

描述/Description

- XNS10S12FT基于Trench FS-IGBT技术，提供紧凑且高性能的变频伺服解决方案，适合较高功率消费和工业领域。
XNS10S12FT is an Advanced IPM Based on Trench FS-IGBT Technology as a Compact and High Performance Inverter or Server Solution for Higher Power Consumption and Industrial Applications.
- XNS10S12FT通过优化开关速度和减小寄生电感实现低电磁干扰（EMI）特性。
XNS10S12FT Features Low Electromagnetic Interference (EMI) Characteristics Through Optimizing Switching Speed and Reducing Parasitic Inductance.
- XNS10S12FT内置优化的保护和驱动电路并与低损耗IGBT匹配，欠压锁定和短路保护进一步提高了系统可靠性。
XNS10S12FT Combines Optimized Circuit Protection and Drive Matched to Low-Loss IGBTs. System Reliability is Further Enhanced by the Integrated Under-Voltage Lock-Out and Short-Circuit Protection.
- XNS10S12FT内置高速HVIC，提供无光耦单电源IGBT栅极驱动能力，进一步减小了逆变器系统设计的总体尺寸。
XNS10S12FT Combines High Speed HVIC Provides Opto-Coupler-Less Single-Supply IGBT Gate Driving Capability that Further Reduce the Overall Size of the Inverter System Design.
- 分开的负直流端子使得变频器的每相电流可以单独监视到。
Each Phase Current of Inverter can be Monitored Separately Due to the Divided Negative DC Terminals.

主要特点

- 1200V-10 A三相IGBT逆变器，包含栅极驱动和保护的控制IC
- 低损耗、短路额定的IGBT
- 采用DBC (Al₂O₃) 基板实现非常低的热阻
- 内置自举二极管和专用的Vs 引脚以简化印刷电路板布局
- 低端IGBT的独立发射极开路引脚用于三相电流感测
- 内置负温度系数的电阻用于温度检测
- 绝缘级别2500V_{rms}/1min
- 单接地电源供电

应用

- 运动控制 – 家用设备 / 工业电机

Features

- 1200V-10A 3-Phase IGBT Inverter Bridge Including Control ICs for Gate Driving and Protection
- Low-Loss, Short-Circuit Rated IGBTs
- Very Low Thermal Resistance Due to Using Al₂O₃ DBC
- Built-In Bootstrap Diodes and Dedicated Vs Pins Simplify PCB Layout
- Separate Open-Emitter Pins from Low-Side IGBTs for Three-Phase Current Sensing
- Temperature feedback via NTC
- Isolation Voltage Rating of 2500 V_{rms} for 1 min.
- Single-Grounded Power Supply Due to Built-In HVIC

Applications

- Motion Control – Home Appliance / Industrial Motor

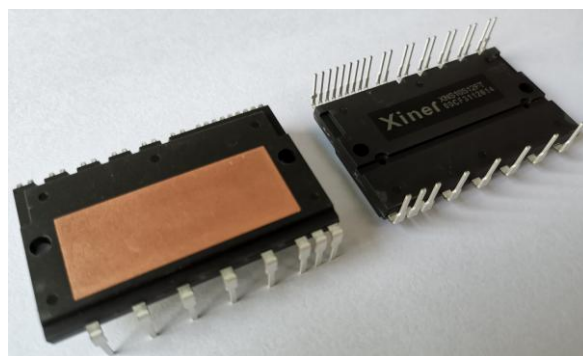


图1. 封装概览

Figure1. Package Overview

绝对最大额定值 / Absolute Maximum Ratings

逆变器部分(单个IGBT, 除非另有说明) / Inverter Part (Each IGBT @ Unless Otherwise Specified)

符号/Symbol	参数/Parameter	工作条件/ Conditions	额定值/Rating	单位/Unit
V_{PN}	加在P-N之间的电源电压 DC link Input Voltage		900	V
$V_{PN(Surge)}$	加在P-N之间的电源浪涌电压 DC link Input Voltage Surge		1000	
V_{CES}	集电极-发射极之间电压 Collector-Emitter Voltage		1200	
I_C	单个IGBT集电极电流 Each IGBT Collector Current	$T_C = 25^\circ\text{C}, T_J \leq 150^\circ\text{C}$	10	A
I_{CP}	单个IGBT集电极峰值电流 Each IGBT Collector Peak Current	$T_C = 25^\circ\text{C}, T_J \leq 150^\circ\text{C}, PW < 1\text{ms}$	20	
P_C	最大功耗 Maximum Power Dissipation	$T_C = 25^\circ\text{C}$, 单个芯片/Per one chip	90	W
T_J	工作结温 Operating Junction Temperature		-30~150	$^\circ\text{C}$

控制部分/ Control Part

符号/Symbol	参数/Parameter	工作条件/ Conditions	额定值/Rating	单位/Unit
V_D	控制电源电压 Control Supply Voltage	施加在 $V_{P1}-V_{NC}$, $V_{N1}-V_{NC}$ 之间 Applied Between $V_{P1}-V_{NC}$, $V_{N1}-V_{NC}$	25	V
V_{DB}	高端偏置电压 High-side Bias Voltage	施加在 $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$ 之间 Applied Between $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$	25	
V_{IN}	输入信号电压 Input Signal Voltage	施加在IN和 V_{NC} 之间 Applied Between IN and V_{NC}	$-1.0 \sim V_D + 0.5$	
V_{FO}	故障输出电源电压 Fault Output Supply Voltage	施加在 V_{FO} 和 V_{NC} 之间 Applied Between V_{FO} and V_{NC}	$-1.0 \sim V_D + 0.5$	
I_{FO}	故障输出电流 Fault Output Current	V_{FO} 引脚处的灌电流 Sink Current at V_{FO} Pin	1	mA
V_{SC}	电流检测输入电压 Current Sensing Input Voltage	施加在CIN和 V_{NC} 之间 Applied Between CIN and V_{NC}	$-1.0 \sim V_D + 0.5$	V

自举二极管部分(单个二极管, 除非另有说明) / Bootstrap Diode Part (Each Bootstrap Diode Unless Otherwise Specified)

符号/Symbol	参数/Parameter	工作条件/ Conditions	额定值/Rating	单位/Unit
V_{RRMB}	最大重复反向电压 Maximum Repetitive Reverse Voltage		1200	V
I_F	正向电流 Forward Current	$T_C = 25^\circ\text{C}, T_J \leq 150^\circ\text{C}$	0.5	A
I_{FP}	正向电流(峰值) Forward Current (Peak)	$T_C = 25^\circ\text{C}, T_J \leq 150^\circ\text{C}, PW < 1\text{ms}$	2.0	
T_J	工作结温 Operating Junction Temperature		-40~150	$^\circ\text{C}$

热阻 / Thermal Resistance

符号/Symbol	参数/Parameter	工作条件/ Conditions	额定值/Rating	单位/Unit
$R_{th(j-c)Q}$	节点-壳体热阻(注1) Junction to Case Thermal Resistance (Note1)	逆变器工作条件下的单个IGBT Each IGBT under Inverter Operating Condition	1.3	$^\circ\text{C}/\text{W}$
$R_{th(j-c)F}$		逆变器工作条件下的单个FRD Each FRD under Inverter Operating Condition (Note 1)	1.5	

注 / Note:

1.关于壳体温度(T_C)的测量点, 参见图2。 / For the Measurement Point of Case Temperature T_C , Please refer to Figure 2.

整个系统 / Total System

符号/Symbol	参数/Parameter	工作条件/ Conditions	额定值/Rating	单位/Unit
$V_{PN(Prot)}$	自我保护电源电压限制 Self Protection Supply Voltage Limit	$V_{CC}=V_{BS}=13.5V\sim 16.5V$, $T_J=125^{\circ}C$, 非重复性, $<2\mu s$	800	V
T_C	模块壳体工作温度 Module Case Operation Temperature	$-40^{\circ}C \leq T_J \leq 150^{\circ}C$	-30 ~ 100	°C
T_{STG}	存储温度 Storage Temperature		-40 ~ 125	
V_{ISO}	绝缘电压 Isolation Voltage	60Hz, 正弦波, 1分钟, 连接基板到引脚 60 Hz, Sinusoidal, 1 minute, Connection Pins to Heatsink	2500	V_{rms}

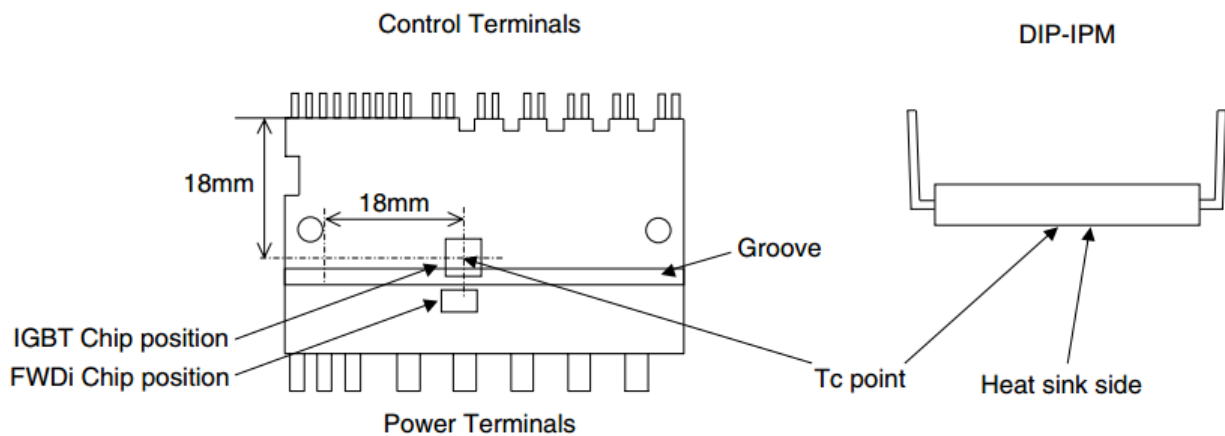


图2. 壳温测量点

Figure2. Tc Measurement Position

引脚描述 / Pin descriptions

引脚号/Pin Number	引脚名/Pin Name	引脚描述/Pin Description
1	VUFS	High-Side Bias Voltage Ground for U-Phase IGBT Driving 上桥臂U相驱动地端
2	VUFB	High-Side Bias Voltage for U-Phase IGBT Driving 上桥臂U相驱动正端
3	VP1	Common Bias Voltage for IC and IGBTs Driver 控制电源正端
4	UP	Signal Input for High-Side U Phase 上半桥U相逻辑输入端
5	VVFS	High-Side Bias Voltage Ground for V-Phase IGBT Driving 上桥臂V相驱动地端
6	VVFB	High-Side Bias Voltage for V-Phase IGBT Driving 上桥臂V相驱动正端
7	VP1	Common Bias Voltage for IC and IGBTs Driver 控制电源正端
8	VP	Signal Input for High-Side V Phase 上半桥V相逻辑输入端
9	VWFS	High-Side Bias Voltage Ground for W-Phase IGBT Driving 上桥臂W相驱动地端
10	VWFB	High-Side Bias Voltage for W-Phase IGBT Driving 上桥臂W相驱动正端
11	VP1	Common Bias Voltage for IC and IGBTs Driver 控制电源正端
12	WP	Signal Input for High-Side W Phase 上半桥W相逻辑输入端
13	VTH	热敏电阻电压 NTC Voltage
14	UN	Signal Input for Low-Side U Phase 下桥臂U相逻辑输入端
15	VN	Signal Input for Low-Side V Phase 下桥臂V相逻辑输入端
16	WN	Signal Input for Low-Side W Phase 下桥臂W相逻辑输入端
17	FO	Fault Output 故障信号输出端
18	CFO	Fault clear time setting 故障消除时间调整
19	CIN	Capacitor for Short-Circuit Current Detector Input 过流电流跳闸电压检测端
20	VNC	Common Supply Ground 下桥臂参考地端
21	VN1	Common Bias Voltage for IC and IGBTs Driver 控制电源正端
22	NW	Negative DC-Link Input for W-Phase 逆变器直流电源负端（W相）
23	NV	Negative DC-Link Input for V-Phase 逆变器直流电源负端（V相）
24	NU	Negative DC-Link Input for U-Phase 逆变器直流电源负端（U相）
25	W	Output for W-Phase 逆变器W相输出端
26	V	Output for V-Phase 逆变器V相输出端
27	U	Output for U-Phase 逆变器U相输出端
28	P	Positive DC-Link Input 逆变器直流电压正端
29	NC	N.C 空引脚

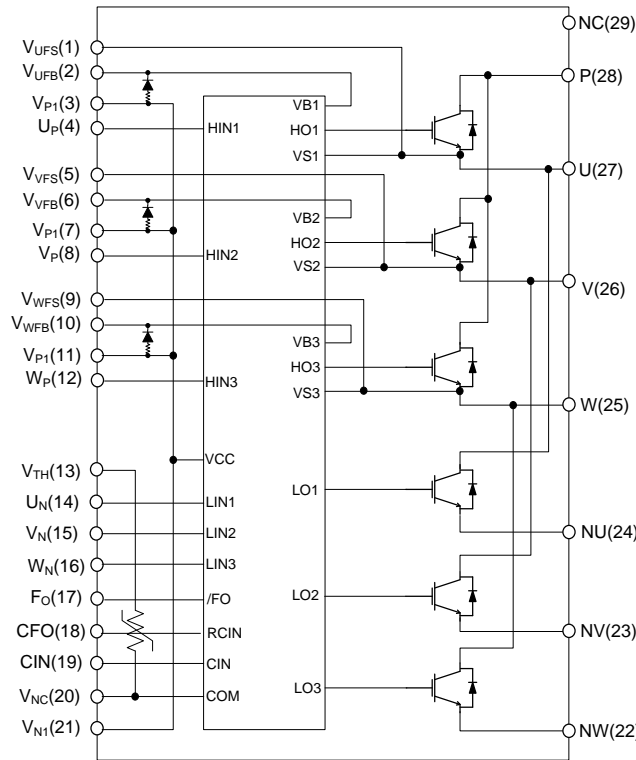


图3. 引脚布局和内部框图（仰视图）

Figure3. Pin Configuration and Internal Block Diagram (Bottom View)

电气特性 ($T_J = 25^\circ\text{C}$, $V_{CC} = V_{BS} = 15\text{V}$, 除非另有说明) / Electrical Characteristics ($T_J = 25^\circ\text{C}$, $V_{CC} = V_{BS} = 15\text{V}$ Unless Otherwise Specified)

逆变器部分 (单个IGBT, 除非另有说明) / Inverter Part (Each IGBT Unless Otherwise Specified)

符号/Symbol	参数/Parameter	工作条件/ Conditions		最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit
$V_{CE(SAT)}$	集电极-发射极间饱和电压 Collector-Emitter Saturation Voltage	$V_D = V_{DB} = 15\text{V}$, $V_{IN} = 5\text{V}$	$I_C = 10\text{A}$, $T_J = 25^\circ\text{C}$,	-	2.0	2.2	V
			$I_C = 10\text{A}$, $T_J = 125^\circ\text{C}$,	-	2.1	2.3	
V_{EC}	FWD正向电压 FWD Forward Voltage	$V_{IN} = 0\text{V}$, $I_C = 10\text{A}$,		-	2.0	2.3	
I_{CES}	集电极-发射极间漏电流 Collector-Emitter Leakage Current	$V_{CE} = V_{CES}$	$T_J = 25^\circ\text{C}$,	-	-	1	mA
			$T_J = 125^\circ\text{C}$,	-	-	10	
HS	开关时间	$V_{PN} = 600\text{V}$, $V_D = V_{DB} = 15\text{V}$, $I_C = 10\text{A}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$, 电感负载 / Inductive Load	t_{ON}	-	800	-	ns
			$T_{C(ON)}$	-	150	-	
			t_{OFF}	-	1200	-	
			$T_{C(OFF)}$	-	380	-	
			t_{rr}	-	60	-	
			t_{rr}	-	800	-	
LS	开关时间	$V_{PN} = 600\text{V}$, $V_D = V_{DB} = 15\text{V}$, $I_C = 10\text{A}$ $V_{IN} = 0\text{V} \leftrightarrow 5\text{V}$, 电感负载 / Inductive Load	t_{ON}	-	800	-	ns
			$T_{C(ON)}$	-	200	-	
			t_{OFF}	-	1200	-	
			$T_{C(OFF)}$	-	380	-	
			t_{rr}	-	100	-	
			t_{rr}	-	100	-	

控制部分/ Control Part

符号/Symbol	参数/Parameter	工作条件/ Conditions		最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit
I_D	V_D 静态电流 Quiescent V_D Current	$V_D=15V$, $V_{IN}=0V$	施加在 V_D 和 V_{NC} 之间 Applied Between V_D and V_{NC}	-	1.5	2.0	mA
I_{DB}	V_{DB} 静态电流 Quiescent V_{DB} Current	$V_{DB}=15V$, $V_{IN}=0V$	施加在 $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$; Applied Between $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$	-	200	300	uA
V_{FOH}	故障输出电压 Fault Output Voltage	$V_{SC}=0V$, V_{FO} 电路: 10KΩ至5V上拉		4.9	-	-	V
V_{FOL}		$V_{SC}=1V$, $I_{FO}=1mA$		-	-	0.95	
$V_{SC(ref)}$	短路电流触发电平 Short Circuit Trip Level	$V_D=15V$ (注2/Note2)(图7)(Figure 7)		0.475	0.5	0.525	
I_{IN}	输入脚电流 Input Current	$V_{IN}=5V$		-	1.0	1.3	mA
t_{FILIN}	输入 $U_P, V_P, W_P, U_N, V_N, W_N$ 滤波时间 Input Filter Time at $U_P, V_P, W_P, U_N, V_N, W_N$	$C_{IN}=0V$, $V_{IN}=0\&5V$		140	290	-	ns
DT	死区时间 Dead Time			200	360	-	
T_{CIN}	保护关断延迟时间 Shutdown Propagation Delay			650	850	1000	
T_{CINMIN}	CIN输入滤波 Input Filter Time CIN	$V_{CIN}=2V$		200	400	600	
T_{FO}	CIN到FO延迟时间 Propagation Delay CIN to FO			-	730	1000	
UV_{DD}	低端欠压保护 (图5) Low-Side Undervoltage Protection (Figure 5)	V_D 欠压保护检测电平 V_D Undervoltage Protection Detection Level		9.3	10.4	11.5	V
UV_{DR}		V_D 欠压保护复位电平 V_D Undervoltage Protection Reset Level		10.2	11.4	12.6	
UV_{DBD}	高端欠压保护 (图6) High-Side Undervoltage Protection (Figure 6)	V_{DB} 欠压保护检测电平 V_{DB} Undervoltage Protection Detection Level		8.3	9.4	10.5	
UV_{DBR}		V_{DB} 欠压保护复位电平 V_{DB} Undervoltage Protection Reset Level		9.2	10.4	11.6	
t_{FOD}	故障输出脉宽 Fault Output Pulse Width	$R=2M\Omega$, $C=1nf$		-	1.75	-	ms
V_{IH}	导通阈值电压 ON Threshold Voltage	逻辑高电平 Logic High Level	施加在 V_{IN} 和 V_{NC} 之间 Applied between I_{N} and V_{NC}	1.7	2.1	2.4	V
V_{IL}	关断阈值电压 OFF Threshold Voltage	逻辑低电平 Logic Low Level		0.7	0.85	1.1	

注 / Note:

2.短路电流保护仅作用于低端。 / Short-Circuit Current Protection is Functioning Only at the Low-Side.

自举二极管部分(单个二极管, 除非另有说明) / Bootstrap Diode Part(Each Bootstrap Diode Unless Otherwise Specified)

符号/Symbol	参数/Parameter	工作条件/ Conditions	最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit
V_F	正向电压 Forward Voltage	$I_f=300mA$, $T_c=25^\circ C$ $I_f=300mA$, $T_c=25^\circ C$	-	0.9	1.2	V
R_{BSD}	串联电阻 Resistance between $V_F=4V$ and $V_F=5V$		-	70	90	Ω

内部NTC(负温度系数)电阻参数/ Internal NTC – Thermistor Characteristics

符号/Symbol	参数/Parameter	工作条件/ Conditions	最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit
R_{25}	电阻 Resistance	$T_c=25^\circ C$, $\pm 5\%$ tolerance	-	47	-	kΩ
R_{125}	电阻 Resistance	$T_c=125^\circ C$ $T_c=125^\circ C$	-	1.34	-	kΩ
B	B-常数(25-50°C) B-constant (25-50°C)	$\pm 2\%$ tolerance	-	4050	-	K

推荐工作条件 / Recommended Operating Condition

符号/Symbol	参数/Parameter	工作条件/ Conditions	最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit	
V_{PN}	电源电压 Supply Voltage	施加在P和N之间 Applied Between P and N	350	600	800	V	
V_D	控制电源电压 Control Supply Voltage	施加在 V_D 和 V_{NC} 之间 Applied Between V_D and V_{NC}	13.5	15	16.5		
V_{DB}	高端偏压 High-Side Bias Voltage	施加在 $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$; Applied Between $V_{UFB}-V_{UFS}$, $V_{VFB}-V_{VFS}$, $V_{WFB}-V_{WFS}$	13.0	15	18.5	V	
d_{VD}/d_t , d_{VDBS}/d_t	控制电源波动 Control Supply Variation		-1	-	1	V/us	
t_{dead}	防止桥臂直通的死区时间 Blanking Time for Preventing Arm-Short	每个输入信号/For Each Input Signal	1	-	-	us	
f_{PWM}	PWM开关频率 PWM Switching Frequency	$-40^{\circ}\text{C} \leq T_c \leq 100^{\circ}\text{C}$, $-40^{\circ}\text{C} \leq T_j \leq 125^{\circ}\text{C}$	-	-	20	kHz	
V_{SEN}	电流感测产生的电压 Voltage for Current Sensing	施加在 N_U , N_V , $N_W - V_{NC}$ 之间 (包括浪涌电压) Applied between N_U , N_V , $N_W - V_{NC}$ (Including Surge Voltage)	-5	-	5	V	
I_o	输出有效电流 Output r.m.s current	$V_{PN}=600\text{V}$, $V_D=V_{DB}=15\text{V}$, P.F=0.8, Sinusoidal PWM, $T_c \leq 100^{\circ}\text{C}$, $T_j \leq 125^{\circ}\text{C}$	$f_{PWM}=5\text{KHz}$	-	-	5.3	Arms
			$f_{PWM}=15\text{KHz}$	-	-	3.6	
T_j	工作结温 Operating Junction Temperature		-20	-	125	$^{\circ}\text{C}$	

机械特性和额定值/Mechanical Characteristics and Ratings

参数/Parameter	工作条件/ Conditions		最小值 /Min	典型值 /Typ	最大值 /Max	单位 /Unit
安装扭矩 Mounting Torque	安装螺钉: M3 Mounting Screw: M3	建议0.78 N.m Recommended 0.78 N.m	0.59	-	0.98	N.m
器件平面度 Device Flatness		见图4 See Figure 4	-50	-	+100	um
重量 Weight			-	21	-	g

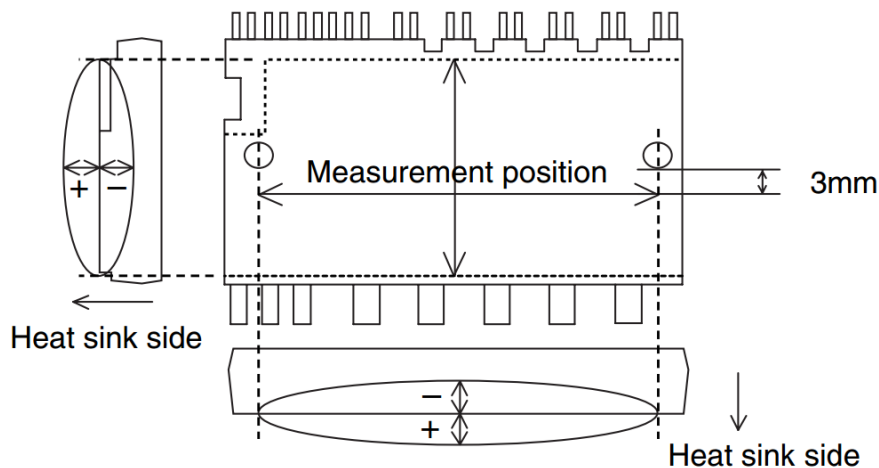


图4. 平面度测量位置

Figure4. Flatness Measurement Position

保护功能时序图

Time Charts of IPMs Protective Function

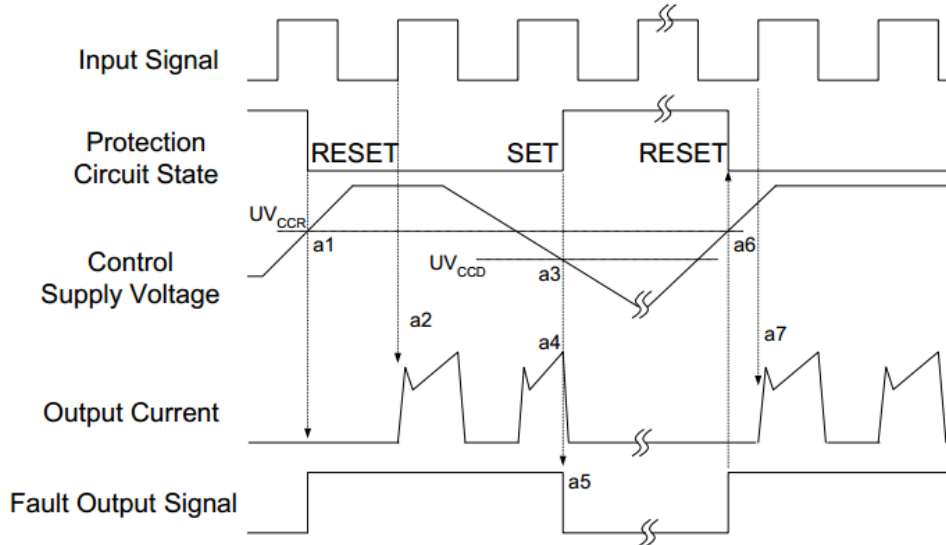


图5. 欠压保护（低端）

Figure 5. Undervoltage Protection (Low-side)

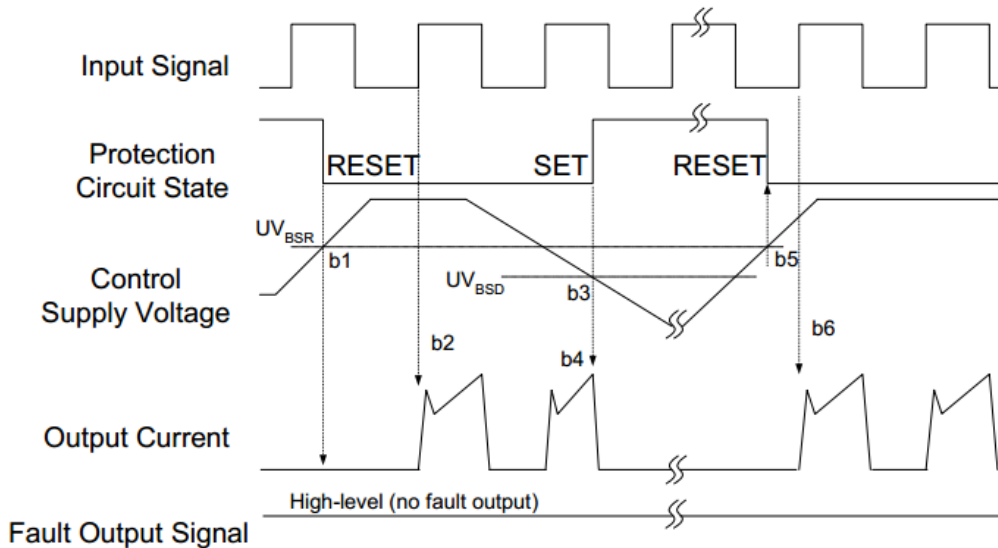


图6. 欠压保护（高端）

Figure 6. Undervoltage Protection (High-side)

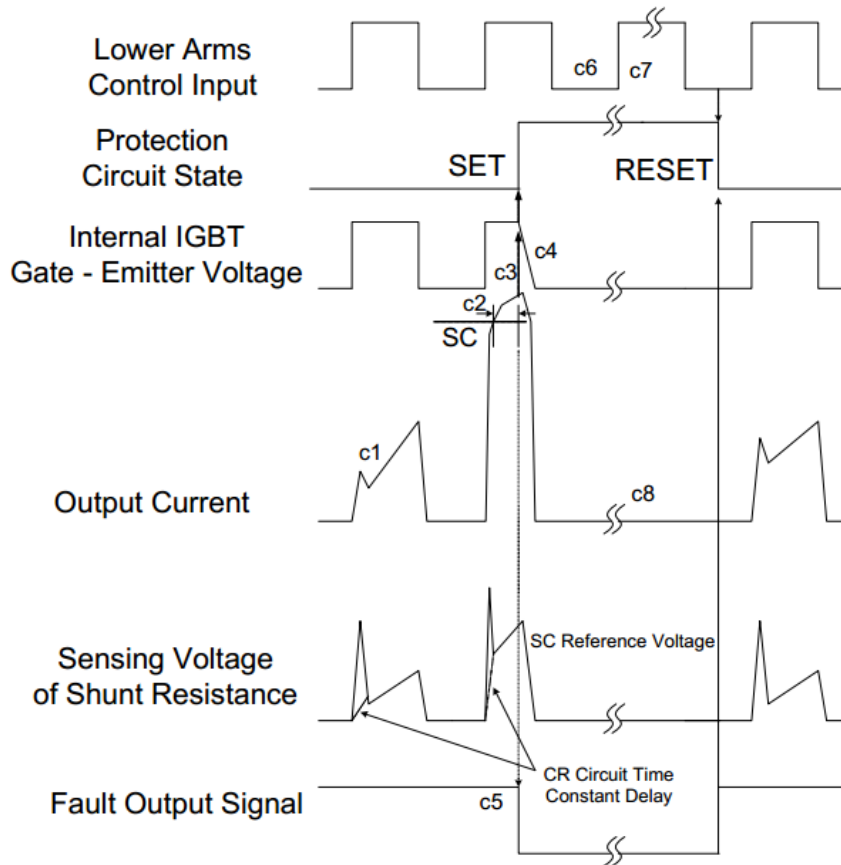


图7. 短路电流保护（低端）

Figure 7. Short-circuit Current Protection (Low-side)

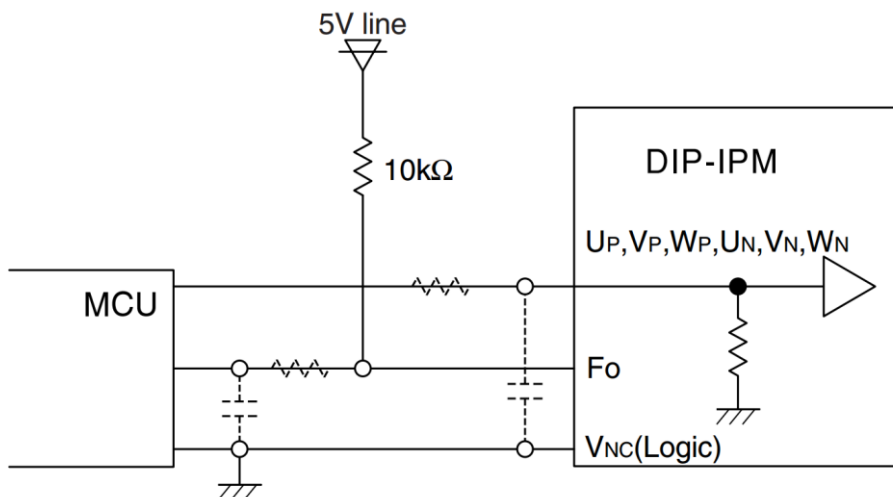


图8. 推荐的MCU接口

Figure8. Recommended MCU Interface and Bootstrap Circuit with Parameters

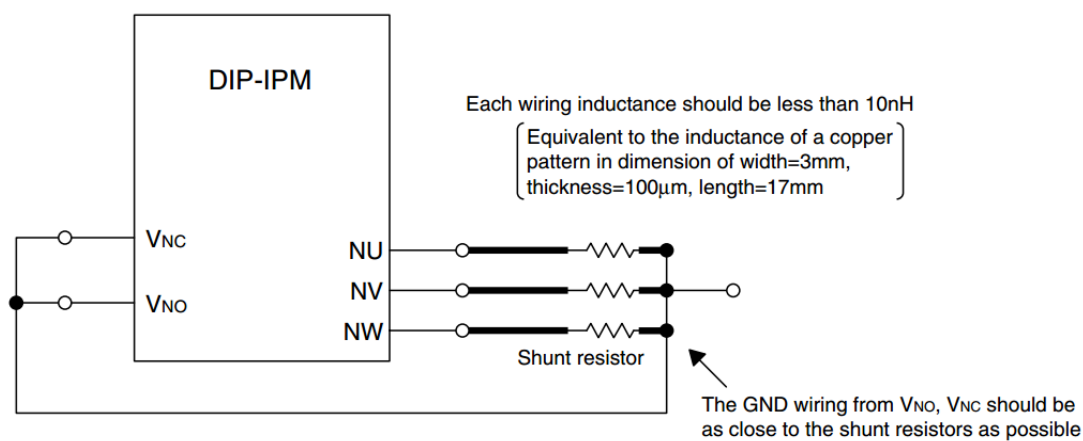


图9. 推荐的分流电阻布线

Figure9. Recommended Wiring Around The Shunt Resistor

R25=47kΩ±5%				B25/50=4050K±2%			
Temp(°C)	Rmin(KΩ)	Rnor(KΩ)	Rmax(KΩ)	Temp(°C)	Rmin(KΩ)	Rnor(KΩ)	Rmax(KΩ)
-40	1399.615	1580.590	1780.504	3	123.714	132.962	142.544
-39	1311.659	1479.301	1664.198	4	117.799	126.478	135.458
-38	1229.811	1385.170	1556.254	5	112.197	120.344	128.760
-37	1153.607	1297.644	1456.016	6	106.890	114.538	122.427
-36	1082.623	1216.220	1362.886	7	101.862	109.043	116.439
-35	1016.468	1140.432	1276.316	8	97.095	103.839	110.773
-34	954.783	1069.857	1195.803	9	92.576	98.910	105.412
-33	897.239	1004.102	1120.885	10	88.290	94.239	100.338
-32	843.531	942.810	1051.138	11	84.224	89.813	95.533
-31	793.381	885.649	986.175	12	80.366	85.617	90.982
-30	746.531	832.315	925.637	13	76.704	81.637	86.671
-29	702.743	782.530	869.197	14	73.226	77.862	82.585
-28	661.798	736.034	816.551	15	69.924	74.281	78.712
-27	623.496	692.592	767.422	16	66.786	70.881	75.040
-26	587.648	651.984	721.554	17	63.805	67.654	71.556
-25	554.084	614.008	678.711	18	60.971	64.590	68.252
-24	522.644	578.477	638.674	19	58.277	61.679	65.116
-23	493.181	545.221	601.245	20	55.715	58.913	62.139
-22	465.559	514.079	566.237	21	53.278	56.284	59.312
-21	439.652	484.905	533.479	22	50.959	53.786	56.627
-20	415.344	457.563	502.814	23	48.752	51.410	54.077
-19	392.606	432.017	474.197	24	46.651	49.150	51.654
-18	371.245	408.047	447.374	25	44.650	47.000	49.350
-17	351.171	385.545	422.225	26	42.669	44.954	47.244
-16	332.299	364.414	398.634	27	40.784	43.007	45.238
-15	314.550	344.563	376.497	28	38.992	41.153	43.326
-14	297.850	325.907	355.716	29	37.286	39.388	41.504
-13	282.132	308.367	336.199	30	35.663	37.706	39.766
-12	267.333	291.871	317.864	31	34.119	36.104	38.110
-11	253.394	276.350	300.632	32	32.648	34.577	36.530
-10	240.260	261.741	284.431	33	31.247	33.122	35.023
-9	227.880	247.987	269.193	34	29.912	31.735	33.584
-8	216.207	235.031	254.857	35	28.641	30.412	32.211
-7	205.196	222.825	241.362	36	27.429	29.150	30.901
-6	194.807	211.319	228.657	37	26.274	27.945	29.649
-5	185.001	200.470	216.690	38	25.172	26.796	28.454
-4	175.742	190.238	205.414	39	24.122	25.700	27.312
-3	166.997	180.583	194.786	40	23.120	24.653	26.222
-2	158.735	171.471	184.765	41	22.164	23.653	25.179
-1	150.925	162.867	175.314	42	21.251	22.698	24.182
0	143.542	154.741	166.397	43	20.381	21.786	23.229
1	136.564	147.069	157.986	44	19.549	20.914	22.318
2	129.962	139.818	150.045	45	18.755	20.081	21.447

R25=47kΩ±5%				B25/50=4050K±2%			
Temp(°C)	Rmin(KΩ)	Rnor(KΩ)	Rmax(KΩ)	Temp(°C)	Rmin(KΩ)	Rnor(KΩ)	Rmax(KΩ)
46	17.997	19.285	20.613	89	3.6434	4.0283	4.4428
47	17.272	18.523	19.815	90	3.5234	3.8982	4.3021
48	16.580	17.795	19.051	91	3.4079	3.7729	4.1665
49	15.919	17.099	18.320	92	3.2966	3.6520	4.0356
50	15.286	16.432	17.621	93	3.1894	3.5355	3.9095
51	14.685	15.799	16.954	94	3.0861	3.4232	3.7877
52	14.110	15.192	16.316	95	2.9865	3.3149	3.6703
53	13.560	14.612	15.705	96	2.8906	3.2105	3.5569
54	13.035	14.056	15.119	97	2.7981	3.1098	3.4475
55	12.532	13.524	14.558	98	2.7090	3.0126	3.3419
56	12.050	13.014	14.021	99	2.6230	2.9189	3.2400
57	11.589	12.526	13.505	100	2.5401	2.8284	3.1416
58	11.148	12.059	13.011	101	2.4602	2.7411	3.0465
59	10.726	11.611	12.537	102	2.3831	2.6568	2.9547
60	10.321	11.181	12.082	103	2.3087	2.5755	2.8660
61	9.9340	10.770	11.646	104	2.2369	2.4970	2.7803
62	9.5628	10.375	11.228	105	2.1676	2.4211	2.6975
63	9.2071	9.9964	10.826	106	2.1007	2.3478	2.6175
64	8.8661	9.6333	10.441	107	2.0361	2.2771	2.5402
65	8.5393	9.2850	10.071	108	1.9738	2.2087	2.4654
66	8.2259	8.9508	9.7153	109	1.9136	2.1427	2.3932
67	7.9253	8.6301	9.3740	110	1.8555	2.0789	2.3233
68	7.6370	8.3222	9.0462	111	1.7994	2.0172	2.2557
69	7.3605	8.0266	8.7312	112	1.7452	1.9576	2.1904
70	7.0951	7.7428	8.4285	113	1.6928	1.8999	2.1271
71	6.8404	7.4702	8.1376	114	1.6421	1.8442	2.0660
72	6.5959	7.2083	7.8579	115	1.5932	1.7903	2.0068
73	6.3611	6.9567	7.5891	116	1.5459	1.7382	1.9496
74	6.1357	6.7150	7.3305	117	1.5002	1.6878	1.8942
75	5.9193	6.4826	7.0819	118	1.4560	1.6391	1.8405
76	5.7113	6.2593	6.8427	119	1.4133	1.5919	1.7886
77	5.5115	6.0446	6.6125	120	1.3720	1.5463	1.7383
78	5.3196	5.8381	6.3911	121	1.3321	1.5021	1.6897
79	5.1351	5.6395	6.1780	122	1.2934	1.4594	1.6425
80	4.9577	5.4485	5.9728	123	1.2560	1.4180	1.5969
81	4.7880	5.2656	5.7763	124	1.2198	1.3780	1.5527
82	4.6248	5.0896	5.5870	125	1.1848	1.3392	1.5099
83	4.4679	4.9202	5.4047	126	1.1510	1.3016	1.4684
84	4.3170	4.7572	5.2292	127	1.1182	1.2653	1.4282
85	4.1717	4.6002	5.0600	128	1.0864	1.2301	1.3892
86	4.0320	4.4491	4.8971	129	1.0557	1.1960	1.3514
87	3.8975	4.3036	4.7400	130	1.0260	1.1629	1.3148
88	3.7681	4.1634	4.5887				

图10. R-T表
Figure 10. R-T Table

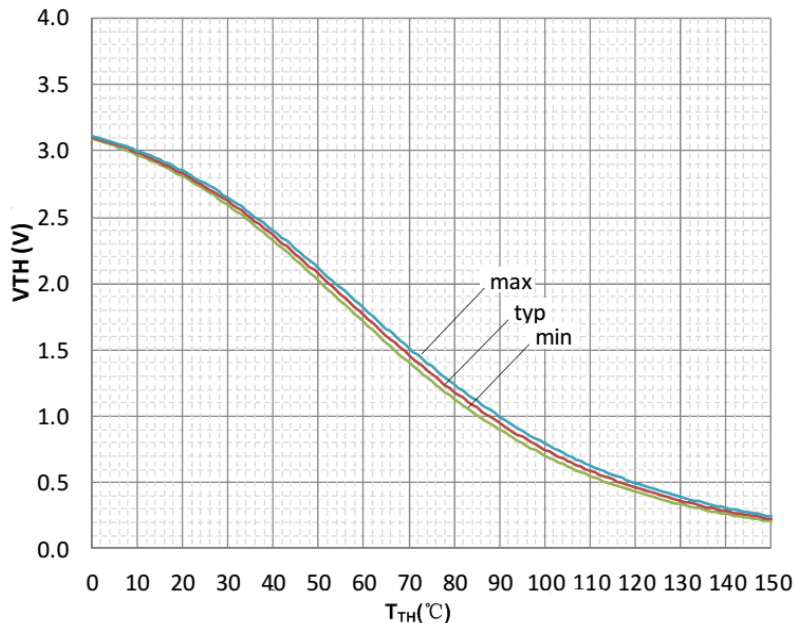


图13. V_{TH} vs T_{TH} , V_{TH} 通过9.76 KΩ (1%, 100ppm)的电阻上拉至3.3的 V_{DD} , 推荐电压波动为1%
Figure13. V_{TH} vs T_{TH} with V_{TH} pin pulled up to V_{DD} with a 9.76KΩ (1%, 100ppm) resistor.
A 3.3V, 1% variation in V_{DD} is assumed.

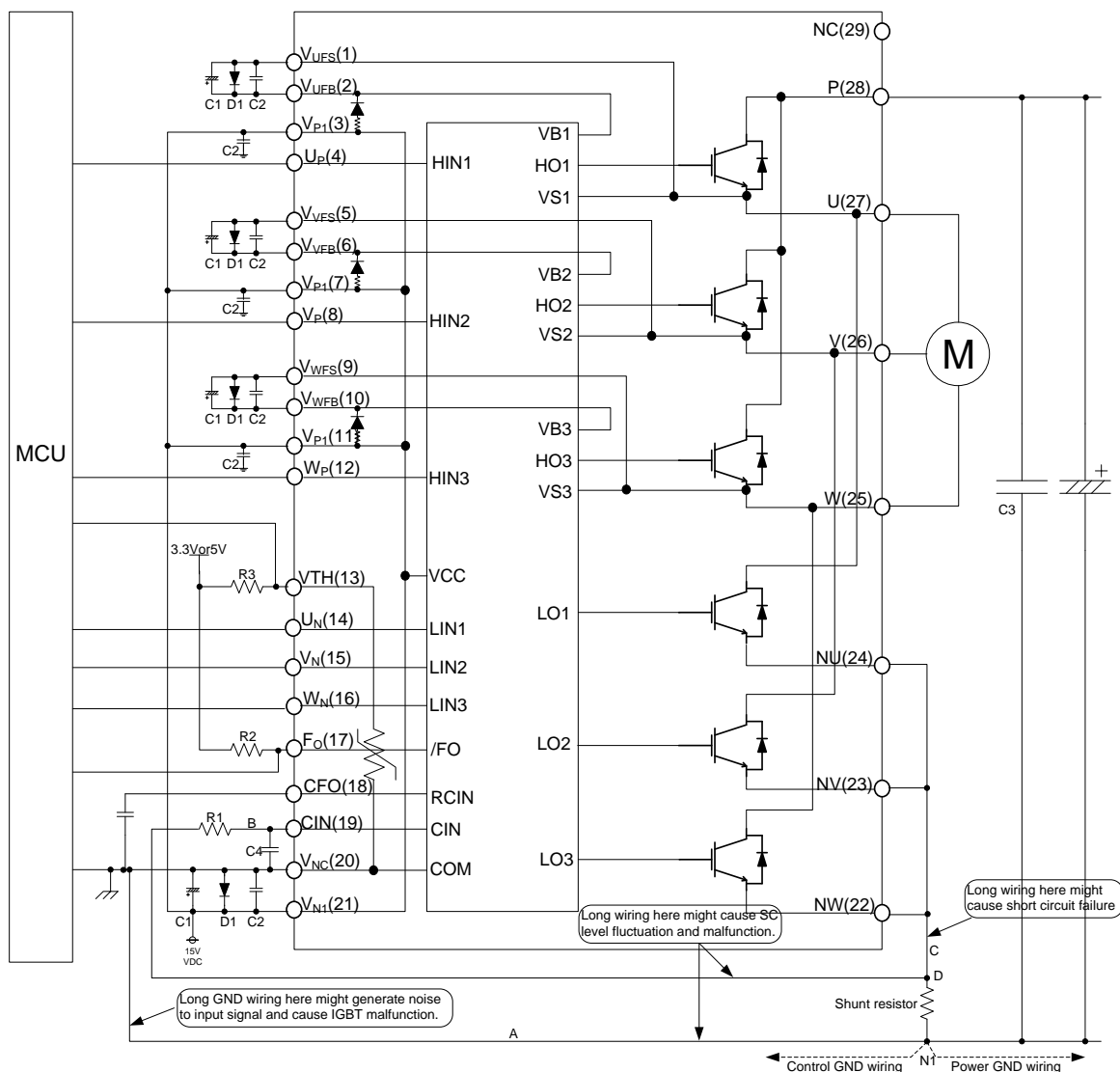


图12. 典型应用电路

Figure12. Typical Application Circuit

注/Note:

1. 推荐在电源上加稳压二极管D1 (24V/1W)，防止浪涌电压损坏IPM。
It is recommended to insert a Zener diode D1 (24V/1W) between each pair of control supply terminals to prevent surge destruction.
2. 输入正逻辑，下拉电阻5.4KΩ。为了避免故障，应尽可能缩短每个输入端的连线（小于2-3cm）。
Input logic is High-active. There is a 5.4KΩ pull down resistor. To avoid malfunction, the wiring of each input should be as short as possible (less than 2-3cm).
3. 为避免保护功能出错，应尽可能缩短R1和C4周围的连线。
To prevent errors of the protection function, the wiring of B, C and D point should be as short as possible.
4. 在短路保护电路中，R1C4的时间常数应在1.5 ~ 2.0 μs 的范围内进行选择。
In the short-circuit protection circuit, please select the R1C4 time constant in the range 1.5 ~ 2.0 μs.
5. 每个电容都应尽可能地靠近产品的引脚安装。（C1: 温度特性好，频率特性好；C2: 0.22u-2uF, 温度特性好，频率特性好）
Each capacitor should be mounted as close to the pins of the product as possible. (C1: good temperature, frequency characteristic electrolytic type and C2: 0.22u-2uF, good temperature, frequency and DC bias characteristic ceramic type are recommended.)
6. 为防止浪涌的破坏，应尽可能缩短滤波电容和P & GND 引脚间的连线。推荐在P & GND 引脚间使用0.1 ~ 0.22 μF 的高频无感电容C3。
To prevent surge destruction, the wiring between the smoothing capacitor and the P & GND pins should be as short as possible. The use of a high-frequency non-inductive C3 capacitor of around 0.1 ~ 0.22 μF between the P & GND pins is recommended.
7. 在各种家用电器设备中，几乎都用到了继电器。在这些情况下，MCU 和继电器之间应留有足够的距离。
Relays are used at almost every systems of electrical equipments at industrial application. In these cases, there should be sufficient distance between the CPU and the relays.
8. 控制地和功率地应该分开不限，相交于一点N1。

- It is recommended to connect control GND and power GND at only a point N1 (near the terminal of shunt resistor).
9. 为避免误动作，A、B、C布线应尽可能的短。
To prevent malfunction, the wiring of A, B, C should be as short as possible.
10. D点应该靠近分流电阻端。当使用一个分流电阻时，NU, NV, NW三个端子应相互靠近。推荐使用高精度温度系数低的分流电阻。
The point D at which the wiring to C4 filter is divided should be near the terminal of shunt resistor. NU, NV, NW terminals should be connected at near NU, NV, NW terminals when it is used by one shunt operation. Low inductance SMD type with tight tolerance, temp-compensated type is recommended for shunt resistor.
11. FO是集电极开路，需要用电阻上拉到MCU的电源电压（5V或3.3V）， I_{FO} 电流不得超过1mA。
FO output is open drain type. It should be pulled up to power supply of MCU (e.g. 5V, 3.3V) by a resistor that makes I_{FO} up to 1mA.
12. 高频噪声施加在控制电源上会造成IC误动作，导致IPM错误运行。为避免这个问题，控制电压应满足 $dV/dt \leq +/-1V/\mu s$, $V_{ripple} \leq 2Vp-p$ 。
If high frequency noise superimposed to the control supply line, IC malfunction might happen and cause DIIPM erroneous operation. To avoid such problem, line ripple voltage should meet $dV/dt \leq +/-1V/\mu s$, $V_{ripple} \leq 2Vp-p$.

轮廓封装详图 / Detailed Package Outline Drawings

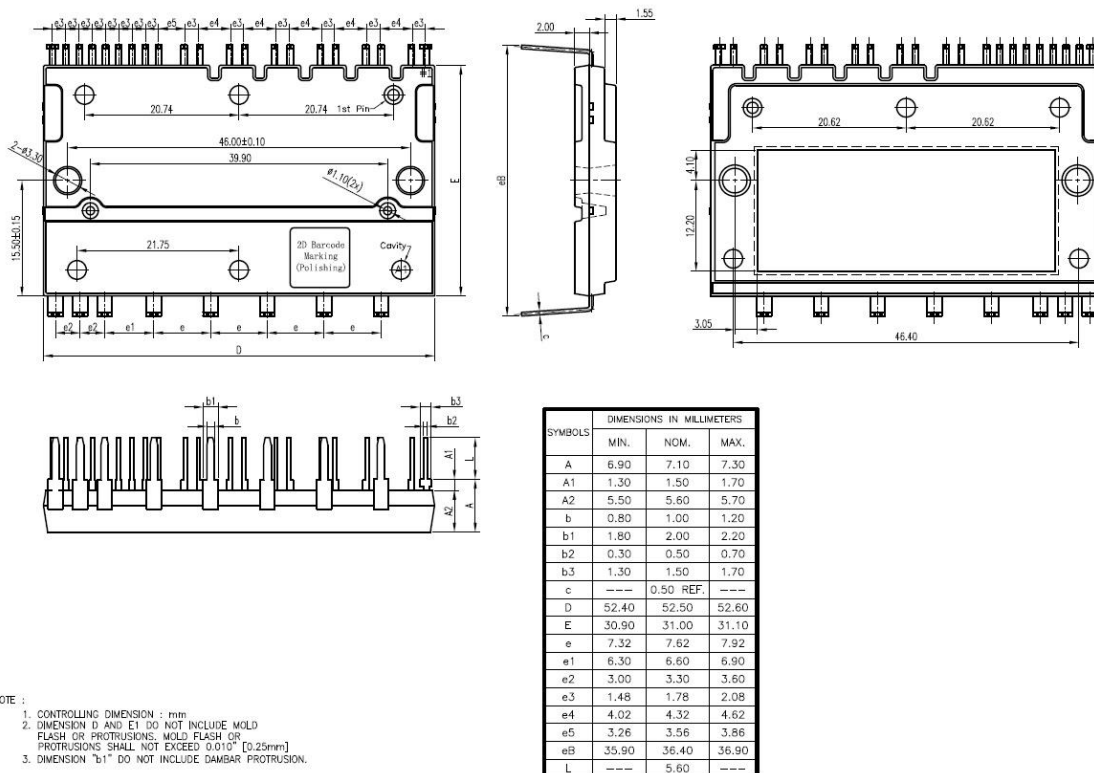


图13. 封装轮廓

Figure13. Package Outline

封装打标和订货信息/Package Marking & Ordering Information

Device Marking	Device	Package	Reel Size	Packing Type	Quantity
XNS10S12FT	XNS10S12FT	IPM-DIP29	-	RAIL	10

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