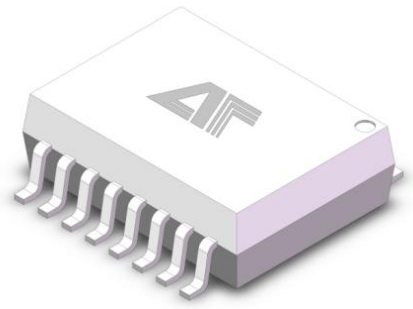
AOTE SEMICONDUCTOR



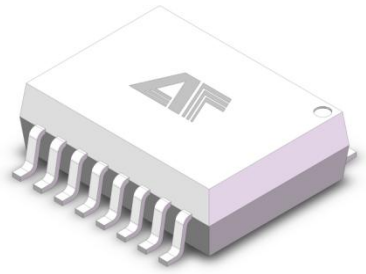
智能栅极驱动光耦
Intelligent gate driven optocoupler

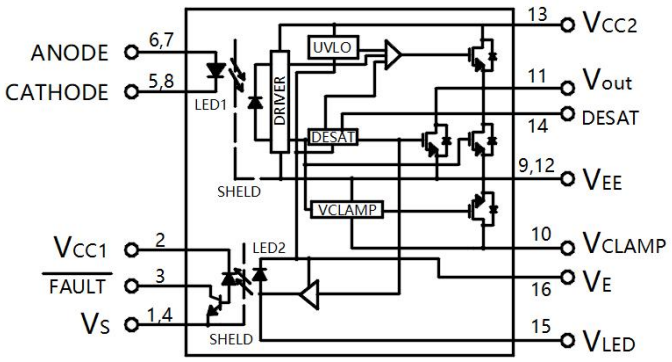
AT331J-CuH-S

Product Data Sheet

AOTE DCC
RELEASE

SOP16





◆ 封装逻辑原理图 Encapsulation logic schematic

AT331J 光耦采用高效光电转换技术，结合先进封装工艺，提供输入输出间的可靠隔离，支持SOP16封装形式，适配多样化场景需求。The AT331J optocoupler adopts high-efficiency photoelectric conversion technology and advanced packaging processes, providing reliable input-output isolation. It supports package types SOP16 to meet diverse application requirements.

◆ 产品特征Product features

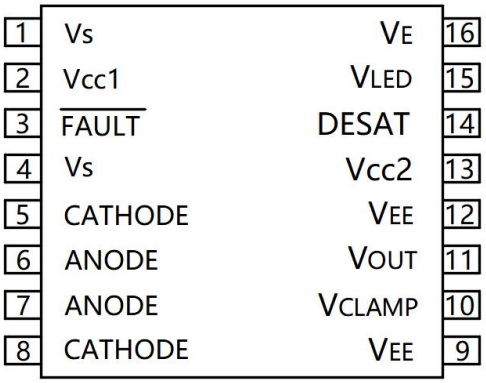
- 输入-输出隔离电压Vios=5000Vrms ； Input output isolation voltage：Vios=5000Vrms
- 15 kV/μs最小共模抑制;15 kV/μs minimum Common Mode Rejection
- 10V 至 30V 宽工作电压范围；10V ~ 30V Wide operating VCC Range
- 峰值输出电流1.5A; peak output current1.5A
- 输出级可驱动100A和1200V 的 IGBTs；The output stage can drive IGBTs with 100A and 1200V；
- 爬电距离>7.0mm ; Creepage distance > 7.0mm；
- 输入-输出绝缘距离 >0.4mm； Input-Output insulation Thickness > 0.4mm
- 防潮等级 class1； MSL class1
- 产品符合 ROHS、REACH 及 HF 等环保法规要求；The products comply with ROHS, REACH and HF；

◆ 应用领域 Applications

- **工业自动化设备：**industrial automation equipment；用于逆变器、交流伺服器，提升系统稳定性和能效；Used for inverters, communication servers, improving system stability and energy efficiency；
- **汽车电子系统：**Automotive Electronic Systems；用于电动汽车的电机驱动，电子刹车系统，增强安全性和开关效率；Motor drive for electric vehicles, Electronic brake system enhances safety and switch efficiency
- **新能源发电领域：**In the field of new energy generation；在光伏、风力发电等，优化电能转换与传输过程Optimize the process of energy conversion and transmission in photovoltaic, wind power generation, etc；
- **电力输送系统：**Power transmission system；支持高压直流输电和柔性交流输电系统，保障输电线路的稳定运行 Support high-voltage direct current transmission and flexible alternating current transmission systems, Ensure the stable operation of transmission lines




◆ 引脚功能说明：pin Function Description



引脚 Pin	符号 Symbol	描述 Description	
1	VS	输入地	Input Ground
2	VCC1	正向输入电源电压 (3.3V～5.5V)	Positive input supply voltage (3.3V to 5.5V)
3	$\overline{\text{FAULT}}$	故障输出。当 DESAT 脚超出内部参考电压 7V 时， FAULT脚将输出一个开路集电极的信号， 在 5us 内；FAULT 脚将从高阻状态转变成一个逻辑低电平。在 同一电路的单个的 FAULT 脚以 “或” 逻辑连接成一条母线到单片机。	Fault output. FAULT changes from a high impedance State to a logic low output within 5μs of the voltage on The DESAT pin exceeding an internal reference voltage of 7V. FAULT output is an open collector which allows the FAULT outputs from all AT332J in a circuit to be connected together in a “wired OR” forming a single fault bus for inter facing directly to the micro-controller.
4	VS	输入地	Input Ground
5	CATHODE	阴极	Cathode
6	ANODE	阳极	Anode
7	ANODE	阳极	Anode
8	CATHODE	阴极	Cathode
9	VEE	输出电源电压	Output supply voltage.
10	VCLAMP	米勒钳位	Miller clamp
11	VOUT	栅极驱动电压输出	Gate drive voltage output
12	VEE	输出电源电压。	Output supply voltage.
13	VCC2	正向输出电源电压	Positive output supply voltage
14	DESAT	去饱和电压输入引脚。当 DESAT 脚电压在 IGBT 导 通时超过内部参考电压 6.5V 时， 故障输出端将在5us 内从高阻状态转变成一个逻辑低电平	Desaturation voltage input. When the voltage on DESAT exceeds an internal reference voltage of 6.5V while the IGBT is on, FAULT output is changed from a high impedance state to a logic low state within 5μs.
15	VLED	LED 阳极。为了保证数据表性能， 此引脚必须保持 不连接。(仅用于光耦测试)	LED anode. This pin must be left unconnected for guaranteed data sheet performance. (For optical coupling testing only)
16	VE	通用(IGBT 发射极)输出电源电压	Common (IGBT emitter) output supply voltage.

◆ 极限参数 Absolute Maximum Ratings (Ta =25℃)

参数 Parameter		符号 Symbol	最小值 Min.	最大值 Max.	单位 Unit
发射端 Input	平均输入电流 Average Input Current	IF(AVG)	-	25	mA
	峰值瞬态输入电流 Peak Transient Input Current	IF(TRAN)	-	1.0	A
	反向输入电压 Reverse Input Voltage	VR	-	5	V
	正输入电源电压 Positive Input Supply Voltage	VCC1	-0.5	5.5	V
	输入 IC 功耗 Input IC Power Dissipation	PI	-	150	mW
输出端 Output	高”峰值输出电流 High” Peak Output Current	OH(PEAK)	-	1.5	A
	低”峰值输出电流 Low” Peak Output Current	IOL(PEAK)	-	1.5	A
	故障输出电流 FAULT Output Current	IFAULT	-	8.0	mA
	故障引脚电压 FAULT Pin Voltage	VFAULT	-0.5	VCC1	V
	总输出电源电压 Total Output Supply Voltage	(VCC2 - VEE)	-0.5	35	V
	负输出电源电压 Negative Output Supply Voltage	(VE - VEE)	-0.5	15	V
	正输出电源电压 Positive Output Supply Voltage	(VCC2 - VE)	-0.5	30	V
	栅极驱动输出电压 Gate Drive Output Voltage	VO(PEAK)	-0.5	VCC2	V
	钳位峰值电流 Peak Clamping Sinking Current	IClamp	-	1.0	A
	米勒钳位引脚电压 Miller Clamping Pin Voltage	VClamp	-0.5	VCC2	V
	DEST 电压 DESAT Voltage	VDESAT	VE	VE + 10	V
	输出 IC 功耗 Output IC Power Dissipation	PO	0	600	mW
隔离电压 Isolation Voltage		Viso	5000		Vrms
工作温度 Operating Temperature		Topr	-55 ~+110		℃
存储温度 Storage Temperature		Tstg	-55 ~+125		℃
焊接温度 Soldering Temperature		Tsol	260		℃

◆ 推荐操作条件 Recommended Operating Conditions

参数 Parameter	符号 Symbol	最小值 Min	最大值 Max	单位 Unit
工作温度 Operating Temperature	TA	-40	+105	℃
输入电压(关) Input Voltage (OFF)	VF(OFF)	0	0.8	V
输入电流(开) Input Current (ON)	IF(ON)	7	16	mA
总输出电源电压 Total Output Supply Voltage	(VCC2 - VEE)	15	30	V
负输出电源电压 Negative Output Supply Voltage	(VE - VEE)	-0.5	15	
正输出电源电压 Positive Output Supply Voltage	(VCC2 - VE)	15	30 - (VE - VEE)	
高电平峰值输出电流 Peak high-level output current	| IOPH |	-	1.5	A
低电平峰值输出电流 Peak low-level output current	| IOPL |	-	1.5	A
DEST 电压 DEST Voltage	VDESAT	VE	VE +10	V
输出 IC 功耗 Output IC Power Dissipation	PO	-	600	mW
工作频率 Operating frequency	f	-	50	KHz

◆ 产品特性参数Product characteristic parameters (Ta =25℃)

除非另有说明， 典型值测量值在 TA =25℃, VCC2 - VEE = 30 V, VE - VEE = 0 V 测得； 所有的最小/最大规格遵照推 荐工作条件。Unless otherwise noted, all typical values at TA =25℃, VCC2 - VEE = 30 V, VE - VEE = 0 V; All Minimum/Maximum specifications are at Recommended Operating Conditions.

参数 Parameter	符号 Symbol	最小值 Min	典型值 Typ	最大值 Max	单位 Unit	条件 Condition	备注 Note
故障逻辑低输出电压 FAULT Logic Low Output Voltage	VFAULTL	-	0.1	0.4	V	IFAULT= 1.1mA VCC1 = 5.5V	-
		-	0.1	0.4	V	IFAULT = 1.1mA VCC1 = 3.3V	-
故障逻辑高输出电流 FAULT Logic High Output Current	IFAULTH	-	0.02	0.5	μA	VFAULT = 5.5 V VCC1= 5.5V	-
		-	0.002	0.3	μA	VFAULT = 3.3 V VCC1= 3.3V	-
高电平输出电流 High Level Output Current	IOH	-0.5	-1.5	-	A	VO = VCC2 - 4V	4,18
		-2.0	-	-	A	VO = VCC2 – 15V	
低电平输出电流 Low Level Output Current	IOL	0.5	1.5	-	A	VO = VEE + 2.5V	5,19
		2.0	-	-	A	VO = VEE + 15V	
故障条件下的低电平输出电流 Low Level Output Current During Fault Condition	IOLF	90	140	230	mA	VOUT - VEE = 14 V	-
高电平输出电压 High Level Output Voltage	VOH	VCC-3.5	VCC-2.5	-	V	IO =100μA	2,4,20
		VCC-2.9	VCC-2.0	-		IO = -650μA	
低电平输出电压 Low Level Output Voltage	VOL	-	0.17	0.5	V	IO = 100mA	3,5,21
钳位引脚阈值电压 Clamp Pin Threshold Voltage	VtClamp	-	-	2.5	V	-	-
低电平钳位电流 Clamp Low Level Sinking Current	ICL	0.5	1.1	-	A	VO = VEE + 2.5	-
高电平电源电流 High Level Supply Current	ICC2H	-	2.5	4.5	mA	IO = 0mA	6,7,23
低电平电源电流 Low Level Supply Current	ICC2L	-	2.5	4.5	mA	IO = 0mA	
极间耦合电容充电电流 Blanking Capacitor Charging Current	ICHG	0.13	-0.24	-0.33	mA	VDESAT = 2V	8,24
极间耦合电容放电电流 Blanking Capacitor Discharge Current	DSCHG	10	30	-	mA	VDESAT = 7.0V	25
DESAT 阈值 DESAT Threshold	VDESAT	6	6.5	7.5	V	VCC2 -VE >VUVLO-	9,27
UVLO 阈值 UVLO Threshold	VUVLO+	10.5	11.6	12.5	V	VO > 5 V	-
	VUVLO-	9.2	10.3	11.1	V	VO < 5 V	-

参数 Parameter	符号 Symbol	最小值 Min	典型值 Typ	最大值 Max	单位 Unit	条件 Condition	备注 Note
UVLO 迟滞 UVLO Hysteresis	(VUVLO+ - VUVLO-)	0.4	1.3	-	V	-	-
输入阈值电流由低至高 Threshold Input Current Low to High	IFLH	-	2.0	5.0	mA	IO = 0mA VO > 5 V	-
输入阈值电压从高到低 Threshold Input Voltage High to Low	VFHL	0.8	-	-	V	-	-
输入正向电压 Input Forward Voltage	VF	1.2	1.6	1.95	V	IF = 10mA	-
输入正向电压的温度系数 Temperature Coefficient of Input Forward Voltage	ΔVF/ΔTA	-	-1.3	-	mV/°C	-	-
输入反向击穿电压 Input Reverse Breakdown Voltage	BVR	5	-	-	V	IR = 10 A	-
输入电容 Input Capacitance	CIN	-	70	-	pF	f = 1 MHz VF = 0 V	-

◆ 开关特性参数Switch characteristic parameters

除非另有说明， TA = 25°C、VCC2 = 30 V、VEE 接地时的所有典型值； 所有最小/最大规格都是在推荐的工作条件下。
Unless otherwise noted, all typical values at TA = 25°C, VCC2 = 30 V, VEE = Ground; All Minimum/Maximum specifications are at Recommended Operating Conditions.

参数 Parameter	符号 Symbol	最小 Min	典型 Typ	最大 Max	单位 Unit	条件 Condition	备注 Note
到达高输出电平的传播延迟时间 Propagation Delay Time to High Output Level	tPLH	50	180	250	ns	Rg = 20Ω, Cg = 5nF, f = 10kHz, Duty Cycle = 50% IF = 10mA VCC2 = 30V	1,10,11 12,13, 26
低输出电平的传播延迟时间 Propagation Delay Time to Low Output Level	tPHL	50	180	250	ns		
脉冲宽度失真 Pulse Width Distortion	PWD	-80	30	80	ns		-
任意两个部件或信道之间的传播延迟差Propagation Delay Difference Between Any Two Parts or Channels	PDD	-100	-	100	ns		-
上升时间 Rise Time	tr	-	50	-	ns		-
下降时间 Fall Time	tf	-	50	-	ns		-
DESAT 检测至 90% VOUT 延迟 DESAT Sense to 90% VOUT Delay	Tdesat (90%)	-	0.25	0.5	μs	CDESAT = 100pF Rg = 20Ω, Cg = 5nF, VCC2 = 30V, RF =2.1kΩ	14,27 32
高电平输出的共模抑制能力 Output High Level Common Mode Transient Immunity	|CMH |	15	-	-	kV/μs	TA = 25°C, IF = 10mA VCM = 1500 V, VCC2 = 30 V, RF = 2.1kΩ, CF = 1nF	
低电平输出的共模抑制能力 Output Low Level Common Mode Transient Immunity	|CML |	15	-	-	kV/μs	TA = 25°C, IF = 10mA VCM = 1500 V, VCC2 = 30 V, RF = 2.1kΩ, CF = 1nF	

◆ 电性特性曲线Electrical characteristic curve(Ta =25℃)

Fig.1 Vout propagation delay wave forms

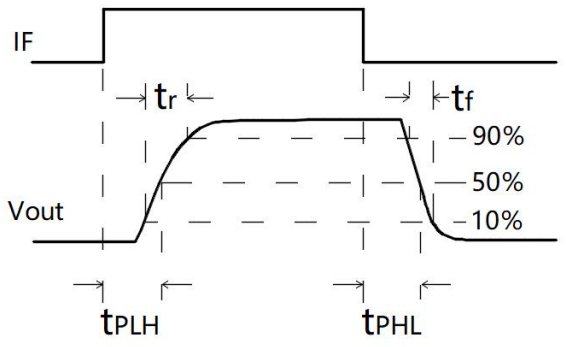


Fig.2 Output High Current vs Ambient Temperature

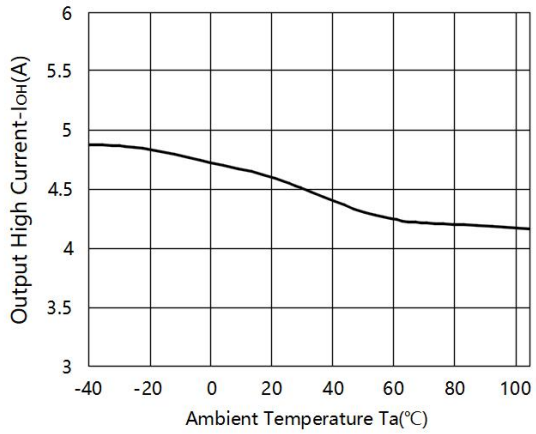


Fig.3 Output Low Current vs Ambient Temperature

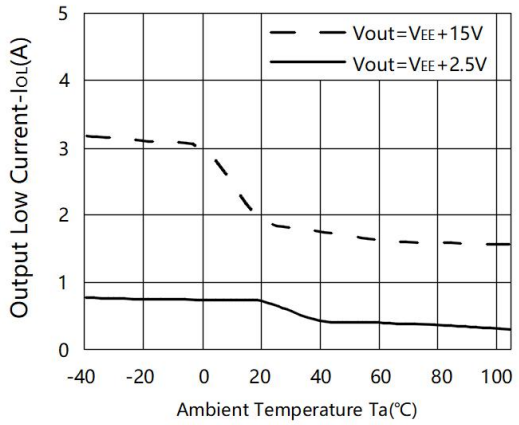


Fig.4 High Output Voltage Drop vs Ambient Temperature

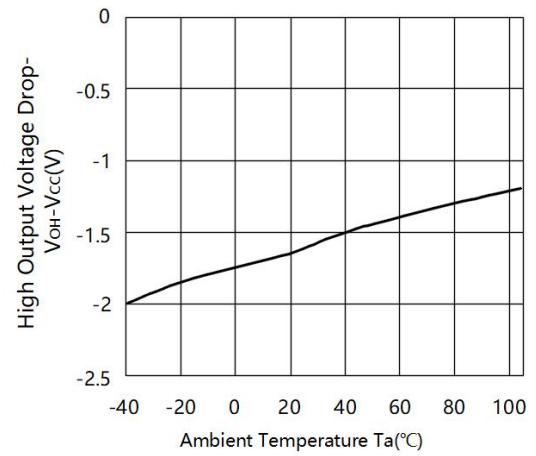


Fig.5 Output Low Voltage vs Ambient Temperature

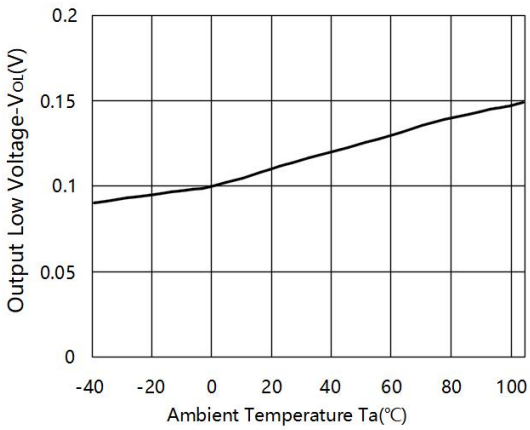


Fig.6 High Output Voltage vs Output High Current

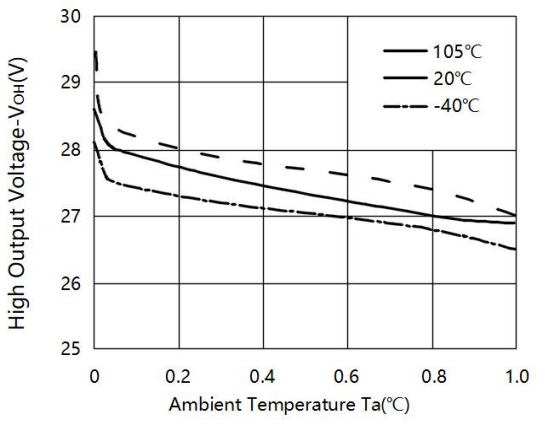


Fig.7 Low Output Voltage vs Output Low Current

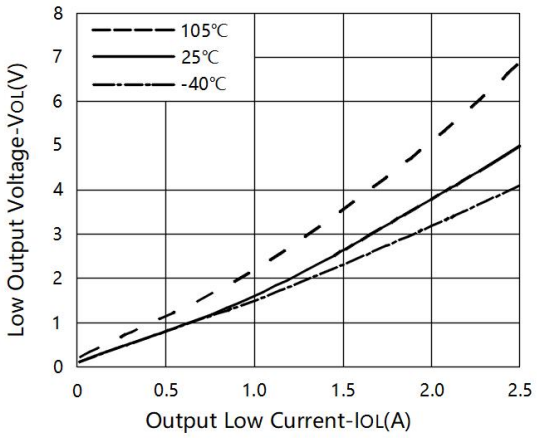


Fig.8 Clamp Low Level Sinking Current vs Ambient Temperture

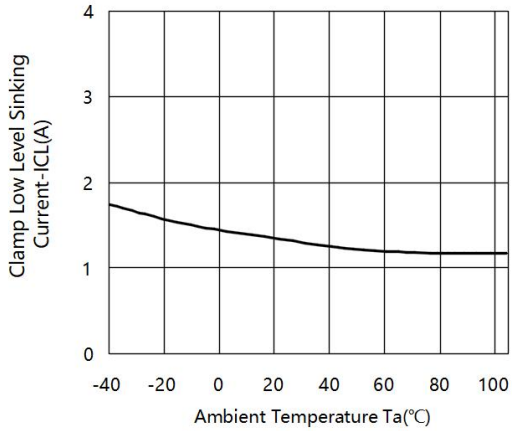


Fig.9 Output Supply Current vs Ambient Temperature

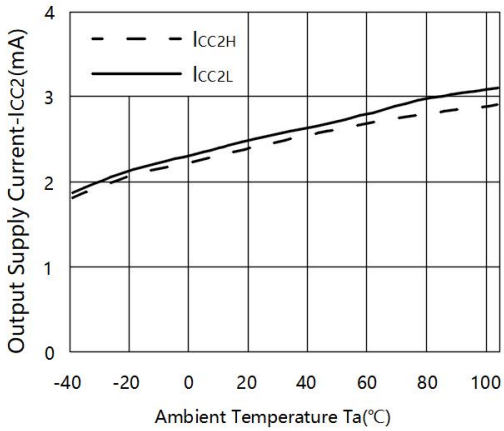


Fig.10 Output Supply Current vs Output Supply Voltage

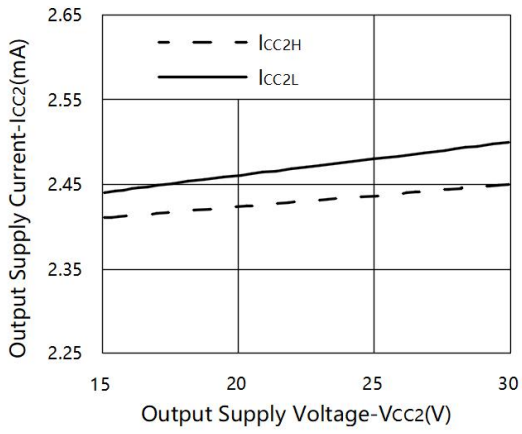


Fig.11 Blanking Capacitor Charging Current vs. Ambient Temperature

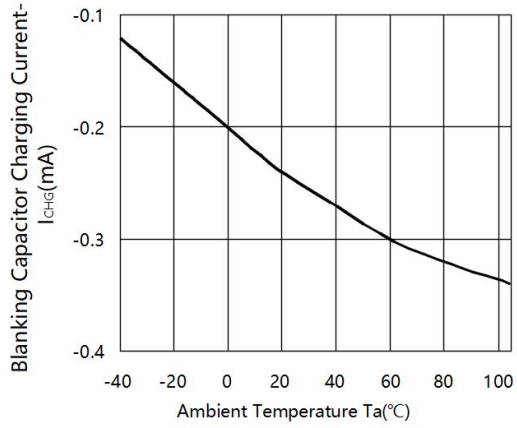


Fig.12 DESAT threshold vs. Ambient Temperature

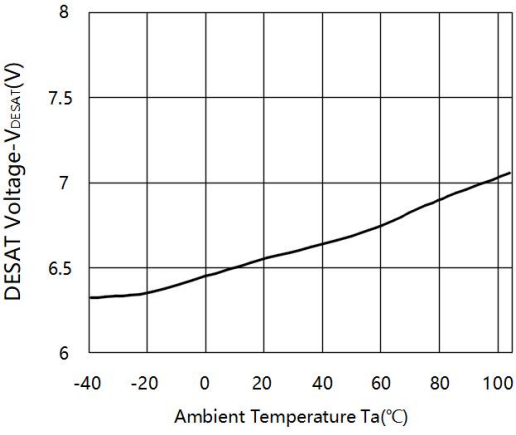


Fig.13 Propagation Delay vs Ambient Temperature

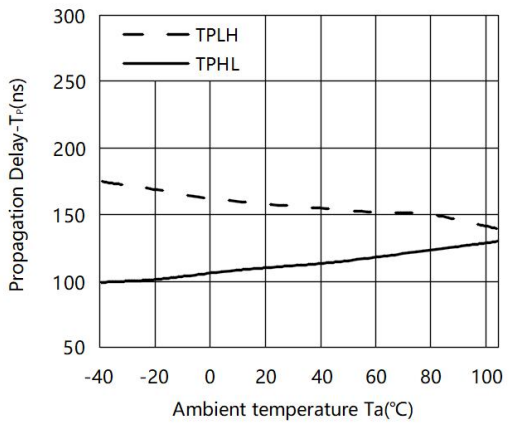


Fig.14 Propagation Delay vs. Supply Voltage

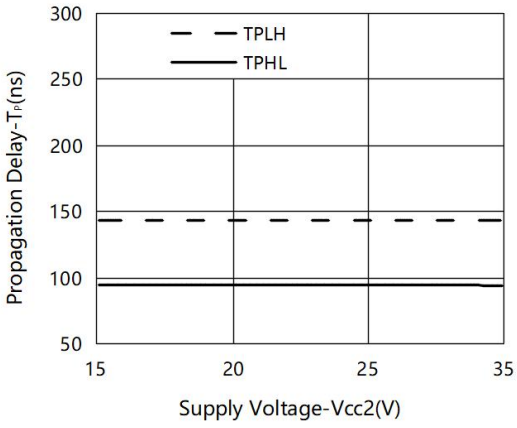


Fig.15 Propagation Delay vs Load Resistance

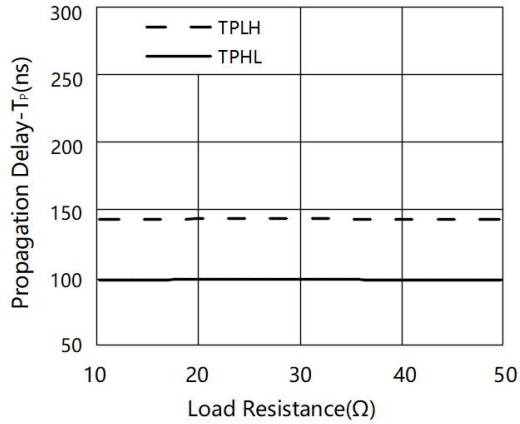


Fig.16 Propagation Delay vs Load Capacitance

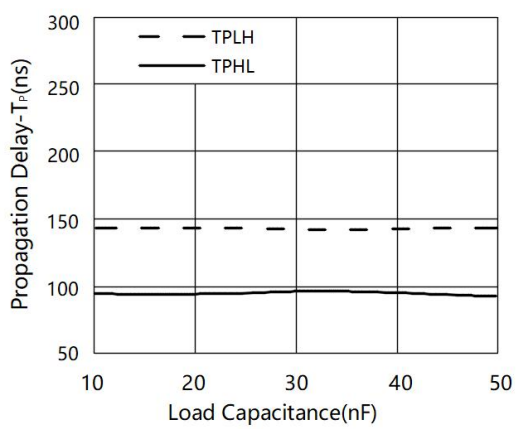


Fig.17 DESAT Sense to 90% Vo Delay vs. Ambient Temperature

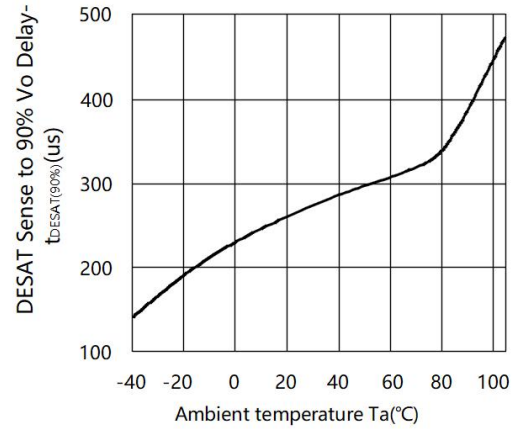


Fig.18 DESAT Sense to 10% Vo Delay vs. Ambient Temperature

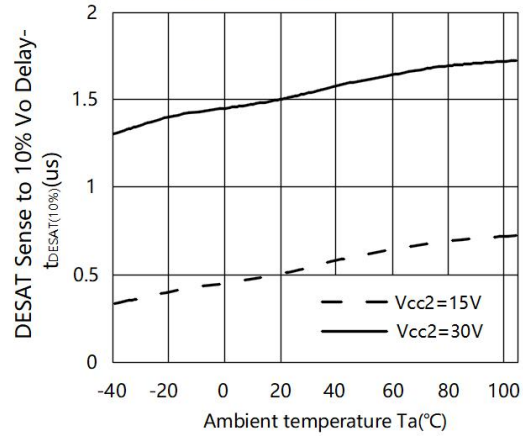


Fig.19 DESAT Sense to 10% Vo Delay vs. Load Resistance

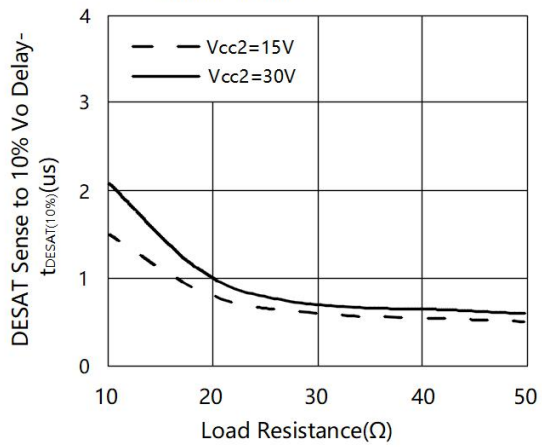
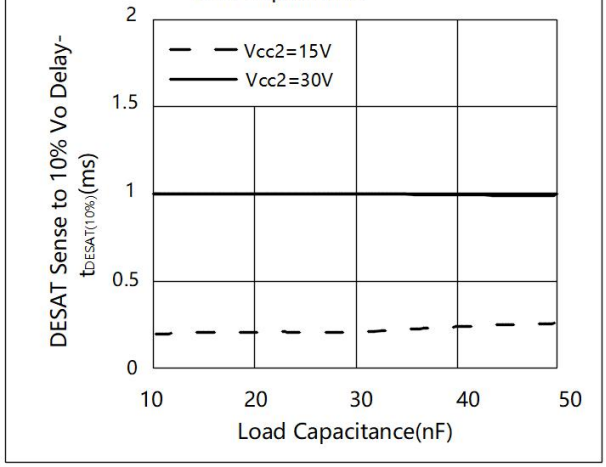


Fig.20 DESAT Sense to 10% Vo Delay vs. Load Capacitance



◆ 测试电路图TestCircuits Diagrams

Fig21. I_{OH} Pulsed Test Circuit

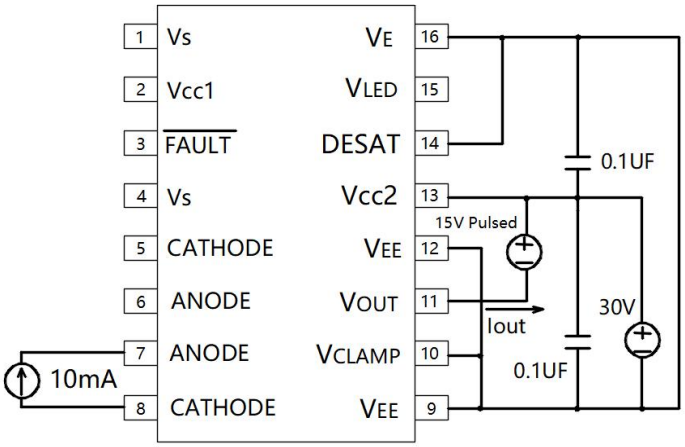


Fig22. I_{OL} Pulsed Test Circuit

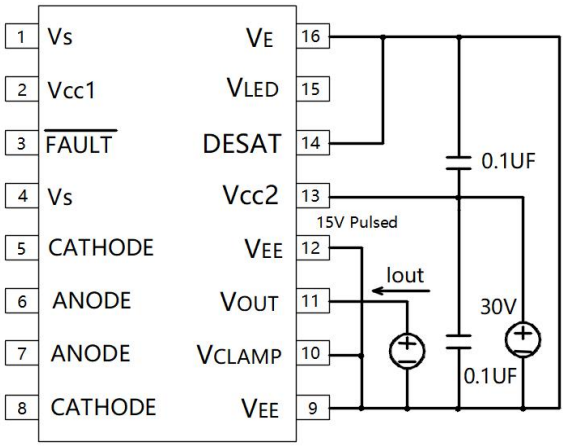


Fig23. V_{OH} Pulsed Test Circuit

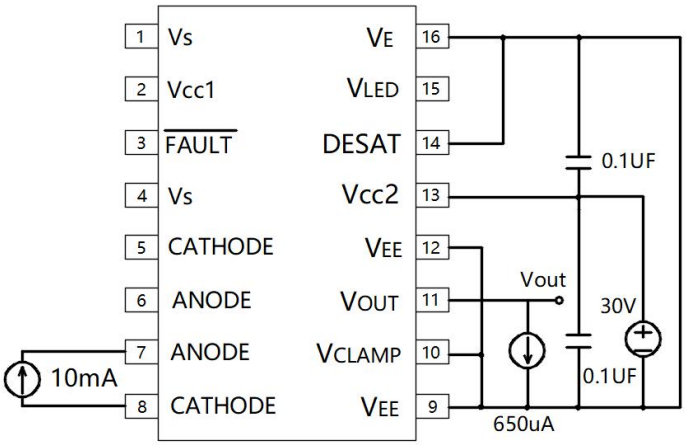


Fig24. V_{OL} Pulsed Test Circuit

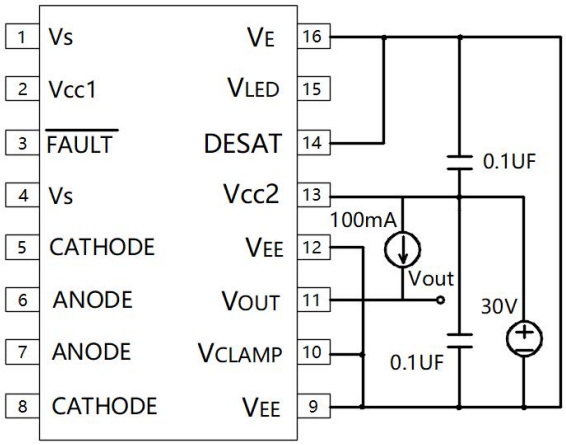


Fig25. I_{CC2H} Test Circuit

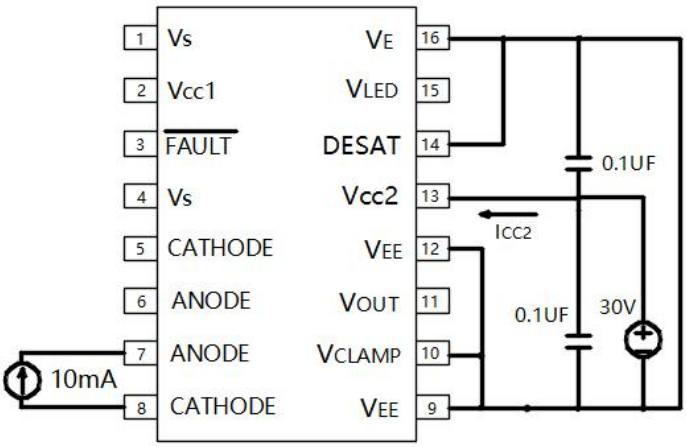


Fig26. I_{CC2L} Test Circuit

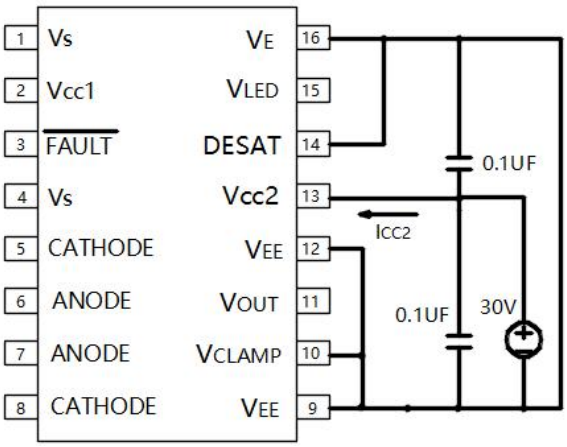


Fig27. I_{CC2H} Pulsed Test Circuit

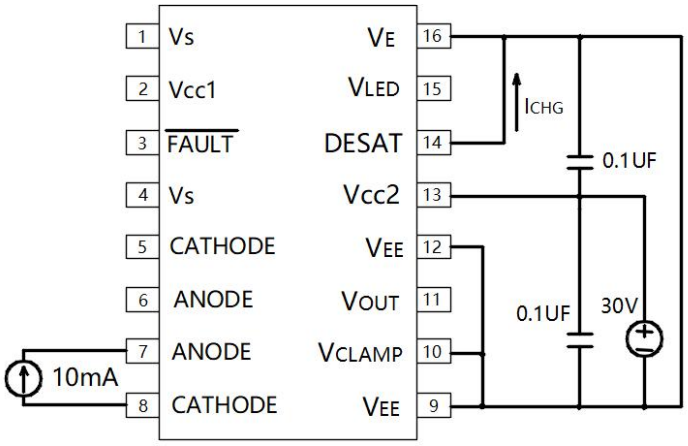


Fig28. I_{DSCHG} Test Circuit

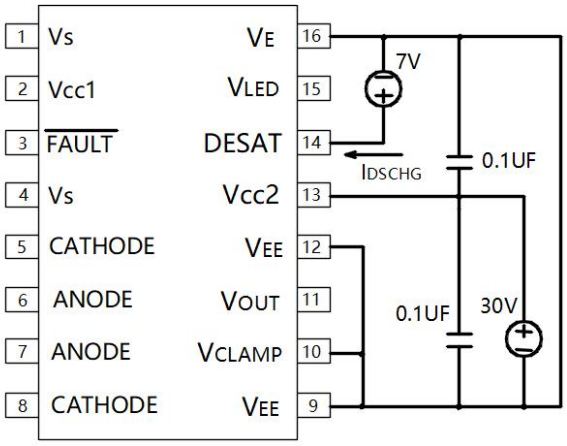


Fig29. T_{PLH},T_{PHL},Tr,Tf, Test Circuit

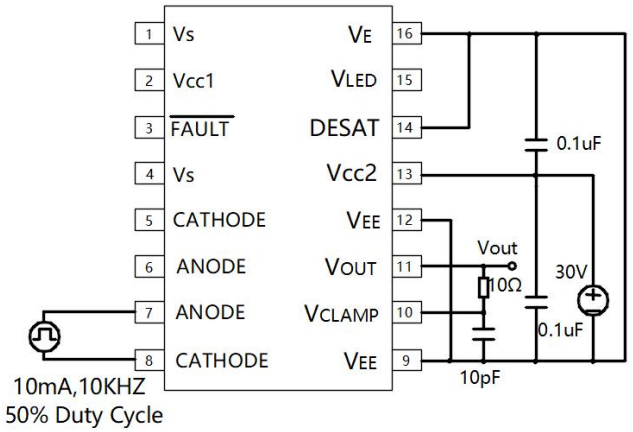


Fig30. T_{DESAT} Fault Test Circuit

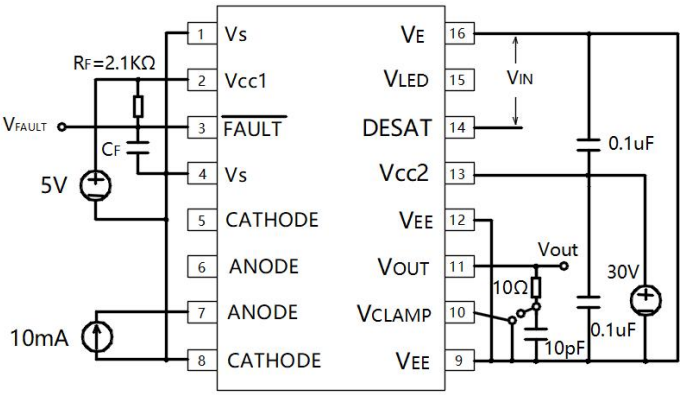


Fig31. CMR Test Circuit LED2 off

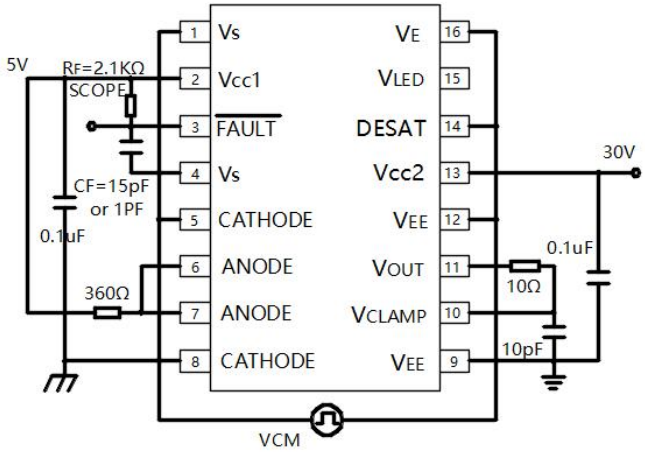


Fig32. CMR Test Circuit LED2 on

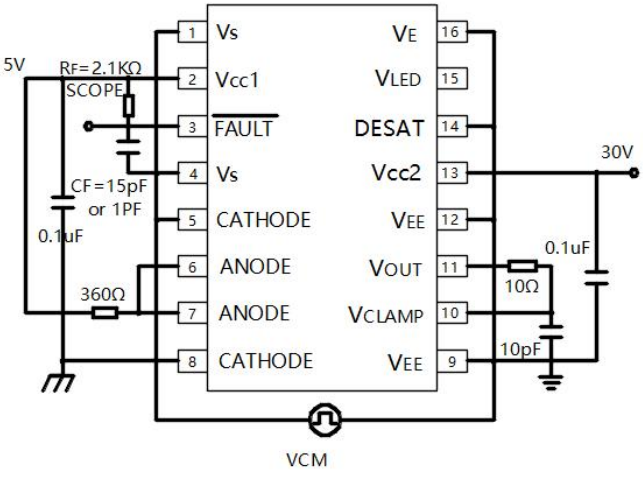


Fig33. CMR Test Circuit LED1 on

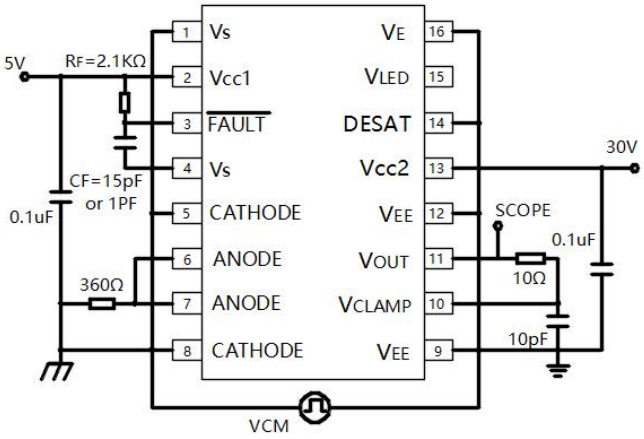
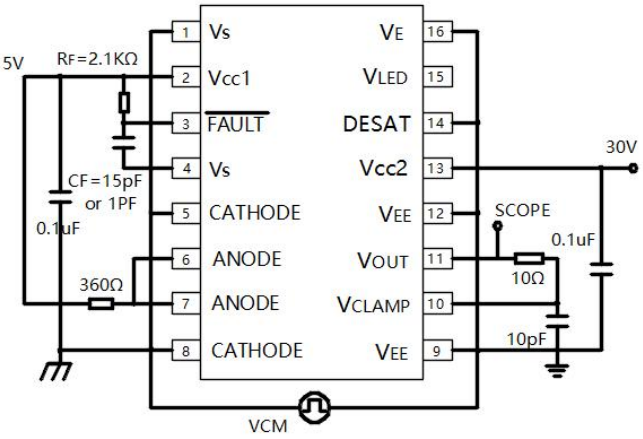


Fig34. CMR Test Circuit LED1 off



◆ 应用信息 Application Information

1、产品概述描述 Product Overview Description

AT331J 是高度集成的功率控制器件， 将完整、隔离型IGBT/MOSFET栅极驱动电路与故障保护和反馈电路所必须的元件集成到一个SOP16 封装中。有源米勒钳位功能消除了大多数应用中对负栅极驱动的需求，并允许高压侧驱动器使用简单的自举电路产生电源。光隔离功率输出级可驱动100A 和1200V的IGBTs。高速内部光链路最大限度地降低了微控制器和IGBT之间的传播延迟， 同时允许两个系统在非常大的共模电压差下运行，这在工业电机驱动和其他电源开关应用中很常见。输出IC为IGBT提供局部保护以防止过电流期间的损坏， 第二光链路为微控制器提供了一个完全隔离的故障状态反馈 信号。UVLO 内置"看门狗"电路， 监测功率级电源电压，以防止因栅极驱动电压不足而导致IGBT故障。这款集成式 IGBT栅极驱动器旨在提高电机驱动器的性能和可靠性，而不增加成本、体积和复杂的分立设计。The AT331J are highly integrated power control devices that incorporates all the necessary components for a complete, isolated IGBT / MOSFET gate drive circuit with fault protection and feedback into one SOP16 package. Active Miller clamp function eliminates the need of negative gate drive in most application application and allows the use of simple bootstrap supply for high side driver. An optically isolated power output stage drives IGBTs with power ratings of up to 100A and 1200V. A high speed internal optical link minimizes the propagation delays between he micro controller and the IGBT while allowing the two systems to operate at very large common mode voltage differences that are common in industrial motor drives and other power switching applications. An output IC provides local protection for the IGBT to prevent damage during over current, and a second opticalink provides a fully isolated fault status feedback signal for the micro controller. A built in “watchdog” circuit, UVLO monitors the power stage supply voltage to prevent IGBT caused by insufficient gate drive voltages. This integrated IGBT gate driver is designed to increase the performance and reliabi ity of a motor drive without the cost, size, and complexity of a discrete design.

在同一封装SOP16 中封装了两个发光二极管和两个集成电路，提供输入控制电路、输出功率级和两个光学通道。输出检测器 IC 采用高压 BiCMOS/功率 DMOS工艺设计制造。如LED1所示，在光信号的正向传输路径传输门极控制信号。如LED2所示，在光信号的反馈传输路径传输故障状态的反馈信号。
Two light emitting diodes and two integrated circuits housed in the same SOP16 package provide the input control circuitry, the output power stage, and two optical channels. The output Detector IC is designed manufactured on a high voltage BiCMOS/Power DMOS process. The forward optical signal path, as indicated by LED1, transmits the gate control signal. The return optical signal path, as indicated by LED2, transmits the fault status feedback signal.

在正常操作下，LED1 通过隔离输出检测器 IC 直接控制 IGBT 门极， LED2 保持关闭。当检测到 IGBT 故障时， 输出检测器 IC 立即开始 “软” 关断， 以可控的方式将 IGBT 电流降低至零， 以避免感应的高压对 IGBT 产生潜在损坏。同时，该故障状态 通过LED2传输回输入端， 故障闩锁使得门极控制输入信号失效， 自动输出低电平故障信号向微控制器发出警报。Under normal operation, the LED1 directly controls the IGBT gate through the isolated output Detector IC, and LED2 remains off. When an IGBT fault is detected, the output detector IC immediately begins a “soft” shutdown sequence, reducing the IGBT current to zero in a controlled manner to avoid potential IGBT damage from inductive over voltages. Simultaneously, this fault status is transmitted back to the input via LED2, where the fault latch disables the gate control input and the active low fault output alerts the microcontroller.

上电期间， 通过强制 AT331J 输出低电平信号， 欠压锁定(UVLO)功能可防止 IGBT 栅极电压不足的现象。一旦输出处于高 电平状态，AT331J 的 DESAT (VCE)检测功能就会提供 IGBT 保护。因此，UVLO 和 DESAT 协同工作， 为 IGBT 提供恒定保 护。During power-up, the Under Voltage Lockout (UVLO) feature prevents the application of insufficient gate voltage to the IGBT, by forcing the AT331J’ s output low. Once the

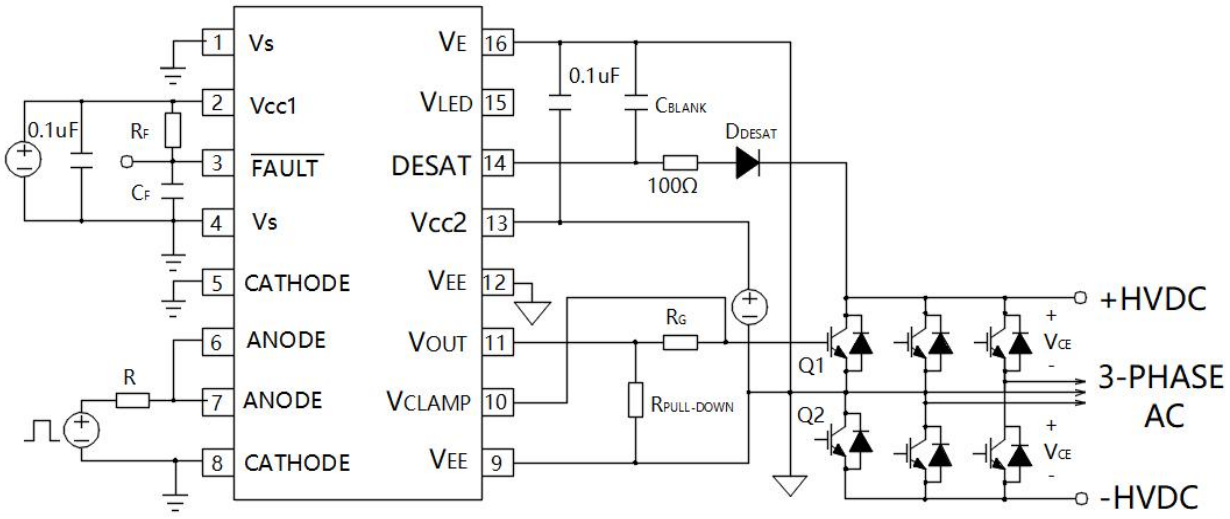
output is in the high state, the DESAT (VCE) detection feature of the AT331JJ provides lGBT protection. Thus, UVLO and DESAT work in conjunction to provide constant lGBT protection.

2、推荐应用电路　Recommended Application Circuit

AT331J 具有一个LED输入栅极控制和一个开路集电极故障输出，适用于“或”逻辑电路应用。图35所示的推荐应用电路显示了使用AT331J的典型栅极驱动电路。下面介绍有关IGBT的驱动。同样，它也适用于MOSFET。根据MOSFET或IGBT栅极阈值要求，设计人员可能需要调整VCC电源电压(对于IGBT， 建议VCC = 17.5V，对于MOSFET，建议VCC = 12.5V)。The AT331J has an LED input gate control, and an open collector fault output suitable for wired ‘OR’ applications. The recommended application circuit shown in Fig35illustrates a typical gate drive implementation using the AT331J. The following describes about driving IGBT. However, it is also applicable to MOSFET. Depending upon the MOSFET or IGBT gate threshold requirements, designers may want to adjust the VCC supply voltage (Recommended VCC=17.5V for IGBT and 12.5V for MOSFET).

两个电源旁路电容(0.1μF)在开关瞬态提供瞬态大电流。由于充电电流的瞬态特性，一个小功率电流(5mA)电源就足够了。 快速恢复型去饱和二极管 DDESAT （600V/ 1200V）、trr 低于75ns(如 ERA34-10)和电容CBLANK是故障检测电路的必要外部部件。栅极电阻 RG 用于限制栅极充电电流，并控制 IGBT 集电极电压的上升和下降时间。开路集电极故障输出端有一个无 源上拉电阻 RF (2.1kΩ)和一个1000pF 的滤波电容CF，VOUT输出端的47kΩ下拉电阻RPULL-DOWN，可提供一个可预测的高电平输出电压(VOH)。在这种应用中，当检测到故障并在IGBT的下一个开通信号将故障复位时，IGBT门驱动器将关断。The two supp y bypass capacitors (0.1μF) provide the arge transient currents necessary during a switching transition. Because of the transient nature of the charging currents, a low current (5mA) power supply suffices. The desaturation diode DDESAT 600V/1200V fast recovery type, trr below 75ns (e.g. ERA34-10) and capacitor CBLANK are necessary external components for the fault detection circuitry. The gate resistor RG serves to limit gate charge current and cont ro s the IGBT collector voltage rise and fall times. The open collector fault output has a passive pul -up resistor RF (2.1kΩ) and a 1000pF filtering capacitor, CF. A 47kΩ pull down resistor RPULL-DOWN on VOUT provides a predictable high level output voltage (VOH). In this application, the IGBT gate driver will shutdown when a fault is detected and fault reset by next cycle of IGBT turn on.

Fig35. Recommended application circuit (Single Supply)
with desaturation detection and active Miller Clamp



◆ 操作描述 Description of Operation

1、正常操作 Normal Operation

正常工作期间，AT331J 的 VOUT由输入LED电流 IF(引脚 5、6、7 和8)控制，IGBT集电极-发射极电压通过DESAT监控。FAULT端输出高电平。参见图 36。During normal operation, VOUT of the AT331J is controlled by input LED current IF (pins 5, 6, 7 and 8), with the IGBT collector-to-emitter voltage being monitored through DESAT. The FAULT output is high. See Fig 36.

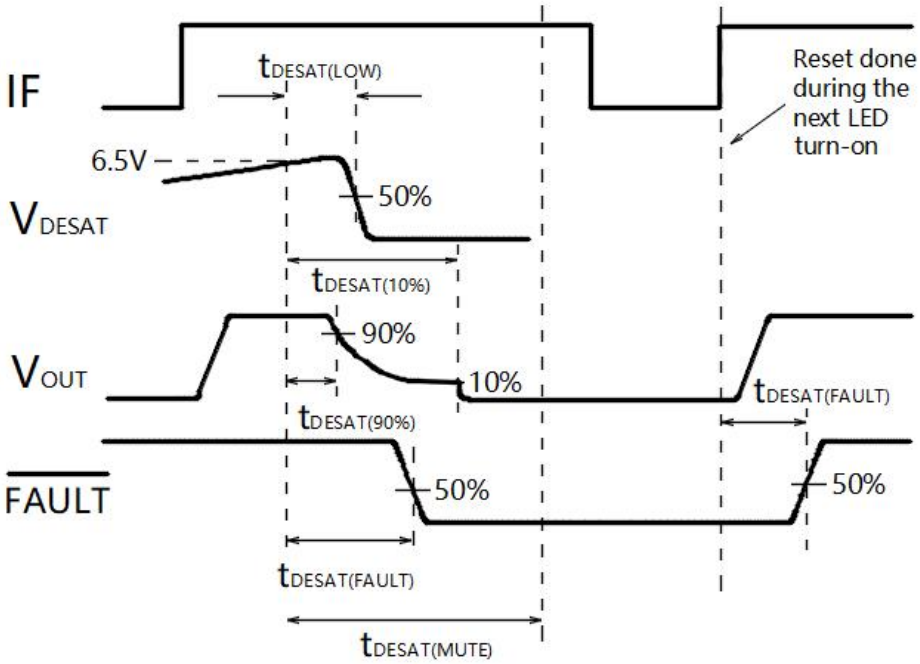
2、故障条件 Fault Condition

DESAT 引脚监控IGBT的Vce压降。当IGBT开启时，DESAT引脚上的电压超过6.5V，VOUT缓慢降低，以实现“软”关断，防止出现过高的di/dt和感应电压。同时激活的还有一个内部反馈通道，当满足报警条件时FAULT端输出低电平，向微控制器报警。The DESAT pin monitors the IGBT Vce voltage. When the voltage on the DESAT pin exceeds 6.5V while the IGBT is on, VOUT is slowly brought low in order to “softly” turn-off the IGBT and prevent large di/dt induced voltages. Also activated is an internal feedback channel which brings the FAULT output low for the purpose of notifying the micro- controller of the fault condition.

3、故障复位 Fault Reset

一旦检测到故障， 输出将在5μs最小值）内衰减。在衰减期间，LED 所有输入信号都将被忽略，让驱动电路完全软关断IGBT。故障状态将在5us最小）衰减时间后的下一次LED开启时复位。见图 36。Once fault is detected, the output will be muted for 5μs (minimum). All input LED signals will be ignored during the mute period to allow the driver to completely soft shut-down the IGBT. The fault mechanism can be reset by the next LED turn-on after the 5us (minimum) mute time. See Fig 36.

Fig 36. Fault Timing diagram



4、输出控制 Output Control

AT331J 的输出部分(VOUT 和 FAULT)由 IF、UVLO 和一个检测到的 IGBT Desat条件组合控制。一旦 UVLO 保护没有激活 (VCC2 - VE > VUVLO)，VOUT 就会被允许输出高电平，AT331J 的 DESAT 检测功能将成为 IGBT 保护的主要手段。一旦 VCC2 从 0V 增加到 VUVLO+ 以上，DESAT 将继续发挥作用，直到 VCC2 < VUVLO-。因此，AT331J 的 DESAT (Pin 14)检测和 UVLO 功能同时工作以确保恒定的IGBT保护。

The outputs (VOUT and FAULT) of the AT331J are controlled by the combination of IF, UVLO and a detected IGBT Desat condition. Once UVLO is not active (VCC2 - VE > VUVLO), VOUT is allowed to go high, and the DESAT (Pin14) detection feature of the AT331J will be the primary source of IGBT protection. Once VCC2 is increased from 0V to above VUVLO+, DESAT will remain functional until VCC2 is decreased below VUVLO- . Thus, the DESAT detection and UVLO features of the AT331J work in conjunction to ensure constant IGBT protection.

IF	UVLO(VCC2-VE)	DESAT 检测状态 DESAT Function	故障输出 FAULT Output	VOUT
导通 ON	有效 Active	无效 Not Active	高 High	低 Low
导通 ON	无效 Not Active	有效(有 DESAT 故障) Active (with DESAT fault)	低(故障) Low (FAULT)	低 Low
导通 ON	无效 Not Active	有效(无 DESAT 故障) Active (no DESAT fault)	高(或无故障) High (or no fault)	高 High
关断 OFF	有效 Active	无效 Not Active	高 High	低 Low
关断 OFF	无效 Not Active	无效 Not Active	高 High	低 Low

5、去饱和检测和大电流保护 Desaturation Detection and High Current Protection

AT331J 满足了将高速、大电流输出驱动器、输入和输出之间的高压光隔离、IGBT饱和检测、关断以及一个光隔离的故障状态信号反馈集成到一个16引脚封装中的标准。The AT331J satisfies these criteria by combining a high speed, high output current driver, high voltage optical isolation between the input and output, local IGBT desaturation detection and shutdown, and an optically isolated fault status feedback signal into a single 16-pin surface mount package.

AT331J 中采用的故障检测方法是通过监测IGBT的饱和 （集电极）电压，并在集电极电压超过预定阈值时触发局部故障停机而实现的。小栅极放电装置缓慢降低由IGBT短路引起的大电流，防止产生破坏性尖峰电压。在能耗达到破坏性水平之前，将IGBT关断。在IGBT关断状态期间，故障检测电路失效，以防止产生虚假的“故障”信号。The fault detection method, which is adopted in the AT331J, is to monitor the saturation (collector) voltage of the IGBT and to trigger a local fault shutdown sequence if the collector voltage exceeds a predetermined threshold. A small gate discharge device s owly reduces the high short circuit IGBT current to prevent damaging voltage spikes. Before the dissipated energy can reach destructive levels, the IGBT is shut off. During the off state of the IGBT, the fault detect circuitry is simply disabled to prevent false ‘fault’ signals.

如果功率器件的短路能力已知，有效的替代保护方案是测量IGBT电流以防止去饱和，但是如果栅极驱动电压降低到仅能将IGBT部分接通，则该方法将失败。通过直接测量集电极电压，AT331J 即使在栅极驱动电压不足的情况下也能限制IGBT 的功耗。去饱和检测方法的另一个更巧妙的优势是监控IGBT的功耗， 采用电流感测法，预设一个电流阈值来预测 安全工作的范围。因此，不需要过于保守的过电流阈值来保护IGBT。

The alternative protection scheme of measuring IGBT current to prevent desaturation is effective if the short circuit capability of the power device is known, but this method will fail if the gate drive voltage decreases enough to only partially turn on the IGBT. By directly measuring the collector voltage, the AT331J limits the power dissipation in the IGBT even with insufficient gate drive voltage. Another more subtle advantage of the desaturation detection method is that power dissipation in the IGBT is monitored, while the current sense method relies on a preset current threshold to predict the safe limit of operation. Therefore, an overly conservative over current threshold is not needed to protect the IGBT.

6、故障情况下 IGBT 门放电缓慢 Slow IGBT Gate Discharge during Fault Condition

当检测到去饱和故障时， AT331J 输出驱动极中弱下拉器件将导通， 以促使IGBT “软” 关断。该器件使 IGBT 栅极缓慢放电，以防止漏电流的快速变化，这种变化会因引线电感而产生破坏性的尖峰电压。在缓慢关断期间， 大型输出下拉器件保持关断，直到输出电压降至VEE+2V以下，此时大型下拉器件将IGBT栅极钳位至 VEE。

When a desaturation fault is detected, a weak pull-down device in the AT331J output drive stage will turn on to ‘softly’ turn off the IGBT. This device slowly discharges the IGBT gate to prevent fast changes in drain current that could cause damaging voltage spikes due to lead and wire inductance. During the slow turn off, the large output pull-down device remains off until the output voltage falls below VEE + 2 Volts, at which time the large pull down device clamps the IGBT gate to VEE.

7、DESAT 故障检测消隐时间 DESAT Fault Detection Blanking Time

IGBT开启后，DESAT故障检测电路必须保持失效一段时间，以使集电极电压降至 DESAT阈值以下。这段时间称为 DESAT消隐时间，由内部DESAT充电电流、DESAT电压阈值和外部DESAT电容控制。

The DESAT fault detection circuitry must remain disabled for a short time period following the turn-on of the IGBT to allow the collector voltage to fall below the DESAT threshold. This time period, called the DESAT blanking time is controlled by the internal DESAT charge current, the DESAT voltage threshold, and the external DESAT capacitor.

理论上消隐时间根据外部电容(CBLANK)、故障阈值电压(VDESAT)和DESAT充电电流(ICHG)计算得出，即 tBLANK = CBLANK x VDESAT / ICHG。推荐的 00pF电容的理论消隐时间为100pF * 6.5V/240μA=2.7μsec。The nominal blanking time is calculated in terms of external capacitance (CBLANK), FAULT threshold voltage (VDESAT), and DESAT charge current (ICHG) as tBLANK=CBLANK x VDESAT / ICHG. The nominal blanking time with the recommended 100pF capacitor is 100pF * 6.5 V / 240μA = 2.7μsec.

可以稍微调整电容值来调整消隐时间，但不建议使用小于100pF 的电容。理论消隐时间代表 AT331J 响应DESAT故障状态所需的最长时间。如果IGBT开启的同时，集电极和发射极之间与供电电源短路(切换为短路)， 则软关断措施将在大约3μs后启动。如果IGBT开启之后，集电极和发射极之间与供电电源短路(切换为短路)，由于DESAT二极管的寄生并联电容，响应时间会大大加快。推荐的100pF电容会提供足够的消隐以适应大多数应用的故障响应时间。The capacitance value can be scaled slightly to adjust the blanking time, though a value smaller than 100pF is not recommended. This nominal blanking time represents the longest time it will take for the AT331J to respond to a DESAT fault condition. If the IGBT is turned on w hi e the collector and emitter are shorted to the supply rails (switching into a short), the soft shut-down sequence will begin after approximately 3μsec. If the IGBT collector and emitter are shorted to the supply rails after the IGBT is already on, the response time will be much quicker due to the parasitic parallel capacitance of the DESAT diode. The recommended 100pF capacitor should provide adequate blanking as well as fault response times for most applications.

8、欠压闭锁 Under Voltage Lockout

AT331J欠压闭锁(UVLO)功能旨在防止在通电期间通过强制AT331J输出电压过低而对IGBT施加足够的栅极电压。IGBTs 通常需要15V的栅极电压来获得其额定的VCE(导通)电压。通常在栅极电压低于13V时，VCE(导通)电压急剧增加，尤其是在较高的电流下。在栅极电压非常低(低于10V)时，IGBT可能会工作在线性区域，并迅速过热。只要施加的工作电源(VCC2) 不足，UVLO功能就会导致输出端被钳位。一旦 VCC2超过VUVLO+ (正向UVLO 阈值)，UVLO钳位就会被释放，允许器件输出响应输入信号打开。当 VCC2 从 0V(低于 VUVLO+) 开始升高，DESAT保护电路首先激活 。 随着VCC2 进一步增加(高于VUVLO+)，UVLO 钳位被释放。在UVLO 钳位被释放之前，DESAT保护已经激活。因此，无论电源电压(VCC2)如何，UVLO 和 DESAT故障检测都可以协同工作，提供全面保护。

The AT331J Under Voltage Lockout (UVLO) feature is designed to prevent the application of insufficient gate voltage to the IGBT by forcing the AT331J output low during power-up. IGBTs typically require gate voltages of 15V to achieve their rated VCE(ON) voltage. At gate voltages below 13V typically, the VCE(ON) voltage increases dramatically, especially at higher currents. At very low gate voltages (below 10V), the IGBT may operate in the linear region and quickly overheat. The UVLO function causes the output to be clamped whenever insufficient operating supply (VCC2) is applied. Once VCC2 exceeds VUVLO+ (the positive-going UVLO thresho d), the UVLO c lamp is released to allow the device output to turn on in response to input signals. As VCC2 is increased from 0V (at some level below VUVLO+), first the DESAT protection circuitry becomes active. As VCC2 is further increased (above VUVLO+), the UVLO c lamp is released. Before the time the UVLO c lamp is released, the DESAT protection is a ready active. Therefore, the UVLO and DESAT Fault detection feature work together to provide seamless protection regardless of supply voltage (VCC2).

9、有源米勒钳位 Active Miller Clamp

米勒钳位允许在高 dV/dt 情况下控制米勒电流，并且在大多数应用中可以取消负电源电压。关断期间，监控栅极电压，当栅极电压低于2V(相对于VEE)时，钳位输出激活。对于高达1100mA的米勒电流，钳位电压典型值为VOL+2.5V。当再次触发LED 入时，钳位失效。A Miller clamp allows the control of the Miller current during a high dV/dt situation and can eliminate the use of a negative supply voltage in most of the applications. During turn-off, the gate voltage is monitored and the clamp output is activated when gate voltage goes below 2V (relative to VEE). The c amp voltage is VOL+2.5V typ for a Miller current up to 1100mA. The clamp is disabled when the LED input is triggered again.

◆ 其他推荐组件 Other Recommended Components

图 35 中的应用电路中一个输出下拉电阻、一个 DESAT端保护电阻、一个 FAULT端电容、一个FAULT 端上拉电阻和有源米勒钳位相连接。

The application circuit in Fig 35 includes an output pull-down resistor, a DESAT pin protection resistor, a FAULT pin capacitor, and a FAULT pin pullup resistor and Active Miller Clamp connection.

Figure 37. Output pull-down resistor

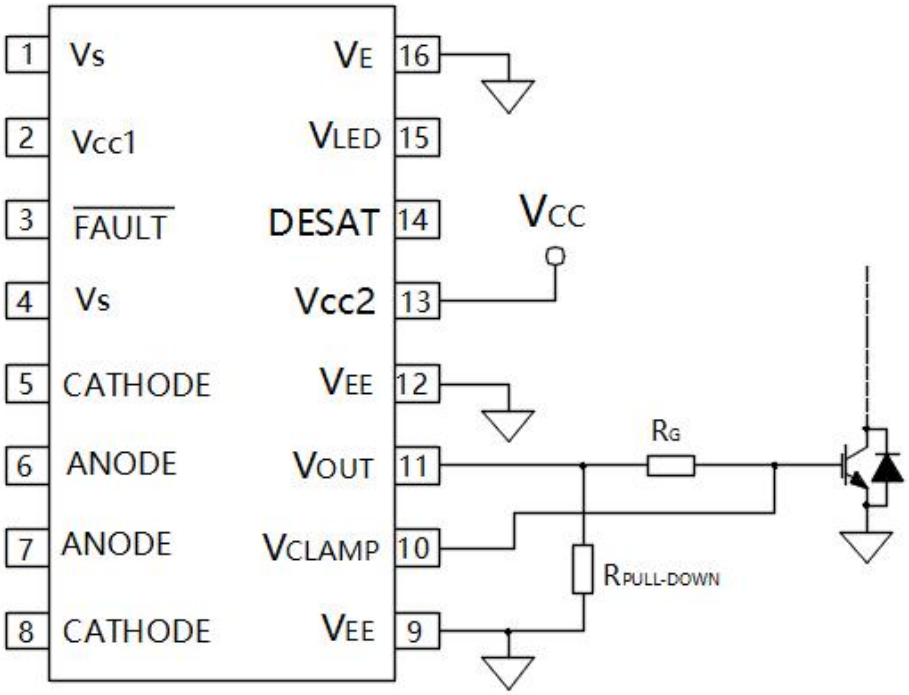
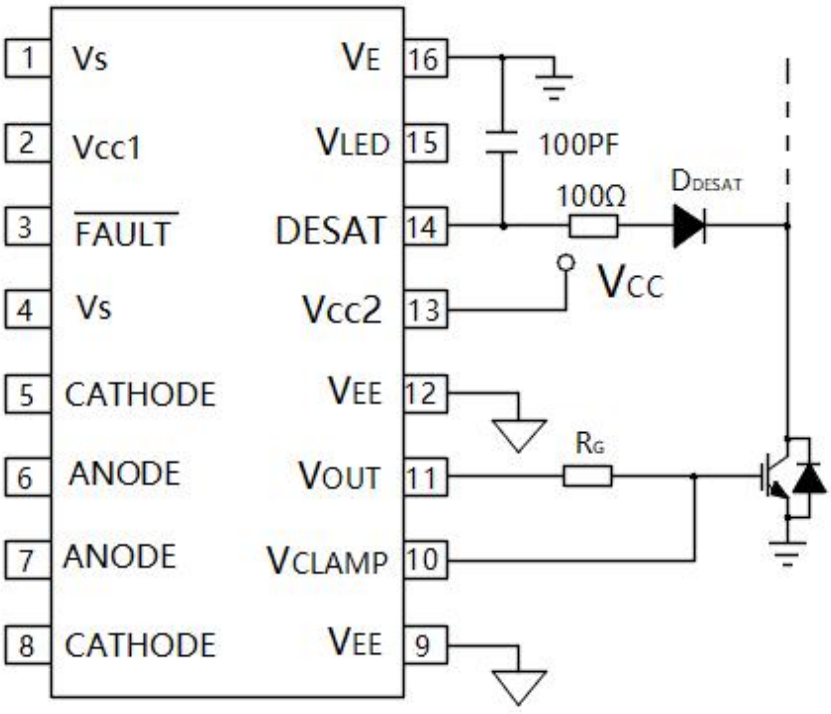


Figure 38. DESAT pin protection



1、输出下拉电阻 Output Pull-Down Resistor

在输出为高电平的转换期间，输出电压迅速上升至 VCC2，并保持在3个二极管压降以内。如果输出电流因容性负载而降至零，输出电压将在几微秒内从大约VCC2-3(VBE)缓慢上升至VCC2。为了将输出电压限制在 VCC2-3(VBE)，建议在输出端与VEE之间接一个下拉电阻 RPULL-DOWN，以便在输出为高电平时产生几个650μA 的灌电流。下拉电阻值取决于正向电源的值，可以根据公式 Rpull-down =[VCC2-3 *(VBE)]/650μA 进行调整。

During the output high transition, the output voltage rapidly rises to within 3 diode drops of VCC2 . If the output current then drops to zero due to a capacitive load, the output voltage will slowly rise from roughly VCC2-3(VBE) to VCC2 within a period of several microseconds. To limit the output voltage to VCC2-3(VBE), a pu l-down resistor, RPULL- DOWN between the output and VEE is recommended to sink a static current of several 650μA w hi e the output is high. Pu l-down resistor values are dependent on the amount of positive supply and can be adjusted according to the formula, Rpull-down = [VCC2-3 * (VBE)] / 650μA.

2、DESAT 引脚保护电阻 DESAT Pin Protection Resistor

与 IGBTs 连接的续流二极管会产生大大超过二极管正向电压理论值的瞬态正向电压值。这可能会导致 DESAT 引脚上产生 较大的反向尖峰电压，如果不采取保护措施的话，将会从驱动器中转移大量电流。为了将此电流限制在不会损坏驱动器IC的水平，需要插入一个100 欧姆的电阻与DESAT二极管串联。这个新增的电阻不会改变DESAT阈值或DESAT消隐时间。

The freewheeling of fly back diodes connected across the IGBTs can have large instantaneous forward voltage transients which greatly exceed the nominal forward voltage of the diode. This may result in a large negative voltage spike on the DESAT pin which will draw substantial current out of the driver if protection is not used. To limit this current to levels that will not damage the driver IC, a 100 ohm resistor should be inserted in series with the DESAT diode. The added resistance will not alter the DESAT threshold or the DESAT blanking time.

3、高 CMR 故障引脚上的电容 Capacitor on FAULT Pin for High CMR

当故障输出处于高电平状态时，快速共模瞬变会影响故障引脚电压。FAULT引脚和地之间应连接一个330pF电容，当额定CMR为50kV/μs 时，可获得足够的CMOS噪声容限。

Rapid common mode transients can affect the fault pin voltage while the fault output is in the high state. A 330pF capacitor should be connected between the fault pin and ground to achieve adequate CMOS noise margins at the specified CMR value of 50kV/μs.

4、FAULT 引脚上的上拉电阻 Pull-up Resistor on FAULT Pin

FAULT 引脚是集电极开路输出， 因此需要一个上拉电阻来提供一个高电平信号。此外，故障输出可以通过“或”运算与其他 类型的保护(例如过热、过压、过流)连接在一起，向微控制器报警。

The FAULT pin is an open collector output and therefore requires a pull-up resistor to provide a high-level signal. Also the FAULT output can be wire ‘OR’ ed together with other types of protection (e.g. over-temperature, over- voltage, over-current) to alert the microcontroller.

5、其他可能的应用电路(输出级) Other Possible Application Circuit (Output Stage)

图.39 具有负栅极驱动、外部升压器和去饱和检测的IGBT驱动 (VClamp 端不使用时，需要与VEE连接) VClamp 作为栅极的二 级放电路径。*表示负栅极驱动拓扑结构所必须的组成部分

Fig 39. IGBT drive with negative gate drive, external booster and desaturation detection (VClamp should be connected to VEE when it is not used) VClamp is used as secondary gate discharge path. * indicates component required for negative gate drive topology.

Fig.39

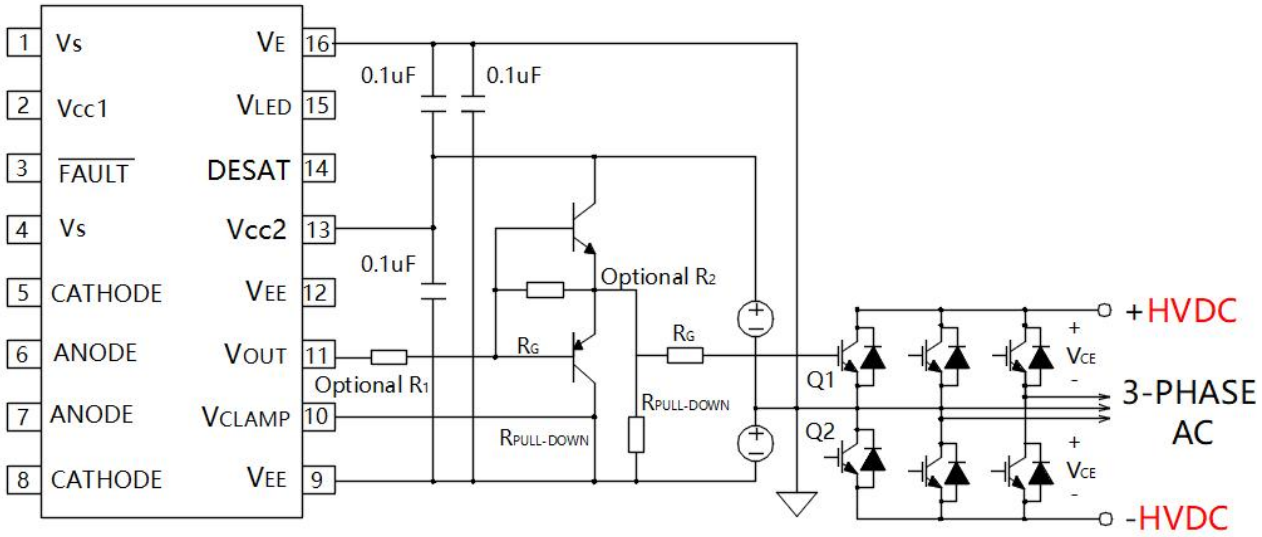
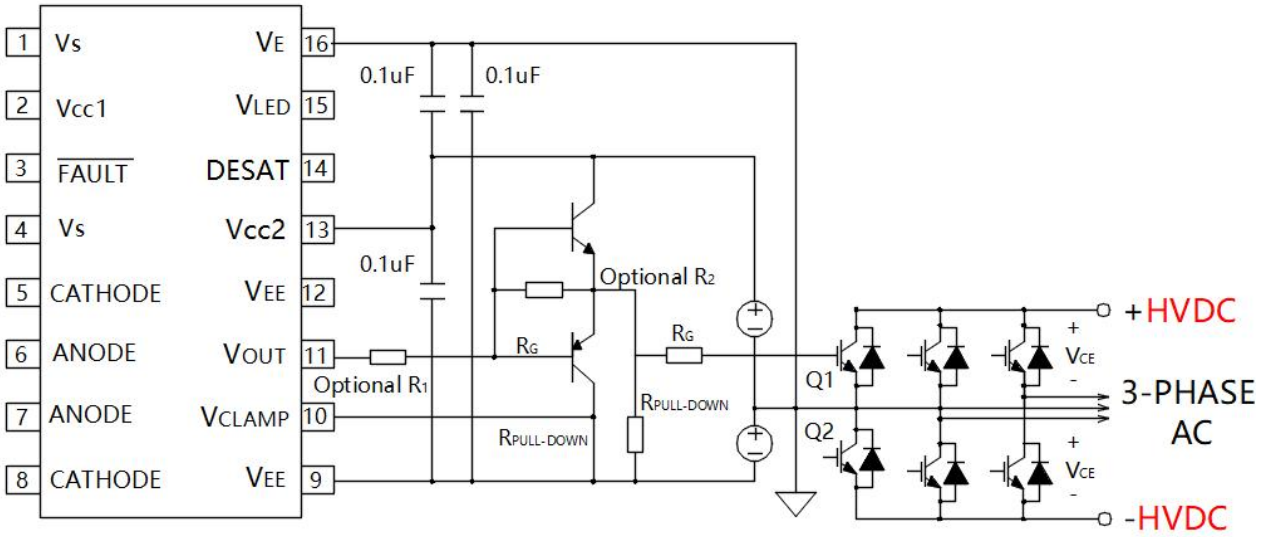


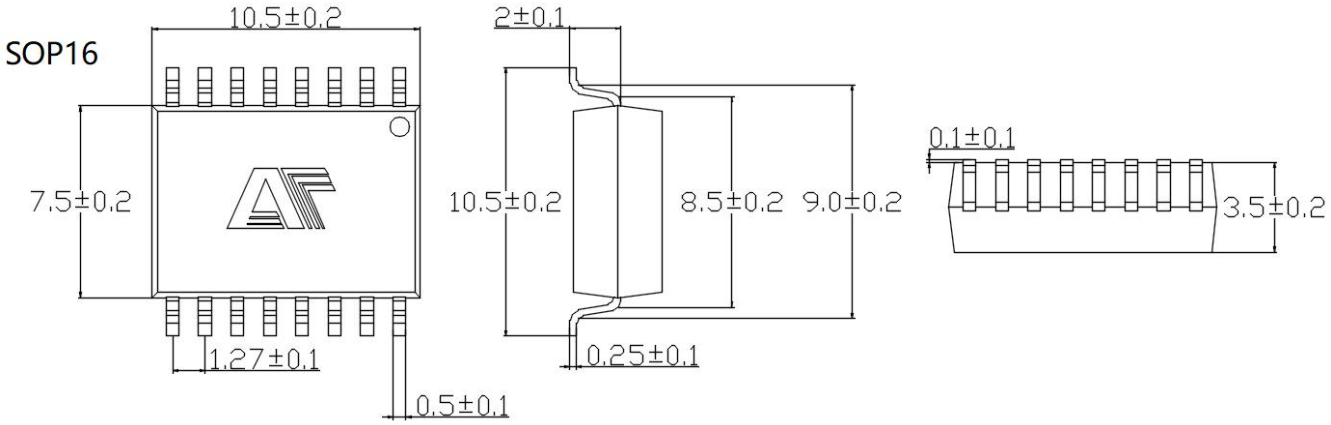
图.40 具有负栅极驱动， 外部增压器的大型IGBT驱动。用于更高功率应用的 VCLAMP 控制二级放电路径

Fig 40. Large IGBT drive with negative gate drive, external booster. VCLAMP control secondary discharge path for higher power application

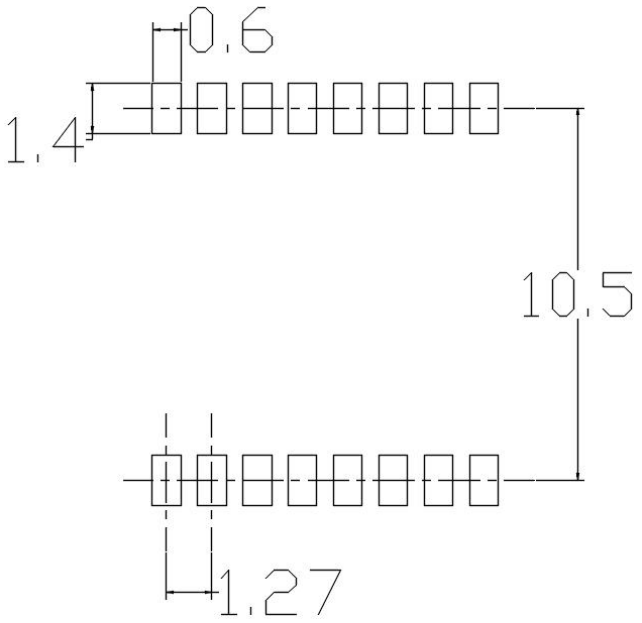
Fig.40



◆ 外形尺寸Overall dimension



推荐焊盘：
Recommended



单位：mm

◆ 产品型号命名规则 Order code

AT 331J - UN Y - W (V) (ZZ)

① ② ③ ④ ⑤ ⑥ ⑦

① 公司代码 Company Code (AT: 奥特 Aote)
② 产品系列 Product Series (331J)
③ 框架类型 Lead Frame (Cu: 铜框架 Copper,Fe: 铁框架 Ferrum)
④ 树脂类型 Epoxy Type (H: 无卤 Halogen-free)
⑤ 封装形式 Package (D:DIP, S:SMD)
⑥ 器件工作温度范围 Device Operating Temperature Range (特殊范围需填或者空白 Special Range need to be filled in or left blank)
⑦ 内部补充代码 Internal Supplementary Code (数字或者空白 Number or None)

◆ 印字信息 Marking Information

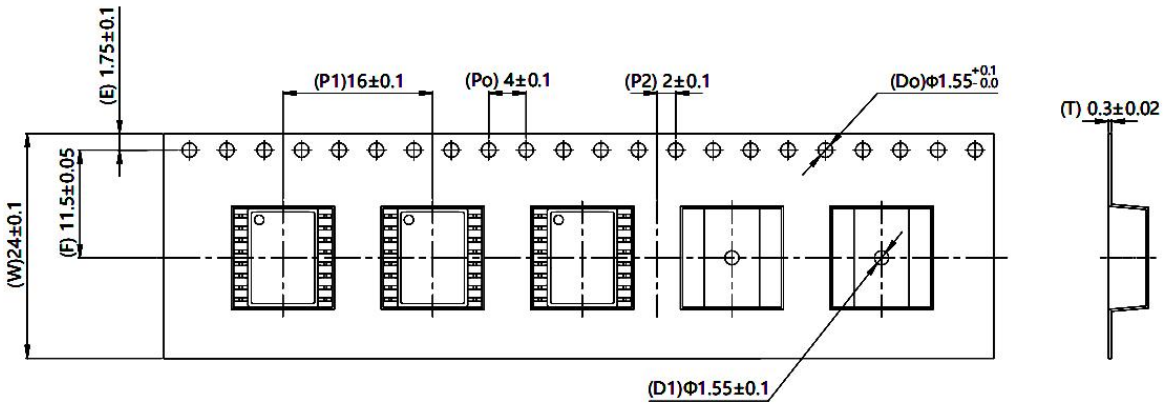
- 印字中“ ”为奥特品牌LOGO
  “ ”denotes LOGO
- 印字中“Y”代表年份; A(2018),B(2019),C(2020) ... ...
  “Y”denotes YEAR: A(2018), B(2019), C(2020) ... ...
- 印字中“WW”代表周号
  “WW”denotes Week’s number
- 印字中“ E”代表内部代码
  “E”denotes Internal code
- 印字中的“H”代表无卤
  “H”denotes Halogen-free

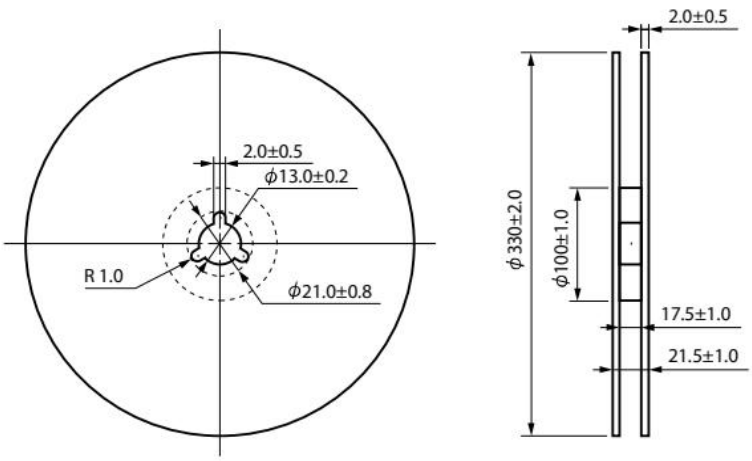
◆ 包装packing

封装形式	包装方式	盘数量	盒数量	箱数量	静电袋规格	盒规格	箱(双瓦楞)规　格	备注
SOP16	Reel (ϕ330mm 蓝盘)	850 只/盘	2　盘/盒	8 盒/箱	450*390*0.1mm	340*340*75 mm	650*375*365mm	首端空 50 个空格, 末端空 100 个空格
Package Type	Packing Form	Quantity per Reel	Quantity per Box	Quantity per Carton	Antistatic Bag Specification	Box Specification	Carton Specification	Note
SOP16	Reel (ϕ330mm Blue)	850 pcs/reel	2 reels/box	8 boxes/ctn	450*390*0.1mm	340*340*75 mm	650*375*365mm	Leave 50 Spaces at the beginning and 100 Spaces at the end

• 编带包装 Tape & Reel

1) 每卷数量：850 只；Qty/reel：850 pcs；
2) 每箱数量：13600 只；Qty/ctn：13600 pcs；
3) 内包装：每盒 2 盘；Inner packing：2 reels/box；
4) 示意图 Schematic:



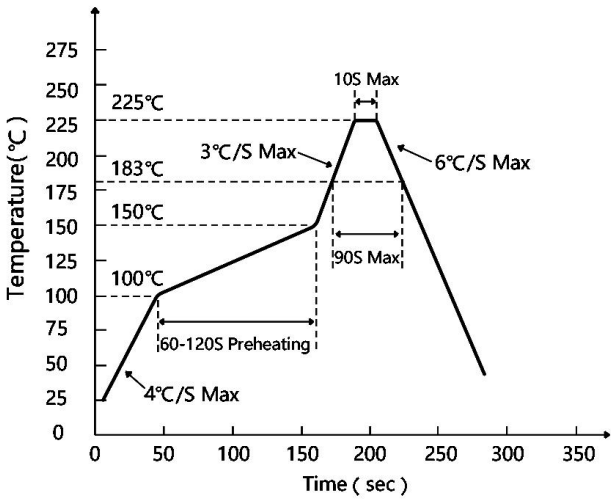


单位：mm

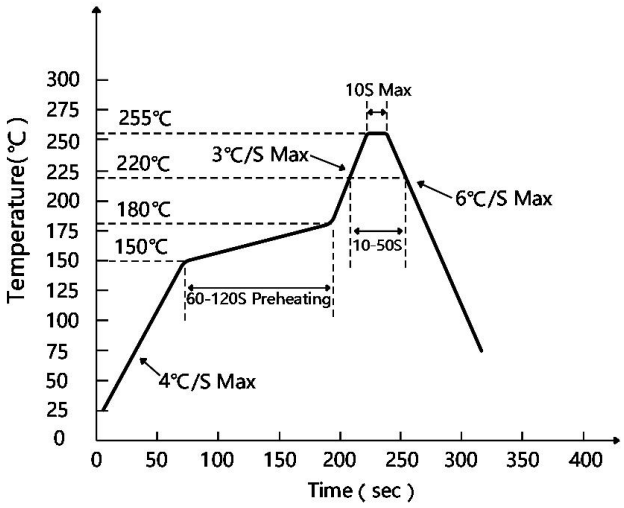
◆ 可靠性测试 Reliability Test Items And Conditions

实验项目 Test Items	参考标准 Reference	实验条件 Test Conditions	时间 Time	样品数 Quantity	判据 Criterion
可焊性 Solderability	JESD22-B102	Tsol=（245±5）℃, t=5s;	1 次1 times	22	0/22
耐焊接热 Resistance to Soldering Heat	JESD22-A106	Tsol=（260±5）℃, t=10s	3 次3 times	22	0/22
静电放电 ESD-HBM	JESD22-A114	Ta=25℃, HBM (2000V)	正反各 3 次 P&N 3 times	10	0/10
高温贮存 High emperature Storage	JESD22-A103	Ta=125℃	1000h	22	0/22
低温贮存 Low Temperature Storage	JESD22-A119	Ta= -55℃	1000h	22	0/22
冷热冲击 Thermal Shock	JESD22-A104	-55℃(15min)←→ 125℃(15min)	循环 300 次 300 cycles	22	0/22
常温寿命试验 Lifespan Test	JESD22-A108	Ta=25℃, IF=50mA ， Vcc=5V	1000h	22	0/22
高温寿命试验 DC Operating Life	JESD22-A108	Ta=110℃, IF=20mA ， Vcc=5V	1000h	76	0/76
高温高湿偏压 High Temperature High Humidity bias Voltage	JESD22-A101	Ta =85℃ , RH=85% IF=0mA ， VCE=64V	1000h	22	0/22
高温偏压 High Temperature bias Voltage	JESD22-A108	Ta =110℃ , IF=0mA ， VCE=80V	1000h	22	0/22
高压蒸汽试验 High pressure steam test	JESD22-A102	P=15PSIG ， 121℃, 100%RH	96h	22	0/22

◆ 回流焊温度曲线图 Solder Reflow Profile

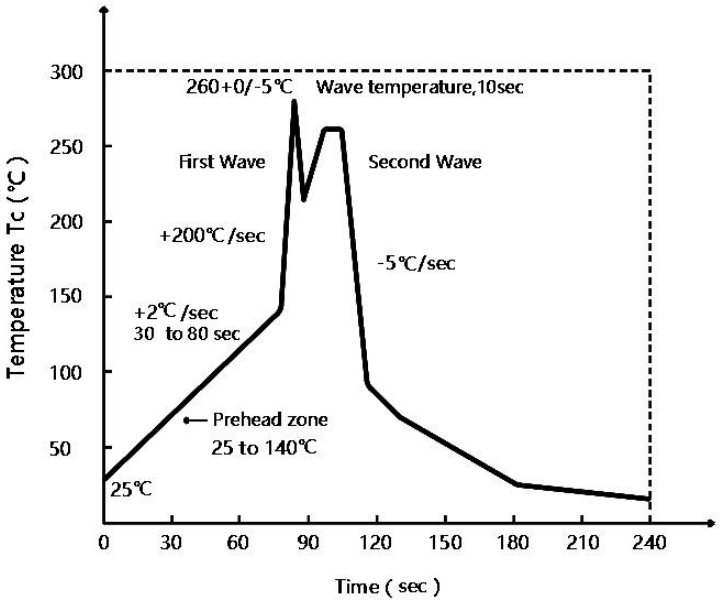


有铅制程 Lead Process



无铅制程 Lead Process

◆ 波峰焊温度曲线图 Wave Soldering Profile



◆ 手工烙铁焊接 Soldering with hand soldering iron

A. 手工烙铁焊仅用于产品返修或样品测试;

Hand soldering iron is only used for product rework or sample testing;

B. 手工烙铁焊要求: 温度 350℃ ± 5℃, 时间≤3s。

Hand soldering iron requirements: Temperature: 350℃ ± 5℃, within 3s.

◆ 注意 Attention

- 奥特半导体实施动态技术迭代机制，产品规格可能随工艺升级调整，最新技术参数以官网发布版本为准。

AOTE implements dynamic technical updates. Specifications are subject to change. Refer to the official website for the latest version.

- 用户需严格遵循本规格书限定的操作条件，因超范围使用（包括但不限于过载、高温、非兼容电路设计）导致的器件失效，不在质量保证范围内。

Users must strictly adhere to specified conditions. Failures caused by misuse (overload, high temperature, incompatible circuits) are excluded from warranty.

- 医疗设备、工业控制等关键场景应用前，需联系技术支持获取定制化验证方案。

Contact technical support for customized validation in critical applications (medical devices, industrial control).

- 本文档有效期至2025年12月31日，后续更新将通过官网公告推送。

This document is valid until Dec 31, 2025. Updates will be notified on the official website.

- 如需对技术参数或应用方案进行进一步确认，欢迎通过以下渠道获取官方支持：

For further clarification on technical specifications or application solutions, please contact us through official channels: