RSR pin Connecting Resistor	R_{RSR}	10 to	kΩ
IS pin Filter Resistor	R_{ISFIL}	to 2.0	kΩ

Electrical Characteristics (Unless otherwise specified Ta = -40 °C to +105 ,VCC = 15 V)

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
[GaN HEMT]						
DRAIN-SOURCE withstand Voltage	$V_{(BR)DSS1}$	650	-	-	V	VCC pin voltage = 0 V
	$V_{(BR)DSS2}$	800	-	-	V	VCC pin voltage = 0 V, t_{pulse} < 1 µs (Note1)
DRAIN Pin Leakage Current	I_{DSS1}	-	-	100	µA	VDS = 650 V, Tj = 25 °C
	I_{DSS2}	-	4.5	-	µA	VDS = 650 V, Tj = 150 °C
DRAIN-SOURCE ON Resistor 1	$R_{DS1A(ON)}$	-	150	195	mΩ	ID = 0.5 A, VCC pin voltage = 15 V, Tj = 25 °C
	$R_{DS1H(ON)}$	-	295	-	mΩ	ID = 0.5 A, VCC pin voltage = 15 V, Tj = 150 °C
DRAIN-SOURCE ON Resistor 2	$R_{DS2A(ON)}$	-	70	85	mΩ	ID = 0.5 A, VCC pin voltage = 15 V, Tj = 25 °C
	$R_{DS2H(ON)}$	-	135	-	mΩ	ID = 0.5 A, VCC pin voltage = 15 V, Tj = 150 °C
SOURCE-DRAIN Reverse Voltage	V_{SD}	-	3.5	-	V	ID = 9.5 A, VCC pin voltage = 0 V
Output Capacity	C_{OSS}	-	24.5	-	pF	VCC pin voltage = 0 V, V_D = 400 V, F = 1 MHz
[Circuit current]						
Circuit Current (ON)1	I_{ON1}	-	0.75	1.20	mA	VS pin voltage = 0 V
Circuit Current (ON)2	I_{ON2}	-	1.0	2.2	mA	At 50 kHz switching
Circuit Current (ON)3	I_{ON3}	50	100	200	uA	PFC OFF state
[VCC Pin Protective Function]						
VCC UVLO Voltage1	V_{UVLO1}	12	13	14	V	at VCC pin voltage rising
VCC UVLO Voltage2	V_{UVLO2}	7	8	9	V	at VCC pin voltage falling
VCC UVLO Hysteresis	V_{UVLO3}	-	5	-	V	$V_{UVLO3} = V_{UVLO1} - V_{UVLO2}$
VCC Recharge Start Voltage	V_{CHG1}	8	9	10	V	
VCC Recharge Stop Voltage	V_{CHG2}	9	10	11	V	
[Gm Amplifier Block]						
VS Pin Pull-up Current	I_{VS}	-	0.1	0.5	µA	VS pin voltage = 0 V
Gm Amplifier Reference Voltage 1	V_{AMP1}	2.465	2.500	2.535	V	Ta = 25 °C
Gm Amplifier Reference Voltage 2	V_{AMP2}	2.44	2.50	2.54	V	Ta = -40 °C to +105 °C
Gm Amplifier Reference Voltage Line Regulation	V_{AMP_LINE}	-	-	10	mV	VCC pin voltage = 10 V to 38 V
Gm Amplifier Transconductance	T_{VS}	80	100	130	µA/V	EO pin voltage = 2.5 V, Ta = 25 °C
Gm Amplifier Source Current	I_{EO_SOURCE}	6.25	12.5	25	µA	VS pin voltage = 2.3 V
Gm Amplifier Sink Current	I_{EO_SINK}	6.25	12.5	25	µA	VS pin voltage = 2.7 V

(Note 1) Duty is less than 1%.

Electrical Characteristics (Ta = -40 °C to +105 unless otherwise specified, VCC = 15 V) - continued

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
[EO Block]						
EO Pin L Voltage	V_{EOL}	-	1.6	1.8	V	VS pin voltage = 2.7 V
Burst Voltage	V_{BURST}	1.8	1.9	-	V	
EO Discharge Current	I_{EO}	0.8	1.8	3.6	mA	VCC pin voltage = 12 V, EO pin voltage = 1.0 V
[MULT Block]						
MULT Pin Pull-up Current	I_{MULT}	-	0.1	0.5	µA	MULT pin voltage = 0 V
MULT Pin Operating Voltage Range	V_{MULT}	0 to 2.5	0 to 3.5	-	V	
EO Pin Operating Voltage Range	V_{EOD}	V_{BURST} to 2.9	V_{BURST} to 3.4	-	V	
MULTIPLIER Gain	K	0.43	0.65	0.87	1/V	MULT pin voltage = 0.5 V, EO = 3.0 V
[ZCD Block]						
ZCD Pin Threshold Voltage 1	V_{ZCD1}	0.8	0.9	1.0	V	at ZCD pin voltage rising
ZCD Pin Threshold Voltage 2	V_{ZCD2}	0.55	0.67	0.79	V	at ZCD pin voltage falling
ZCD Output Delay Time	t_{ZCD}	-	200	520	ns	
Input Clamp Voltage (High)	V_{IH}	6.1	6.7	-	V	Isink = 3 mA
Input Clamp Voltage (Low)	V_{IL}	-0.3	-0.1	-	V	Isource = -3 mA
Restart Timer	t_{REST}	15	30	45	µs	
Max Switching Frequency	F_{swmax}	225	250	275	kHz	
[VS Protection Block]						
VS Short Circuit Protection Detection Voltage	V_{SHORT}	0.090 x V_{AMP1}	0.120 x V_{AMP1}	1.50 x V_{AMP1}	V	
VS Short Protection Detection Time	t_{VS_SH}	50	150	300	µs	
Overvoltage Reduction Detection Voltage at Startup	V_{OVR}	-	0.9 x V_{AMP1}	-	V	
VS Overvoltage Protection Detection Voltage 1	V_{OVP1}	1.065 x V_{AMP1}	1.080 x V_{AMP1}	1.095 x V_{AMP1}	V	at VS pin voltage rising. Ta = 25 °C
VS Overvoltage Protection Detection Voltage 2	V_{OVP2}	1.020 x V_{AMP1}	1.040 x V_{AMP1}	1.060 x V_{AMP1}	V	at VS pin voltage falling, Ta = 25 °C
[IS Block]						
Over Current Protect Voltage	V_{OCP}	-0.415	-0.400	-0.385	V	
Output Delay Time	t_{DELAY}	-	150	300	ns	
IS Pin Source Current	I_{SOURCE}	-	15	-	µA	IS pin voltage = 0 V
IS Open Protection Detection Voltage	V_{ISOP}	0.05	0.20	0.35	V	

Electrical Characteristics (Ta =-40 °C to +105 unless otherwise specified, VCC = 15 V) - continued

Parameter	Symbol	Min	Typ	Max	Unit	Conditions
[PFCOFF Block]						
PFC ON Voltage	V_{PFCON}	1.5	1.6	1.7	V	
PFC OFF Voltage	V_{PFCOFF}	1.3	1.4	1.5	V	
PFC ON/OFF Hysteresis	V_{PFCHYS}	-	0.20	-	V	
PFC ON Delay Time	t_{PFCON}	1.15	1.92	2.70	ms	
PFC OFF Delay Time	t_{PFCOFF}	60	100	140	µs	
[RSR Block]						
Turn-off Slew Rate 1	SR1	-	30	-	V/ns	RSR pin open, Vd = 400 V
Turn-off Slew Rate 2	SR2	-	11	-	V/ns	RSR pin = 47 kΩ, Vd = 400 V
Turn-off Slew Rate 3	SR3	-	5	-	V/ns	RSR pin = 10 kΩ, Vd = 400 V
RSR Short Detection Voltage	V_{RSRSHT}	0.015	0.040	0.065	V	
RSR Pin Source Current	I_{RSRSC}	5	10	20	µA	
[Startup Circuit Block]						
Startup Current 1	I_{START1}	0.1	0.3	1.0	mA	VCC = 0 V *(Note 2)*
Startup Current 2	I_{START2}	1.0	3.0	6.0	mA	VCC = 10 V *(Note 2)*
OFF Current	I_{START3}	-	10	25	µA	The inrush current from the DRAIN pin after releasing UVLO. (at MOSFET OFF)
Startup Current Switching Voltage	V_{SC}	0.7	1.4	2.8	V	*(Note 2)*

(Note 2) Tj = 25 °C warranty.

Typical Performance Curves

(Reference Data)

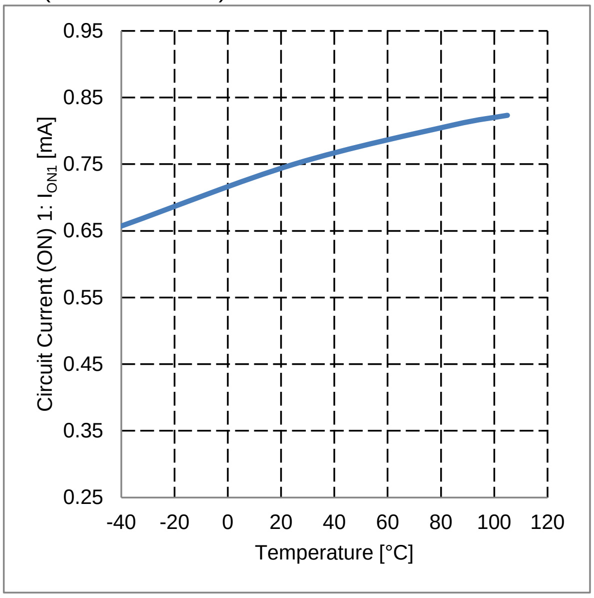


Figure 15. Circuit Current (ON) 1 vs Temperature

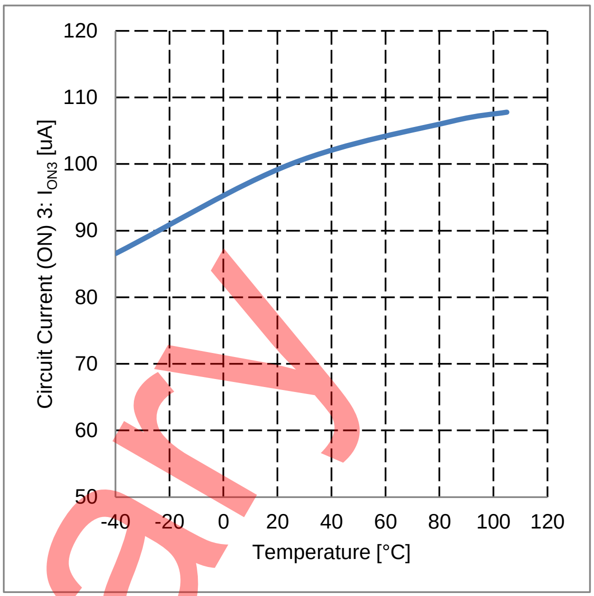


Figure 16. Circuit Current (ON) 3 vs Temperature

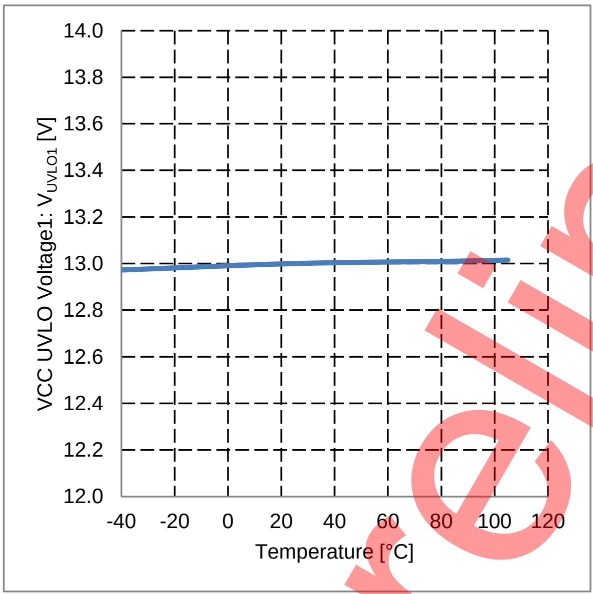


Figure 17. VCC UVLO Voltage1 vs Temperature

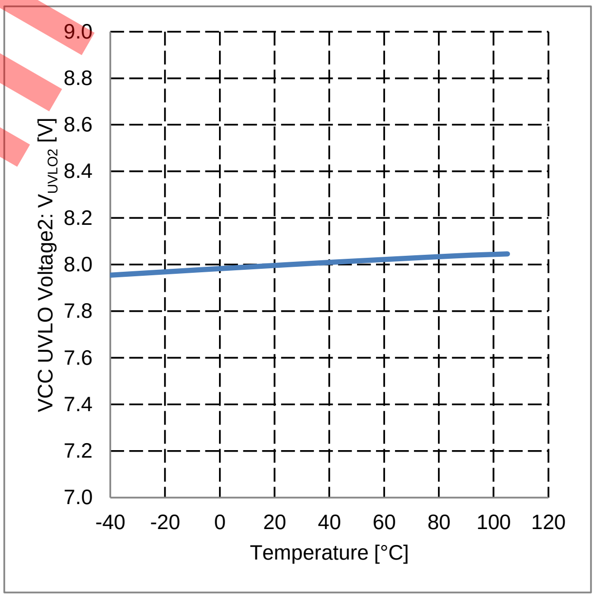


Figure 18. VCC UVLO Voltage2 vs Temperature

Typical Performance Curves – continued

(Reference Data)

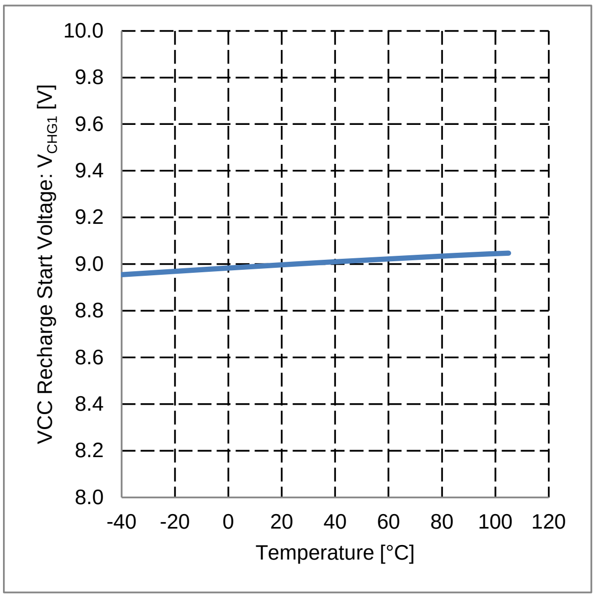


Figure 19. VCC Recharge Start Voltage vs Temperature

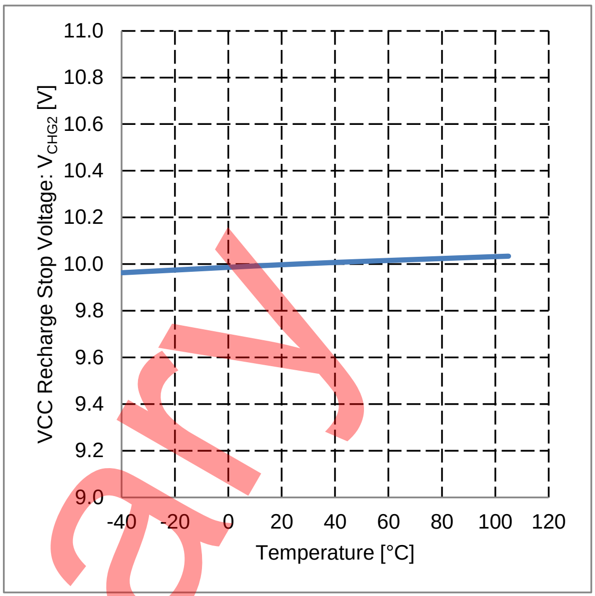


Figure 20. VCC Recharge Stop Voltage vs Temperature

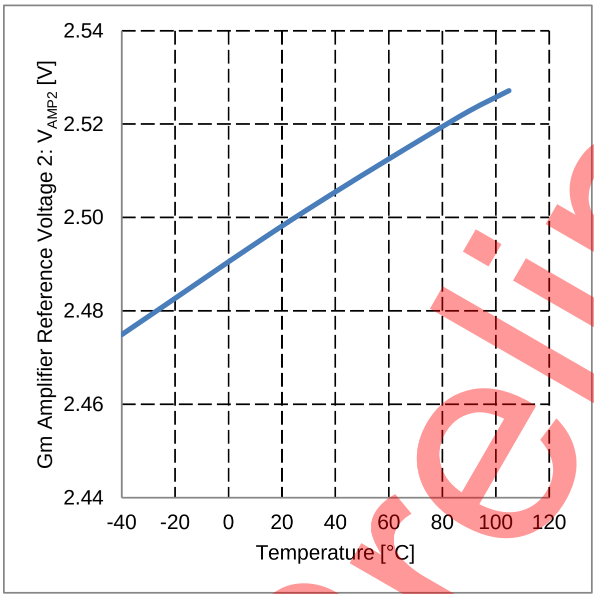


Figure 21. Gm Amplifier Reference Voltage 2 vs Temperature

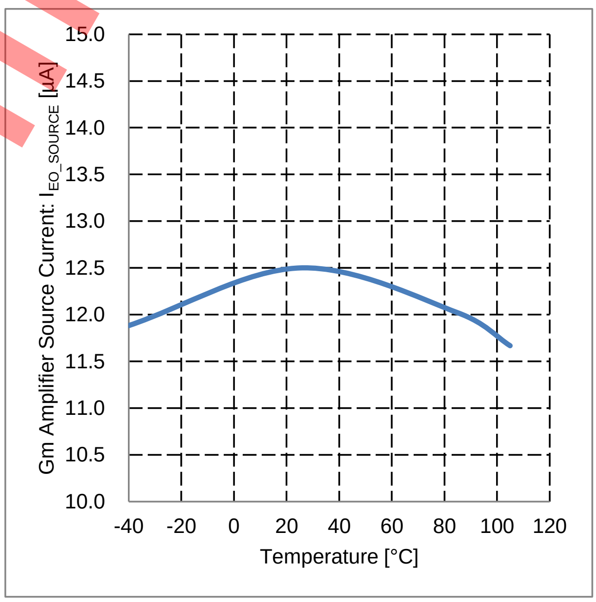


Figure 22. Gm Amplifier Source Current vs Temperature

Typical Performance Curves – continued

(Reference Data)

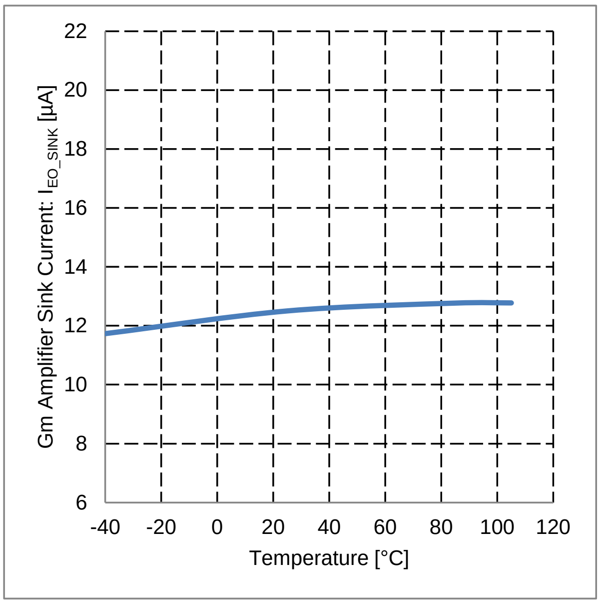


Figure 23. Gm Amplifier Sink Current vs Temperature

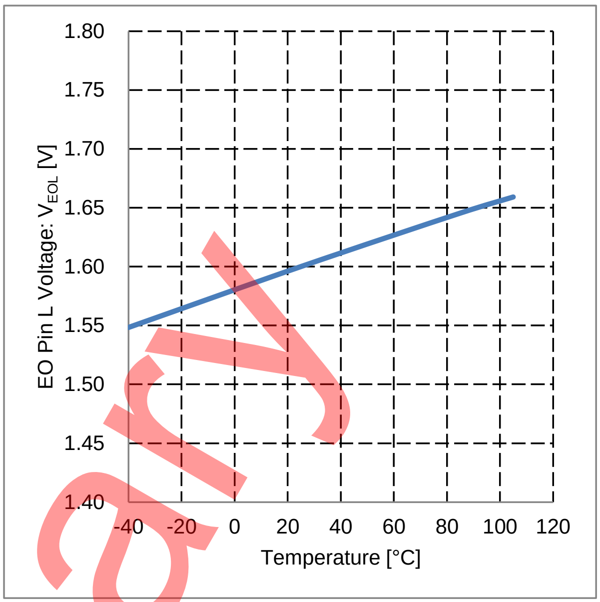


Figure 24. EO Pin L Voltage vs Temperature

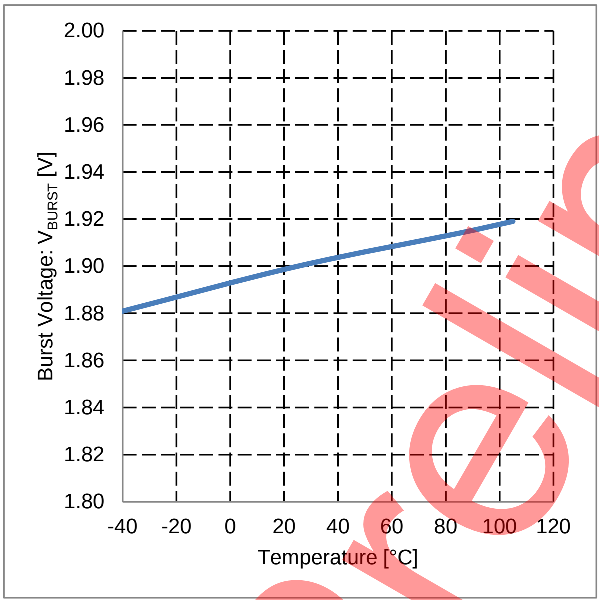


Figure 25. Burst Voltage vs Temperature

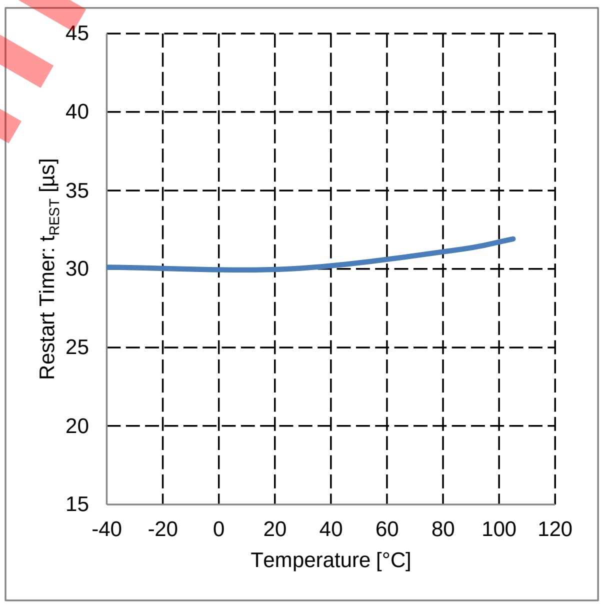


Figure 26. Restart Timer vs Temperature

Typical Performance Curves – continued
(Reference Data)

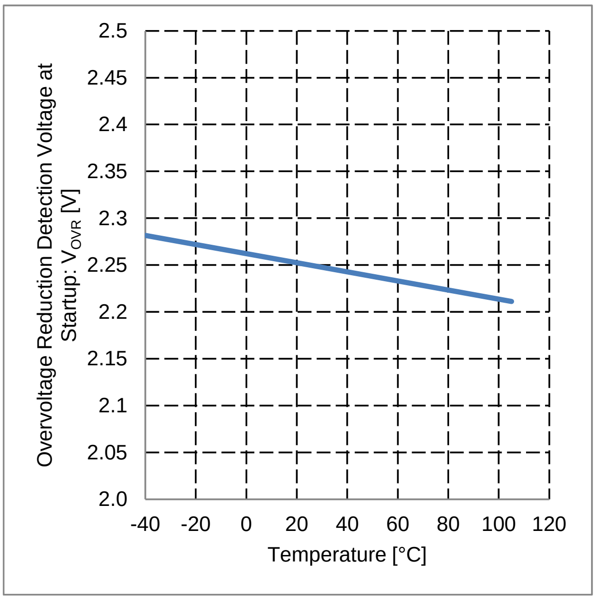


Figure 27. Overvoltage Reduction Detection Voltage at Startup vs Temperature

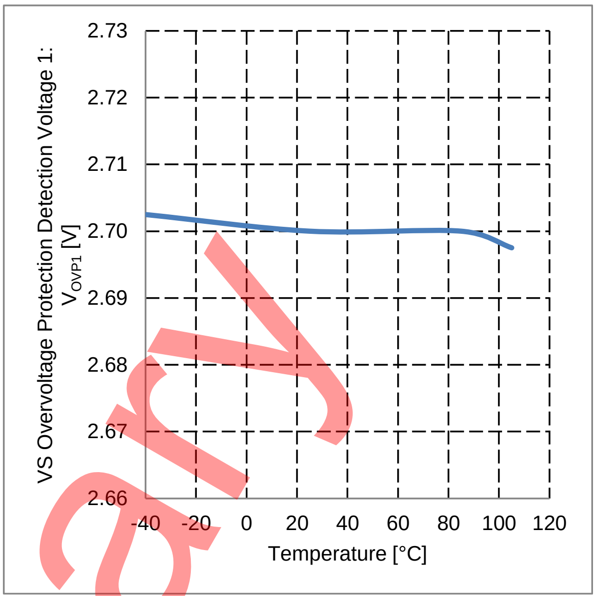


Figure 28. VS Overvoltage Protection Detection Voltage 1 vs Temperature

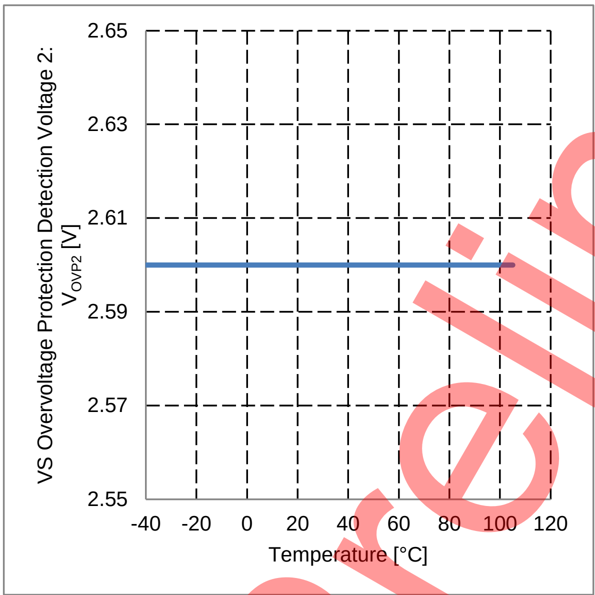


Figure 29. VS Overvoltage Protection Detection Voltage 2 vs Temperature

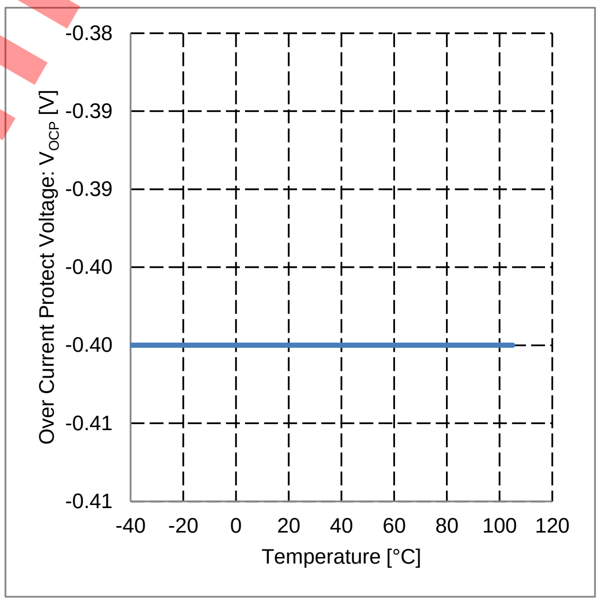


Figure 30. Over Current Protect Voltage vs Temperature

Typical Performance Curves – continued
(Reference Data)

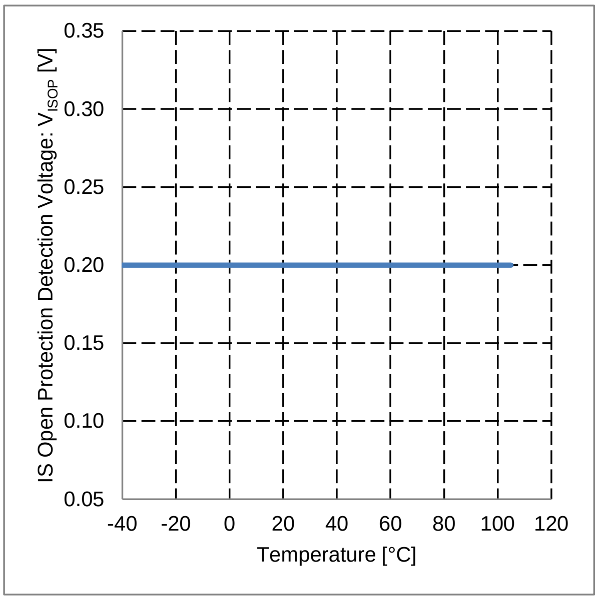


Figure 31. IS Open Protection Detection Voltage vs Temperature

Typical Connection Diagram

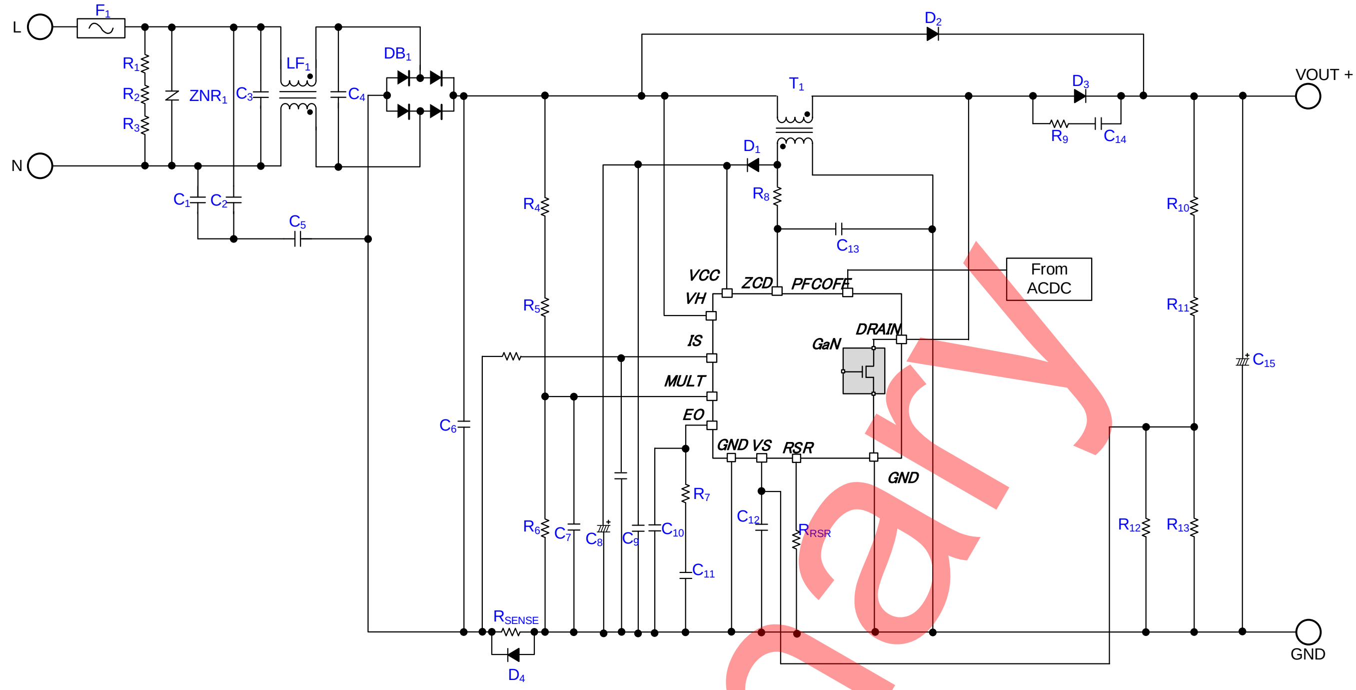


Figure 32. Application Example

1 Output-voltage Setting

The output-voltage is determined by the feedback resistor connected to the VS pin.

$$V_{OUT} = \left(1 + \frac{(R_{10}+R_{11})}{(R_{12}//R_{13})}\right) \times V_{AMP} = \left(1 + \frac{1582\ k\Omega}{10\ k\Omega}\right) \times 2.5\ V = 398\ \ [\mathrm{V}]$$

$R_{10} + R_{11}$:	Upper resistance value of output feedback
$R_{12}//R_{13}$:	Lower resistance value of output feedback
V_{AMP}:	Gm amplifier reference voltage 1

2 Calculation of inductance

Reference when V_{OUT} = 400 V and power = 200 W

$L = 250\ \mu H$

If L is set to a larger value, THD will be lowered, but the part size will be larger.

3 External Setting of VCC

VCC pin voltage variation during switching can be reduced by installing a capacitor on VCC pin.

We recommend using an electric-field capacitor with a withstand voltage of 50 V or more and 22 µF or more for VCC pin capacitor.

In addition, when generating VCC pin voltage from the start resistor and the auxiliary winding of the transformer, check VCC pin voltage evaluation when starting time and protection are detected on the actual device. When switching is stopped after starting, the current consumption of the IC decreases. Therefore, VCC pin voltage may rise depending on the starting resistor. VCC pin voltage discharge function prevents overvoltage breakdown of VCC pin.

This function makes it possible to reduce the starting resistance value and make the starting time faster.

Important Note in PWB Designing

Parts Arrangement

The components in Figure 35 dashed lines should be located as close to the ICs as possible. Also, arrange components to avoid interfering with switching lines, inductors, DRAIN, and other high current lines.

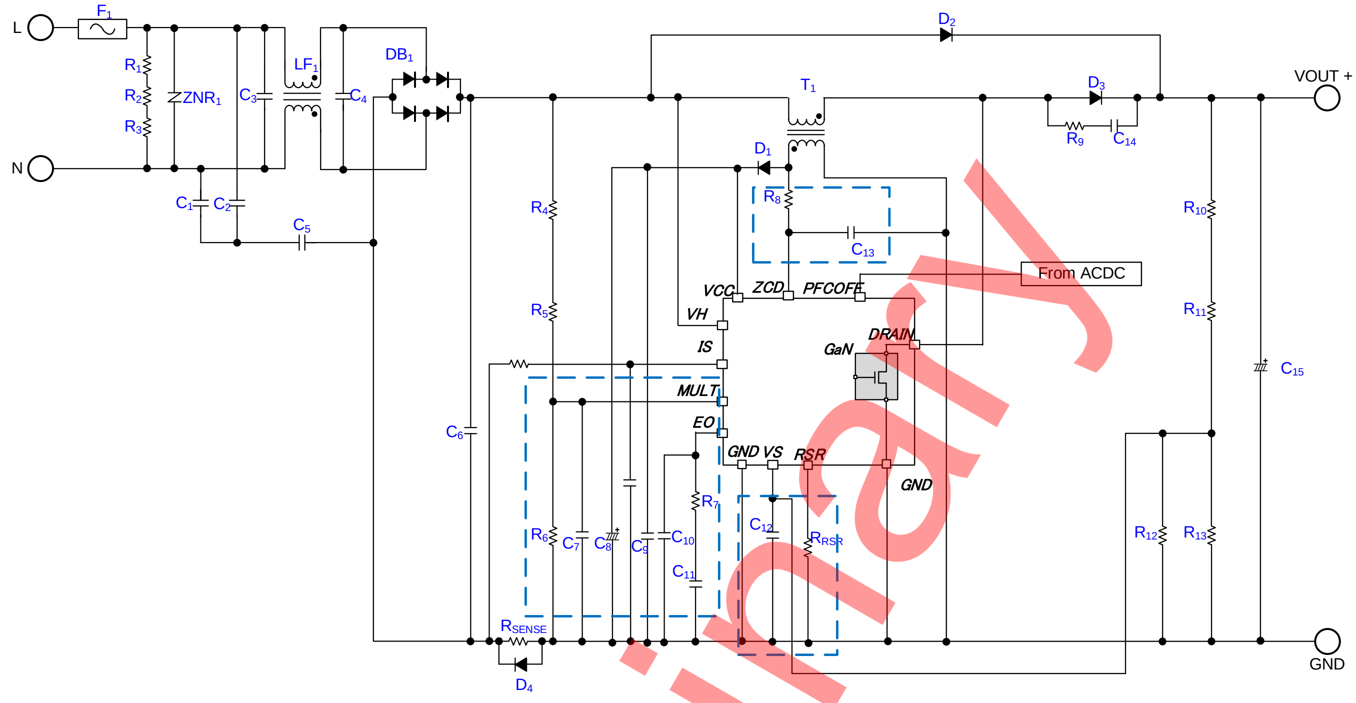


Figure 33. Parts Placement

GND Wiring Routing

The red wire of Figure 36 is a ground wire through which a large current flows. Wire each line independently and pull it thick and short. The blue line is the GND of the IC. Make the GND of IC and the GND of IC peripheral parts common.

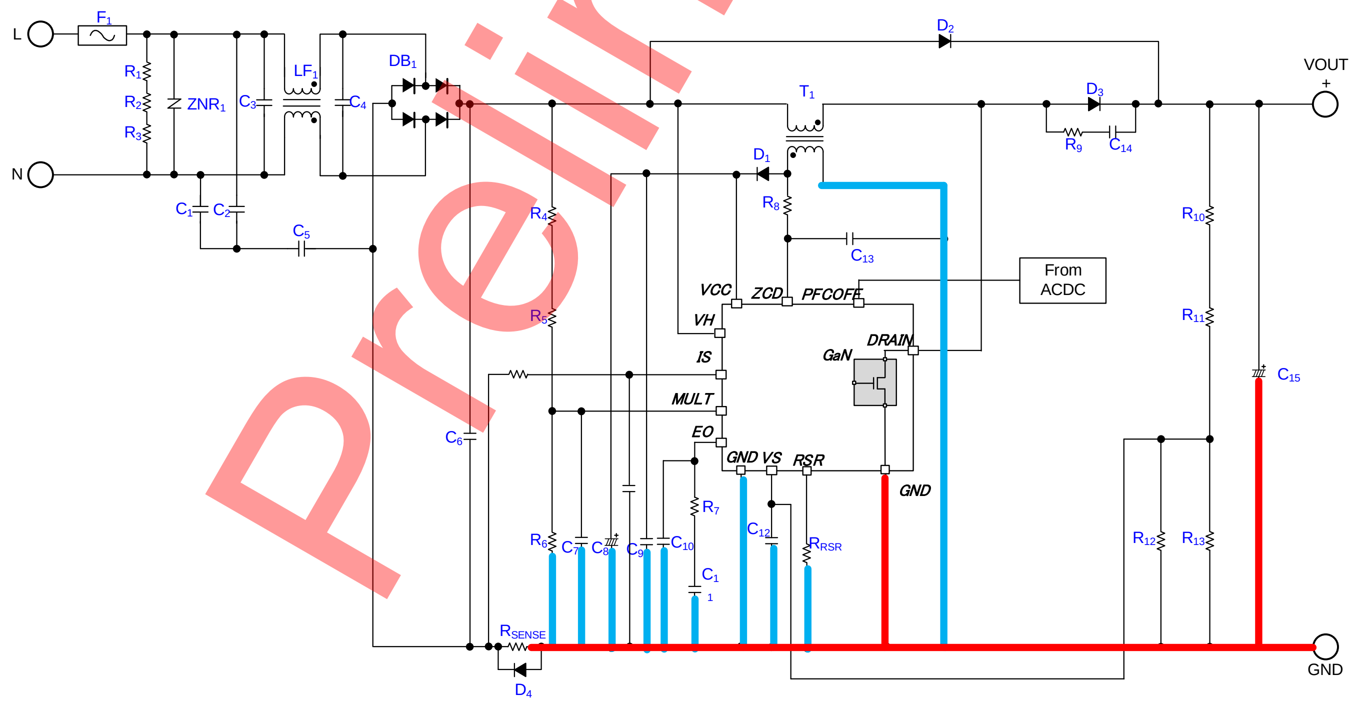


Figure 34. GND Line Layout

Board Design Notes-continued

High Current Line

The red line of Figure 37 carries a large amount of circuit current. Draw the red line part thick and short. Also, avoid routing lines with high IC or impedance nearby, as this may result in lines with high noise.

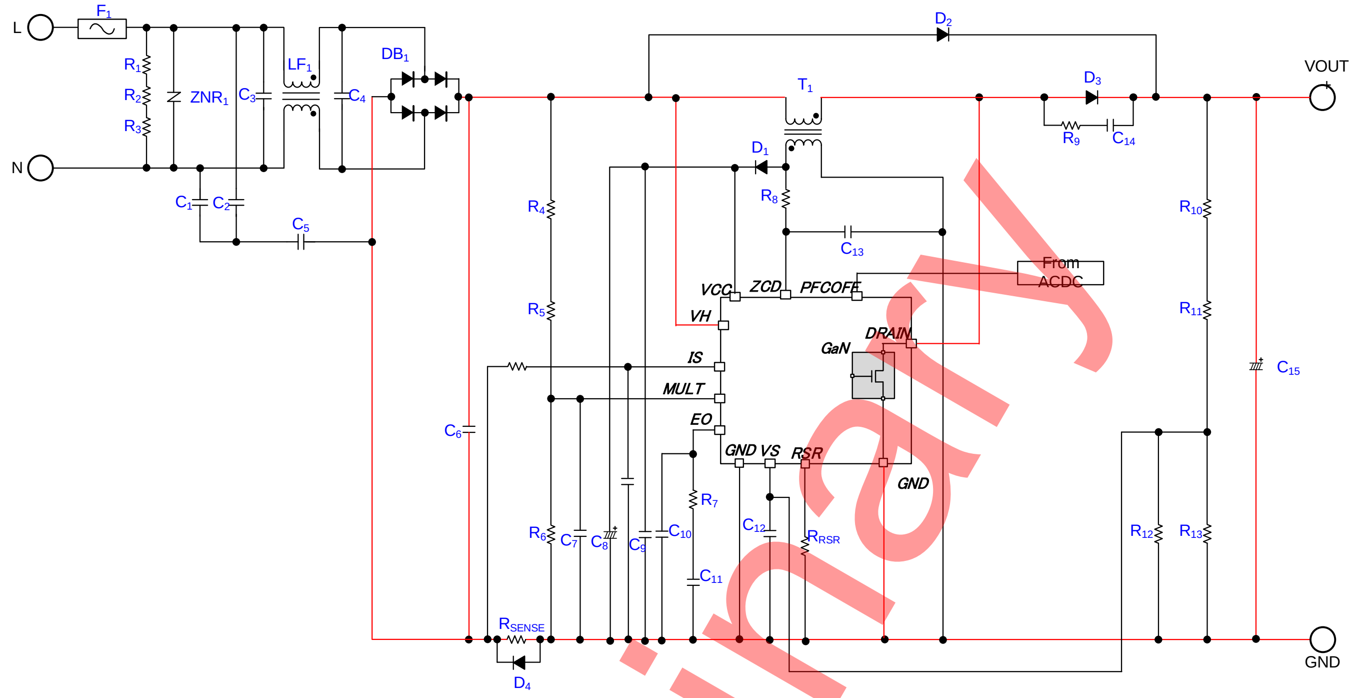
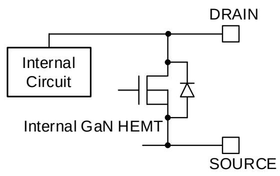


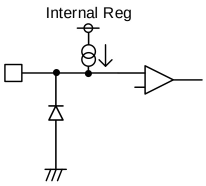
Figure 35. Large Current Line Layout

I/O Equivalent Circuit Diagram

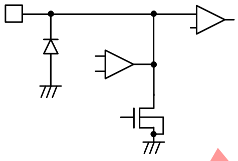
1,2,17-22,25-32 | SOURCE



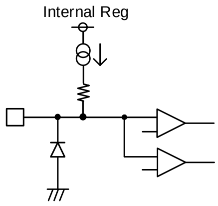
3 | VS



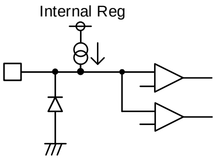
4 | EO



5 | RSR



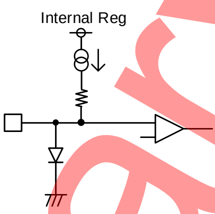
6 | MULT



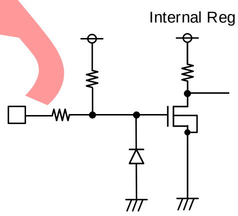
7,9-10,12,14,23,24 | N.C.

No Connection

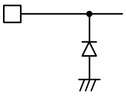
8 | IS



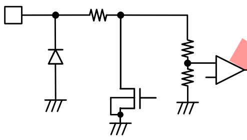
11 | PFCOFF



13 | VCC

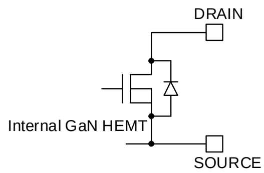


15 | ZCD

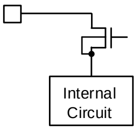


16 | GND

33-39 | DRAIN



40-41 | VH



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. **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.

8. **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.

9. **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

10. Regarding the Input Pin of the IC

This monolithic 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.

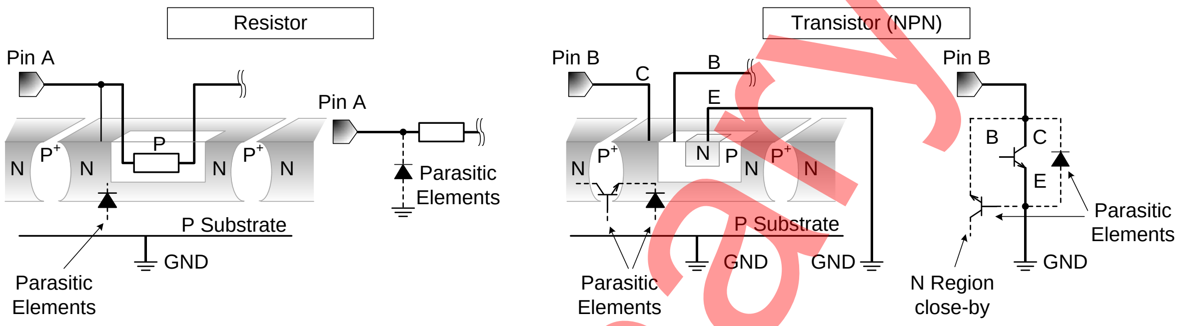


Figure 36. Example of Monolithic IC Structure

11. 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.

12. Thermal Shutdown Circuit (TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's maximum junction temperature rating. If however the rating is exceeded for a continued period, the junction temperature (Tj) will rise which will activate the TSD circuit that will turn OFF power output pins. When the Tj falls below the TSD threshold, the circuits are automatically restored to normal operation.
Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

13. Over Current Protection Circuit (OCP)

This IC incorporates an integrated over current protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

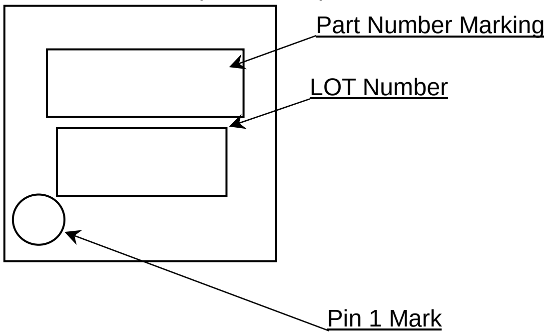
Ordering Information

B M 3 G F X X M U V - L B Z E 2

- GaN HEMT D-S ON resistor (Typ)
  - 01: 150 mΩ
  - 02: 70 mΩ
- Package
  - MUV: VQFN41V8080K
- Product rank
  - LB: For industrial equipment
- Packaging and forming specifications
  - E2: Embossed tape & reel

Marking Diagram

VQFN41V8080K (TOP VIEW)



Lineup

Part Number Marking	Orderable Part Number	GaN HEMT D-S ON State Resistance (Typ)	Product Name
M3GF01MUV	BM3GF01MUV-LBZE2	150 mΩ	BM3GF01MUV-LBZ
M3GF02MUV	BM3GF02MUV-LBZE2	70 mΩ	BM3GF02MUV-LBZ

Physical Dimension and Packing Information

Package Name	VQFN41V8080K

TBD

Reel

Revision history

Date	Revision	Changes
17 Sep 2024	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

JAPAN	USA	EU	CHINA
CLASSⅢ	CLASSⅢ	CLASSⅡb	CLASSⅢ
CLASSⅣ		CLASSⅢ	

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 (Exclude cases where no-clean type fluxes is used. However, recommend sufficiently about the residue.); 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 Cl_2, H_2S, NH_3, SO_2, and NO_2
   [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.

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