Ordering number : ENA2290

STK984-090A-E

Intelligent Power Module

3-phase Brushless DC Motor Driver

ON Semiconductor®

http://onsemi.com

Overview

The STK984-090A-E is an Intelligent Power Module designed to be used in Brushless DC Motor.

Applications

Fan , Water pump (3-phase Motor for Automotive.)

Function

- FET can be driven (built-in pre-driver IC) by microcontroller output (logic system).
- Various protections (Over current Protection, Over Temperature Protection, and Low Voltage Protection, Over Voltage Protection) are incorporated.
- Intelligent DIAG Function that externally outputs each protection status, such as Over current Protection, Over Temperature Protection.
- Protection functions can be reset by external inputs.
- AEC-Q100 qualified and PPAP capable.

Specifications

Absolute Maximum Ratings at Tc=25°C

Parameter	Symbol	Condition	Ratings	Unit
Supply Voltage	V+B1	+B1 to PG	–0.3 to 40	V
	V+B2	+B2 to SG		
Control Input Voltage	Vin max	UT,VT,WT,UB,VB,WB to SG	–0.3 to 6	V
DIAG Terminal Voltage	VDIAG	DIAG1,DIAG2 to SG	–0.3 to 6	V
Drain Current	Id max	DC	20	A
		Pulse (Single-Shot within 10μs)	180	A
Junction Temperature	Tj max	Semiconductor Device	150	°C
Storage Temperature	Tstg		–40 to +125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Special Instruction 1

- Please use this Intelligent Power Module within its absolute maximum ratings. Exceeding the absolute maximum ratings may cause the Intelligent Power Module damage and lead to smoke or fire. ON Semiconductor assumes no responsibility for equipment failure that result from using products at exceeding the absolute maximum ratings.
- Please be sure to implement safety measures to prevent the possibility of physical injury, injury or damage caused by fire and social damage in the event of the failure of this Intelligent Power Module, such as redundant design, anti-fire design, and malfunction prevention design.

ORDERING INFORMATION

See detailed ordering and shipping information on page 20 of this data sheet.

March, 2014

33114HK 018-14-0006 No.A2290-1/20

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Test Conditions	Ratings			Unit
			min.	typ.	max.	
Supply Voltage	V+B1	+B1 to PG	8	13.5	18	V
	V+B2	+B2 to SG				
Output Current	Io	Io∞ON Duty, ON Duty100% 120deg Excitation Method	-	-	20	A
Operating Substrate Temperature	Tc	Thick Film IC Substrate Temperature	–40	-	125	°C
Drive PWM Frequency	Fo	ONDuty : 10 to 90%,100%	-	-	20	kHz

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Thermal Resistance

Parameter	Symbol	Conditions	Ratings			Unit
			min.	typ.	max.	
Chip-Case Resistance	θjc	Junction -to- backside of the substrate MOSFET/ch	-	4.5	-	°C /W

Electrical Characteristics at Ta = 25°C, V+B1 (V+B2) = 13.5V unless otherwise specifed

Parameter	Symbol	Test Conditions		min	typ	max	Unit
Current consumption (Control system)	I_{CC}	V+B1=V+B2=16V			10	15	mA
Output saturation voltage	V_{DS}(sat)	I_O=20A	+B1 to U, V, W		0.3	0.5	V
			U, V, W to PG		0.2	0.4	
Current sensing resistor	Rs			2.91	3.00	3.09	mΩ
Time delay (ON)	td(on)	20A	U, V, W	0.9	1.8	2.8	μs
			U⁻, V⁻, W⁻	0.9	1.9	3.0	
Rise time	tr	20A			0.3		μs
Time delay (OFF)	td(off)	20A	U, V, W	1.3	2.9	4.5	μs
			U⁻, V⁻, W⁻	0.8	2.2	3.5	
Fall time	tf	20A			0.3		μs

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

Motor Control Input Terminal at 8V≤V+B1(V+B2)≤18V, –40°C≤Ta≤125°C

Parameter	Symbol	Conditions	Ratings			Unit
			min.	typ.	max.	
Input ON Voltage	Vin(on)	Output on UT,VT,WT,UB,VB,WB to SG	3.5	-	-	V
Input OFF Voltage	Vin(off)	Output off UT,VT,WT,UB,VB,WB to SG	-	-	1.5	V

Reset Input Terminal at 8V≤V+B1(V+B2) ≤18V, –40°C≤Ta≤125°C

Parameter	Symbol	Test Conditions	Ratings			Unit
			min.	typ.	max.	
Reset High Voltage	Vreset(Hi)	Output ON	3.5	-	-	V
Reset Low Voltage	Vreset(Lo)	Output OFF	-	-	1.5	V
Output Delay Time (ON)	treset(on)	From Reset Input Terminal (RESET=Hi) to Output ON	-	0.25	-	ms
Output Delay Time (OFF)	treset(off)	From Reset Input Terminal (RESET=Lo) to Output OFF	-	2	-	μs

Protective Function at Ta=25°C, V+B1(V+B2)=13.5V unless otherwise specified

Parameter	Symbol	Test Conditions	Ratings			Unit
			min.	typ.	max.	
Low Voltage Protection Threshold	Vuv	-	4.45	4.75	5.1	V
Low Voltage Protection Hysteresis	Vuv(hy)	-	0.07	0.2	0.3	V
Low Voltage Shutdown Output Delay	Tuvoff	-	-	1.0	-	μs
Over Current Threshold	ISD	Automatic Recovery	21	34	44	A
Over Current DIAG Output Delay Time	Tocdgoff	-	-	4.3	-	μs
Over Current Shutdown Interval	tint	-	-	1	-	ms
Over Current Shutdown Output Delay	Tocoff	-	-	4.3	-	μs
Ground Fault Short-Circuit Protection	IOC	Power-Cycle	47	84	113	A
Ground Fault Short-Circuit Detection DIAG Output Delay Time	Tspdgoff	-	-	3.0	-	ms
Ground Fault Short-Circuit Shutdown Output Delay Time	Tspoff	-	-	3.0	-	ms
Temperature Protection Shutdown	Tst	Thick Film IC Substrate Temperature, Automatic Restoration	146	155	165	°C
Temperature Protection Recovery	Tst(hy)	Thick Film IC Substrate Temperature	126	135	145	°C
Over Temperature DIAG Output Delay Time	Tthdgoff	-	-	3.4	-	μs
Over Temperature Shutdown Output Delay	Tthoff	-	-	3.4	-	μs
Over Voltage Threshold	Vov	-	24	-	-	V
Over Voltage Protection Hysteresis Width	Vov(hy)	-	-	0.5	-	V
Over Voltage Shutdown Output Delay	Tovoff	-	-	1.0	-	μs

DIAG Output at Open Drain Output

Parameter	Symbol	Conditions	Ratings			Unit
			min.	typ.	max.	
DIAG Output Voltage (DIAG1, DIAG2)	VDIAG	Output Lo/DIAG Terminal Current =1mA	-	-	0.2	V
DIAG Output Leakage Current (DIAG1, DIAG2)	IDILK	VDIAG=5V	-	-	1	μA

DIAG Output Function

Parameter	Symbol	Test Conditions	Detection Time	Non Detection Time
Over Current Detector	DIAG1	5V Pull-up Open Drain	Hi	Lo
Over Temperature Protection Detector	DIAG2	5V Pull-up Open Drain	Hi	Lo

Pin Function Description

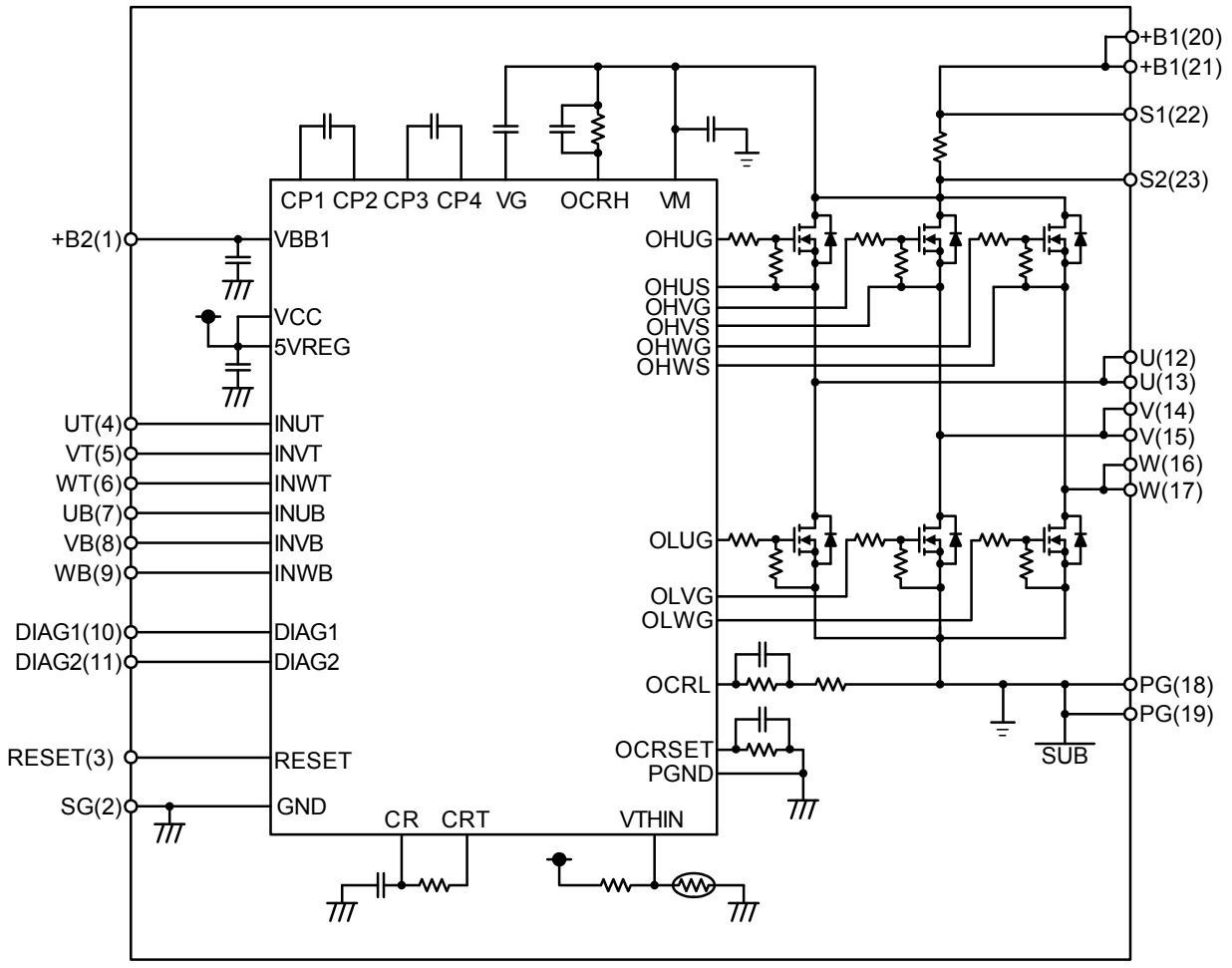
Pin No.	Pin Name	Description	Pin*
1	+B2	Control System Power	S
2	SG	Control System GND	S
3	RESET	RESET Terminal Normal operating in RESET = H or Open-State The Gate Output will be Lo-state for both Hi/Lo sides with RESET = L (Output OFF) Output OFF Latch Release terminal of Short-circuit Protection	S
4	UT	Driving Signal Input Upper U-phase	S
5	VT	Driving Signal Input Upper V-phase	S
6	WT	Driving Signal Input Upper W-phase	S
7	UB	Driving Signal Input Lower U-phase	S
8	VB	Driving Signal Input Lower V-phase	S
9	WB	Driving Signal Input Lower W-phase	S
10	DIAG1	Fault Diagnosis Output 1 (Overcurrent) Normal Operation: Lo Abnormal Operation: Hi	S
11	DIAG2	Fault Diagnosis Output 2 (Over Temperature) Normal Operation: Lo Abnormal Operation: Hi	S
12	U	U-phase Output	P
13	U	U-phase Output	P
14	V	V-phase Output	P
15	V	V-phase Output	P
16	W	W-phase Output	P
17	W	W-phase Output	P
18	PG	Power System GND	P
19	PG	Power System GND	P
20	+B1	Power System Supply	P
21	+B1	Power System Supply	P
22	S1	Current Sense Resistor Sensing (+) terminal	S
23	S2	Current Sense Resistor Sensing (-) terminal	S

*

S: Signal terminal

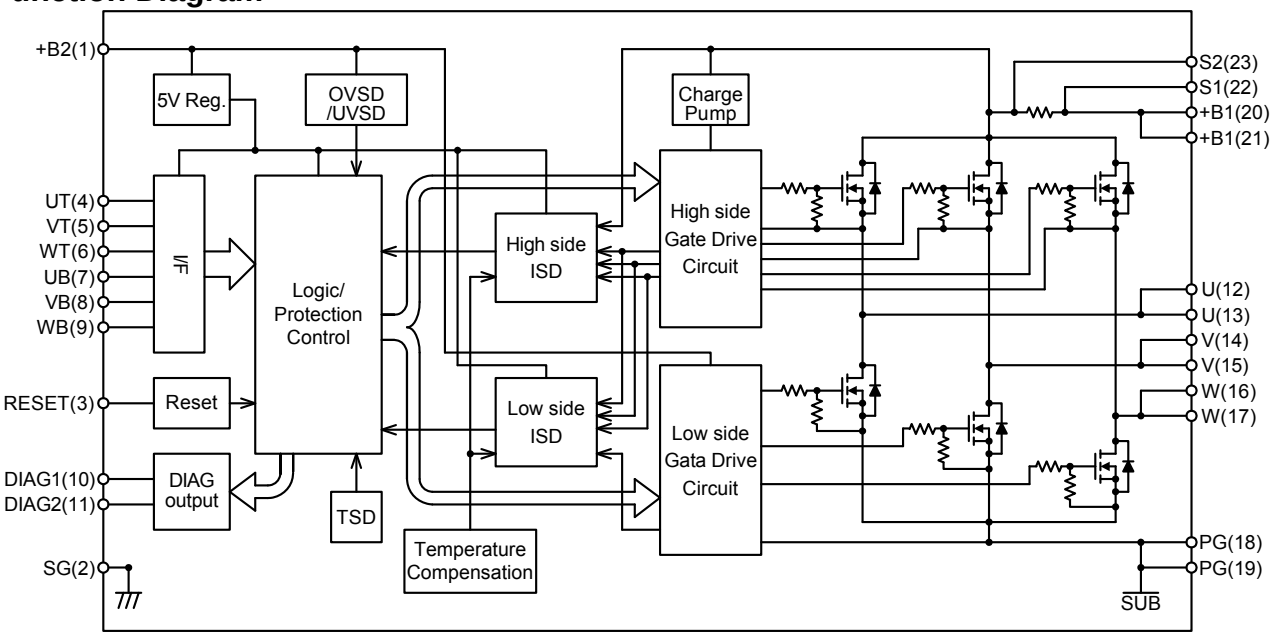
P: Power terminal

Block Diagram



The number in “( )” indicates the pin number.

Function Diagram



Truth Table

<Normal Operating>

Input			Output			Operation Mode
UT*1	UB*2	RESET	U*3	DIAG1	DIAG2	
L	L	H	OFF	L	L	Output OFF
L	H	H	L	L	L	Lo Side ON
H	L	H	H	L	L	Hi Side ON
H	H	H	OFF	L	L	Output OFF
L/H	L/H	L	OFF	H	H	Output OFF

*1 : the same for VT and WT. *2 : the same for VB and WB. *3 : the same for V and W.

<Over current/Short-Circuit Protection Operating>

Input			Output			Operation Mode
UT*1	UB*2	RESET	U*3	DIAG1	DIAG2	
L	L	H	OFF	L	L	Output OFF
L	H	H	OFF	H	L	Over Current Protection Operating
H	L	H	OFF	H	L	Short-Circuit Protection Operating
H	H	H	OFF	L	L	Output OFF
L/H	L/H	L	OFF	H	H	Output OFF

*1 : the same for VT and WT. *2 : the same for VB and WB. *3 : the same for V and W.
The Over Current Protection operates only when UB, VB, WB are H-state.
The Short-circuit Protection operates only when UT, VT, WT are H-state.

<Over Temperature Protection Operating>

Input			Output			Operating Mode
UT*1	UB*2	RESET	U*3	DIAG1	DIAG2	
L/H	L/H	H	OFF	L	H	Over Temperature Protection Operating
L/H	L/H	L	OFF	H	H	Output OFF

*1 : the same for VT and WT. *2 : the same for VB and WB. *3 : the same for V and W.

<Low Voltage Protection Operating>

Input			Output			Operating Mode
UT*1	UB*2	RESET	U*3	DIAG1	DIAG2	
L/H	L/H	H	OFF	L	L	Low Voltage Protection Operating
L/H	L/H	L	OFF	H	H	Output OFF

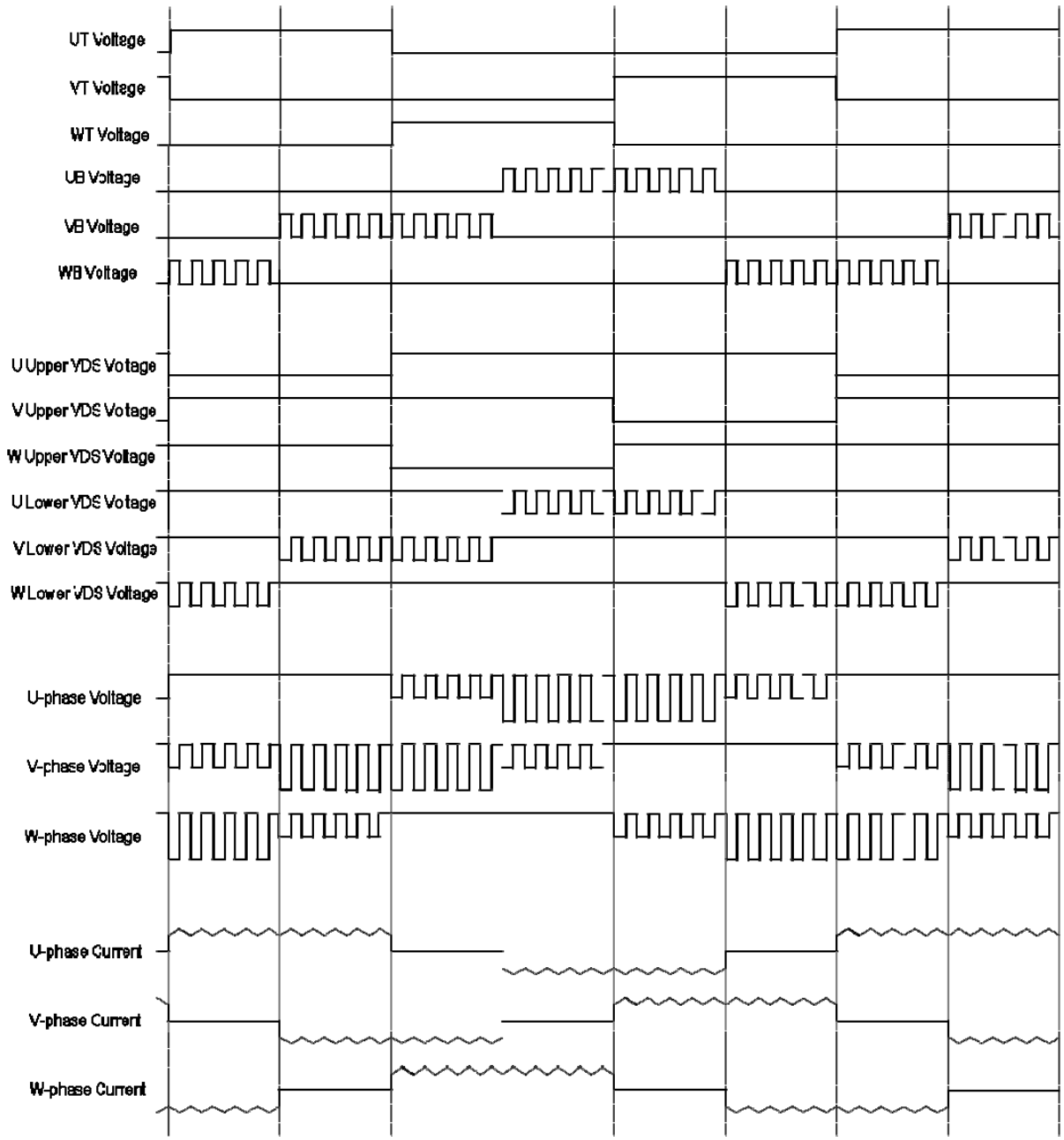
*1 : the same for VT and WT. *2 : the same for VB and WB. *3 : the same for V and W.

<Over Voltage Protection Operating>

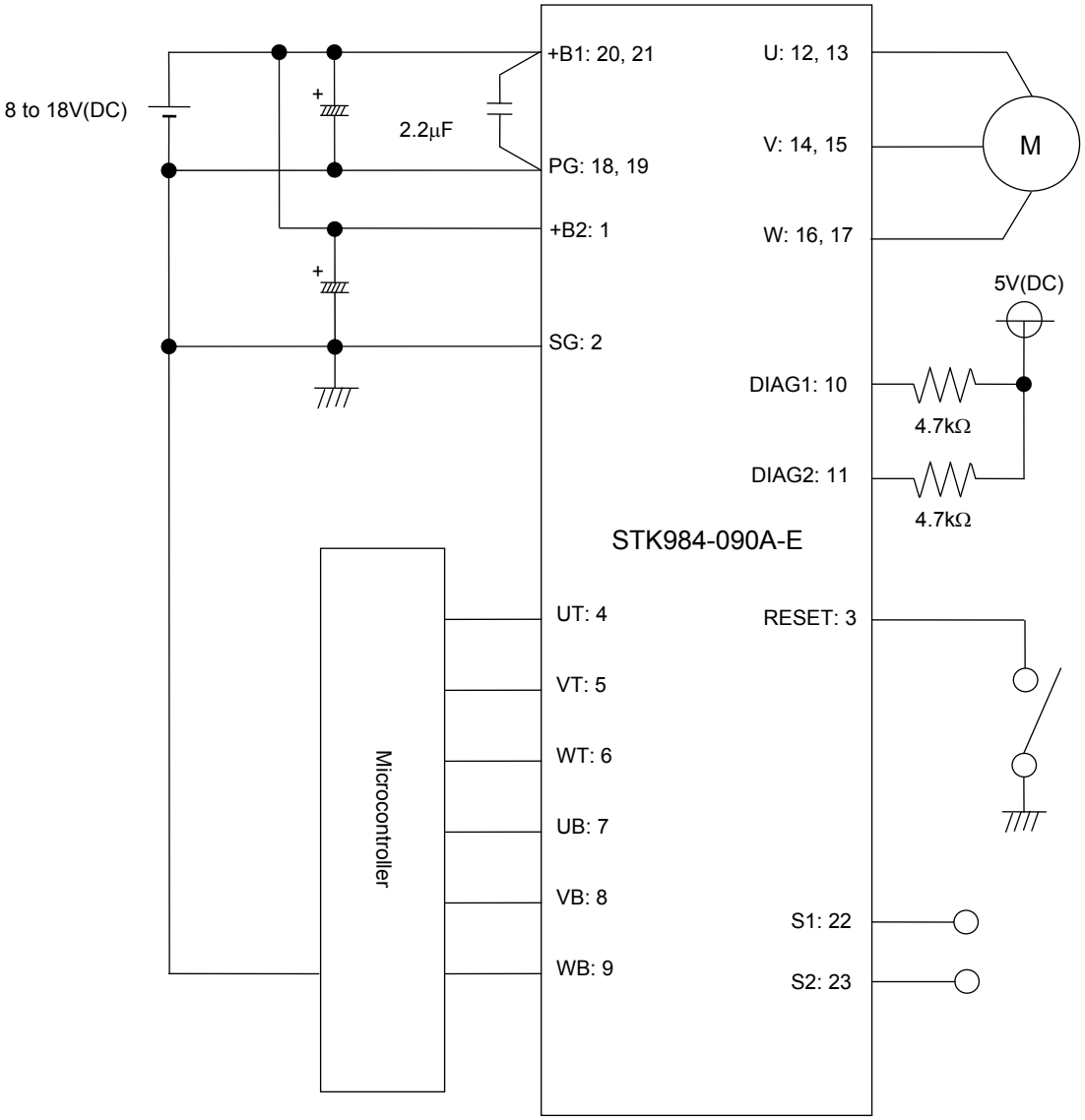
Input			Output			Operating Mode
UT*1	UB*2	RESET	U*3	DIAG1	DIAG2	
L/H	L/H	H	OFF	L	L	Over Voltage Protection Operating
L/H	L/H	L	OFF	H	H	Output OFF

*1 : the same for VT and WT. *2 : the same for VB and WB. *3 : the same for V and W.

Sample Timing Diagram



Application Circuit



NOTE

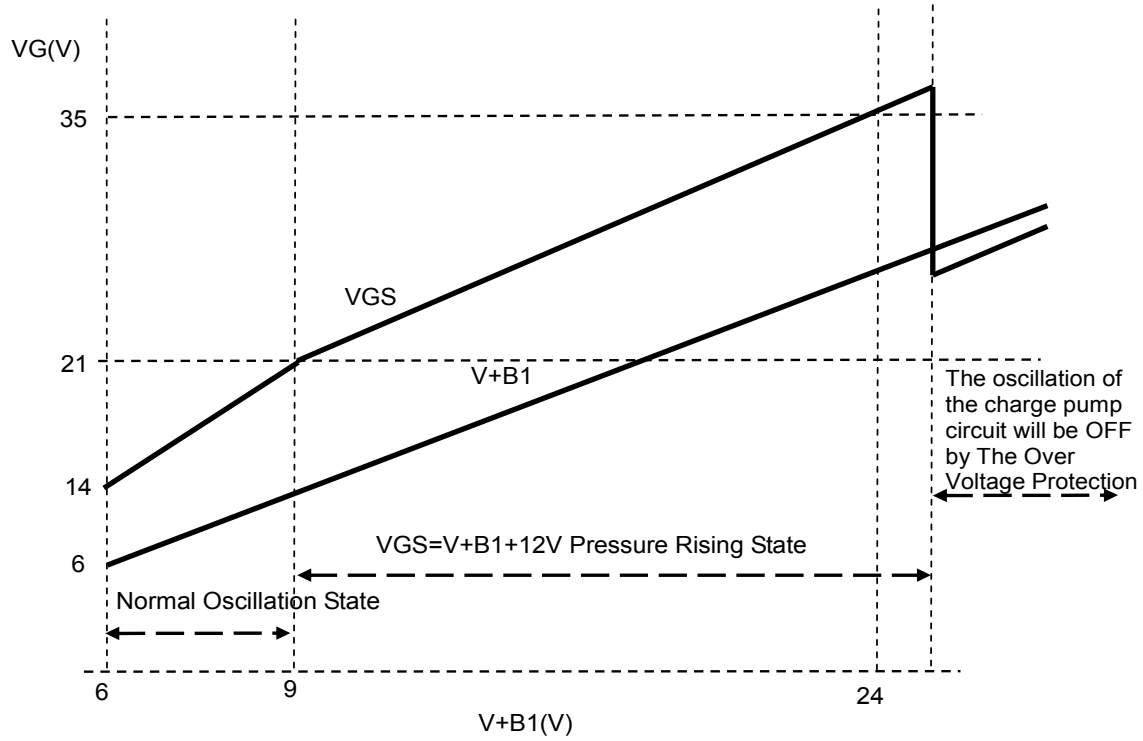
1. A voltage overshoot with vibration will be occurred during a switching operation due to floating inductance of the power source wiring connected between terminal +B1 and PG. In order that the voltage overshoot between +B1 and PG, +B1 and each –UBW, each UVW and PG will not exceed its rating, please minimize wiring inductance by shortening the wiring, also connect a snubber circuit close to between +B1 and PG terminals.
2. With the object of the over current protection circuit fail-safe design, inserting a fuse in +B1 line is recommended.
3. There is a 100kΩ (Typ) pull-down resister connected inside of the signal input terminal. However, in the case of mounting a resister externally to reduce noise due to wiring, please satisfy the input voltage threshold of this Hybrid-IC.
4. Terminal DIAG 1 and DIAG 2 are the open drain output configuration. Please pull up with 4.7kΩ resister to 5V power supply.
5. There is a 100kΩ (Typ) pull-up resister connected inside of the RESET terminal. It operates normally in the open-state. When the short-circuit protection operates and latches the output OFF, the latched output OFF can be released by making RESET terminal Low and re-opened.

Description of Operation

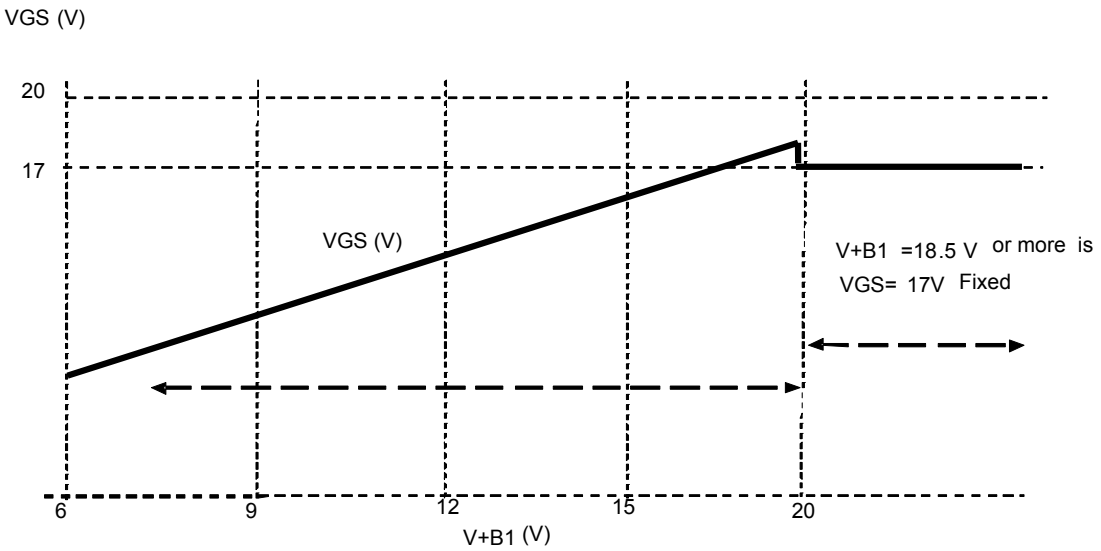
3-phase DC Motor Driver Hybrid-IC controlling outputs with signal input terminals UT to WT and UB to WB.
The output section is “Active Hi” control type that goes to ON operation when the input control signal is Hi level.

1. Method of Driving MOSFET Output Section

(1) Upper-phase MOSFET
The upper-phase MOSFET will be driven by the built-in charge pump circuit. The gate voltage VG from the built-in charge pump circuit is set at VG= V+B1+12V



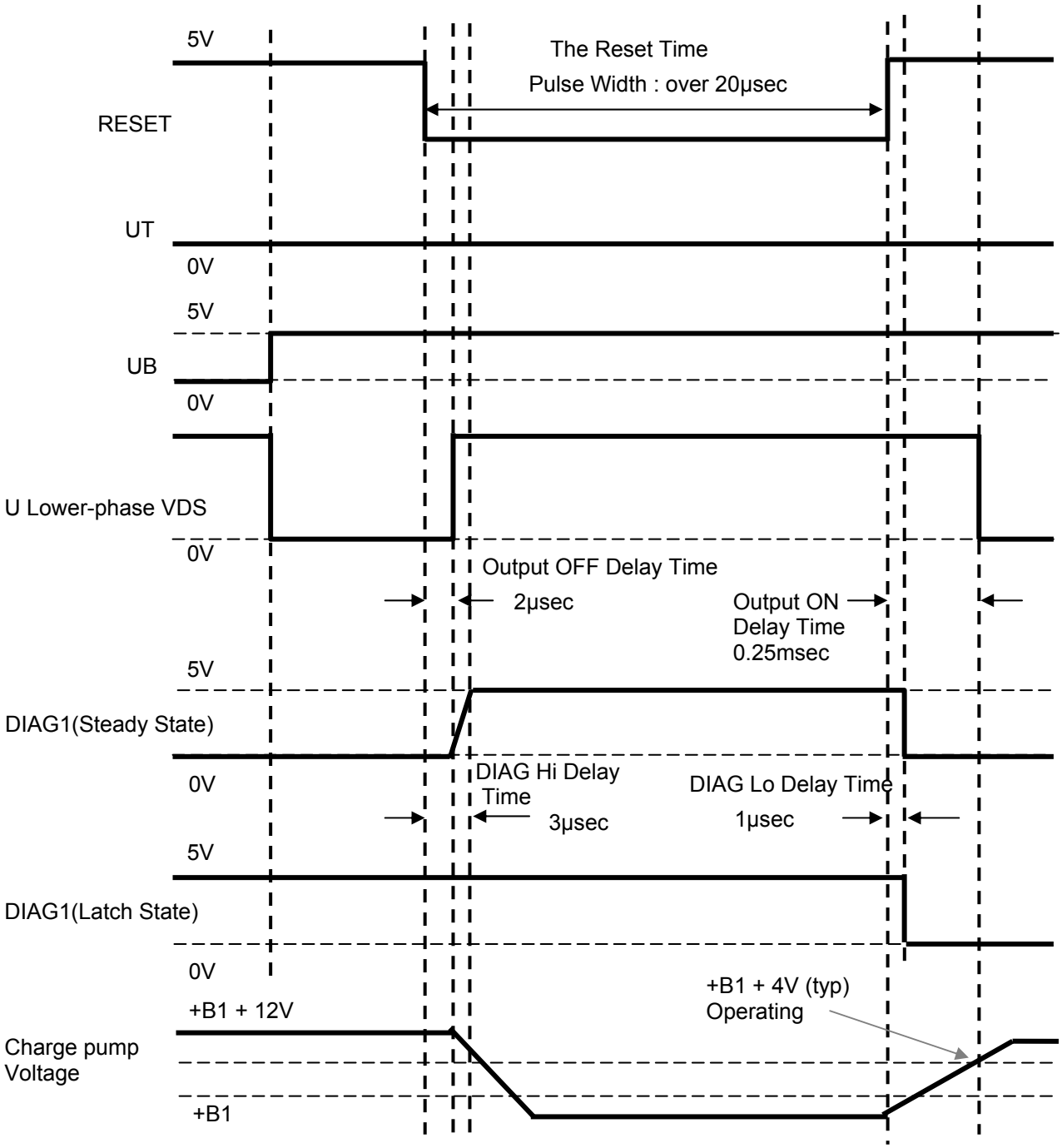
(2) Lower-phase MOSFET
Lower-phase MOSFET operates the supply voltage V+B1 as the supply source of the drive voltage VGS.



2. Reset Circuit

This circuit performs to release the latch when the Short-circuit Protection is activated and output is latched off. It will be a normal operation at the RESET=H or in the open-state, and at RESET=L, the gate output will be Lo-state (Output OFF) for both upper and lower phase.

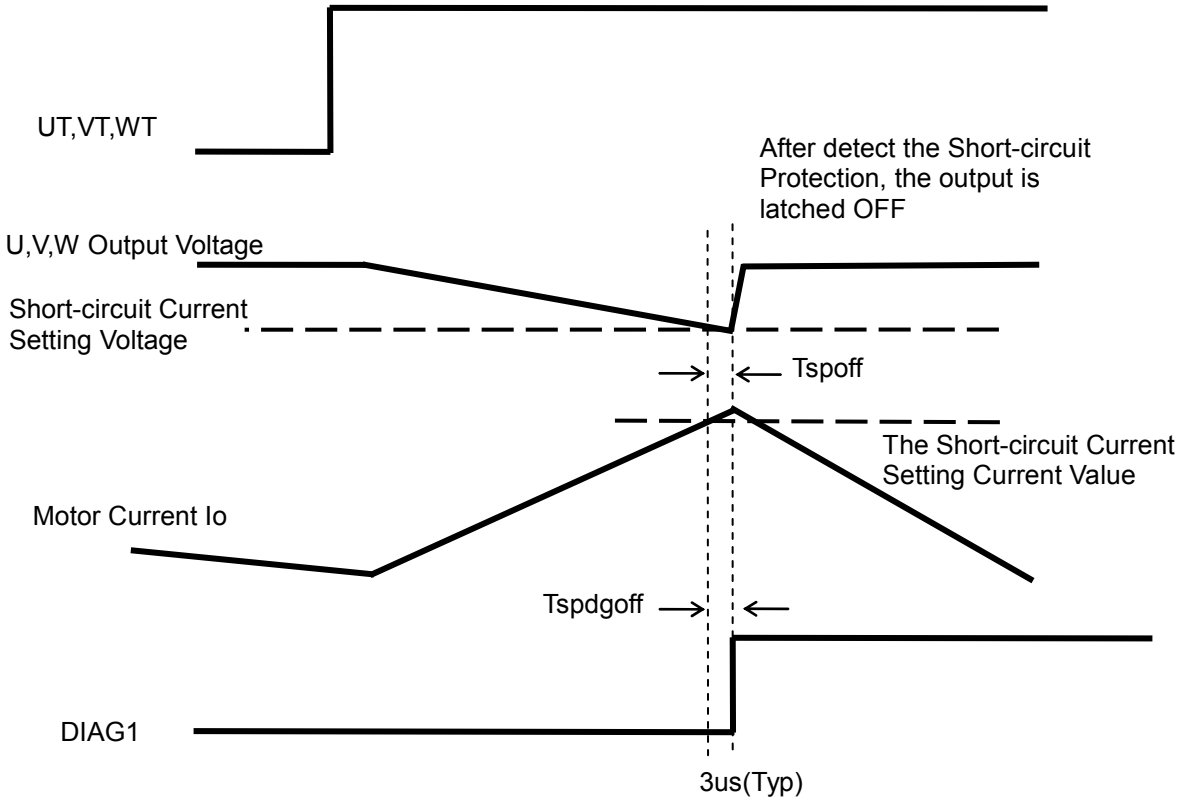
Reset Circuit Timing Chart



3. Short-Circuit Protection Circuit

- The Short Circuit Protection Circuit monitors the VDS of the upper-phase MOSFET to detect short circuits. This circuit detects a short circuit when the short circuit current flows over 3μsec (TYP) and shifts to the OFF operation through the driver circuit. Also this circuit will output the abnormal detection signal as DIAG 1 and goes into the latch-state.
- This Short-Circuit Protection Circuit can release the latch by changing the reset signal from L to H but it may detect a short circuit and go into the latch state again if the current Io is exceeding the short circuit detection range.
- Also, the MOSFET Ron will be varied as the chip temperature is changing. VDS setting Voltage has to be changed as temperature is changing in order to detect the setting current. To do this, place a thermistor as a temperature detecting device on the substrate close to 3-phase MOSFET so this thermistor can sense the chip temperature of MOSFET and detect the current that following the MOSFET Ron characteristics.

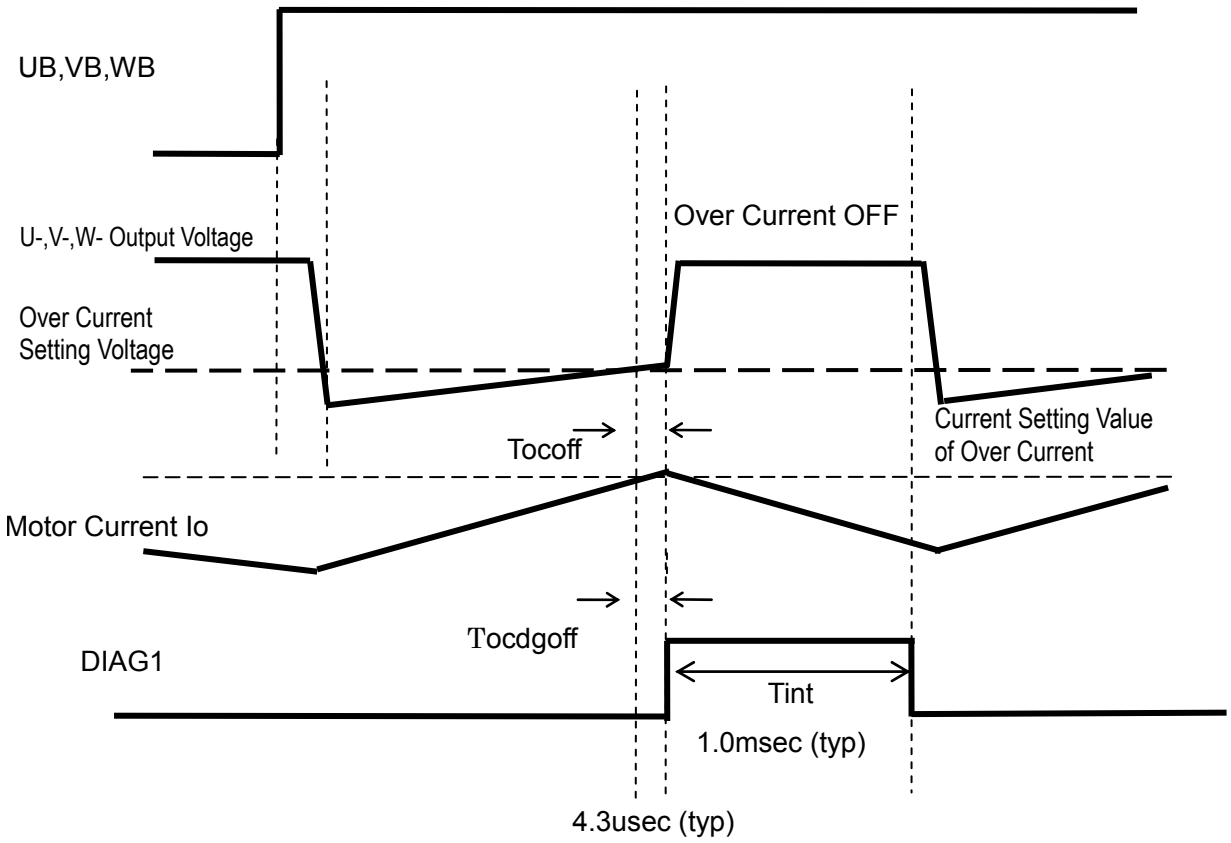
Short Circuit Protection Timing Chart



4. Over Current Protection Circuit

- The Over Current Protection Circuit monitors the VDS of the lower-phase MOSFET to detect over currents. This circuit detects the over current when it flows over 4.3μsec (TYP) and shifts to the OFF operation through the driver circuit. Also this circuit will output the abnormal detection signal as DIAG 1.
- Initially, the Over Current Protection Circuit will be recovered after 1msec.
- Also the MOSFET Ron will be varied as the chip temperature is changing. VDS setting Voltage has to be changed as temperature is changing in order to detect the setting current. To do this, place a thermistor as a temperature detecting device on the substrate close to 3-phase MOSFET so this thermistor can sense the chip temperature of MOSFET and detect the current that follows the Ron MOSFET characteristics.

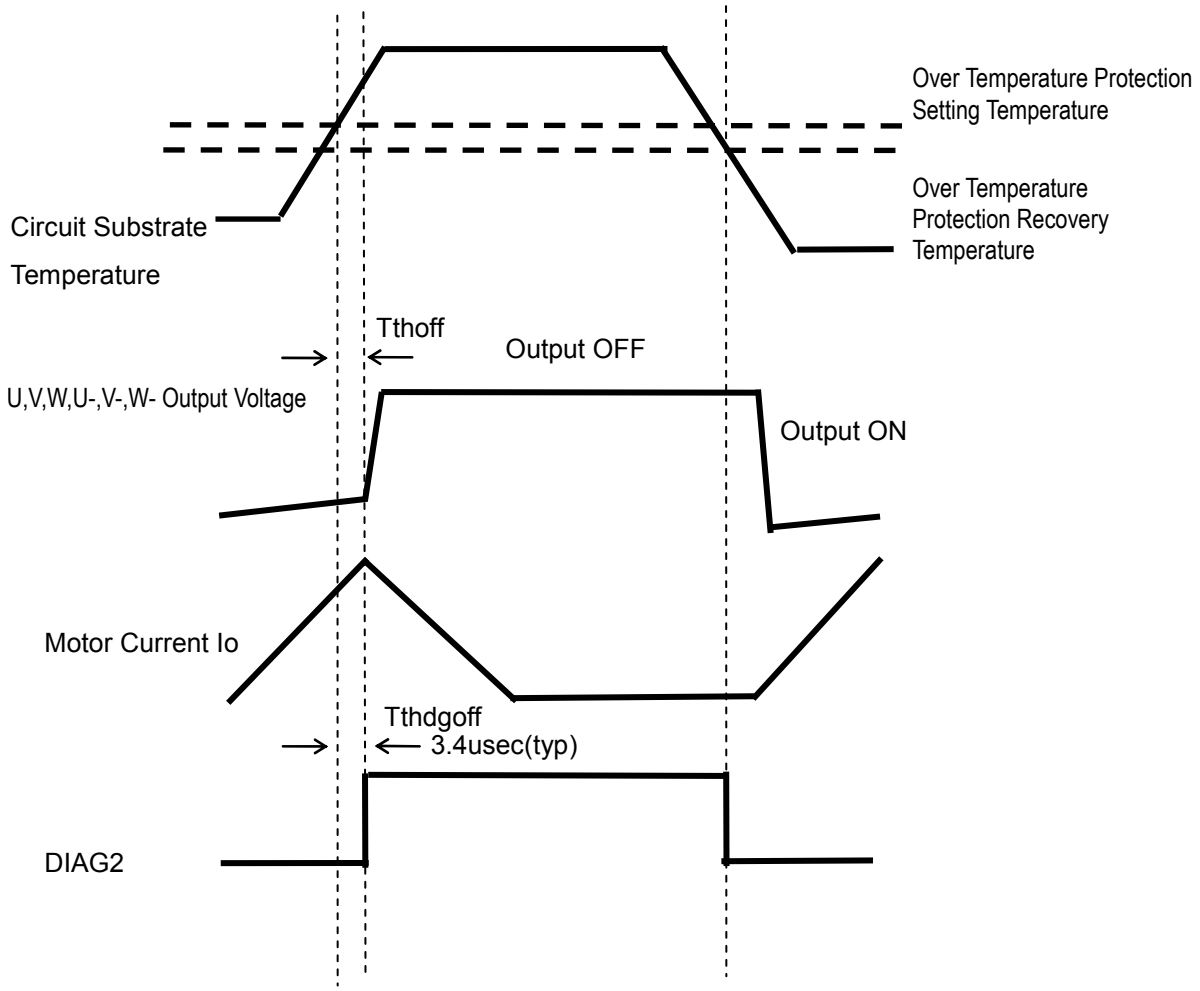
Over Current Protection Timing Chart



5. Over Temperature Protection Circuit

- The Over Temperature Protection Circuit monitors the circuit substrate temperature to detect over temperature. When this circuit detects the over temperature, it will shift to the OFF operation through the driver circuit and also will output the abnormal detection signal as DIAG 2.
- The Over Temperature Protection Circuit has the hysteresis width and it will be recovered automatically when the circuit substrate temperature decreases below the auto recovery temperature.
- The Over Temperature Protection cannot be released. It will be released by switching supply voltage (V+B2) from OFF to ON.

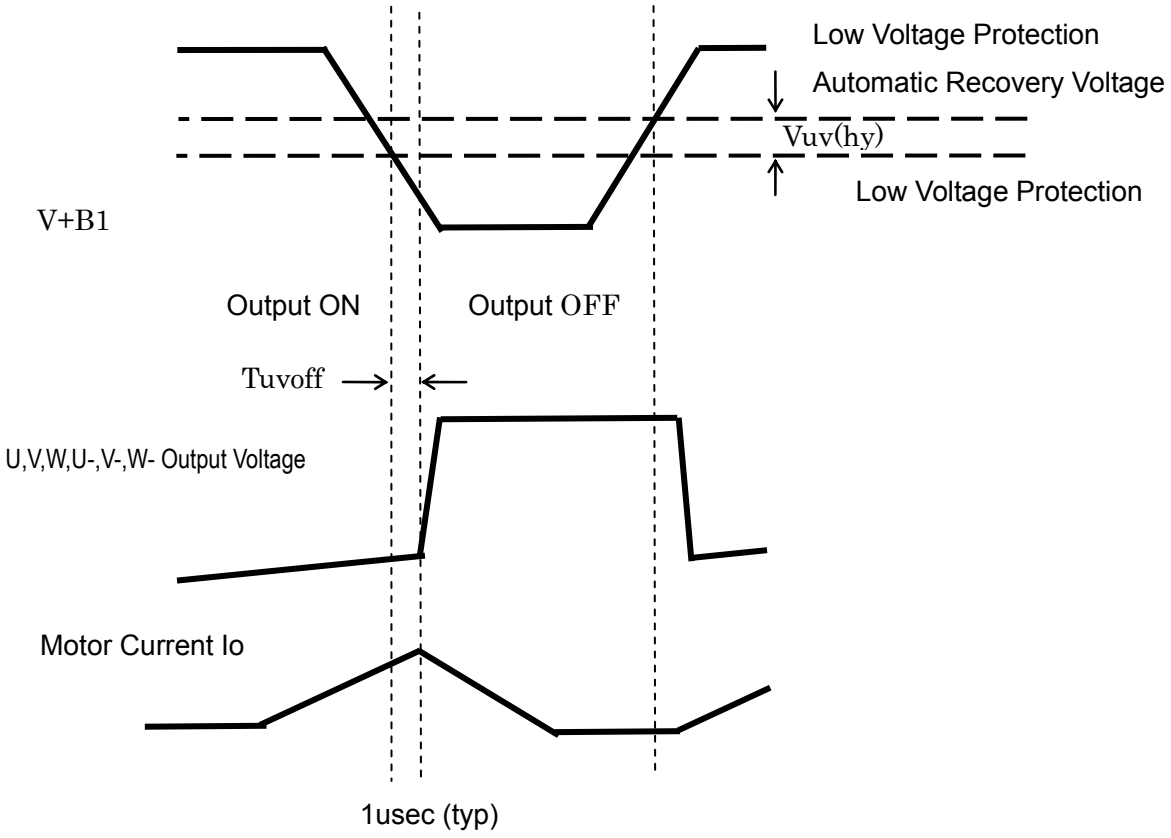
Over Temperature Protection Timing Chart



6. Low Voltage Protection Circuit

- The Low Voltage Protection Circuit monitors voltages supplied to +B1 pin to detect low voltages. When this circuit detects the low voltage, it will shift to the OFF operation through the driver circuit.
- The Low Voltage Protection Circuit has the hysteresis width and it will be recovered automatically when the voltage V+B1 is over the auto recovery voltage.

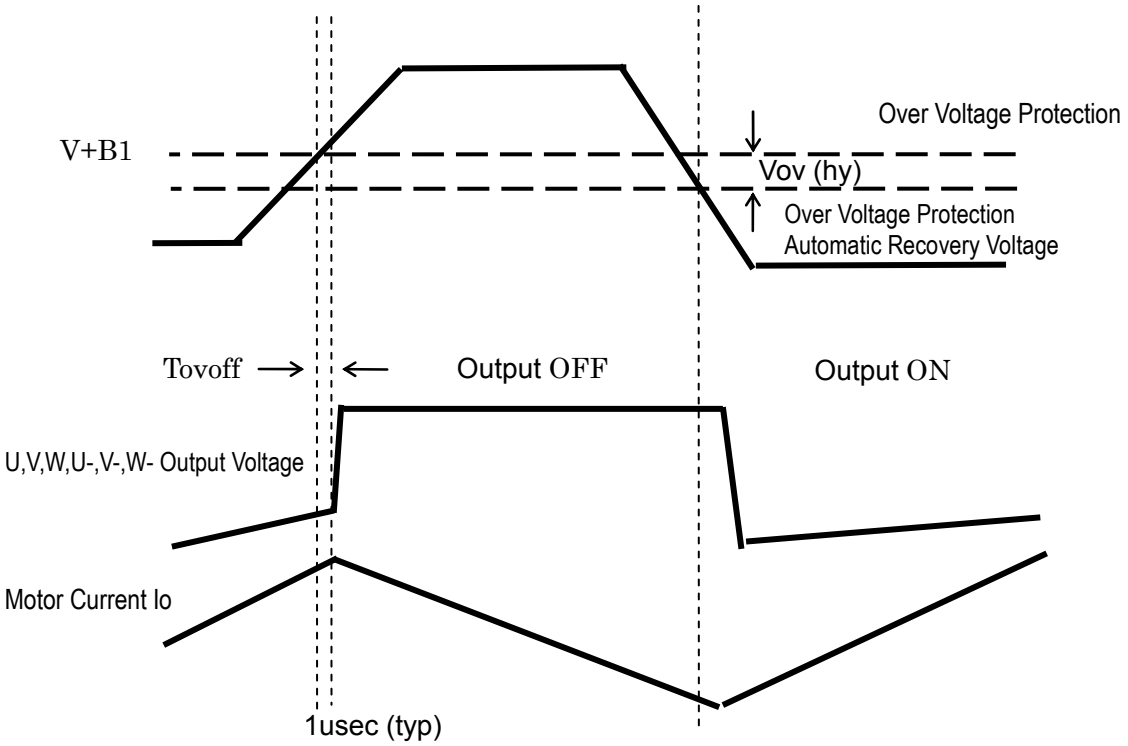
Low Voltage Protection Timing Chart



7. Over Voltage Protection Circuit

- The Over Voltage Protection Circuit monitors the voltage V + B1 supplied to +B1 pin to detect over voltages. When this circuit detects the over voltage, it will shift to the OFF operation through the driver circuit.
- The Over Voltage Protection Circuit has the hysteresis width and it will be recovered automatically when the voltage V+B1 is under the auto recovery voltage.

Over Voltage Protection Timing Chart

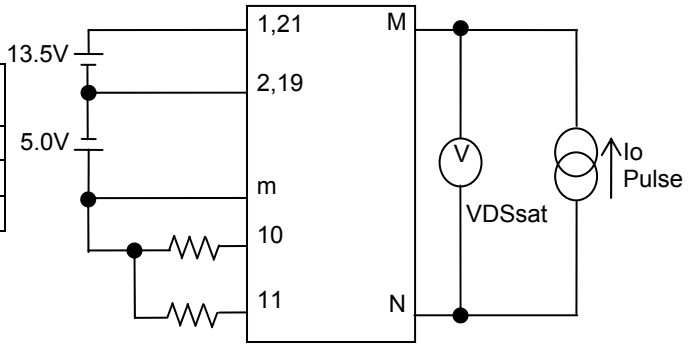


Measurement Circuit

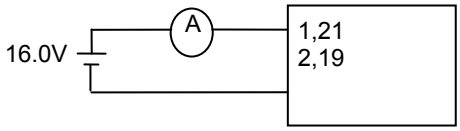
■ VDS(sat) measurement (Pulse Measurement)

Pin No

Measured Phase	U	V	W	U-	V-	W-
M	21	21	21	13	15	17
N	13	15	17	19	19	19
m	4	5	6	7	8	9



■ ICC Measurement



■ ISD Measurement

Pin No

Measured Phase	Short-Circuit Threshold			Overcurrent Threshold		
	U	V	W	U-	V-	W-
M	19	19	19	13	15	17
N	13	15	17	21	21	21
m	4	5	6	7	8	9

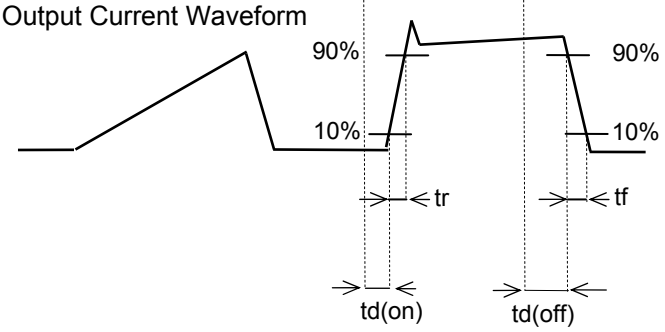
■ td (on), td (off), tr, tf measurement

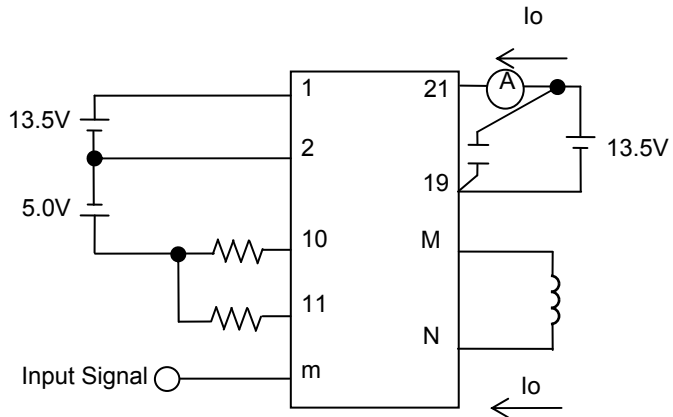
Pin No

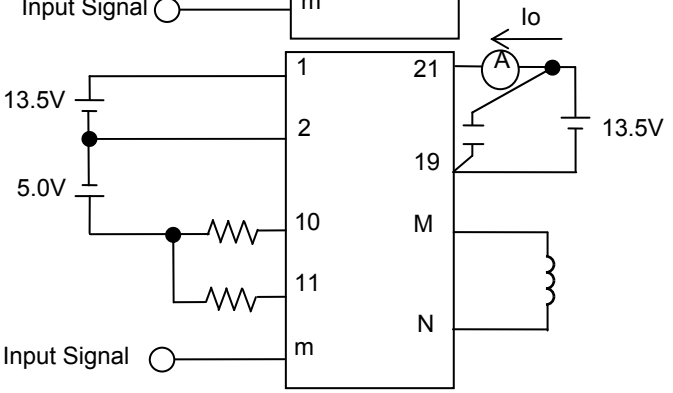
Measured Phase	U	V	W	U-	V-	W-
M	19	19	19	13	15	17
N	13	15	17	21	21	21
m	4	5	6	7	8	9

Input Signal Waveform

Output Current Waveform







Reliability Specification

Ta=25°C±5°C, Relative humidity 65%±20% unless otherwise specified

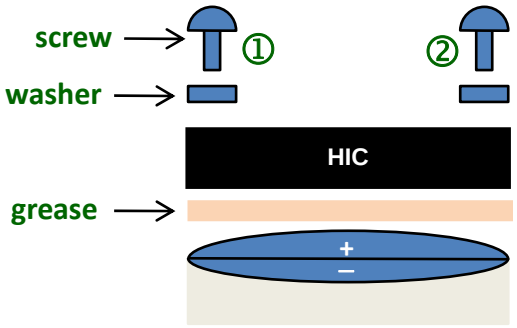
Parameter		Test Conditions	Evaluation Time	Evaluation Method	Test Time
Mechanical Strength	Free-Fall	High = 75cm, drop on a woodblock Woodblock : maple 30×30×3cm Conform to JIS C 7021 A-8	Drop Time = 3 times	Electrical Characteristics	N = 5
	Vibration Fatigue	Vibration Frequently f = 10HZ to 55HZ Logarithmic Sweep Total Amplitude = 1.5+0.2mm	X,Y,Z Each direction 2hr	Electrical Characteristics Visual Inspection	N = 11
Environmental Test	Thermal Shock (Vapor Tank)	Ta = −40°C↔125°C (30min. each) Elapsed time after the test =2hr	1000 Cycles	Electrical Characteristics Visual Inspection Solder Junction	N = 11
	Pressure Cooker	Ta = 121°C, RH=100%, 2 air pressure	48hr	Electrical Characteristics	N = 11
Life Test	High-Temperature Storage	Ta = 125°C Elapsed time after the test = 3hr Conform to JIS C 7201 B-10	1000hr	Electrical Characteristics	N = 11
	Low-Temperature Storage	Ta = −40°C Elapsed time after the test=3hr Conform to JIS C 7021 B-12	1000hr	Electrical Characteristics	N = 11
	High Temperature High Humidity Bias	Ta = 85°C±2°C, RH = 85%±5% V+B1(V+B2) = 70% of Maximum Rating	1000hr	Electrical Characteristics	N = 11

Method of Fixation of Hybrid-IC

Mount on a Heat Sink

Item	Recommended Condition
Pitch	55.7±0.1mm (Please refer to Package Outline Diagram)
Screw	diameter : M3 Bind machine screw, Truss machine screw, Pan machine screw
Washer	Plane washer The size is D:7mm, d:3.2mm and t:0.5mm (Fig.2) JIS B 1256
Heat sink	Material : copper or Aluminum Warpage (the surface that contacts H-IC) : –50 to 100 μm Screw holes must be countersunk. No contamination on the heat sink surface that contacts H-IC.
Torque	Final tightening : 0.6 to 0.9Nm Temporary tightening : 20 to 30 % of final tightening
Grease	Silicon grease Thickness : 100 to 200 μm Uniformly apply silicon grease to whole back. (Fig.3)

Fig 1 : mount HIC on a Heat Sink



■ About procedure for mount HIC on a Heat Sink

1st : Temporarily tighten maintaining a left/right balance.

2nd : Finally tighten maintaining a left/right balance.

*** Make 2nd the same as 1st.**
(example : 1st ① → ②, 2nd ① → ②)

Fig 2 : size of washer

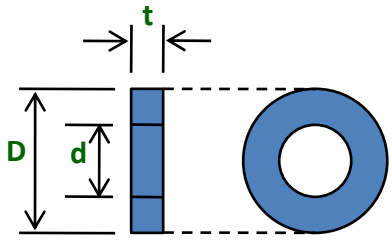
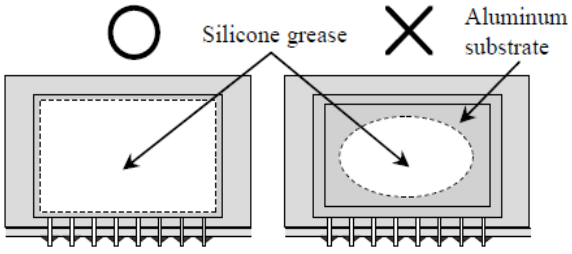


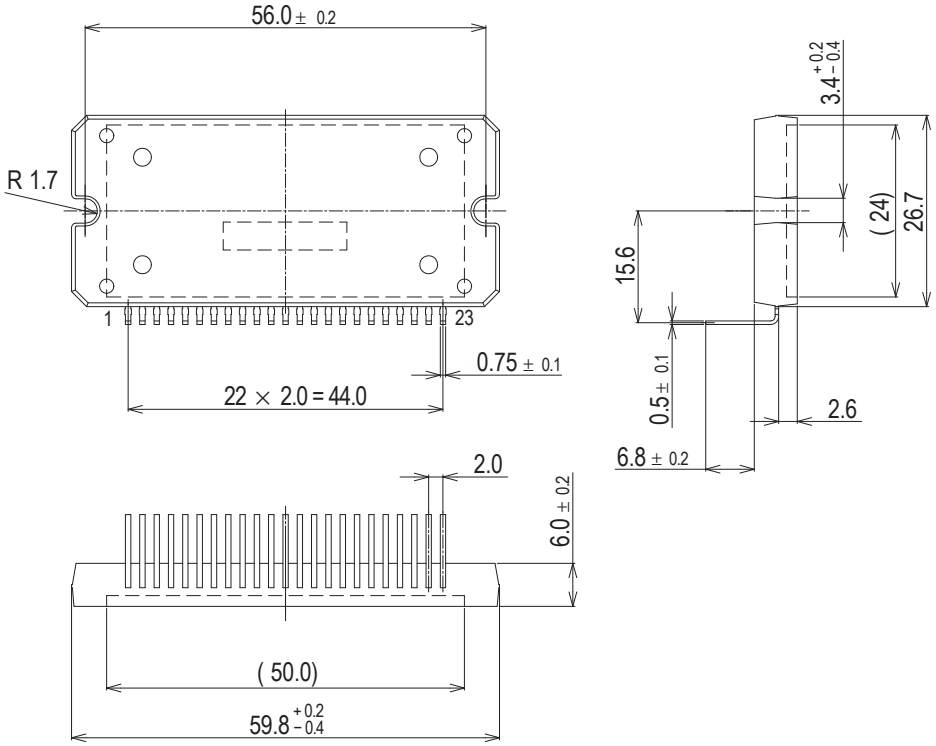
Fig 3 : About uniformly application



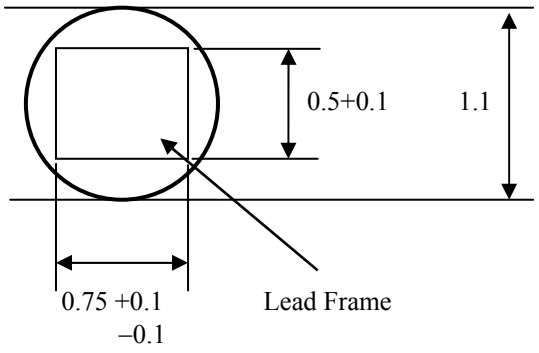
Package Dimensions

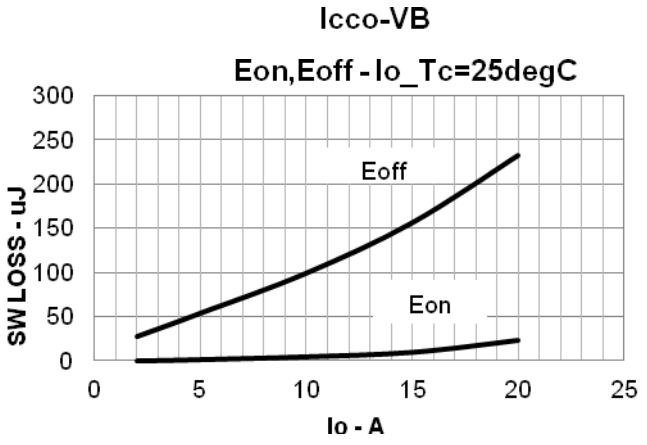
unit : mm

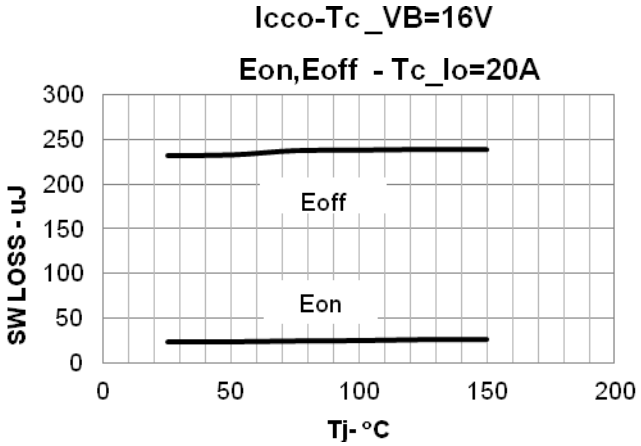
SIP23 59.8x26.7
CASE 127CZ
ISSUE O

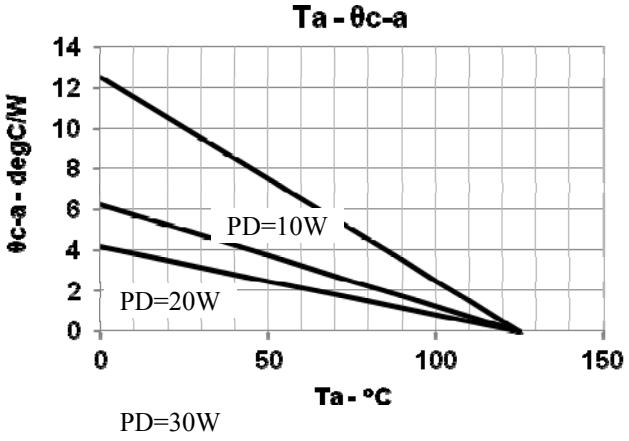


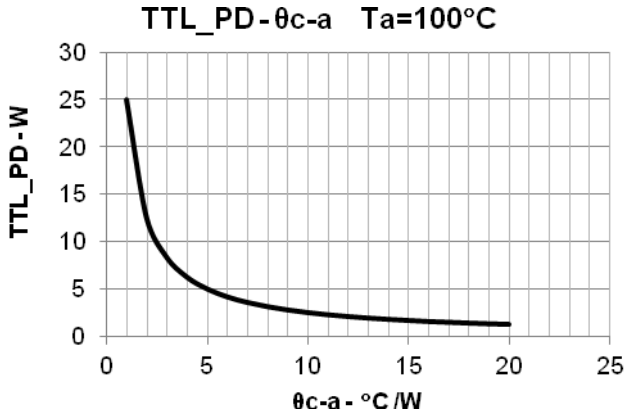
Recommend hole size for Lead Frame on PCB ; 1.1 mm(max)











ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
STK984-090A-E	SIP-23 (Pb-Free)	9 / Tube

Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

ON Semiconductor:

STK984-090A-E