High performance Regulators for PCs

Switching Regulator Controller for Graphic Chip Cores

BD9560MUV

No.10030ECT10

●Description

BD9560MUV is a switching regulator controller with high output current which can achieve low output voltage (0.412V ~ 1.2875V) from a wide input voltage range (4.5V ~ 25V). The setting of output voltage depends on DAC built in. High efficiency for the switching regulator can be realized by utilizing an external N-MOSFET power transistor. SLLM (Simple Light Load Mode) technology is also integrated to improve efficiency in light load mode, providing high efficiency over a wide load range. For protection and ease of use, the soft start function, variable frequency function, short circuit protection function with timer latch, over voltage protection, over current protection and power good function are all built in. This switching regulator is specially designed for GMCH.

●Features

1) Switching Regulator Controller
2) Light Load Mode and Continuous Mode Changeable
3) Thermal Shut Down circuit built-in (TSD)
4) Under Voltage Lockout circuit built-in (UVLO)
5) Over Current Protection circuit built-in (OCP)
6) Over Voltage Protection circuit built-in (OVP)
7) Short circuit protection with timer-latch built-in
8) Power good circuit built-in
9) Soft start function to minimize rush current during startup
10) Switching Frequency Variable (f=200 KHz ~ 600 KHz)
11) VQFN032V5050 package

●Applications

Laptop PC, Desktop PC, Digital Components

●Maximum Absolute Ratings (Ta=25℃)

Parameter	Symbol	Ratings	Unit
Input voltage 1	VCC	7 *1*2	V
Input voltage 2	PVCC	7 *1*2	V
Input voltage 3	VIN	35 *1*2	V
BOOT voltage	BOOT	35 *1*2	V
BOOT-SW voltage	BOOT-SW	7 *1*2	V
HG-SW voltage	HG-SW	7 *1*2	V
LG voltage	LG	PVCC	V
VREF voltage	VREF	VCC	V
VRON input voltage	VRON	7 *1	V
Logic input voltage	CL/SCP/SS/TON/SLLM/VID4-0/PWRGD_C/DAC_C	VCC	V
Logic output voltage 1	PWRGD	7	V
Logic output voltage 2	SUS_OUT	VCC	V
Power dissipation1	Pd1	0.38*3	W
Power dissipation2	Pd2	0.88*4	W
Operating Temperature Range	Topr	-10 ~ +100	℃
Storage Temperature Range	Tstg	-55 ~ +150	℃
Junction Temperature	Tjmax	+150	℃

*1 Not to exceed Pd..
*2 Maximum voltage that can be proof against instantaneous applied voltage such as serge, back electromotive voltage or continuous pulse applied voltage (Duty ratio : less than 10%)
*3 Reduced by 3.0mW for each increase in Ta of 1℃ over 25℃ (when don't mounted on a heat radiation board)
*4 Reduced by 7.0mW for increase in Ta of 1℃ over 25℃. (when mounted on a board 70.0mm × 70mm × 1.6mm Glass-epoxy PCB.)

●**Operating Conditions (Ta=25℃)**

Parameter	Symbol	Ratings		Unit
		Min.	Max.	
Input voltage 1	VCC	4.5	5.5	V
Input voltage 2	PVCC	4.5	5.5	V
Input voltage 3	VIN	4.5	25	V
BOOT voltage	BOOT	4.5	30	V
SW voltage	SW	-2	25	V
BOOT-SW voltage	BOOT-SW	4.5	5.5	V
VRON input voltage	VRON	-0.3	5.5	V
Logic input voltage	CL/SCP/SS/TON/SLLM/VID4-0/PWRGD_C/DAC_C	-0.3	VCC+0.3	V
Logic output voltage 1	PWRGD	-	5.5	V
Logic output voltage 2	SUS_OUT	-0.3	VCC	V

*This product should not be used in a radioactive environment.

●**ELECTRICAL CHARACTERISTICS**

(Unless otherwise noted, Ta=25℃, VCC=5V,VIN=12V, VRON=5V,VDAC=1.2811V,SLLM=0V)

Parameter	Symbol	Limits			Unit	Conditions
		MIN.	TYP.	MAX.		
[Total block]						
VCC bias current	ICC_VCC	-	4	10	mA	VCC=5V
VIN bias current	ICC_VIN	-	20	50	μA	VIN=12V
VCC shut down mode current	IST_VCC	-	0	10	μA	VRON=0V
VIN shut down mode current	IST_VIN	-	0	10	μA	VRON=0V
VRON low voltage	VRON_L	GND	-	0.8	V	
VRON high voltage	VRON_H	2.3	-	5.5	V	
VRON bias current	IVRON	-	10	20	μA	VRON=5V
[Reference voltage block]						
Reference output voltage	VREF	2.475	2.500	2.525	V	IREF=0 to 100μA
Maximum source current	IREF_source	0.5	-	-	mA	
Line regulation	Reg.l	-	0.1	0.3	%/V	VCC=4.5 to 5.5V
Load regulation	Reg.L	-	5	20	mV	IREF=0 to 0.5mA
[Over voltage protection block]						
Threshold voltage	VOVPL	1.400	1.500	1.600	V	
Hysterisys voltage	VOVPH	50	150	250	mV	
[Under voltage lock-out block]						
VCC input threshold voltage	VCC_UVLO	4.0	4.1	4.2	V	VCC: Sweep up
VCC hysterics voltage	dVCC_UVLO	50	100	200	mV	VCC: Sweep down
[VID block]						
VID input high voltage	VVID_H	2.0	-	VCC	V	
VID input low voltage	VVID_L	GND	-	0.8	V	
VID bias current	IVID	-	0	1	μA	VVID=3.3V
DAC delay charge current	IDAC+	90	170	250	μA	
DAC output voltage	VDAC	1.2683	1.2811	1.2939	V	VID[0:4]=0V
[Error amplifier block]						
Output feedback voltage	VFB	VDAC-0.5%	VDAC	VDAC+0.5%	V	
[Current limit protection block]						
Current limit threshold1	Ilim	22	30	38	mV	CL=0.48V
CL adjustment range	VCL	0.2	-	1.5	V	
CL bias current	ICL	-	0	1	μA	CL=5V

●ELECTRICAL CHARACTERISTICS

(Unless otherwise noted, Ta=25℃, VCC=5V,VIN=12V, VRON=5V,VDAC=1.2811V,SLLM=0V)

Parameter	Symbol	Limits			Unit	Conditions
		MIN.	TYP.	MAX.		
[Load slope setup block]						
Offset voltage	VLS	TBD	0	TBD	mV	
[Soft start block]						
Delay time	TSS	-	65	-	μs	Css=100pF
SS Delay charge current	ISS	1.5	2.0	2.5	μA	
[Short circuit Protection]						
Delay time	TSCP	-	60	-	μs	Cscp=100pF
SCP Delay charge current	ISCP	1.5	2.0	2.5	μA	
[SLLM block]						
Continuous mode threshold	Vthcon	GND	-	0.5	V	
SLLM threshold	VthSL^{2}M	VCC-0.5	-	VCC	V	
[Operating frequency]						
Switching frequency	Fosc	-	300	-	kHz	TON=1V
[On time pulse width]						
On time pulse width	Fosc	250	350	450	ns	TON=1V
TON adjustment voltage	VTON	0.2	-	2.0	V	
TON bias current	ITON	-	0	1	μA	TON=5V
[OFF time width]						
Min off time	MinOff	0.25	0.5	1.0	μs	
[Driver block]						
HG high side ON resistor	RonHGH	-	1	2	Ω	
HG low side ON resistor	RonHGL	-	1	2	Ω	
LG high side ON resistor	RonLGH	-	1	2	Ω	
LG high side ON resistor	RonLGL	-	0.5	1	Ω	
[Power good block]						
PWRGD Low threshold voltage	PGDLow	VDAC-0.4	VDAC-0.3	VDAC-0.2	V	
PWRGD High threshold voltage	PGDHigh	VDAC+0.1	VDAC+0.2	VDAC+0.3	V	
PWRGD Output voltage	VPWRGD	-	-	0.4	V	IPRGD=4mA
PWRGD Output leakage current	PGDLeak	-	-	10	μA	PWRGD=3.6V
PWRGD_C Delay charge current	IPD	1.5	2.0	2.5	μA	

●DAC code table

State	VRON	VID4	VID3	VID2	VID1	VID0	VCCGFX	VDAC	SUS OUT
Render Performance States	1	0	0	0	0	0	1.28750V	1.2811V	0
	1	0	0	0	0	1	1.26175V	1.2554V	0
	1	0	0	0	1	0	1.23600V	1.2298V	0
	1	0	0	0	1	1	1.21025V	1.2042V	0
	1	0	0	1	0	0	1.18450V	1.1786V	0
	1	0	0	1	0	1	1.15875V	1.1530V	0
	1	0	0	1	1	0	1.13300V	1.1273V	0
	1	0	0	1	1	1	1.10725V	1.1017V	0
	1	0	1	0	0	0	1.08150V	1.0761V	0
	1	0	1	0	0	1	1.05575V	1.0505V	0
	1	0	1	0	1	0	1.03000V	1.0249V	0
	1	0	1	0	1	1	1.00425V	0.9992V	0
	1	0	1	1	0	0	0.97850V	0.9736V	0
	1	0	1	1	0	1	0.95275V	0.9480V	0
	1	0	1	1	1	0	0.92700V	0.9224V	0
	1	0	1	1	1	1	0.90125V	0.8967V	0
	1	1	0	0	0	0	0.87550V	0.8711V	0
	1	1	0	0	0	1	0.84975V	0.8455V	0
Render Suspend States	1	1	0	0	1	0	0.82400V	0.8199V	1
	1	1	0	0	1	1	0.79825V	0.7943V	1
	1	1	0	1	0	0	0.77250V	0.7686V	1
	1	1	0	1	0	1	0.74675V	0.7430V	1
	1	1	0	1	1	0	0.72100V	0.7174V	1
	1	1	0	1	1	1	0.69525V	0.6918V	1
	1	1	1	0	0	0	0.66950V	0.6662V	1
	1	1	1	0	0	1	0.64375V	0.6405V	1
	1	1	1	0	1	0	0.61800V	0.6149V	1
	1	1	1	0	1	1	0.59225V	0.5893V	1
	1	1	1	1	0	0	0.56650V	0.5637V	1
	1	1	1	1	0	1	0.54075V	0.5380V	1
	1	1	1	1	1	0	0.51500V	0.5124V	1
	1	1	1	1	1	1	0.41200V	0.4099V	1
	0	×	×	×	×	×	0.000V	×	1

●Reference Data

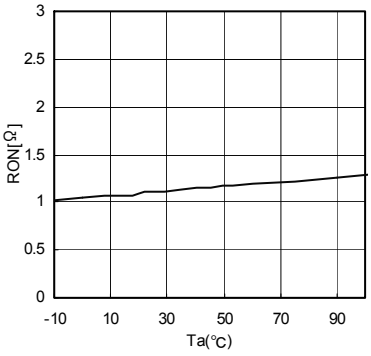


Fig.1 HG high side ON resistance

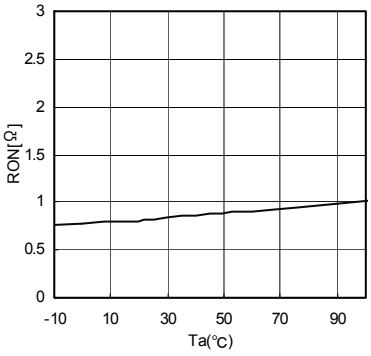


Fig.2 HG low side ON resistance

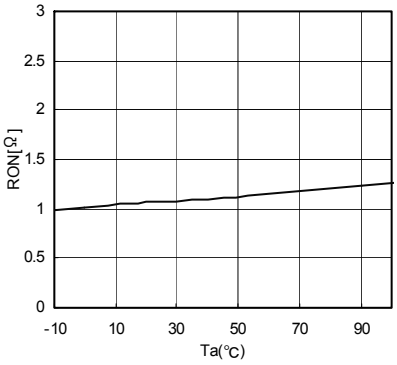


Fig.3 LG high side ON resistance

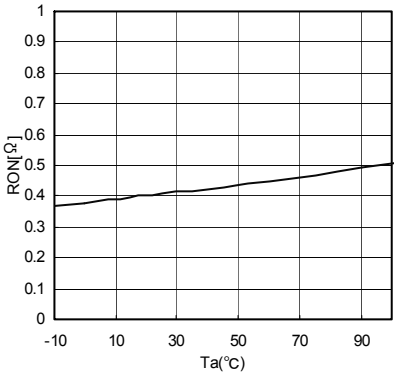


Fig.4 LG low side ON resistance

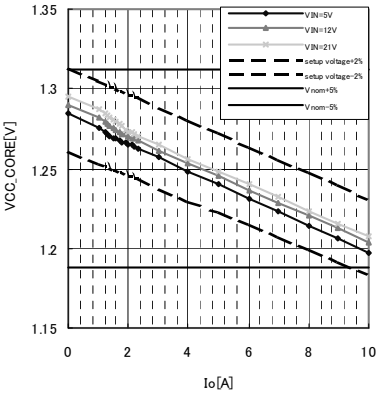


Fig.5 Load slope

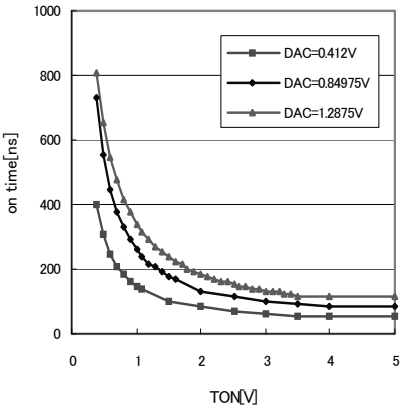


Fig.6 Ton_On time

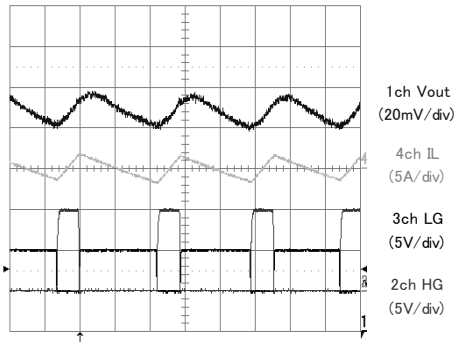


Fig.7 (VIN=5V)
Switching wave form (Iout=0A)

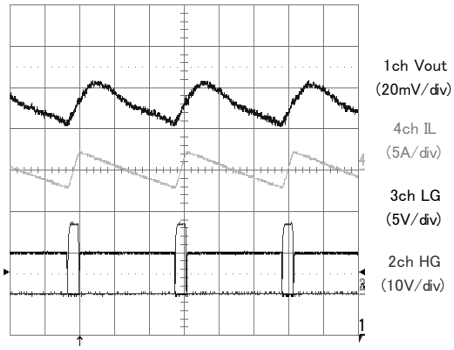


Fig.8(VIN=12V)
Switching wave form (Iout=0A)

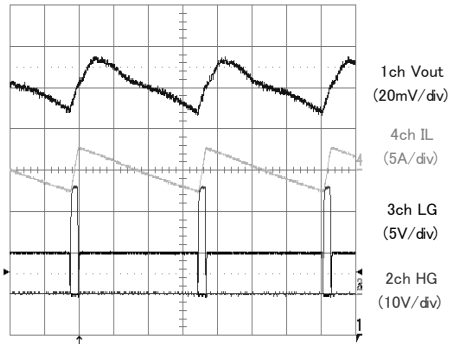


Fig.9 (VIN=21V)
Switching wave form (Iout=0A)

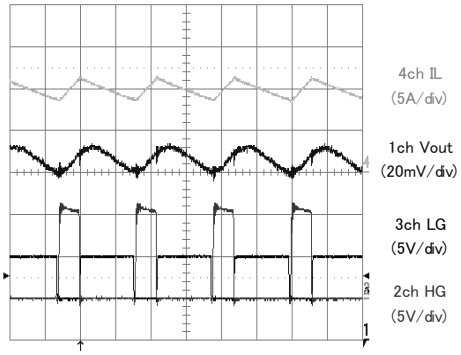


Fig.10 (VIN=5V)
Switching wave form (Iout=10A)

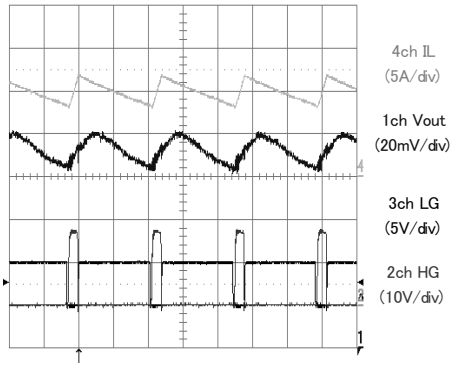


Fig.11(VIN=12V)
Switching wave form (Iout=10A)

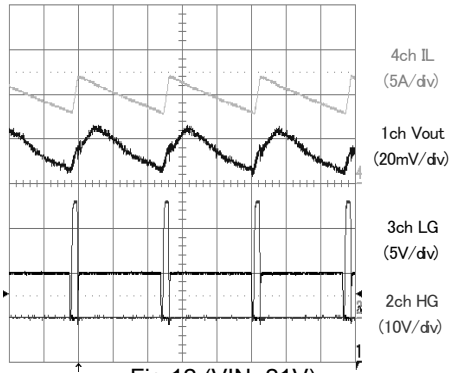


Fig.12 (VIN=21V)
Switching wave form (Iout=10A)

●Reference Data

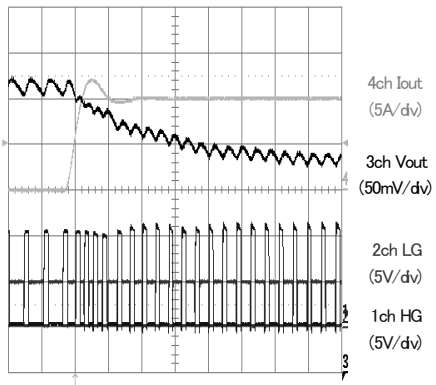


Fig.13 Transient Response (VIN=5V)
VOUT=1.2875V, IOUT=0A→10A

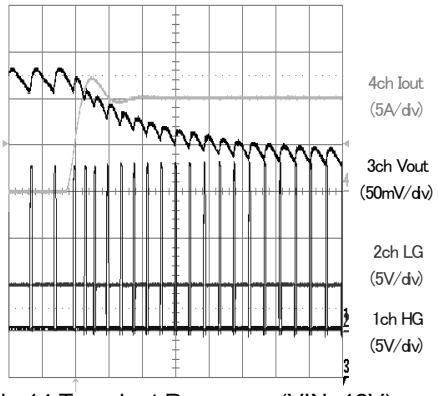


Fig.14 Transient Response (VIN=12V)
VOUT=1.2875V, IOUT=0A→10A

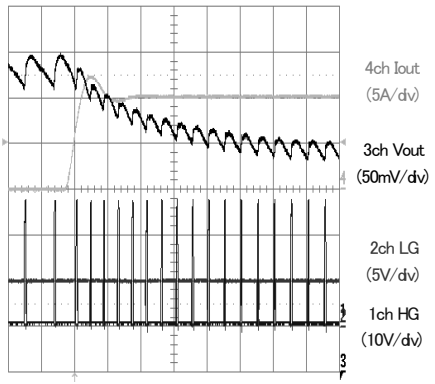


Fig.15 Transient Response (VIN=21V)
VOUT=1.2875V, IOUT=0A→10A

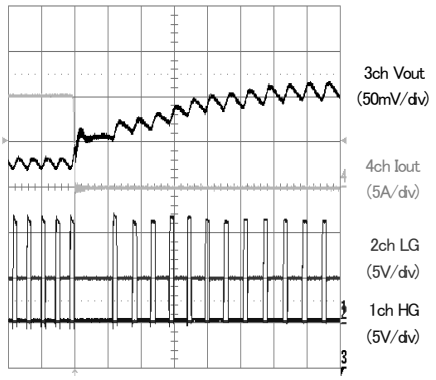


Fig.16 Transient Response (VIN=5V)
VOUT=1.2875V, IOUT=10A→0A

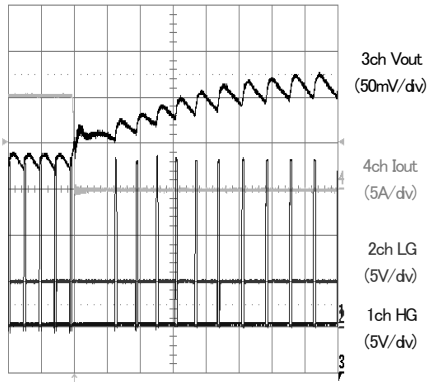


Fig.17 Transient Response (VIN=12V)
VOUT=1.2875V, IOUT=10A→0A

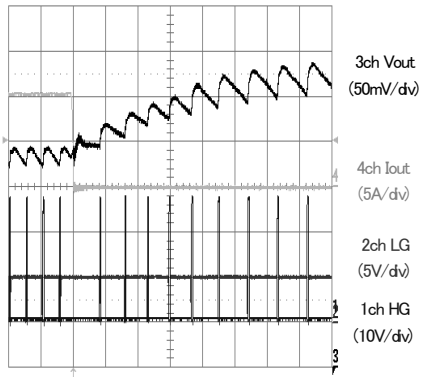


Fig.18 Transient Response (VIN=21V)
VOUT=1.2875V, IOUT=10A→0A

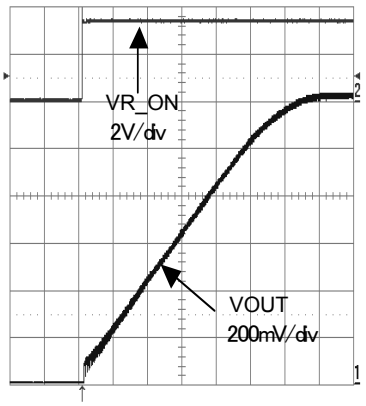


Fig.19 Wakeup wave form
VOUT=1.2875V,VIN=12V, IOUT=0A

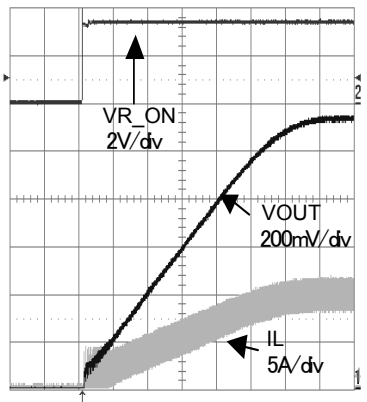


Fig.20 Wakeup wave form
VOUT=1.2875V,VIN=12V, RVOUT=120mΩ

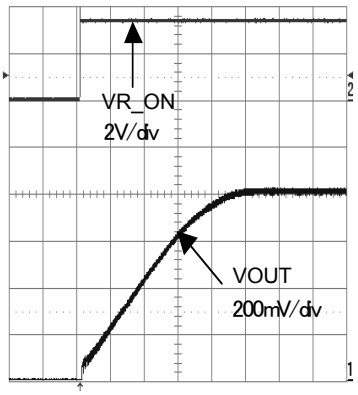


Fig.21 Wakeup wave form
VOUT=0.84975V,VIN=12V, IOUT=0A

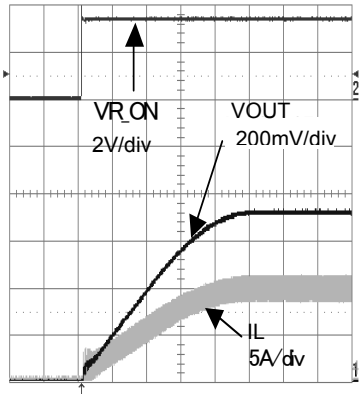


Fig.22 Wakeup wave from
VOUT=0.84975V,VIN=12V, RVOUT=80mΩ

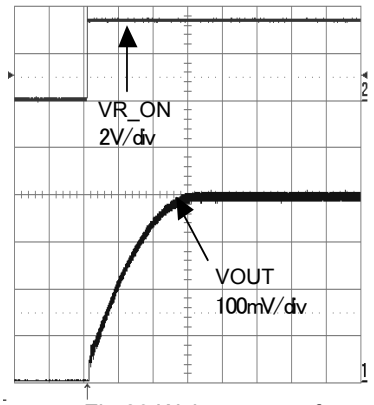


Fig.23 Wakeup wave form
VOUT=0.412V,VIN=12V, IOUT=0A

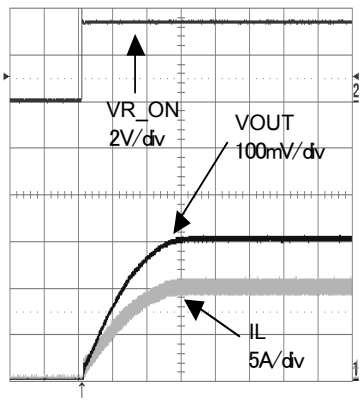
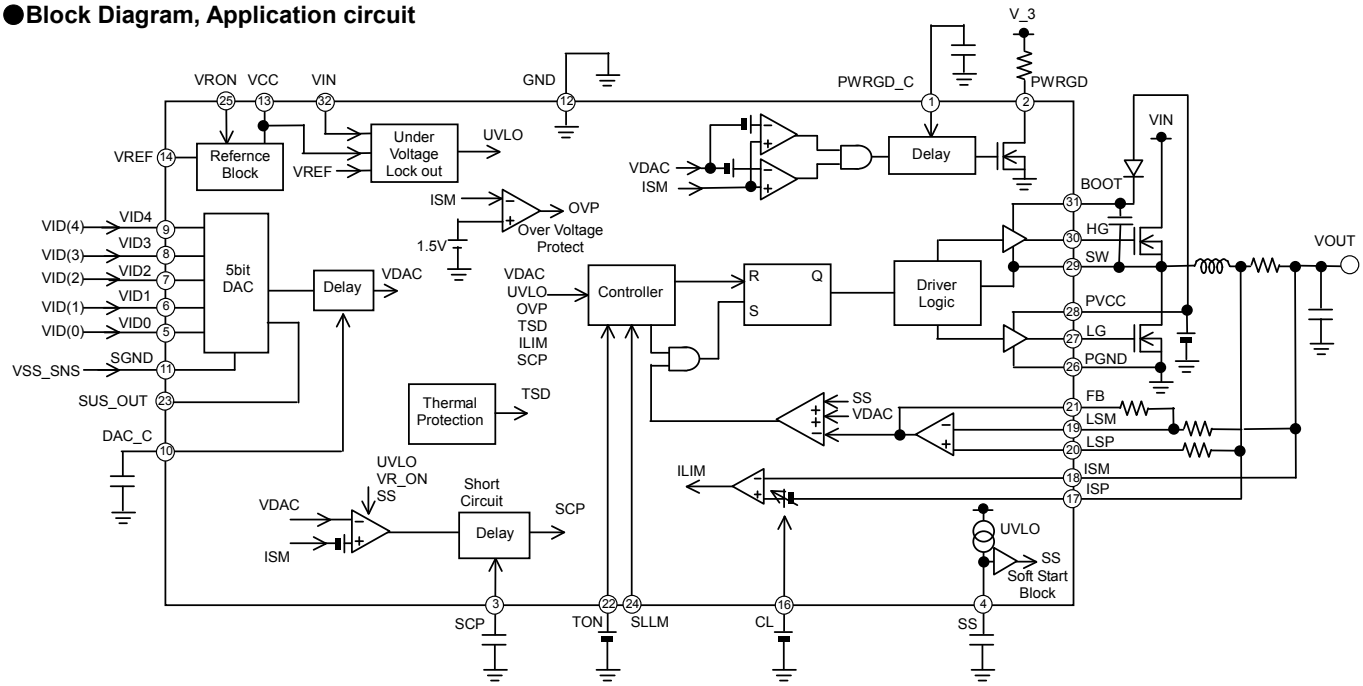


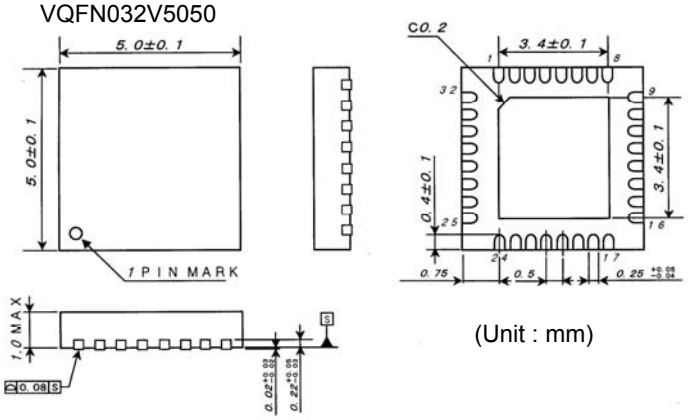
Fig.24 Wakeup wave form
VOUT=0.412V,VIN=12V, RVOUT=40mΩ

●Block Diagram, Application circuit



●Pin Configuration

VQFN032V5050



(Unit : mm)

●Pin Function Table

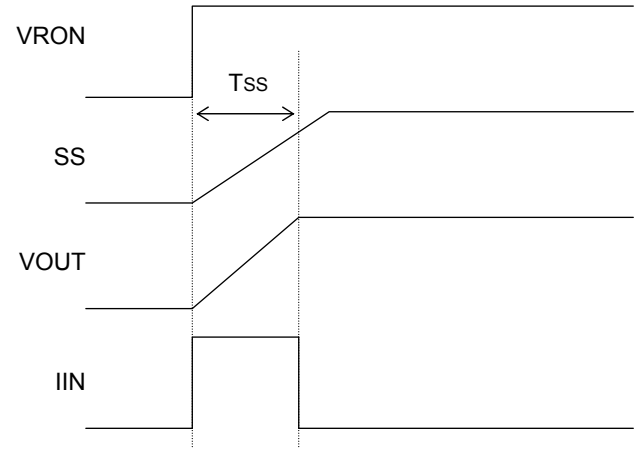
Pin No.	Pin name	Pin No.	Pin name
1	PWRGD_C	17	ISP
2	PWRGD	18	ISM
3	SCP	19	LSM
4	SS	20	LSP
5	VID0	21	FB
6	VID1	22	TON
7	VID2	23	SUS_OUT
8	VID3	24	SLLM
9	VID4	25	VRON
10	DAC_C	26	PGND
11	SGND	27	LG
12	GND	28	PVCC
13	VCC	29	SW
14	VREF	30	HG
15	NC	31	BOOT
16	CL	32	VIN

●Pin Descriptions

- VCC
  This is the power supply pin for IC internal circuits, except the FET driver. The input supply voltage range is 4.5V to 5.5V. It is recommended that a 1uF bypass capacitor be put in this pin.
- VRON
  When VRON pin voltage at least 2.3V, the status of this switching regulator become active. Conversely, the status switches off when VRON pin voltage goes lower than 0.8V and circuit current becomes 10μA or less.
- VREF
  This is the reference voltage output pin. The voltage is 2.5V, with 100μA current ability. It is recommended that a 0.1uF capacitor be established between VREF and GND.
- CL
  BD9560MUV detects the voltage between ISP pin and ISM pin and limits the output current (OCP) voltage equivalent to 1/16 of the CL voltage drop of external current sense resistor. A very low current sense resistor or inductor DCR can also be used for this platform.
- SS
  This is the adjustment pin to set the soft start time. SS voltage is low during shutdown status. When VRON is the status of high, the soft start time can be determined by the SS charge current and capacitor between SS and GND. Until SS reaches DAC output voltage, the output voltage VOUT is equivalent to SS voltage.
- SCP
  This is the pin to adjust the timer latch time for short circuit protection. The timer circuit is active when the output voltage VOUT becomes 70% of DAC output voltage, and the output switches OFF (HG=L, LG=L) and is latched after the specified time. When the UVLO circuit is active or VRON is low, this latch function is cancelled.
- VIN
  Since the VIN line is also the input voltage of switching regulator, stability depends in the impedance of the voltage supply. It is recommended to establish a bypass capacitor or CR filter suitable for the actual application.
- TON
  This is the adjustment pin to set the ON time. On time is determined by the applied voltage to TON pin.
- ISP, ISM
  These pins are connected to both sides of the current sense resistor detect output current. The voltage drop between ISP and ISM is compared with the voltage equivalent to 1/16 of CL voltage. When this voltage drop hits the specified voltage level, the output voltage is OFF. And these are the pins returned output voltage for Power Good block, SCP block and OVP block.
- BOOT
  This is the voltage supply to drive the high side FET. The maximum absolute ratings are 35V (from GND) and 7V (from SW). BOOT voltage swings between (VIN+VCC) and VCC during active operation.
- HG
  This is the voltage supply to drive the Gate of the high side. This voltage swings between BOOT and SW. High-speed Gate driving for the high side FET is achieved due to the low on-resistance (1.5 ohm when HG is high, 1.0 ohm when HG is low) driver.
- SW
  This is the source pin for the high side FET. The maximum absolute ratings are 30V (from GND). SW voltage swings between VIN and GND.
- PVCC
  This is the power supply to drive the low side FET Gate. It is recommended that a 10uF bypass capacitor be established to compensate for rush current during the FET ON/OFF transition.
- LG
  This is the voltage supply to drive the Gate of the low side FET. This voltage swings between PVCC and PGND. High–speed Gate driving for the low side FET is achieved due to the low on-resistance (1.5 ohm when LG is high, 0.5 ohm when LG is low) driver.
- PGND
  This is the power ground pin connected to the source of the low side FET.
- PWRGD
  This is the Power Good output pin with open drain. When VOUT range is (VDAC-300mV) to (VDAC+200mV), the status is high, and when it is in out of range, the status is low.
- PWRGD_C
  This is the pin to adjust the delay time of Power Good. When the status of the output voltage is Power Good, the delay time is determined by the capacitor connected between the fixed current for internal IC and PWRGD_C-GND.
- SLLM
  This is the adjustment pin to set the control mode. When SLLM pin voltage goes lower than 0.5V, the status is continuous mode. Conversely the status is SLLM (Simple Light Load Mode) when SLLM pin voltage is at least (VCC-0.5).
- VID[0:4]
  This is the logic input pin for 5bit DAC.
- LSP, LSM
  This is the input pin for the amplifier to set the load slope.
- SUS_OUT
  The output is SUS_OUT=”H” in performance states, is SUS_OUT=”L” in sleep states.

● **Timing Chart**

・Soft Start Function



Soft start is exercised with the VRON pin set high. Current control takes effect at startup, enabling a moderate output voltage “ramping start.” Soft start timing and incoming current are calculated with formulas (1) and (2) below.

Soft start time

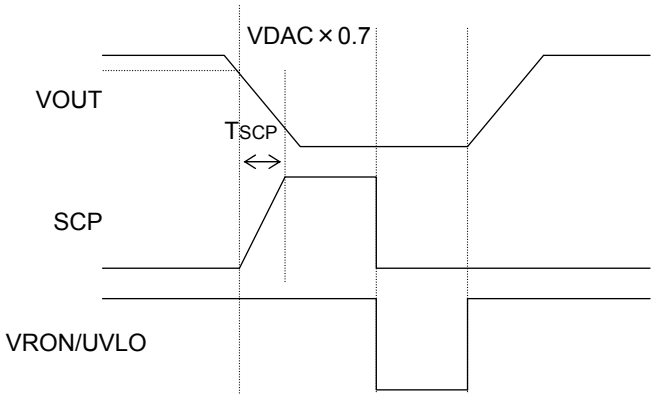
$$Tss = \frac{VDAC \times Css}{2\mu A(typ)} \text{ [sec]} \quad \cdot\cdot\cdot (1)$$

Incoming current

$$IIN = \frac{Co \times VOUT}{Tss} \text{ [A]} \quad \cdot\cdot\cdot (2)$$

(Css: Soft start capacitor; Co: Output capacitor)

・Timer Latch Type Short Circuit Protection

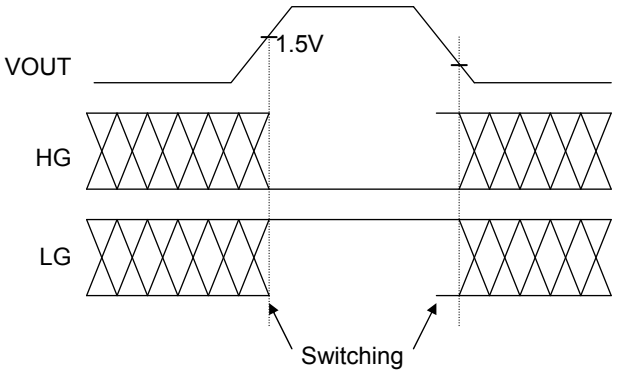


Short protection kicks in when output falls to or below (VDAC X0.7).
When the programmed time period elapses, output is latched OFF to prevent destruction of the IC. Output voltage can be restored either by reconnecting the VRON pin or disabling UVLO. Short Circuit Protection timing is calculated with formulas (3) below.

Short Circuit Protection time

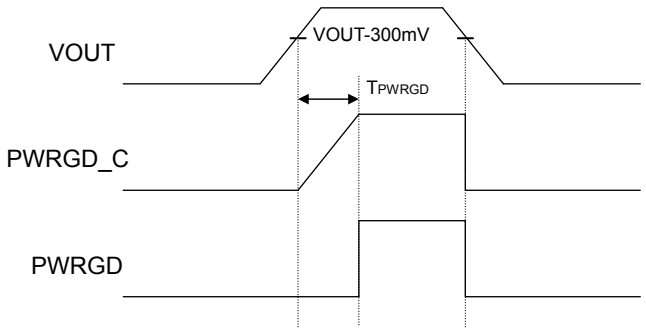
$$Tscp = \frac{1.2(V) \times CSCP}{2\mu A(typ)} \text{ [sec]} \quad \cdot\cdot\cdot (3)$$

・Output Over Voltage Circuit Protection



Over voltage protection kicks and low side FET is the status of full ON in when output is up to 1.5V or more （LG=High、HG=Low）. It is operated ordinary with falling of output.

・Power good function



Power good function kicks in when output is from (VOUT-300mV) to (VOUT+200mV). After setting, power good pin is the status of high. (Pull up the resistance outside) Delay timing of power good is calculated with formulas (4) below.

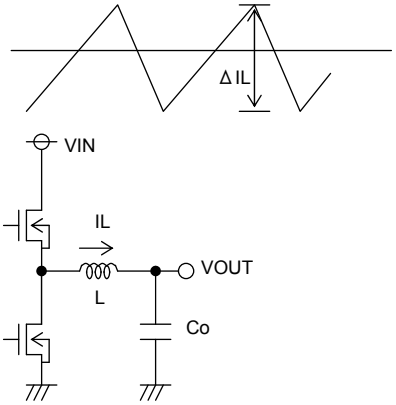
Power good delay time

$$TPWRGD = \frac{1.2(V) \times CPWRGD\_C}{2\mu A(typ)} \text{ [sec]} \quad \cdot\cdot\cdot (4)$$

(CPWRGD : PWRGD_C pin capacitor)

●External Component Selection

1. Inductor (L) selection



Output ripple current

The inductor value is a major influence on the output ripple current. As formula (5) below indicates, the greater the inductor or the switching frequency, the lower the ripple current.

$$\Delta I_L = \frac{(V_{IN}-V_{OUT}) \times V_{OUT}}{L \times V_{IN} \times f} \quad [A] \cdots (5)$$

The proper output ripple current setting is about 30% of maximum output current.

$$\Delta I_L = 0.3 \times I_{OUT}max. \quad [A] \cdots (6)$$

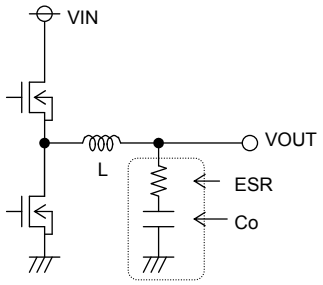
$$L = \frac{(V_{IN}-V_{OUT}) \times V_{OUT}}{L \times V_{IN} \times f} \quad [H] \cdots (7)$$

(ΔI_L: output ripple current; f: switch frequency)

※Passing a current larger than the inductor's rated current will cause magnetic saturation in the inductor and decrease system efficiency. In selecting the inductor, be sure to allow enough margin to assure that peak current does not exceed the inductor rated current value.

※To minimize possible inductor damage and maximize efficiency, choose a inductor with a low (DCR, ACR) resistance.

2. Output Capacitor (Co) Selection



Output Capacitor

When determining the proper output capacitor, be sure to factor in the equivalent series resistance required to smooth out ripple volume and maintain a stable output voltage range.
Output ripple voltage is determined as in formula (8) below.

$$\Delta V_{OUT} = \Delta I_L \times ESR \quad [V] \cdots (8)$$

(ΔI_L: Output ripple current; ESR: CO equivalent series resistance)

※In selecting a capacitor, make sure the capacitor rating allows sufficient margin relative to output voltage. Note that a lower ESR can minimize output ripple voltage.

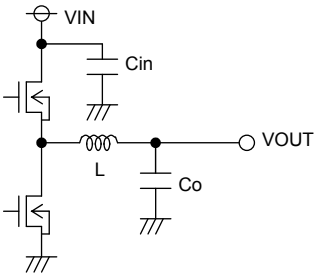
Please give due consideration to the conditions in formula (9) below for output capacity, bearing in mind that output rise time must be established within the soft start time frame.

$$Co \leqq \frac{Tss \times (Limit-I_{OUT})}{V_{OUT}} \cdots (9)$$

Tss: Soft start time
Limit: Over current detection 2A(Typ)

Note: Improper capacitor may cause startup malfunctions.

3. Input Capacitor (Cin) Selection



Input Capacitor

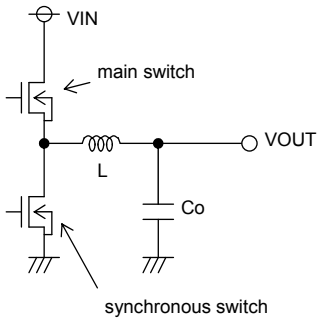
The input capacitor selected must have low enough ESR resistance to fully support large ripple output, in order to prevent extreme over current.
The formula for ripple current IRMS is given in (10) below.

$$IRMS = IOUT \times \frac{\sqrt{V_{CC}(V_{CC}-V_{OUT})}}{V_{CC}} \quad [A] \cdots (10)$$

Where $V_{CC} = 2 \times V_{OUT}$, $I_{RMS} = \frac{IOUT}{2}$

A low ESR capacitor is recommended to reduce ESR loss and maximize efficiency.

4. MOSFET Selection



Loss on the main MOSFET

$P_{main}=P_{RON}+P_{GATE}+P_{TRAN}$

$$= \frac{V_{OUT}}{V_{IN}} \times R_{ON} \times I_{OUT}^2 + Ciss \times f \times V_{DD} + \frac{V_{IN}^2 \times Crss \times I_{OUT} \times f}{I_{DRIVE}} \quad \cdot\cdot\cdot (11)$$

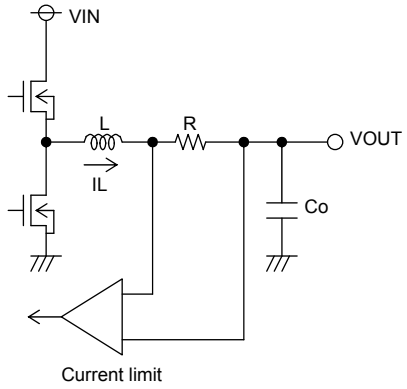
(Ron: On-resistance of FET; Ciss: FET gate capacity;
f: Switching frequency Crss: FET inverse transfer function;
I_{DRIVE}: Gate bottom current)

Loss on the synchronous MOSFET

$P_{syn}=P_{RON}+P_{GATE}$

$$= \frac{V_{IN}-V_{OUT}}{VIN} \times R_{ON} \times I_{OUT}^2 + Ciss \times f \times V_{DD} \quad \cdot\cdot\cdot (12)$$

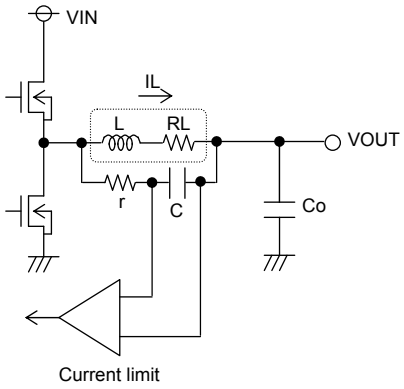
5. Setting Detection Resistance



The over current protection function detects the output ripple current bottom value. This parameter (setting value) is determined as in formula (13) below.

$$I_{LMIT} = \frac{V_{CL} \times 1/16}{R} \text{ [A]} \cdot\cdot\cdot (13)$$

(V_{ILIM}: ILIM voltage; R: Detection resistance)



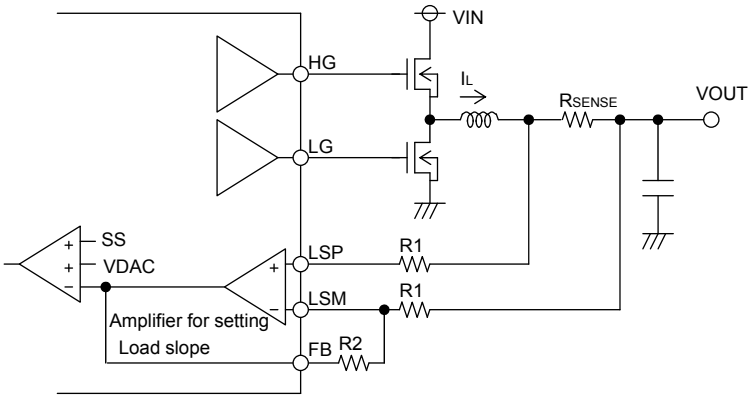
When it detect the over current protection from DCR of “the coil L”, this parameter (setting value) is determined as in formula (14) below.

$$I_{LMIT} = V_{CL} \times 1/16 \times \frac{r \times C}{L} \text{ [A]} \cdot\cdot\cdot (14)$$

$$(R_L = \frac{L}{r \times C})$$

(V_{CL}:CL voltage RL:DCR value of the coil)

6. Setting Load Line Slope



$$FB = \frac{R2}{R1} \times R_{SENSE} \times I_L + R_{SENSE} \times I_L + V_{OUT}$$

$$= (1+\frac{R2}{R1}) \times R_{SENSE} \times I_L + V_{OUT}$$

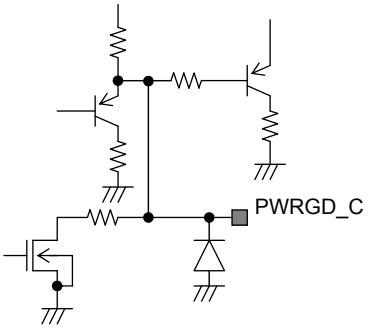
So that,

$$SLOPE_{LL} = (1+\frac{R2}{R1}) \times R_{SENSE}$$

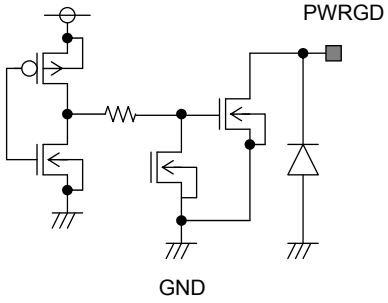
($SLOPE_{LL}$: Load Line Slope)

●I/O Equivalent Circuit

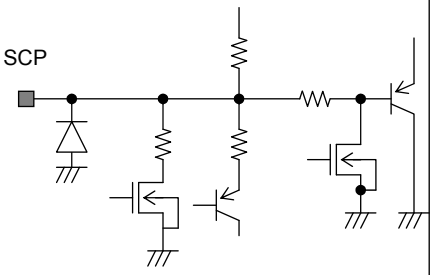
1pin(PWRGD_C)



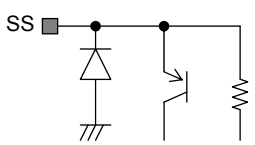
2pin(PWRGD)



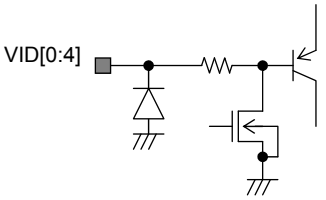
3pin(SCP)



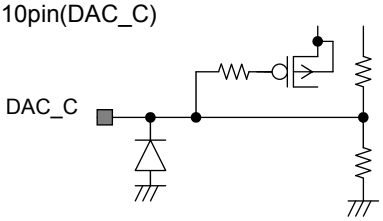
4pin(SS)



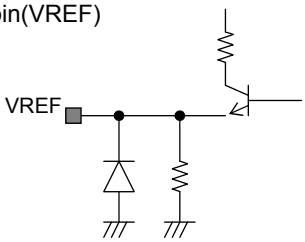
5pin(VID0) ~ 9pin(VID4)



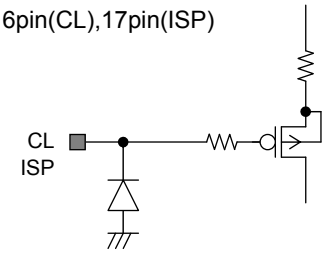
10pin(DAC_C)



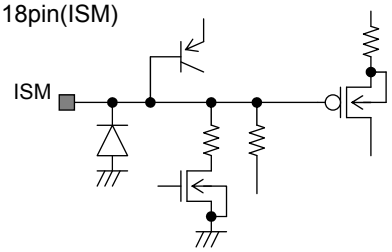
14pin(VREF)



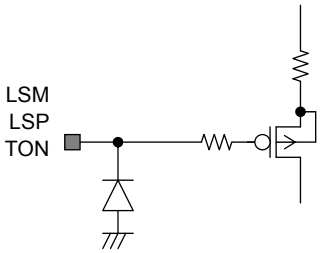
16pin(CL),17pin(ISP)



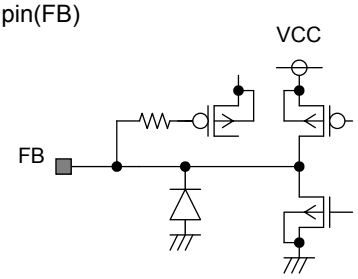
18pin(ISM)



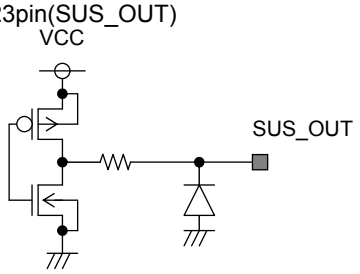
19pin(LSM),20pin(LSP),22pin(TON)



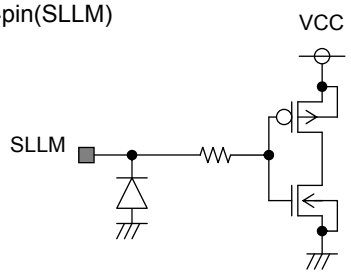
21pin(FB)



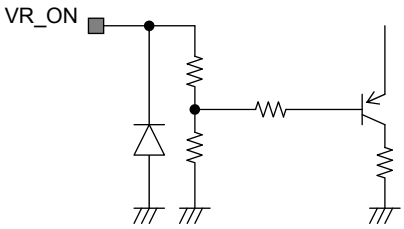
23pin(SUS_OUT)



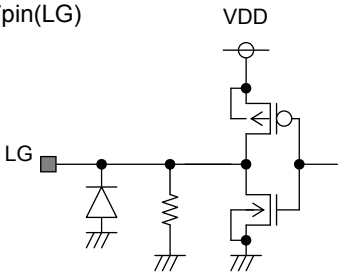
24pin(SLLM)



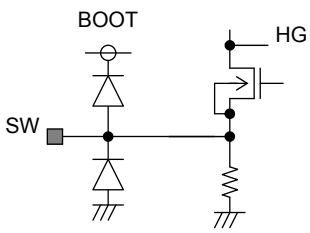
25pin(VRON)



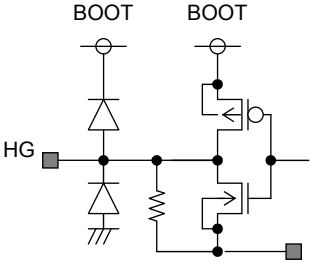
27pin(LG)



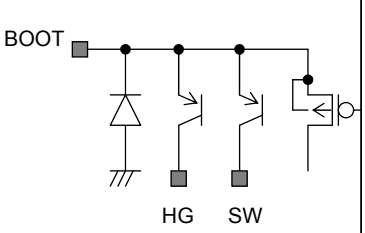
29pin(SW)



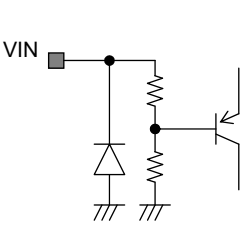
30pin(HG)



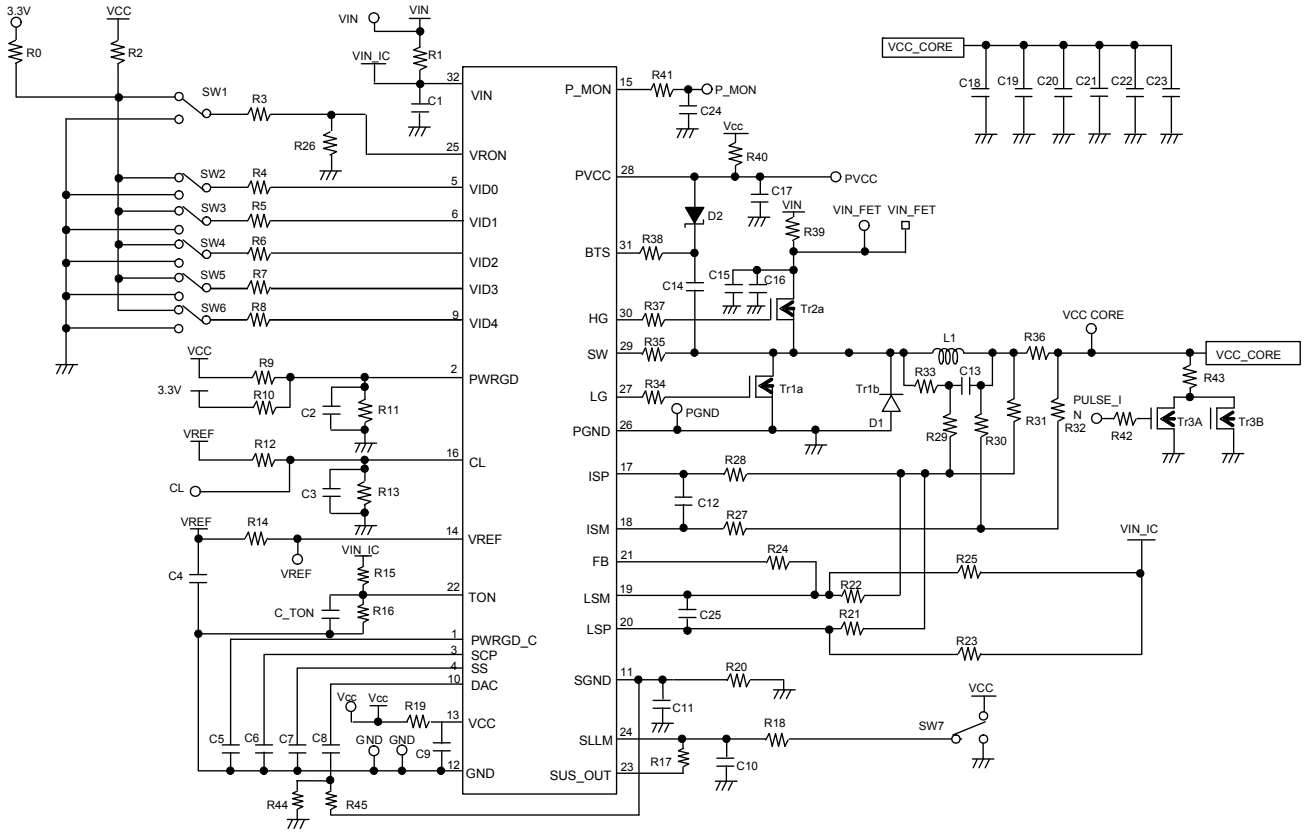
31pin(BOOT)



32pin(VIN)



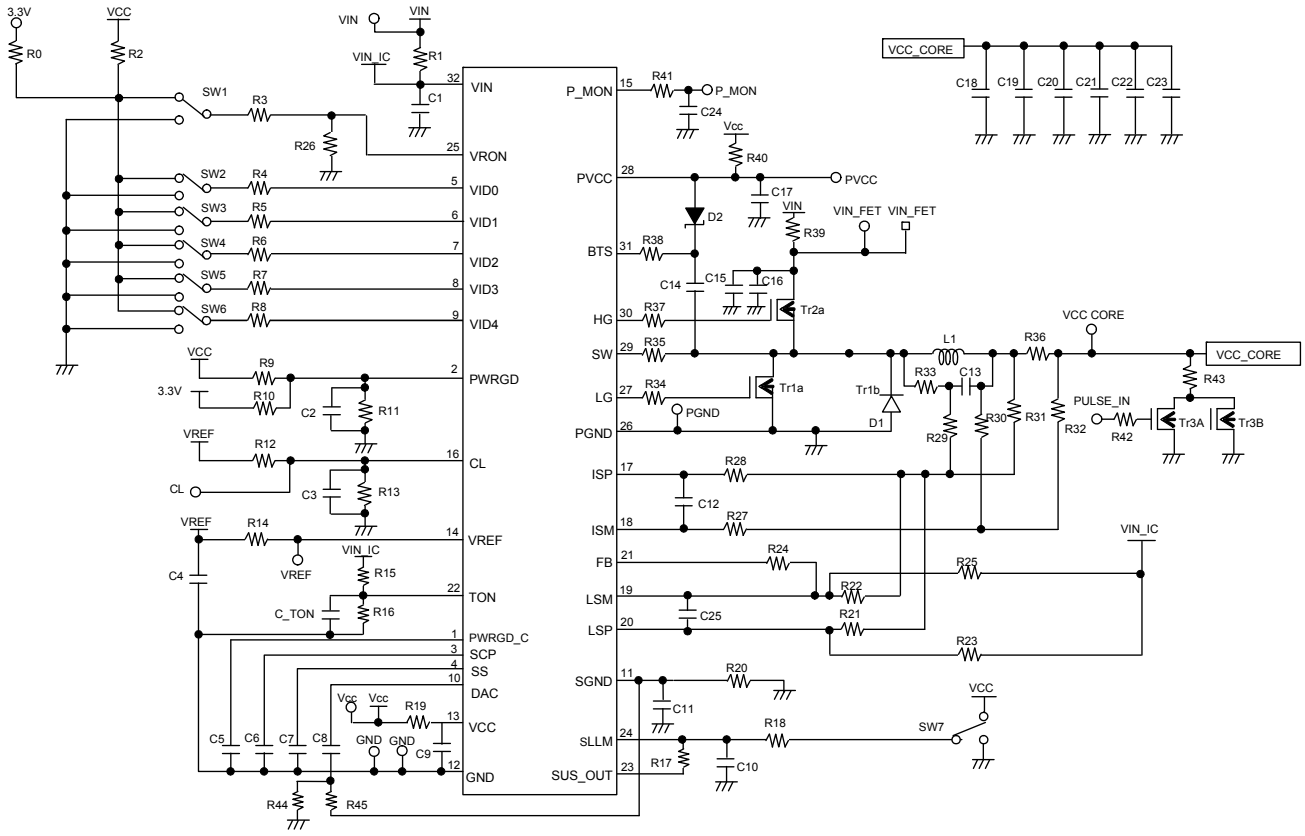
●Evaluation Board Circuit(Application for POS CAP)



●**Evaluation Board Parts List**

Part No	Value	Company	Part name	Part No	Value	Company	Part name
R0	0Ω	ROHM	MCR03 Series	R41	-	-	-
R1	-	-	-	R42	-	-	-
R2	-	-	-	R43	-	-	-
R3	0Ω	ROHM	MCR03 Series	R44	-	-	-
R4	0Ω	ROHM	MCR03 Series	R45	0Ω	ROHM	MCR03 Series
R5	0Ω	ROHM	MCR03 Series	C1	0.01uF	MURATA	GMR18 Series
R6	0Ω	ROHM	MCR03 Series	C2	-	-	-
R7	0Ω	ROHM	MCR03 Series	C3	-	-	-
R8	0Ω	ROHM	MCR03 Series	C4	0.1uF	MURATA	GMR18 Series
R9	-	-	-	C5	0.01uF	MURATA	GMR18 Series
R10	20kΩ	ROHM	MCR03 Series	C6	0.01uF	MURATA	GMR18 Series
R11	-	-	-	C7	0.01uF	MURATA	GMR18 Series
R12	300kΩ	ROHM	MCR03 Series	C8	2200pF	MURATA	GMR18 Series
R13	47kΩ	ROHM	MCR03 Series	C9	1uF	MURATA	GMR18 Series
R14	0Ω	ROHM	MCR03 Series	C10	-	-	-
R15	560kΩ	ROHM	MCR03 Series	C11	-	-	-
R16	62kΩ	ROHM	MCR03 Series	C12	-	-	-
R17	-	-	-	C13	-	-	-
R18	0Ω	ROHM	MCR03 Series	C14	0.22uF	MURATA	GMR18 Series
R19	10Ω	ROHM	MCR03 Series	C15	10uF	KYOCERA	CM32X7R106M25A
R20	-	-	-	C16	-	-	-
R21	1kΩ	ROHM	MCR03 Series	C17	10uF	MURATA	GMR21 Series
R22	1kΩ	ROHM	MCR03 Series	C18	-	-	-
R23	1MΩ	ROHM	MCR03 Series	C19	-	-	-
R24	3kΩ	ROHM	MCR03 Series	C20	10uF×8	KYOCERA	CM21B106M06A
R25	1MΩ	ROHM	MCR03 Series	C21	-	-	-
R27	0Ω	ROHM	MCR03 Series	C22	-	-	-
R28	0Ω	ROHM	MCR03 Series	C23	330uF	Panasonic	EEFSX0D331XE
R29	-	-	-	C24	-	-	-
R30	-	-	-	C25	-	-	-
R31	0Ω	ROHM	MCR03 Series	C-Ton	-	-	-
R32	0Ω	ROHM	MCR03 Series				
R33	-	-	-	L1	0.7uH	TDK	VLM10055T-R70M120
R34	0Ω	ROHM	MCR03 Series	D1	-	-	-
R35	0Ω	ROHM	MCR03 Series	D2	Diode	ROHM	RB521S-30
R36	2mΩ	ROHM	PMR100				
R37	0Ω	ROHM	MCR03 Series	TR1A	FET	NEC	uPA2702
R38	0Ω	ROHM	MCR03 Series	TR2A	FET	NEC	uPA2702
R39	0Ω	ROHM	MCR03 Series	TR3A	-	-	-
R40	10Ω	ROHM	MCR03 Series	TR3B	-	-	-

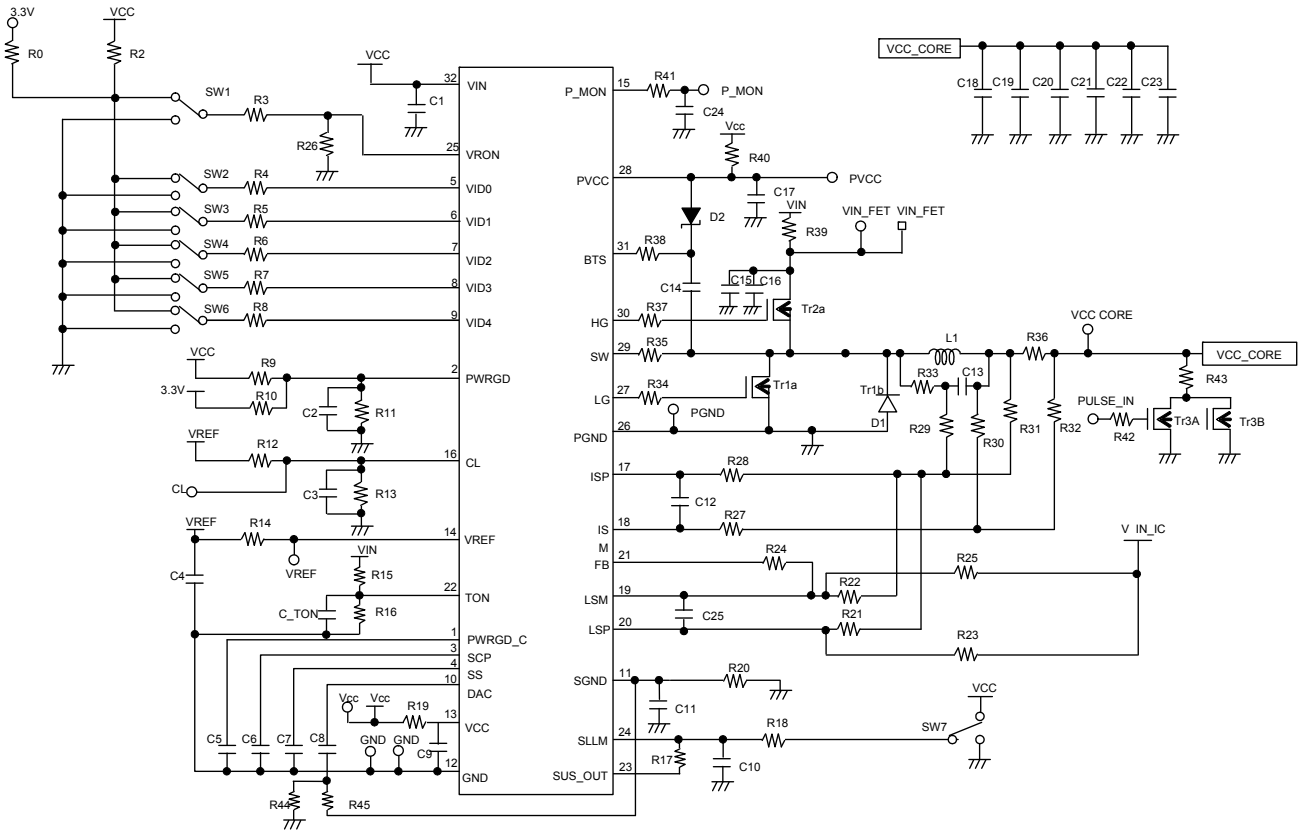
●Evaluation Board Circuit(Application for ceramic capacitor)



●**Evaluation Board Parts List**

Part No	Value	Company	Part name	Part No	Value	Company	Part name
R0	0Ω	ROHM	MCR03 Series	R41	-	-	-
R1	1kΩ	ROHM	MCR03 Series	R42	-	-	-
R2	-	-	-	R43	-	-	-
R3	0Ω	ROHM	MCR03 Series	R44	-	-	-
R4	0Ω	ROHM	MCR03 Series	R45	0Ω	ROHM	MCR03 Series
R5	0Ω	ROHM	MCR03 Series	C1	0.01uF	MURATA	GMR18 Series
R6	0Ω	ROHM	MCR03 Series	C2	-	-	-
R7	0Ω	ROHM	MCR03 Series	C3	-	-	-
R8	0Ω	ROHM	MCR03 Series	C4	0.1uF	MURATA	GMR18 Series
R9	-	-	-	C5	0.01uF	MURATA	GMR18 Series
R10	20kΩ	ROHM	MCR03 Series	C6	0.01uF	MURATA	GMR18 Series
R11	-	-	-	C7	0.01uF	MURATA	GMR18 Series
R12	300kΩ	ROHM	MCR03 Series	C8	2200pF	MURATA	GMR18 Series
R13	47kΩ	ROHM	MCR03 Series	C9	1uF	MURATA	GMR18 Series
R14	0Ω	ROHM	MCR03 Series	C10	-	-	-
R15	560kΩ	ROHM	MCR03 Series	C11	-	-	-
R16	62kΩ	ROHM	MCR03 Series	C12	-	-	-
R17	-	-	-	C13	-	-	-
R18	0Ω	ROHM	MCR03 Series	C14	0.47uF	MURATA	GMR21 Series
R19	10Ω	ROHM	MCR03 Series	C15	10uF	KYOCERA	CM32X7R106M25A
R20	-	-	-	C16	-	-	-
R21	1kΩ	ROHM	MCR03 Series	C17	10uF	MURATA	GMR21 Series
R22	1kΩ	ROHM	MCR03 Series	C18	-	-	-
R23	1MΩ	ROHM	MCR03 Series	C19	47uF×4	KYOCERA	CM32B476M06A
R24	3kΩ	ROHM	MCR03 Series	C20	47uF×4	KYOCERA	CM32B476M06A
R25	1MΩ	ROHM	MCR03 Series	C21	-	-	-
R27	0Ω	ROHM	MCR03 Series	C22	-	-	-
R28	0Ω	ROHM	MCR03 Series	C23	-	-	-
R29	-	-	-	C24	-	-	-
R30	-	-	-	C25	-	-	-
R31	0Ω	ROHM	MCR03 Series	C-Ton	-	-	-
R32	0Ω	ROHM	MCR03 Series				
R33	-	-	-	L1	0.7uH	Panasonic	ETQP2H0R7BFA
R34	0Ω	ROHM	MCR03 Series	D1	-	-	-
R35	0Ω	ROHM	MCR03 Series	D2	Diode	ROHM	RB521S-30
R36	2mΩ	ROHM	PMR100				
R37	0Ω	ROHM	MCR03 Series	TR1A	FET	NEC	uPA2702
R38	0Ω	ROHM	MCR03 Series	TR2A	FET	NEC	uPA2702
R39	0Ω	ROHM	MCR03 Series	TR3A	-	-	-
R40	10Ω	ROHM	MCR03 Series	TR3B	-	-	-

●Evaluation Board Circuit(Application for VIN UVLO OFF)



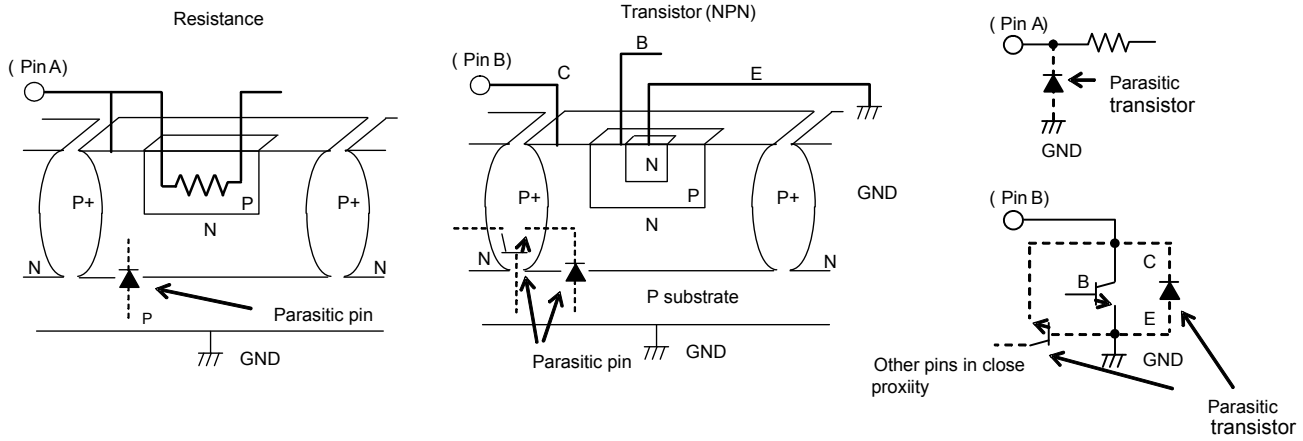
●**Evaluation Board Parts List**

Part No	Value	Company	Part name	Part No	Value	Company	Part name
R0	0Ω	ROHM	MCR03 Series	R41	-	-	-
R1	1kΩ	ROHM	MCR03 Series	R42	-	-	-
R2	-	-	-	R43	-	-	-
R3	0Ω	ROHM	MCR03 Series	R44	-	-	-
R4	0Ω	ROHM	MCR03 Series	R45	0Ω	ROHM	MCR03 Series
R5	0Ω	ROHM	MCR03 Series	C1	0.01uF	MURATA	GMR18 Series
R6	0Ω	ROHM	MCR03 Series	C2	-	-	-
R7	0Ω	ROHM	MCR03 Series	C3	-	-	-
R8	0Ω	ROHM	MCR03 Series	C4	0.1uF	MURATA	GMR18 Series
R9	-	-	-	C5	0.01uF	MURATA	GMR18 Series
R10	20kΩ	ROHM	MCR03 Series	C6	0.01uF	MURATA	GMR18 Series
R11	-	-	-	C7	0.01uF	MURATA	GMR18 Series
R12	300kΩ	ROHM	MCR03 Series	C8	2200pF	MURATA	GMR18 Series
R13	47kΩ	ROHM	MCR03 Series	C9	1uF	MURATA	GMR18 Series
R14	0Ω	ROHM	MCR03 Series	C10	-	-	-
R15	560kΩ	ROHM	MCR03 Series	C11	-	-	-
R16	62kΩ	ROHM	MCR03 Series	C12	-	-	-
R17	-	-	-	C13	-	-	-
R18	0Ω	ROHM	MCR03 Series	C14	0.22uF	MURATA	GMR18 Series
R19	10Ω	ROHM	MCR03 Series	C15	10uF	KYOCERA	CM32X7R106M25A
R20	-	-	-	C16	-	-	-
R21	1kΩ	ROHM	MCR03 Series	C17	10uF	MURATA	GMR21 Series
R22	1kΩ	ROHM	MCR03 Series	C18	-	-	-
R23	1MΩ	ROHM	MCR03 Series	C19	-	-	-
R24	3kΩ	ROHM	MCR03 Series	C20	10uF×8	KYOCERA	CM21B106M06A
R25	1MΩ	ROHM	MCR03 Series	C21	-	-	-
R27	0Ω	ROHM	MCR03 Series	C22	-	-	-
R28	0Ω	ROHM	MCR03 Series	C23	330uF	Panasonic	EEFSX0D331XE
R29	-	-	-	C24	-	-	-
R30	-	-	-	C25	-	-	-
R31	0Ω	ROHM	MCR03 Series	C-Ton	-	-	-
R32	0Ω	ROHM	MCR03 Series				
R33	-	-	-	L1	0.7uH	TDK	VLM10055T-R70M120
R34	0Ω	ROHM	MCR03 Series	D1	-	-	-
R35	0Ω	ROHM	MCR03 Series	D2	Diode	ROHM	RB521S-30
R36	2mΩ	ROHM	MCR03 Series				
R37	0Ω	ROHM	MCR03 Series	TR1A	FET	NEC	uPA2702
R38	0Ω	ROHM	MCR03 Series	TR2A	FET	NEC	uPA2702
R39	0Ω	ROHM	MCR03 Series	TR3A	-	-	-
R40	10Ω	ROHM	MCR03 Series	TR3B	-	-	-

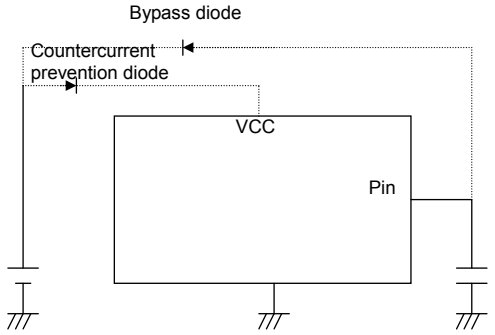
● **Operation Notes and Precautions**

1. This integrated circuit is a monolithic IC, which (as shown in the figure below), has P isolation in the P substrate and between the various pins. A P-N junction is formed from this P layer and N layer of each pin, with the type of junction depending on the relation between each potential, as follows:
   - ・When GND＞ element A＞ element B, the P-N junction is a diode.
   - ・When element B＞GND element A, 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, as well as operating malfunctions and physical damage. Therefore, be careful to avoid methods by which parasitic diodes operate, such as applying a voltage lower than the GND (P substrate) voltage to an input pin.



2. In some modes of operation, power supply voltage and pin voltage are reversed, giving rise to possible internal circuit damage. For example, when the external capacitor is charged, the electric charge can cause a VCC short circuit to the GND. In order to avoid these problems, inserting a VCC series countercurrent prevention diode or bypass diode between the various pins and the VCC is recommended.



3. Absolute maximum rating

   Although the quality of this IC is rigorously controlled, the IC may be destroyed when applied voltage or operating temperature exceeds its absolute maximum rating. Because short mode or open mode cannot be specified when the IC is destroyed, it is important to take physical safety measures such as fusing if a special mode in excess of absolute rating limits is to be implemented.

4.GND potential

   Make sure the potential for the GND pin is always kept lower than the potentials of all other pins, regardless of the operating mode.

5. Thermal design

   In order to build sufficient margin into the thermal design, give proper consideration to the allowable loss (Power Dissipation) in actual operation.

6. Short-circuits between pins and incorrect mounting position

   When mounting the IC onto the circuit board, be extremely careful about the orientation and position of the IC. The IC may be destroyed if it is incorrectly positioned for mounting. Do not short-circuit between any output pin and supply pin or ground, or between the output pins themselves. Accidental attachment of small objects on these pins will cause shorts and may damage the IC.

7. Operation in strong electromagnetic fields
   Use in strong electromagnetic fields may cause malfunctions. Use extreme caution with electromagnetic fields.

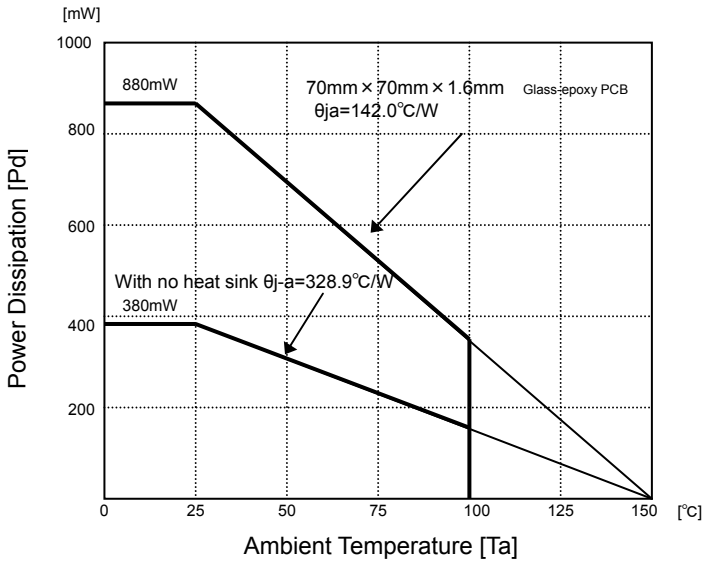
8. Thermal shutdown circuit
   This IC is provided with a built-in thermal shutdown (TSD) circuit, which is activated when the operating temperature reaches 175℃ (standard value), and has a hysteresis range of 15℃ (standard). When the IC chip temperature rises to the threshold, all the inputs automatically turn OFF. Note that the TSD circuit is provided for the exclusive purpose shutting down the IC in the presence of extreme heat, and is not designed to protect the IC per se or guarantee performance when or after extreme heat conditions occur. Therefore, do not operate the IC with the expectation of continued use or subsequent operation once the TSD is activated.

9. Capacitor between output and GND
   When a larger capacitor is connected between the output and GND, Vcc or VIN shorted with the GND or 0V line – for any reason – may cause the charged capacitor current to flow to the output, possibly destroying the IC. Do not connect a capacitor larger than 1000uF between the output and GND.

10. Precautions for board inspection
    Connecting low-impedance capacitors to run inspections with the board may produce stress on the IC. Therefore, be certain to use proper discharge procedure before each process of the operation. To prevent electrostatic accumulation and discharge in the assembly process, thoroughly ground yourself and any equipment that could sustain ESD damage, and continue observing ESD-prevention procedures in all handling, transfer and storage operations. Before attempting to connect components to the test setup, make certain that the power supply is OFF. Likewise, be sure the power supply is OFF before removing any component connected to the test setup.

11. GND wiring pattern
    When both a small-signal GND and high current GND are present, single-point grounding (at the set standard point) is recommended, in order to separate the small-signal and high current patterns, and to be sure the voltage change stemming from the wiring resistance and high current does not cause any voltage change in the small-signal GND. In the same way, care must be taken to avoid wiring pattern fluctuations in any connected external component GND.

● **Power Dissipation**

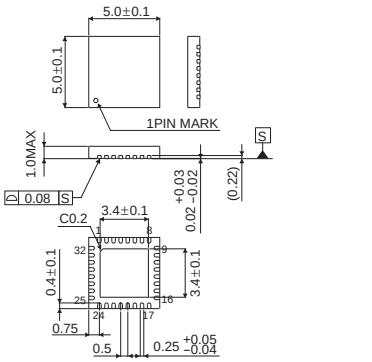


●Ordering part number

B	D	9	5	6	0	M	U	V	-	E	2

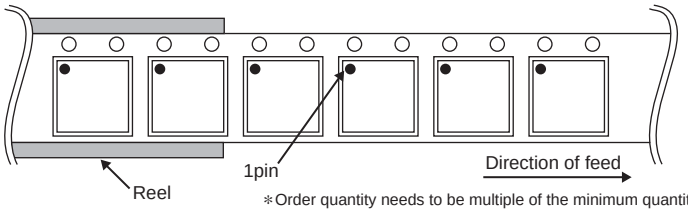
Part No. Part No. Package MUV : VQFN032V5050 Packaging and forming specification E2: Embossed tape and reel

VQFN032V5050



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	2500pcs
Direction of feed	E2 (The direction is the 1pin 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)



∗Order quantity needs to be multiple of the minimum quantity.

Notes

No copying or reproduction of this document, in part or in whole, is permitted without the consent of ROHM Co.,Ltd.

The content specified herein is subject to change for improvement without notice.

The content specified herein is for the purpose of introducing ROHM's products (hereinafter "Products"). If you wish to use any such Product, please be sure to refer to the specifications, which can be obtained from ROHM upon request.

Examples of application circuits, circuit constants and any other information contained herein illustrate the standard usage and operations of the Products. The peripheral conditions must be taken into account when designing circuits for mass production.

Great care was taken in ensuring the accuracy of the information specified in this document. However, should you incur any damage arising from any inaccuracy or misprint of such information, ROHM shall bear no responsibility for such damage.

The technical information specified herein is intended only to show the typical functions of and examples of application circuits for the Products. ROHM does not grant you, explicitly or implicitly, any license to use or exercise intellectual property or other rights held by ROHM and other parties. ROHM shall bear no responsibility whatsoever for any dispute arising from the use of such technical information.

The Products specified in this document are intended to be used with general-use electronic equipment or devices (such as audio visual equipment, office-automation equipment, communication devices, electronic appliances and amusement devices).

The Products specified in this document are not designed to be radiation tolerant.

While ROHM always makes efforts to enhance the quality and reliability of its Products, a Product may fail or malfunction for a variety of reasons.

Please be sure to implement in your equipment using the Products safety measures to guard against the possibility of physical injury, fire or any other damage caused in the event of the failure of any Product, such as derating, redundancy, fire control and fail-safe designs. ROHM shall bear no responsibility whatsoever for your use of any Product outside of the prescribed scope or not in accordance with the instruction manual.

The Products are not designed or manufactured to be used with any equipment, device or system which requires an extremely high level of reliability the failure or malfunction of which may result in a direct threat to human life or create a risk of human injury (such as a medical instrument, transportation equipment, aerospace machinery, nuclear-reactor controller, fuel-controller or other safety device). ROHM shall bear no responsibility in any way for use of any of the Products for the above special purposes. If a Product is intended to be used for any such special purpose, please contact a ROHM sales representative before purchasing.

If you intend to export or ship overseas any Product or technology specified herein that may be controlled under the Foreign Exchange and the Foreign Trade Law, you will be required to obtain a license or permit under the Law.

ROHM SEMICONDUCTOR

Thank you for your accessing to ROHM product informations.
More detail product informations and catalogs are available, please contact us.

ROHM Customer Support System

http://www.rohm.com/contact/