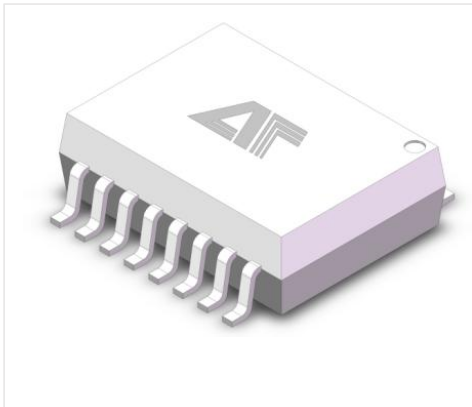




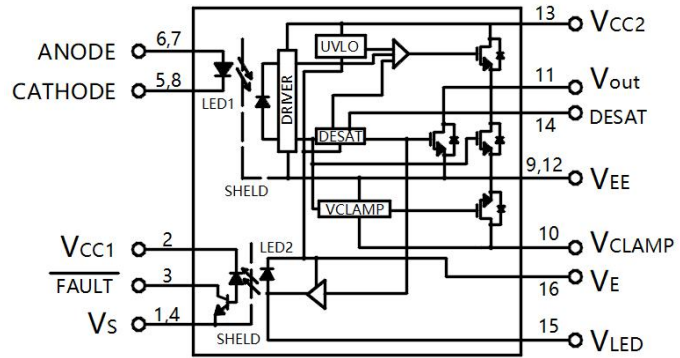
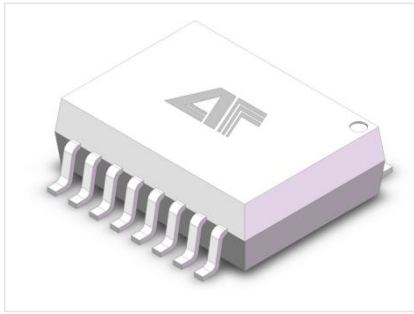
智能栅极驱动光耦
Intelligent gate driven
optocoupler

AT333J

Product Data Sheet

AOTE DCC
RELEASE

SOP16



◆ 封装逻辑原理图 Encapsulation logic schematic

AT333J 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 AT333J 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 $V_{ios}=5000V_{rms}$; Input output isolation voltage: $V_{ios}=5000V_{rms}$
- 50 kV/ μs 最小共模抑制; 50 kV/ μs minimum Common Mode Rejection
- 15V 至 30V 宽工作电压范围; 15V ~ 30V Wide operating VCC Range
- 峰值输出电流 2.5A; peak output current 2.5A
- 输出级可驱动150A 和 1200V 的 IGBTs; The output stage can drive IGBTs with 150A 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电驱动, 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

1	Vs	VE	16
2	Vcc1	VLED	15
3	FAULT	DESAT	14
4	Vs	Vcc2	13
5	CATHODE	VEE	12
6	ANODE	VOUT	11
7	ANODE	VCLAMP	10
8	CATHODE	VEE	9

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	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°C)

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
	瞬态输入峰值电流 (< 1 μs脉冲宽度, 300pps) peak Transient Input current, (<1 μs pulse width, 300pps)	IF(TRAN)	-	1.0	A
	反向输入电压 Reverse Input Voltage	VR	-	5	V
	正向输入电源电压 positive Input supply Voltage	Vcc1	-0.5	7.0	V
	IC 输入功耗 Input IC Power Dissipation	Pin	-	150	mW
输出端 Output	高电平峰值输出电流 "High" Peak Output Current	OH(PEAK)	-	2.5	A
	低电平峰值输出电流 "Low" Peak Output Current	IOL(PEAK)	-	2.5	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
	正输出电源电压 Total Output Supply Voltage	(VCC2 - VEE)	-0.5	30	V
	负输出电源电压 Negative Output Supply Voltage	(VE - VEE)	-0.5	15	V
	总输出电源电压 Total output supply Voltage	(VCC2 - VEE)	-0.5	35	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	-	1.7	A
	米勒钳位引脚电压 Miller Clamping Pin Voltage	VClamp	-0.5	VCC2	V
	DEsAT 电压 DEsAT Voltage	VDEsAT	VE	VE +10	V
	IC 输出功耗 output IC Power Dissipation	Po	-	600	mW
隔离电压 Isolation Voltage		Viso	5000		Vrms
工作温度 Operating Temperature		Topr	-55 ~ +110		°C
存储温度 Storage Temperature		Tstg	-55 ~ +125		°C
焊接温度 Soldering Temperature		Tsol	260		°C

◆ 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	+110	°C
输入电压 (OFF) Input Voltage (OFF)	VF(OFF)	0	0.8	V
输入电流 (ON) 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	V
正输出电源电压 positive Output supply Voltage	(VCC2 - VE)	-0.5	30 - (VE - VEE)	V

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

除非另有说明，典型值测量值在 TA =25°C, 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°C, VCC2 - VEE = 30 V, VE - VEE = 0 V; All Minimum/Maximum specifications are at Recommended Operating Conditions.

参数 Parameter	符号 Symbol	条件 Condition	最小 Min.	典型 Typ.	最大 Max.	单位 Unit	备注 Note
故障逻辑低输出电压 FAULT Logic Low Output Voltage	VFAULTL	IFault=1.1mA, VCC1 = 5.5V	-	0.1	0.4	V	-
		IFault = 1.1mA, VCC1 = 3.3V	-	0.1	0.4	V	-
故障逻辑高输出电流 FAULT Logic High Output Current	IFaultH	VFAULT = 5.5V, VCC1 = 5.5V	-	0.02	0.5	μA	-
		VFAULT = 3.3 V, VCC1 = 3.3V	-	0.002	0.3	μA	-
高电平输出电流 High Level Output Current	IOH	VO = VCC2 - 4	-0.5	-1.5	-	A	2,4,21
		VO = VCC2 -15	-2.0	-	-	A	
低电平输出电流 Low Level Output Current	IOL	VO = VEE + 2.5	0.5	1.5	-	A	3,5,22
		VO = VEE + 15	2.0	-	-	A	
故障条件下低电平输出电流 Low Level Output Current During Fault Condition	IOLF	VOUT - VEE = 14V	90	140	230	mA	-
高电平输出电压 High Level Output Voltage	VOH	IO = -650μA	VCC-0.3	VCC-0.1	-	V	4,6,23
低电平输出电压 Low Level Output Voltage	VOL	IO = 100mA	-	0.17	0.5	V	5,7,24
钳位端阈值电压Clamp pin Threshold Voltage	VtClamp	-	-	-	2.5	V	-
低电平钳位电流 Clamp Low Level sinking Current	ICL	VO = VEE + 2.5	0.5	1.1	-	A	8
高电平电源电流 High Level Supply current	Icc2H	IO = 0mA	-	2.4	4.5	mA	9, 10 25, 26
低电平电源电流 Low Level Supply current	Icc2L	IO = 0mA	-	2.4	4.5	mA	
极间耦合电容充电电流 Blanking capacitor charging current	IcHG	VDESAT = 2V	-0.13	-0.24	-0.33	mA	11, 27
极间耦合电容放电电流 Blanking capacitor Discharge current	IDScHG	VDESAT = 7.0V	10	30	-	mA	28

参数 Parameter	符号 Symbol	条件 Condition	最小 Min.	典型 Typ.	最大 Max.	单位 Unit	备注 Note
DESAT 國值 DESAT Threshold	VDESAT	$V_{cc2} - V_E > V_{UVLO-}$	6	6.5	7.5	V	12
UVLO 國值 UVLO Threshold	VUVLO+	$I_F = 10mA, V_O > 5V$	10.5	11.6	12.5	V	-
	VUVLO-	$I_F = 10mA, V_O < 5V$	9.2	10.3	11.1	V	-
UVLO 迟滞 UVLO Hysteresis	(VUVLO+ - VUVLO-)	-	-	1.3	-	V	-
由低至高的輸入國值電流 Threshold Input current Low to High	IFLH	$I_O = 0mA, V_O > 5V$	-	2.0	5.0	mA	-
由高到低的輸入國值電壓 Threshold Input Voltage High to Low	VFHL	$I_O = 0mA, V_O < 5V$	0.8	-	-	V	-
輸入正向電壓 Input Forward Voltage	VF	$I_F = 10mA$	1.2	1.6	1.95	V	-
正向輸入電壓的溫度係數 Temperature coefficient of Input Forward Voltage	$\Delta VF/\Delta TA$	-	-	-1.3	-	mV/°C	-
反向輸入击穿電壓 Input Reverse Breakdown Voltage	BVR	$I_R = 10A$	5	-	-	V	-
輸入電容 Input capacitance	C-in	$f = 1MHz, V_F = 0V$	-	70	-	pF	-

◆ 开关特性参数 Switch characteristic parameters

除非另有说明, $T_A = 25^{\circ}\text{C}$ 、 $V_{CC2} = 30\text{ V}$ 、 V_{EE} 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 $T_A = 25^{\circ}\text{C}$, $V_{CC2} = 30\text{ V}$, $V_{EE} = \text{Ground}$; All Minimum/Maximum specifications are at Recommended Operating Conditions.

参数 Parameter	符号 Symbol	条件 Condition	最小 Min.	典型 Typ.	最大 Max.	单位 Unit	备注 Note
高电平输出的传输延迟时间 propagation Delay Time to High output Level	tpLH	$R_g = 10\ \Omega$, $C_g = 10\text{ nF}$, $f = 10\text{ KHz}$, Duty Cycle = 50%, $I_F = 10\text{ mA}$, $V_{CC2} = 30\text{ V}$	50	180	250	ns	1,13,14, 15,16,29
低电平输出的传输延迟时间 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输 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 翻转到 V_o 降至 90%之间的 延迟时间 DESAT Sense to 90% V_o Delay	tDESAT (90%)	$C_{DESAT} = 100\text{ pF}$, $R_g = 10\ \Omega$, $C_g = 10\text{ nF}$, $V_{CC2} = 30\text{ V}$	-	0.25	0.5	μs	17,3035
DESAT 翻转到 V_o 降至 10%之间的 延迟时间 DESAT Sense to 10% V_o Delay	tDESAT (10%)		-	2	3	μs	18,1920,3035
DESAT 翻转到低电平故障信号输 出的 延迟时间 DESAT Sense to Low Level FAULT Signal Delay	tDESAT (FAULT)	$C_{DESAT} = 100\text{ pF}$, $R_F = 2.1\text{ K}\Omega$, $C_F = \text{open}$, $R_g = 10\ \Omega$, $C_g = 10\text{ nF}$, $V_{CC2} = 30\text{ V}$	-	0.25	0.5	μs	30,35
DESAT 翻转到 DESAT 低电平传 播 延迟时间 DESAT Sense to DESAT Low propagation Delay	tDESAT (LoW)		-	0.25	-	μs	30,35
DESAT 输入静音时间 DESAT Input Mute	tRESET (MUTE)	-	5	15	-	μs	35
故障信号复位至高电平的延迟时间 RESET to High Level FAULT Signal Delay	tRESET (FAULT)	$C_{DESAT} = 100\text{ pF}$, $R_F = 2.1\text{ K}\Omega$, $R_g = 10\ \Omega$, $C_g = 10\text{ nF}$, $V_{CC1} = 5.5\text{ V}$, $V_{CC2} = 30\text{ V}$	-	1	2.0	μs	-

参数 Parameter	符号 Symbol	条件 Condition	最小 Min.	典型 Typ.	最大 Max.	单位 Unit	备注 Note
高电平输出的共模抑制能力 Output High Level Common Mode Transient Immunity	CMH	TA = 25°C, IF = 10mA VCM = 1500 V, VCC2 = 30 V, RF = 2.1kΩ, CF = 1nF	50	60	-	kV/μs	
低电平输出的共模抑制能力 Output Low Level Common Mode Transient Immunity	CML	TA = 25°C, VF = 0 V VCM = 1500 V, VCC2 = 30 V, RF = 2.1kΩ, CF = 1nF	50	60	-	kV/μs	
UVLO 开启延迟 UVLO turn-on delay	tUVLO ON	IF = 10 mA, VO > 5 V	-	5	-	μs	-
UVLO 关闭延迟 UVLO turn-off delay	tUVLO OFF	IF = 10 mA, VO < 5 V	-	5	-	μs	-

◆ 电性特性曲线Electrical characteristic curve($T_a = 25^\circ\text{C}$)

Fig.1 Vout propagation delay wave forms

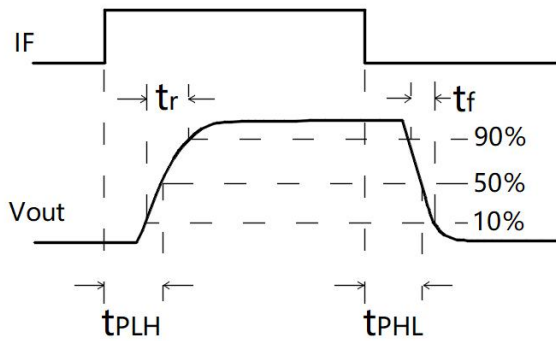


Fig.2 Output High Current vs Ambient Temperature

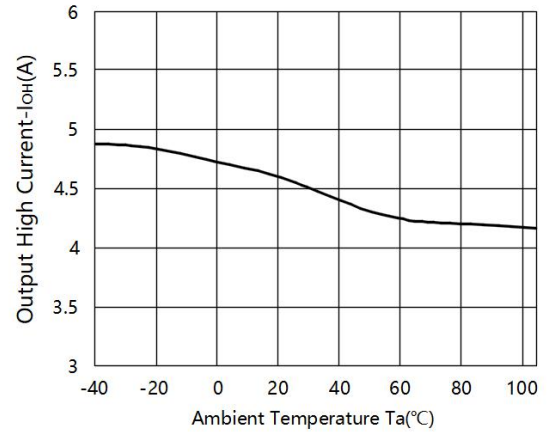


Fig.3 Output Low Current vs Ambient Temperature

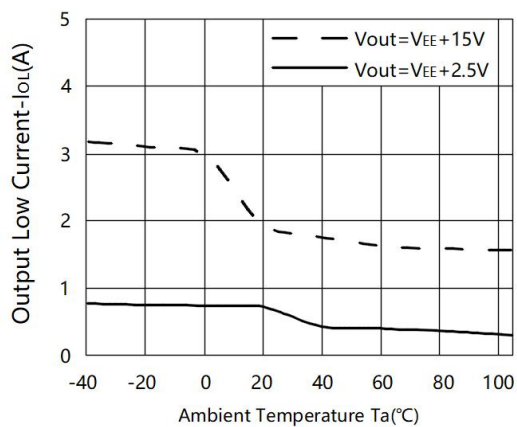


Fig.4 High Output Voltage Drop vs Ambient Temperature

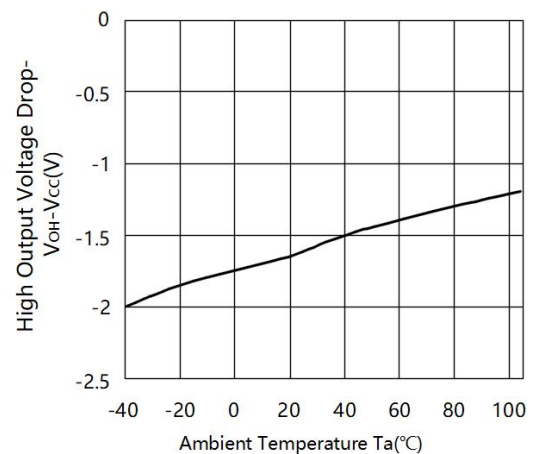


Fig.5 Output Low Voltage vs Ambient Temperature

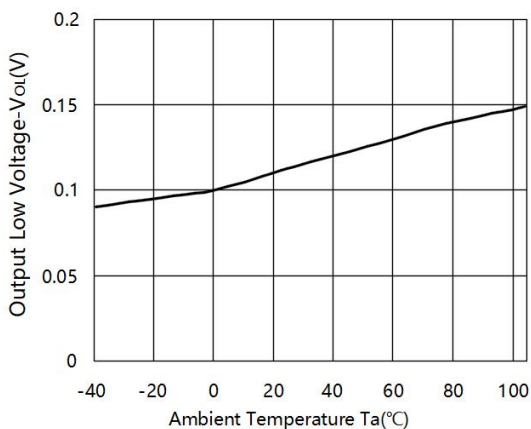


Fig.6 High Output Voltage vs Output High Current

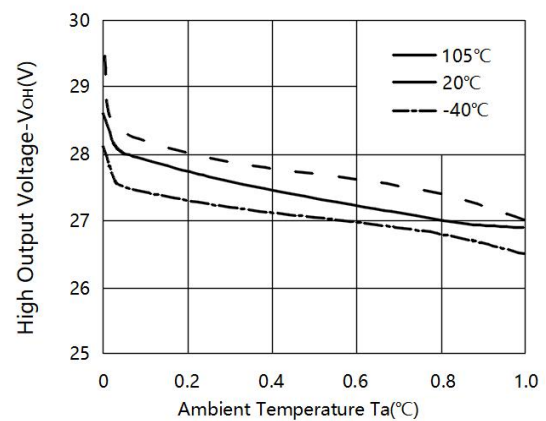


Fig.7 Low Output Voltage vs Output Low Current

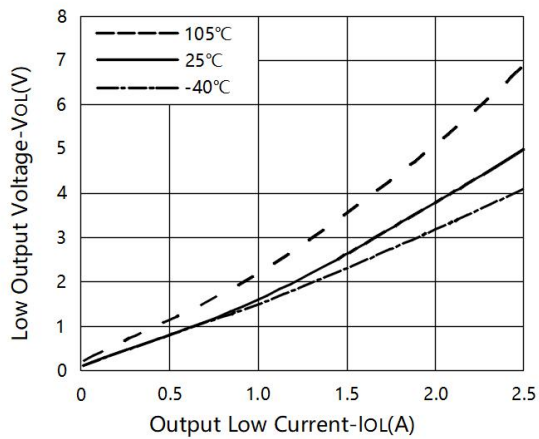


Fig.8 Clamp Low Level Sinking Current vs Ambient Temperature

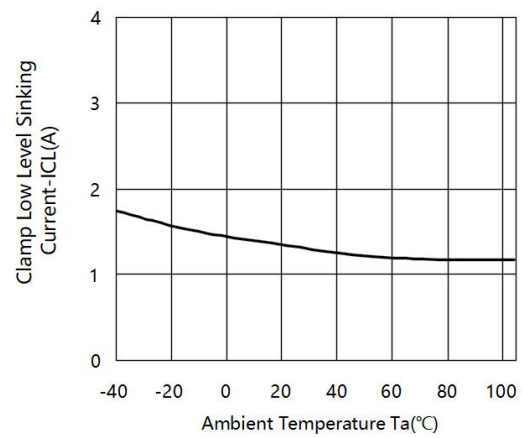


Fig.9 Output Supply Current vs Ambient Temperature

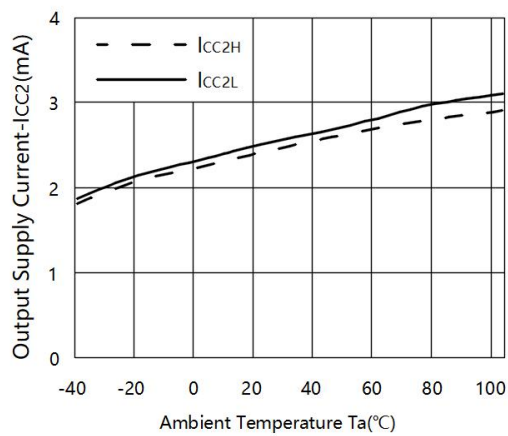


Fig.10 Output Supply Current vs Output Supply Voltage

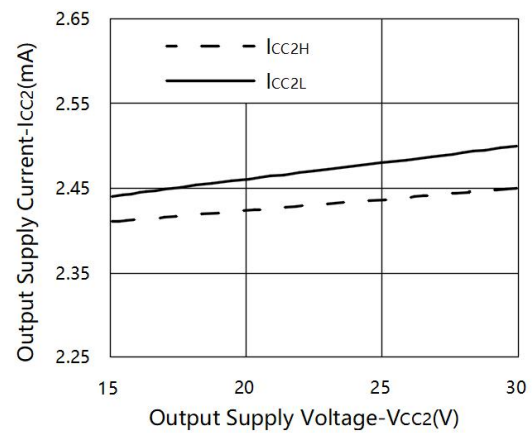


Fig.11 Blanking Capacitor Charging Current vs. Ambient Temperature

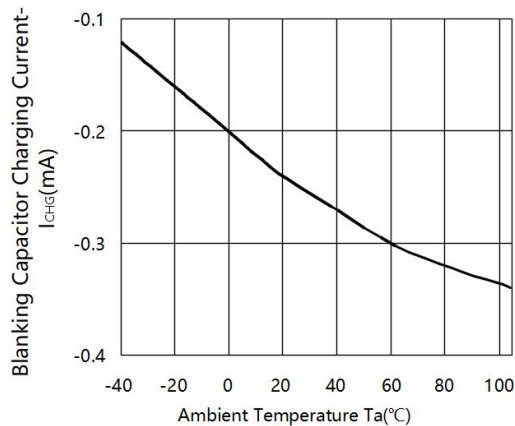


Fig.12 DESAT threshold vs. Ambient Temperature

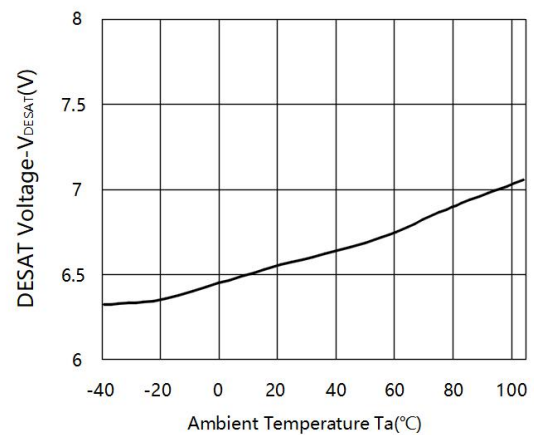


Fig.13 Propagation Delay vs Ambient Temperature

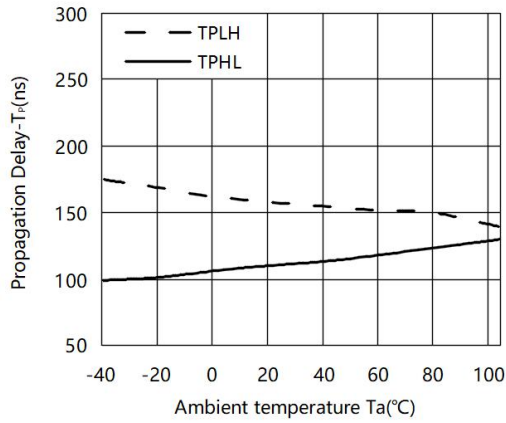


Fig.14 Propagation Delay vs. Supply Voltage

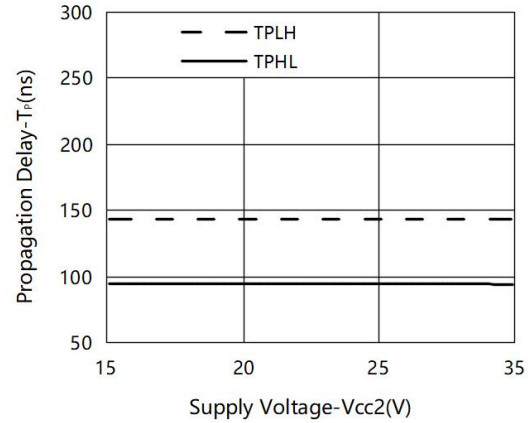


Fig.15 Propagation Delay vs Load Resistance

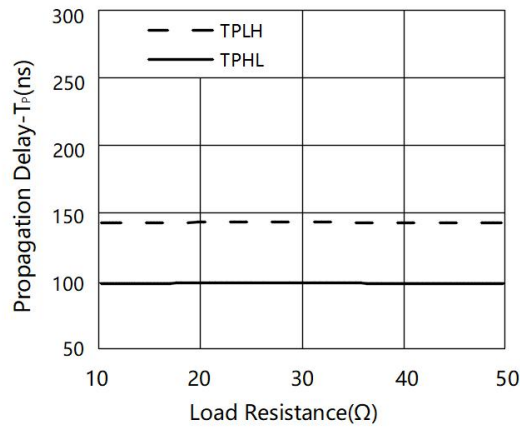


Fig.16 Propagation Delay vs Load Capacitance

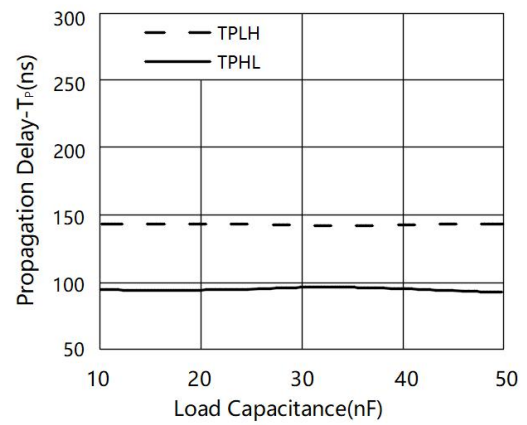


Fig.17 DESAT Sense to 90% Vo Delay vs. Ambient Temperature

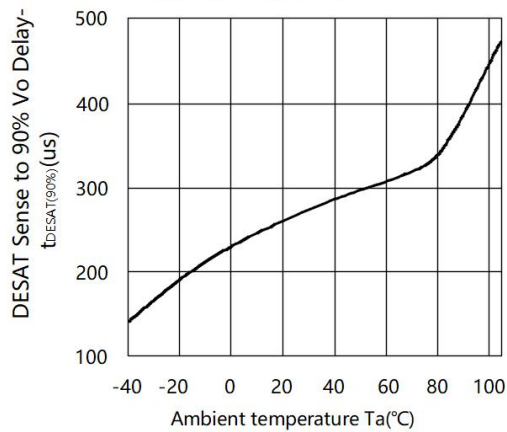


Fig.18 DESAT Sense to 10% Vo Delay vs. Ambient Temperature

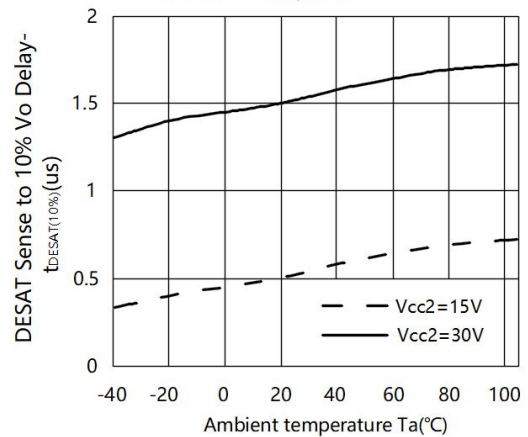


Fig.19 DESAT Sense to 10% Vo Delay vs. Load Resistance

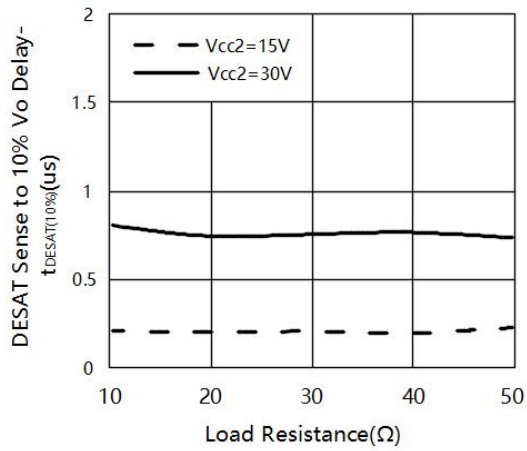
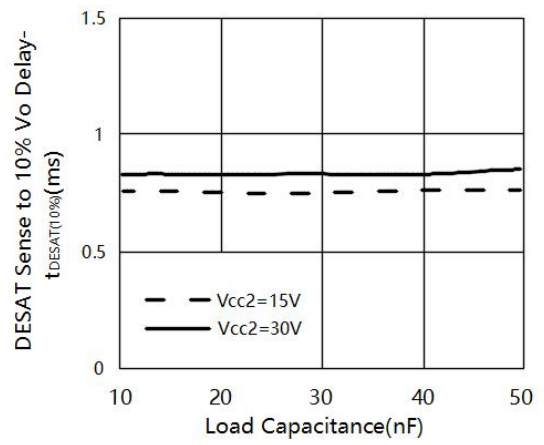


Fig.20 DESAT Sense to 10% Vo Delay vs. Load Capacitance



◆ **测试电路图 Test Circuits Diagrams**

Fig21. I_{OH} Pulsed Test Circuit

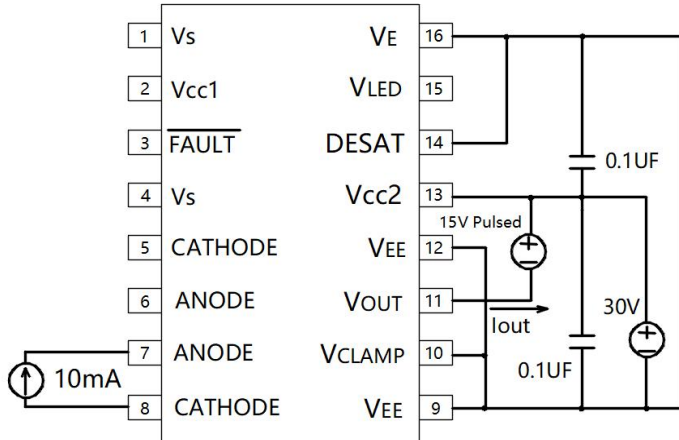


Fig22. I_{OL} Pulsed Test Circuit

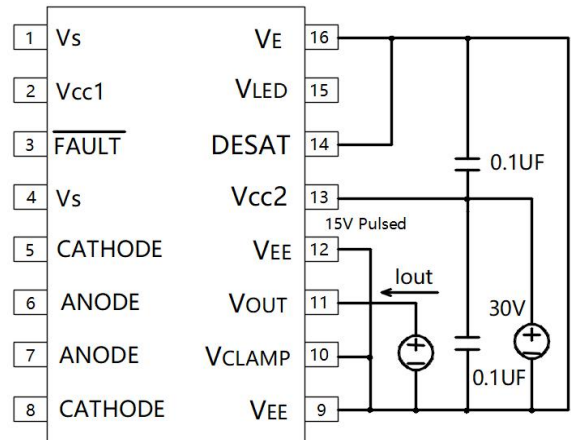


Fig23. V_{OH} Pulsed Test Circuit

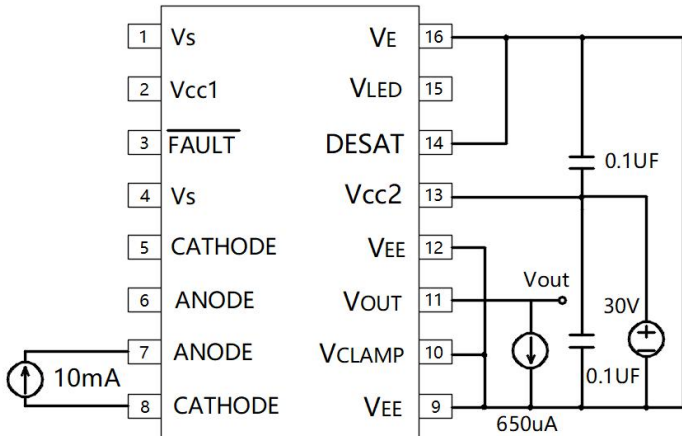


Fig24. V_{OL} Pulsed Test Circuit

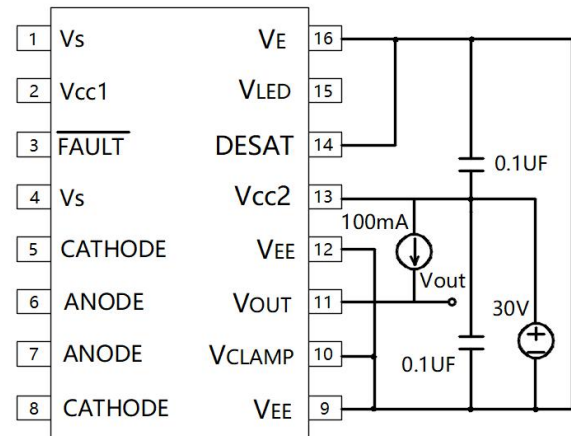


Fig25. I_{CC2H} Test Circuit

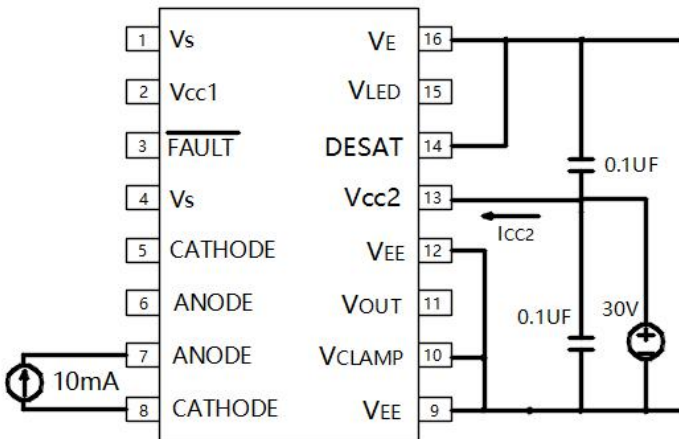


Fig26. I_{CC2L} Test Circuit

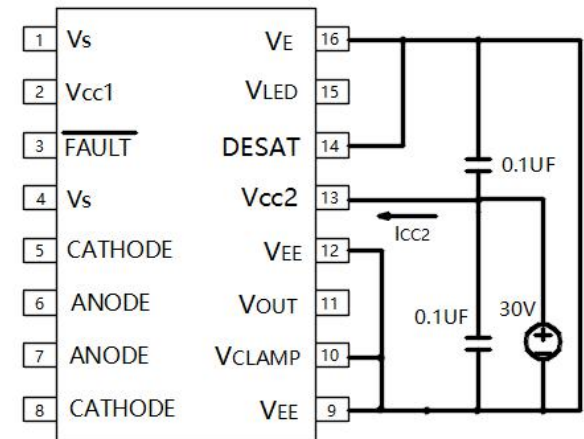


Fig27. I_{CC2H} Pulsed Test Circuit

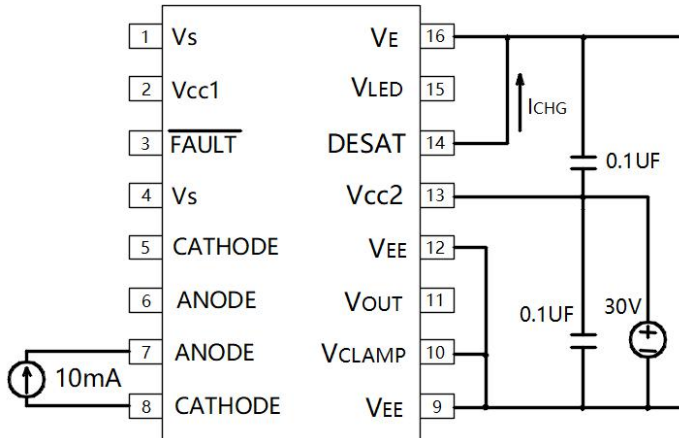


Fig28. I_{DSCHG} Test Circuit

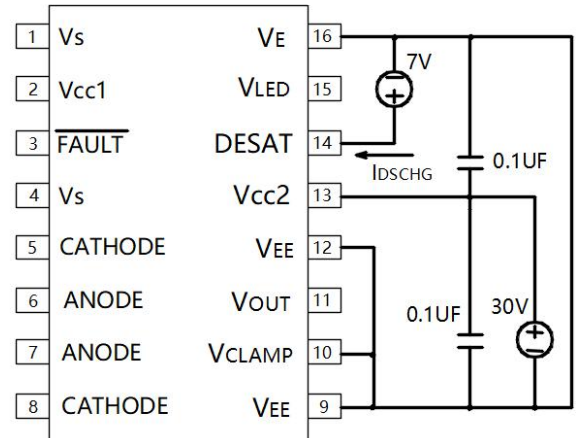


Fig29. T_{PLH} , T_{PHL} , T_r , T_f Test Circuit

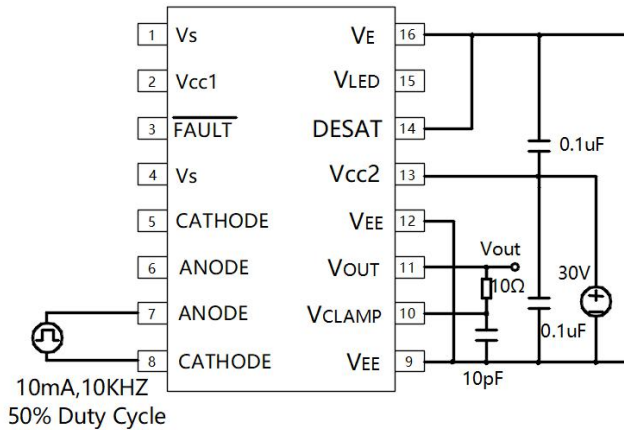


Fig30. T_{DESAT} Fault Test Circuit

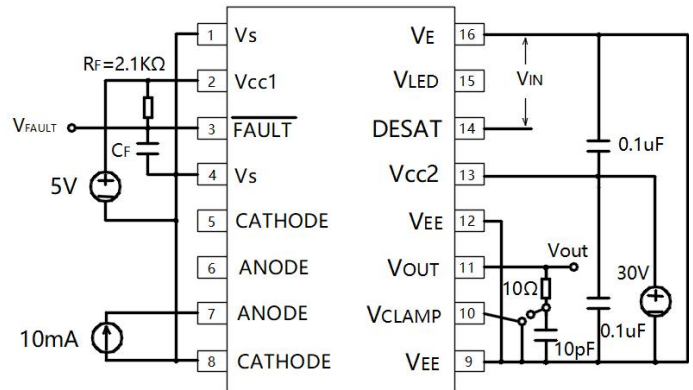


Fig31. CMR Test Circuit LED2 off

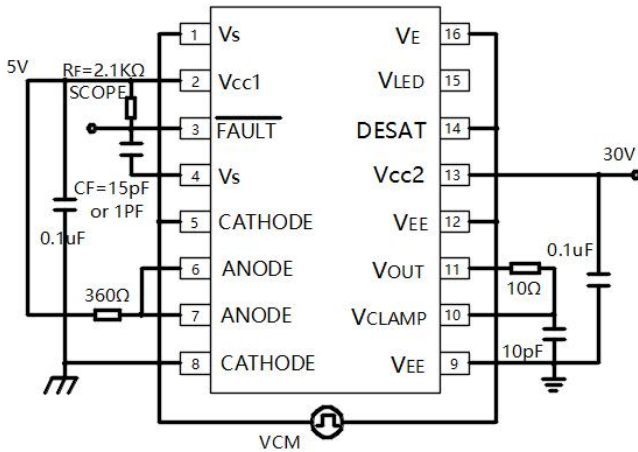


Fig32. CMR Test Circuit LED2 on

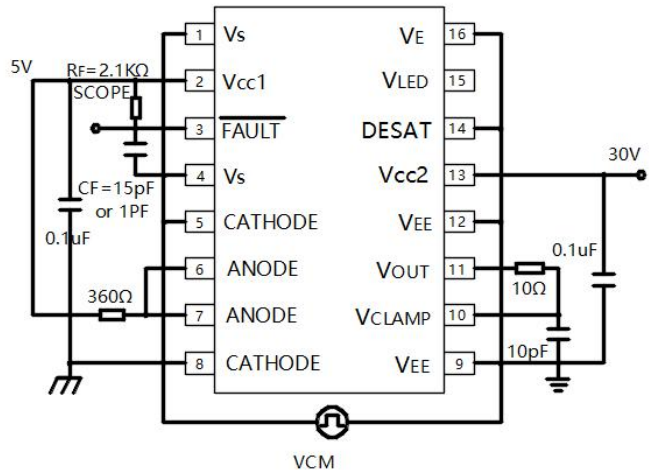
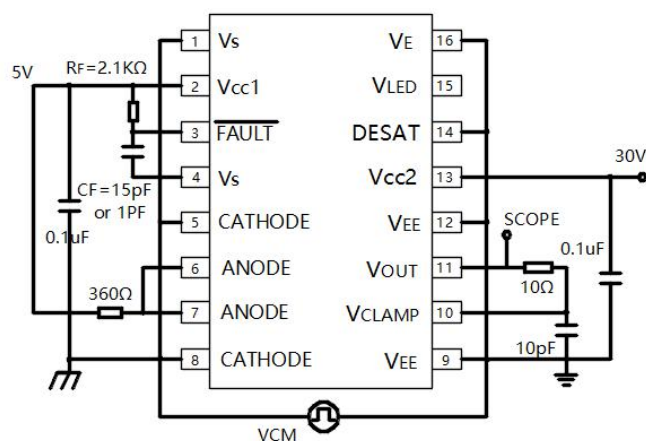


Fig34. CMR Test Circuit LED1 off



◆ 应用信息 Application Information

1、产品概述描述 Product Overview Description

AT333J 是高度集成的功率控制设备，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150A/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产生损坏，第二光链路为微控制器提供完全隔离的故障状态反馈信号。内置的“看门狗”电路，UVLO和监控电源级电源电压，以防止IGBT出现栅极驱动电压不足的现象。这款集成式IGBT栅极驱动器旨在提高电机驱动的性能和可靠性，而不增加成本、体积和复杂的分立设计。

The AT333J 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 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 150A and 1200V. A high speed internal optical link minimizes the propagation delays between the microcontroller 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 optical link provides a fully isolated fault status feedback signal for the microcontroller. 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 reliability 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 接控制IGBT门，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，故障门锁定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AT333J 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，AT333J 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

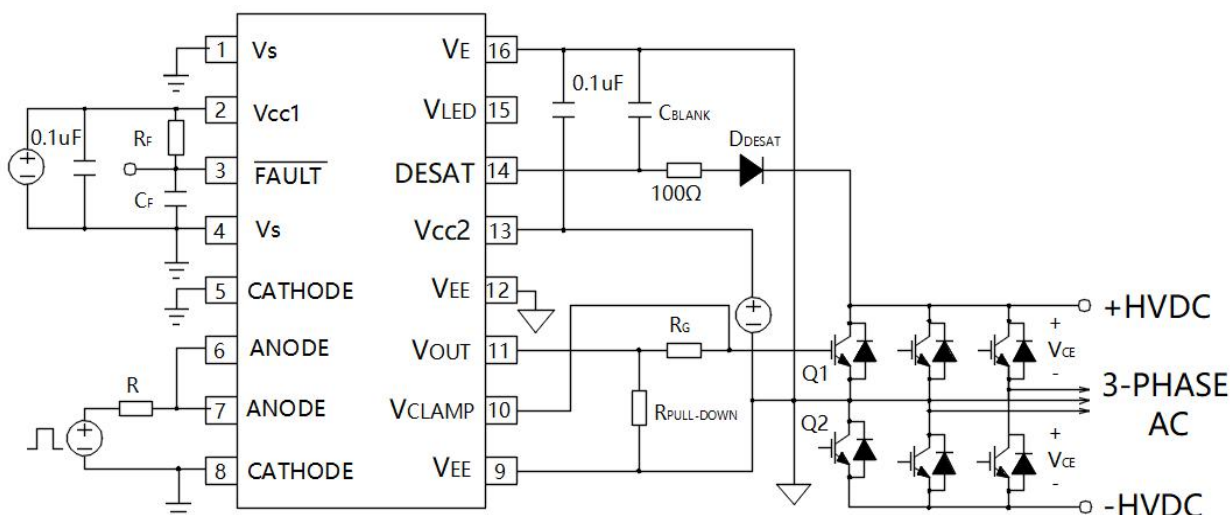
application of insufficient gate voltage to the IGBT, by forcing the AT333J's output low. Once the output is in the high state, the DESAT (VCE) detection feature of the AT333J provides IGBT protection. Thus, UVLO and DESAT work in conjunction to provide constant IGBT protection.

2、推荐应用电路 Recommended Application Circuit

AT333J 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AT333J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 AT333J has an LED input gate control, and an open collector fault output suitable for wired 'OR' applications. The recommended application circuit shown in Figure35 illustrates a typical gate drive implementation using the AT333J. 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 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 supply bypass capacitors (0.1 μF) provide the large 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 controls the IGBT collector voltage rise and fall times. The open collector fault output has a passive pull-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 shut down 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，AT333J 的 V_{OUT} 由输入 LED 电流 I_F (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, V_{OUT} of the AT333J is controlled by input LED current I_F (pins 5, 6, 7 and 8), with the IGBT collector-to-emitter voltage being monitored through DESAT. The FAULT output is high.

2、故障条件 Fault Condition

DESAT 引脚监控 IGBT 的 V_{ce} 压降。当 IGBT 开启时，DESAT 引脚上的电压超过 6.5 V， V_{OUT} 将逐渐降低电平，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。

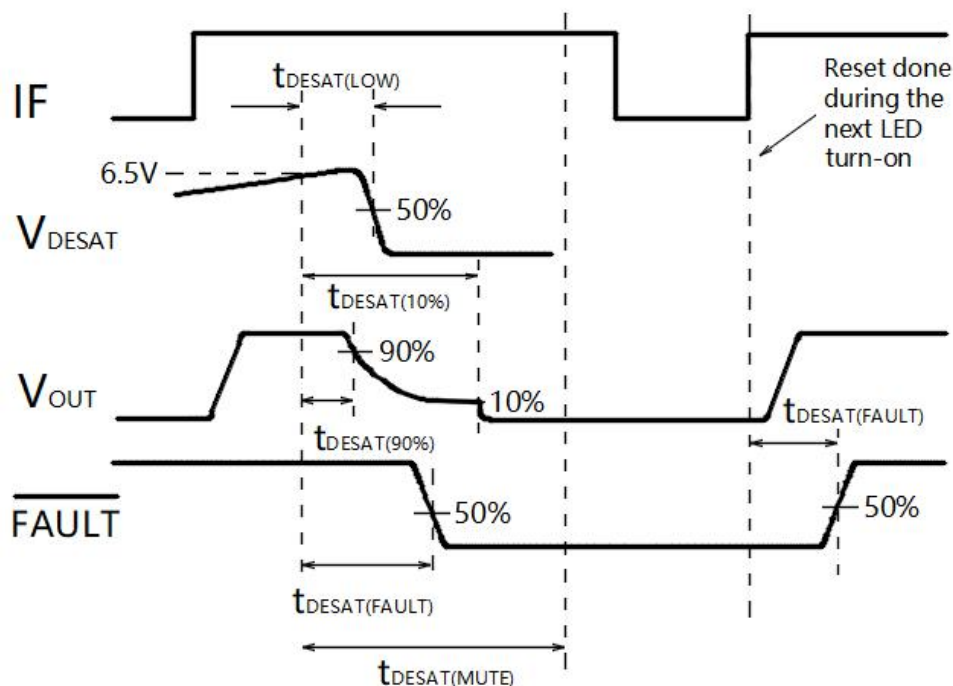
The DESAT pin monitors the IGBT V_{ce} voltage. When the voltage on the DESAT pin exceeds 6.5 V while the IGBT is on, V_{OUT} is slowly brought low in order to “softly” turn-off the IGBT and prevent large di/dt induced voltages. Also activated is an internal feedback channel which brings the FAULT output 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，输出端将被软关断至低电平。在故障期间，LED 所有输入信号都将被忽略，让驱动电路完全软关断 IGBT。对于 AT333J，驱动电路将在 25 μ s 典型) 的固定静音时间后令故障端自动复位。见图 36。

Once fault is detected, the output will be soft-shut down to low. All input LED signals will be ignored during the fault period to allow the driver to completely soft shut-down the IGBT. For AT333J, the driver will automatically reset the FAULT pin after a fixed mute time of 25 μ s (typical). See Figure 36

Fig 36. Fault Timing diagram



4、输出控制 Output Control

AT333J 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, AT333J 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, AT333J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 AT333J 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 AT333J 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 AT333J 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

AT333J 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 AT333J 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 shut down, and an optically isolated fault status feedback signal into a single 16-pin surface mount package.

AT333J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 AT333J, 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 slowly 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，AT333J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 AT333J 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，AT333J 输出驱动阶段中弱下拉器件将开通，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 AT333J 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 $t_{BLANK} = CBLANK \times VDESAT / ICHG$ 。推荐的100pF电容的理论消隐时间为 $100pF \times 6.5V / 240\mu A = 2.7\mu sec$ 。

The nominal blanking time is calculated in terms of external capacitance (CBLANK), FAULT threshold voltage (VDESAT), and DESAT charge current (ICHG) as $t_{BLANK} = CBLANK \times VDESAT / ICHG$. The nominal blanking time with the recommended 100pF capacitor is $100pF \times 6.5 V / 240\mu A = 2.7\mu sec$.

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 AT333J 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 AT333J to respond to a DESAT fault condition. If the IGBT is turned on while the collector and emitter are shorted to the supply rails (switching into a short), the soft shut-down sequence will begin after approximately 3 μsec. 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

AT333J欠压闭锁(UVLO)功能旨在防止在通电期间通过强制AT333J 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 AT333J Under Voltage Lockout (UVLO) feature is designed to prevent the application of insufficient gate voltage to the IGBT by forcing the AT333J 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 threshold), the UVLO clamp 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 clamp is released. Before the time the UVLO clamp is released, the DESAT protection is already 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 $V_{OL}+2.5V$ 。当再次触发 LED 输入时, 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 clamp voltage is $V_{OL}+2.5V$ 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

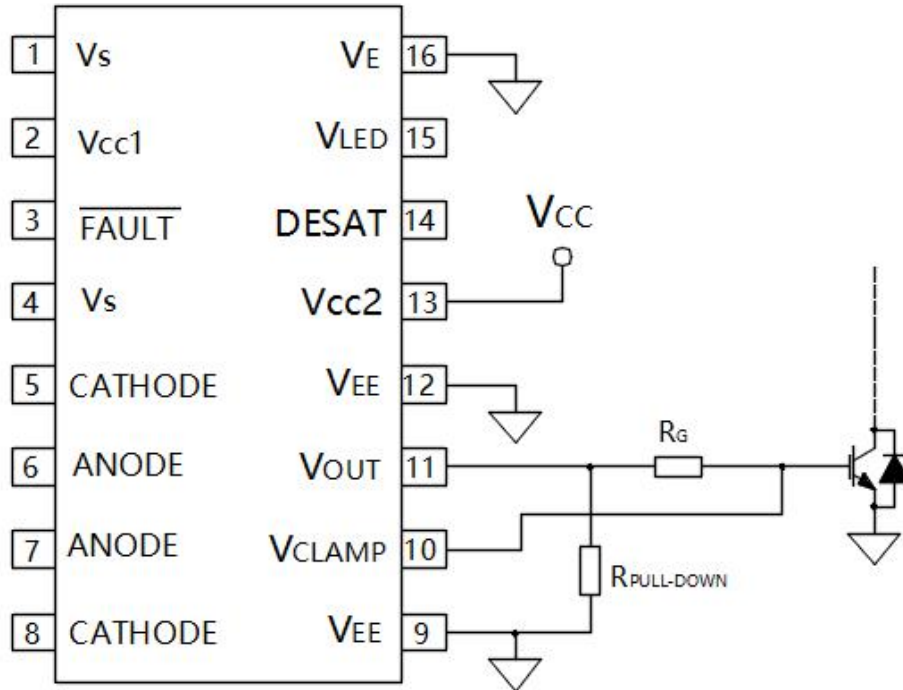
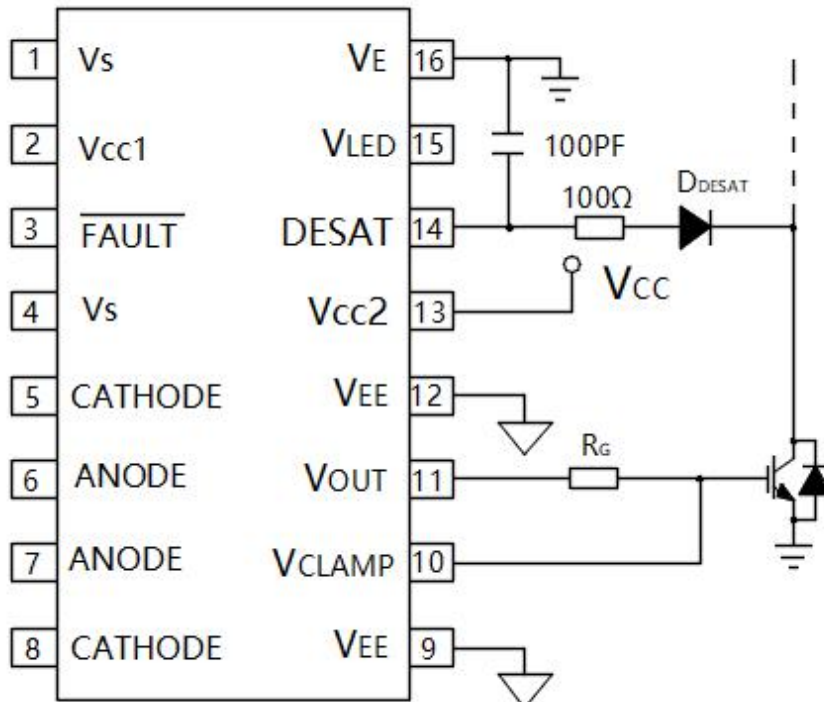


Figure 38. DESAT pin protection



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 V_{CC2} ，并保持在3 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缓慢上升约至 $V_{CC2} - 3(V_{BE})$ 与 V_{CC2} 之间。为了将输出电压限制在 $V_{CC2} - 3(V_{BE})$ ，建议在输出端与VEE之间接一个下拉电阻 $R_{PULL-DOWN}$ ，以便在输出为高电平时产生几个 $650\mu A$ 的灌电流。下拉电阻值取决于正向电源的值，可以根据公式 $R_{pull-down} = [V_{CC2} - 3 * (V_{BE})] / 650\mu A$ 进行调整。

During the output high transition, the output voltage rapidly rises to within 3 diode drops of V_{CC2} . If the output current then drops to zero due to a capacitive load, the output voltage will slowly rise from roughly $V_{CC2} - 3(V_{BE})$ to V_{CC2} within a period of several microseconds. To limit the output voltage to $V_{CC2} - 3(V_{BE})$, a pull-down resistor, $R_{PULL-DOWN}$ between the output and VEE is recommended to sink a static current of several $650\mu A$ while the output is high. Pull-down resistor values are dependent on the amount of positive supply and can be adjusted according to the formula, $R_{pull-down} = [V_{CC2} - 3 * (V_{BE})] / 650\mu A$.

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端电压。FAULT 和地之间应连接一个1000pF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 1000pF 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

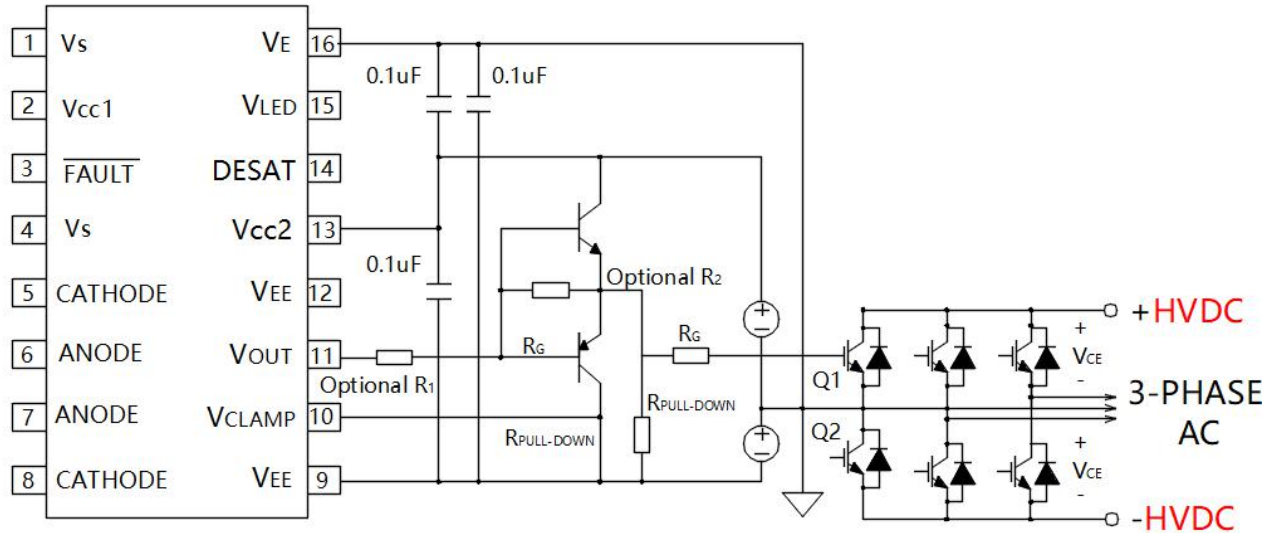
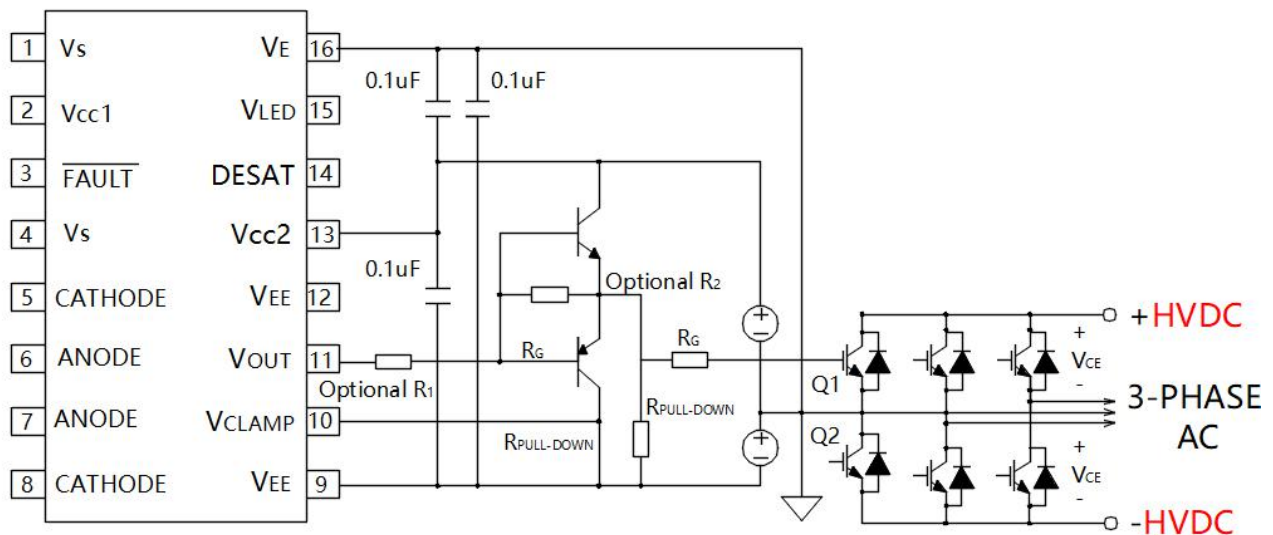


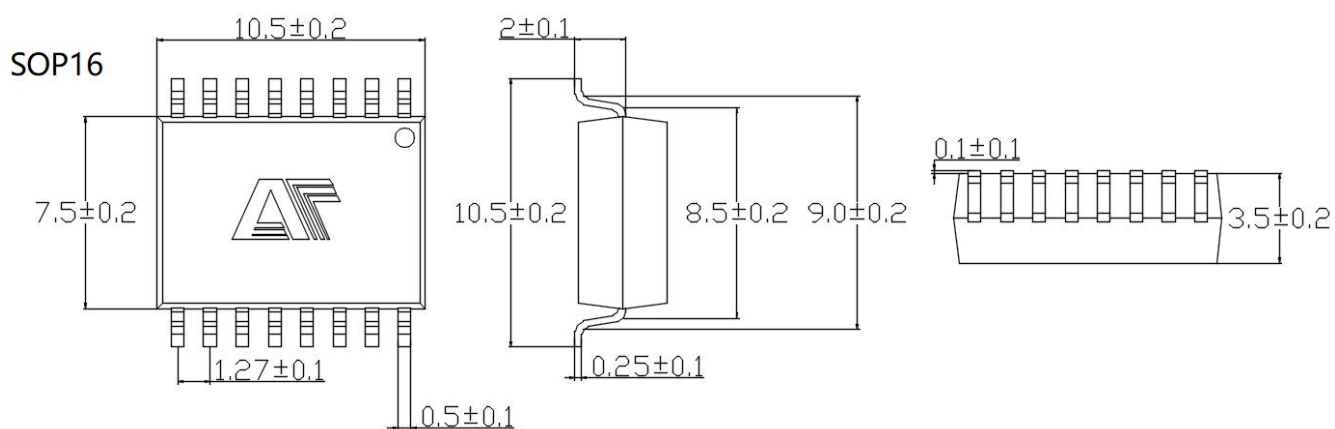
图.40 具有负栅极驱动，外部增压器的大型 IGBT 驱动。用于更高功率应用的 VCLAMP 控制二级放电路径

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

Fig.40

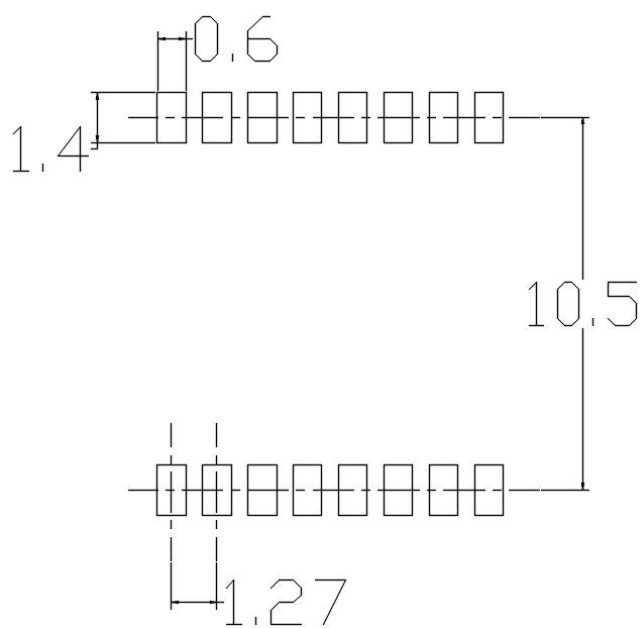


◆ 外形尺寸Overall dimension



推荐焊盘:

Recommended



单位: mm

◆ 产品型号命名规则 Order code

AT 333J - 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 (333J)
- 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

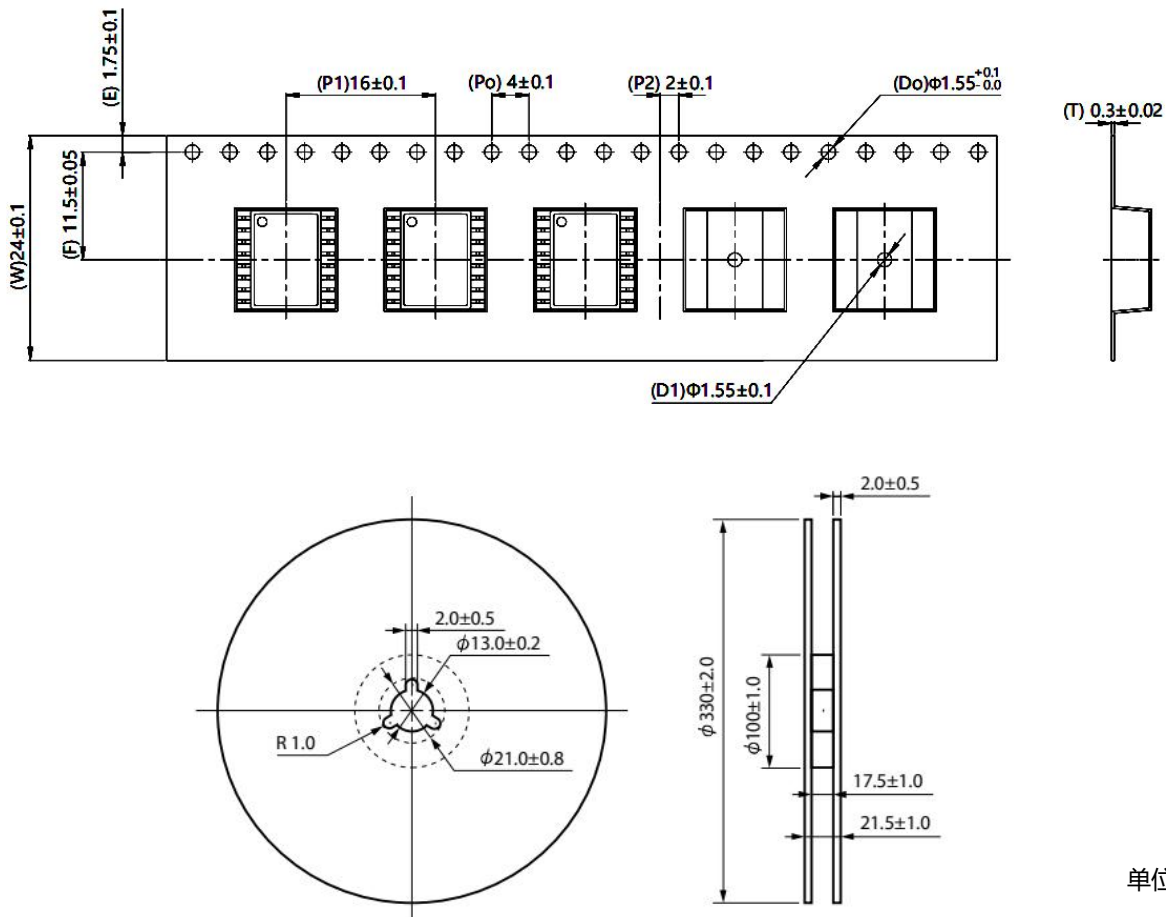


◆ 包装packing

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 ($\phi 330$ mm 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 ($\phi 330$ mm 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:

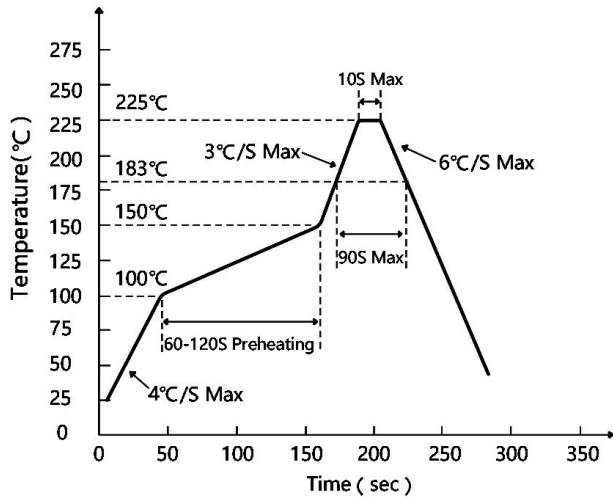


单位: mm

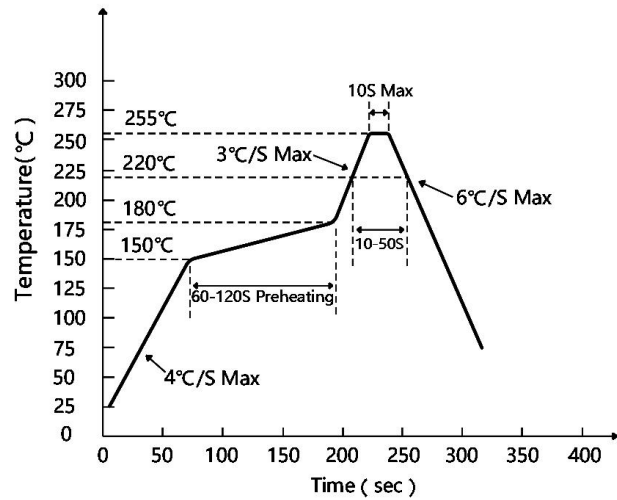
◆ 可靠性测试 Reliability Test Items And Conditions

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) °C, t=5s;	1 次1 times	22	0/22
耐焊接热 Resistance to Soldering Heat	JESD22-A106	Tsol= (260±5) °C, t=10s	3 次3 times	22	0/22
静电放电 ESD-HBM	JESD22-A114	Ta=25°C, 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°C	1000h	22	0/22
低温贮存 Low Temperature Storage	JESD22-A119	Ta= -55°C	1000h	22	0/22
冷热冲击 Thermal Shock	JESD22-A104	-55°C(15min)←→ 125°C(15min)	循环 300 次 300 cycles	22	0/22
常温寿命试验 Lifespan Test	JESD22-A108	Ta=25°C, IF=50mA , Vcc=5V	1000h	22	0/22
高温寿命试验 DC Operating Life	JESD22-A108	Ta=110°C, IF=20mA , Vcc=5V	1000h	76	0/76
高温高湿偏压 High Temperature High Humidity bias Voltage	JESD22-A101	Ta =85°C , RH=85% IF=0mA , VCE=64V	1000h	22	0/22
高温偏压 High Temperature bias Voltage	JESD22-A108	Ta =110°C , IF=0mA , VCE=80V	1000h	22	0/22
高压蒸汽试验 High pressure steam test	JESD22-A102	P=15PSIG , 121°C, 100%RH	96h	22	0/22

◆ 回流焊温度曲线图 Solder Reflow Profile

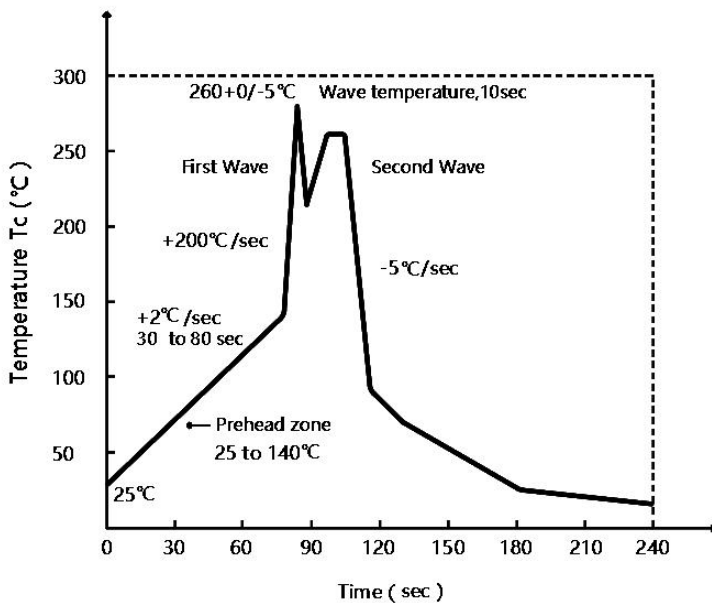


有铅制程 Lead Process



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°C ± 5°C, 时间 ≤ 3s.

Hand soldering iron requirements: Temperature: 350°C ± 5°C, 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: