BIPN60015C

Intelligent Power Module

General Description

BIPN60015C is an advanced intelligent power module that BYD has newly developed and designed to provide very compact and high performance as ac motor drivers mainly targeting low-power inverter-driven applications like air conditioner and washing machine. It combines optimized circuit protection and drive matched to low-loss IGBT. System reliability is further enhanced by the integrated under-voltage lock-out and Over-current protection. The high speed built-in HVIC provides optocoupler less single-supply IGBT gate driving capability that further reduce the over all size of the inverter system design. Each phase current of inverter can be monitored separately due to the divided negative dc terminals.

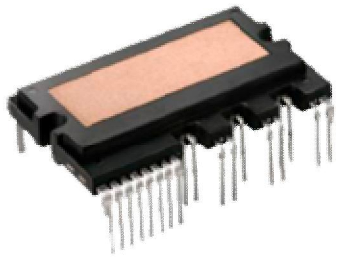
Applications

- Three-phase inverter drive for small power ac motor control
- Home appliances applications like air conditioner and washing machine

Package BIP27-4426

Features

- Very low thermal resistance due to using DBC
- 600V-15A 3-phase IGBT inverter bridge including control ICs for gate driving and protection
- Divided negative dc-link terminals for inverter current sensing applications
- Single-grounded power supply due to built-in HVIC and bootstrap diode
- Isolation rating of 2500Vrms/min



Typical Application Circuit

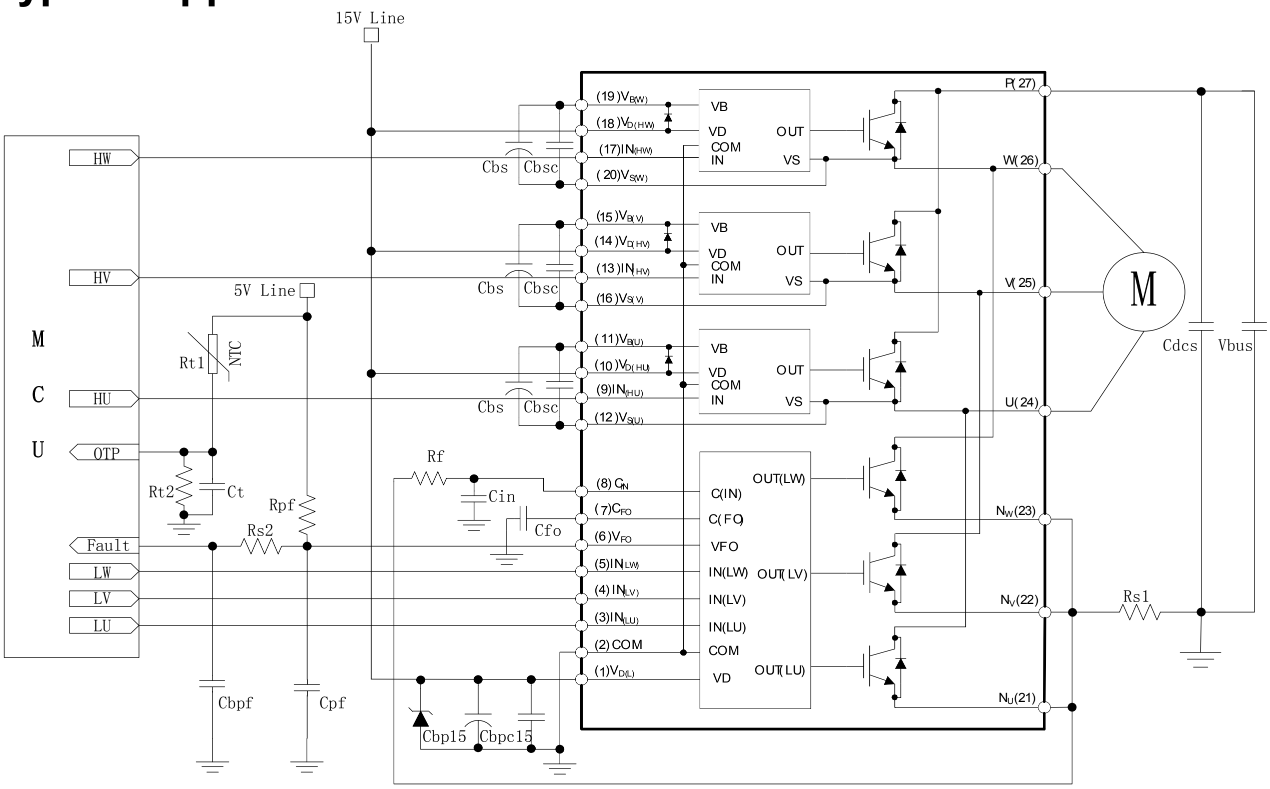


Fig 1. Typical Application Circuit

Pin Configuration

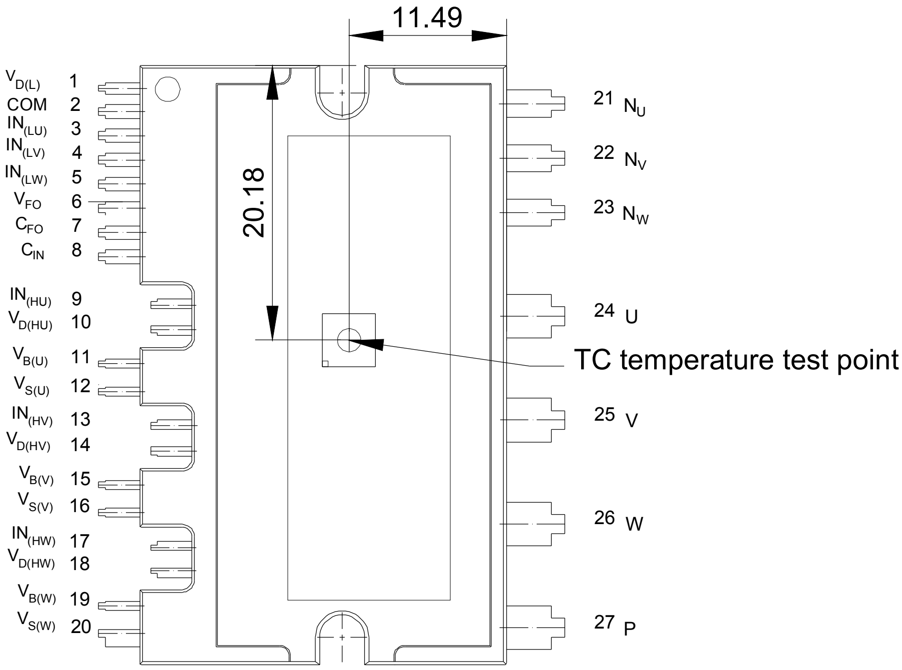


Fig 2. Pin Configuration(Top View)

Pin Descriptions

Pin	Name	Descriptions
1	$V_{D(L)}$	Low-side common bias voltage for IC and IGBTs driving
2	COM	Common supply ground
3	$IN_{(LU)}$	Signal input for low-side U phase
4	$IN_{(LV)}$	Signal input for low-side V phase
5	$IN_{(LW)}$	Signal input for low-side W phase
6	V_{FO}	Fault output
7	C_{FO}	Capacitor for fault output duration time selection
8	C_{IN}	Capacitor (low-pass Filter) for over-current detection input
9	$IN_{(HU}$	Signal input for high-side U phase
10	$V_{D(HU)}$	High-side bias voltage for U phase IC
11	$V_{B(U)}$	High-side bias voltage for U phase IGBT driving
12	$V_{S(U)}$	High-side bias voltage ground for U phase IGBT driving
13	$IN_{(HV)}$	Signal input for high-side V phase
14	$V_{D(HV)}$	High-side bias voltage for V phase IC
15	$V_{B(V)}$	High-side bias voltage for V phase IGBT driving
16	$V_{S(V)}$	High-side bias voltage ground for V phase IGBT driving
17	$IN_{(HW)}$	Signal input for high-side W phase
18	$V_{D(HW)}$	High-side bias voltage for w phase IC
19	$V_{B(W)}$	High-side bias voltage for w Phase IGBT driving
20	$V_{S(W)}$	High-side bias voltage ground for W phase IGBT driving
21	N_U	Negative dc–link input for U phase
22	N_V	Negative dc–link input for V phase
23	N_W	Negative dc–link input for W phase
24	U	Output for U phase

25	V	Output for V phase
26	W	Output for W phase
27	P	Positive dc–link input

Absolute Maximum Ratings (T_J = 25°C, unless otherwise noted)

Inverter Part

Symbol	Parameter	Conditions	Ratings	Units
V_{PN}	Supply voltage	Applied between P-N_U, N_V, N_W	450	V
V_{PN}(surge)	Supply voltage (surge)	Applied between P-N_U, N_V, N_W	500	V
V_{CES}	Collector-emitter voltage	V_{GE}=0V,I_{CES}=100uA,T_J=25°C	600	V
$\pm I_C$	Each IGBT collector current	T_C = 25°C	15	A
$\pm I_{CP}$	Each IGBT collector current (peak)	T_C = 25°C , less than 1ms	30	A
P_C	Collector dissipation	T_C = 25°C, per 1 chip	50	W
T_J	Junction temperature	(**Note 1**)	-20~+125	°C

Note 1 : The maximum junction temperature rating of the power chips integrated within the IPM is 150°C (@ $T_C \le$ 100°C). However, to ensure safe operation of the IPM, the average junction temperature should be limited to T_J (ave) ≤ 125°C (@ $T_C \le$ 100°C).

Control Part

Symbol	Parameter	Conditions	Ratings	Units
V_D	Control supply voltage	Applied between $V_{D(HU)}$, $V_{D(HV)}$, $V_{D(HW)}$, $V_{D(L)}$ -COM	20	V
V_{DB}	Control supply voltage	Applied between $V_{B(U)}$-$V_{S(U)}$, $V_{B(V)}$-$V_{S(V)}$, $V_{B(W)}$ -$V_{S(W)}$	20	V
V_{IN}	Input voltage	Applied between $IN_{(HU)}$, $IN_{(HV)}$, $IN_{(HW)}$, $IN_{(LU)}$, $IN_{(LV)}$,$IN_{(LW)}$)-COM	-0.3~VD+0.3	V
V_{FO}	Fault output supply voltage	Applied between V_{FO}-COM	-0.3~V_D+0.3	V
I_{FO}	Fault output current	Sink current at V_{FO} terminal	5.0	mA
V_{CIN}	Current sensing input voltage	Applied between C_{IN}-COM	-0.3~V_D+0.3	V

Bootstrap Diode Part

Symbol	Parameter	Conditions	Ratings	Units
V_{RRM}	Maximum Repetitive Reverse Voltage		600	V
I_F	Forward Current	TC = 25°C	0.5	A
I_{FP}	Forward Current (Peak)	T_C = 25°C, Under 1ms Pulse Width	2	A
T_J	Junction temperature		-20~+125	°C

Total System

Symbol	Parameter	Conditions	Ratings	Units

$V_{PN(PROT)}$	Self protection supply voltage limit (short circuit protection capability)	V_D = 13.5~16.5V, inverter part T_J = 125°C,non-repetitive,less than 5us	400	V
T_C	Module case operation temperature	–20 °C≤T_J ≤125 °C	-20~+100	°C
T_{STG}	Storage temperature		-40~+125	°C
V_{ISO}	Isolation voltage	60Hz, sinusoidal, AC 1 minute, connecting pins to heat-sink plate	2500	Vrms

Thermal Resistance

Symbol	Parameter	Conditions	Limits			Units
			Min.	Typ.	Max.	
Rth(j-c)Q	Junction to case thermal resistance	Inverter IGBT part (per 1/6 module)	-	-	2.02	°C/W
Rth(j-c)F		Inverter FRD part (per 1/6 module)	-	-	3.15	°C/W

Electrical Characteristics (T_J = 25°C, unless otherwise noted)

Inverter Part

Symbol		Parameter	Conditions	Limits			Units
				Min.	Typ.	Max.	
$V_{CE(SAT)}$		Collector-emitter saturation voltage	V_D=V_{BS}=15V,V_{IN}=5V,I_C=15A, T_J =25°C	---	2.0	2.3	V
V_F		FRD forward voltage	V_{IN}=0V , I_C=10A, T_J =25°C	---	1.6	2.0	
HS	ton	Switching times	V_{PN}=300V, V_D=V_{BS}=15V, I_C = 15A, V_{IN} = 0 ↔ 5V, Inductive load (**Note 2**)	---	680	---	ns
	tc(on)			---	200	---	
	toff			---	850	---	
	tc(off)			---	150	---	
LS	ton			---	630	---	
	tc(on)			---	240	---	
	toff			---	850	---	
	tc(off)			---	160	---	
I_{CES}		Collector-emitter leakage current	V_{CE}=V_{CES},V_{GE}=0V, T_J =25°C	---	---	100	μA

Note 2 : ton and toff include the propagation delay time of the internal drive IC. tc(on) and tc(off) are the switching time of IGBT itself under the given gate driving condition internally.See figure 3.

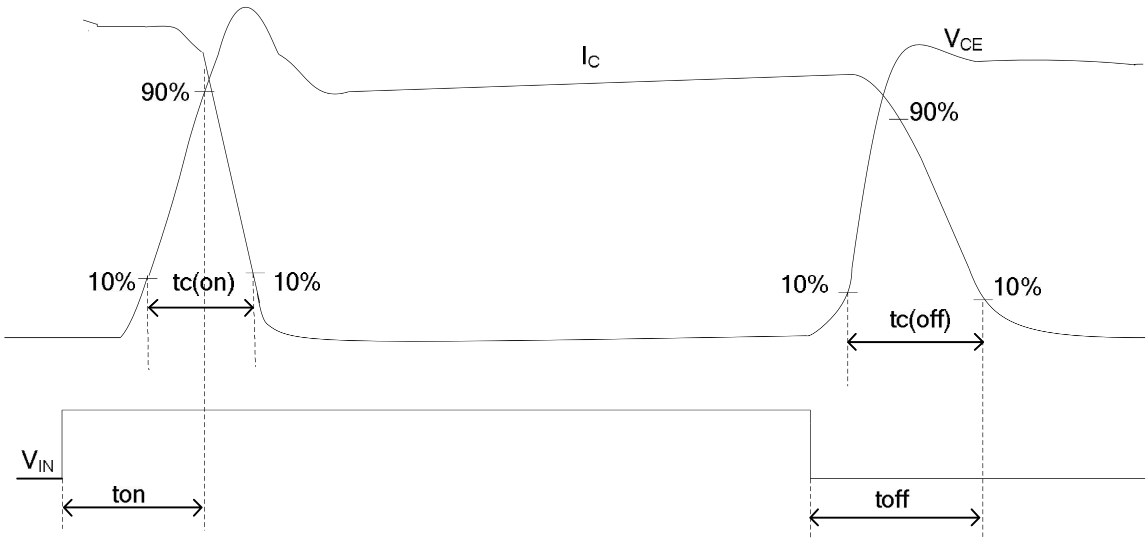


Fig 3. Switching Time Definition

Control Part

Symbol	Parameter	Conditions		Limits Min.	Limits Typ.	Limits Max.	Units
I_{DL}	Quiescent V_D supply current	V_D=15V,IN($_{LU,LV,LW}$) =0V	$V_{D(L)}$ -COM	---	---	600	μA
I_{DH}		V_D=15V,IN($_{HU,HV,HW}$) =0V	$V_{D(HU)}$,$V_{D(HV)}$, $V_{D(HW)}$ -COM	---	---	300	μA
I_{QBS}	Quiescent V_{BS} supply current	V_{BS}=15V,IN($_{HU,HV,HW}$)=0V	$V_{B(U)}$-$V_{S(U)}$,$V_{B(V)}$-$V_{S(V)}$,$V_{B(W)}$-$V_{S(W)}$	---	---	150	
V_{FOH}	Fault output voltage	V_{SC}=0V,V_{FO} circuit:4.7K to 5V pull-up		4.5	---	---	V
V_{FOL}		V_{SC}=1V,V_{FO} circuit:4.7K to 5V pull-up		---	---	0.8	
$V_{CIN(ref)}$	Short circuit trip level	TC = -20~100°C, V_D = 15V（**Note3**）		0.44	0.51	0.56	
UV_{DLD}	Supply circuit under-voltage protection	Detection level（LS）		11.0	12.0	13.0	V
UV_{DLR}		Rest level（LS）		12.0	13.0	14.0	
UV_{BSD}		Detection level（HS）		9.0	10.0	11.0	
UV_{BSR}		Rest level（HS）		10.0	11.0	12.0	
t_{FO}	Fault-out pulse width	C_{FO}=26nF（**Note4**）		---	1.80	---	ms
		C_{FO}=33nF（**Note4**）		---	2.30	---	
$V_{IN(ON)}$	ON threshold voltage	Applied between $IN_{(HU)}$, $IN_{(HV)}$, $IN_{(HW)}$, $IN_{(LU)}$,$IN_{(LV)}$,$IN_{(LW)}$-COM		3.0	---	---	V
$V_{IN(OFF)}$	OFF threshold voltage			---	---	0.8	

Note 3 : Short circuit protection is functioning only at the low-side.
Note 4 : The fault output pulse-width t_{FO} depends on the capacitance value of C_{FO} according to the following approximate equation : $C_{FO} \approx 14.3 * 10^{-6} * t_{FO}$ [F].

Bootstrap Diode Part

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_F	Forward Voltage	I_F = 0.5A, T_C = 25°C	---	1.15	---	V
t_{rr}	Reverse Recovery Time	I_F = 0.5A, T_C = 25°C	---	40	---	ns

Mechanical Characteristics and Ratings

Parameter	Conditions		Limits			Units
			Min.	Typ.	Max.	
Mounting torque	Mounting screw: - M3	Recommended 0.62N.m	0.51	0.62	0.72	N.m
Weight			---	15.0	---	g
Device flatness		(**See Fig 4**)	0	---	120	um

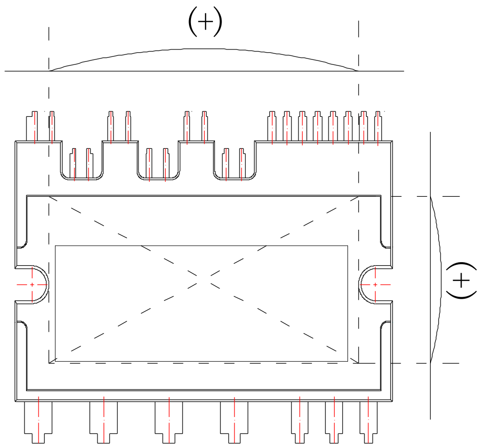


Fig 4. Flatness Measurement Position

Recommended Operating Conditions

Symbol	Parameter	Conditions	Recommended value			
			Min.	Typ.	Max.	Units
V_{PN}	Supply voltage	Applied between P -N_U,N_V,N_W	---	300	400	V
V_D	Control supply voltage	Applied between $V_{D(HU)}$,$V_{D(HV)}$,$V_{D(HW)}$, $V_{D(L)}$-COM	13.5	15.0	16.5	
V_{BS}	High-side bias voltage	Applied between $V_{B(U)}$ -$V_{S(U)}$,$V_{B(V)}$ -$V_{S(V)}$, $V_{B(W)}$ -$V_{S(W)}$	13.5	15.0	18.5	
ΔV_D, ΔV_{DB}	Control supply variation		-1	---	1	V/μs
t_{DEAD}	Blanking time for preventing arm-short	For each input signal	2.0	---	---	μs
f_{PWM}	PWMinput signal	-20°C≤T_C≤100°C, -20°C≤T_J≤125°C	---	---	20	KHz
V_{SEN}	Voltage for current sensing	Applied between N_U,N_V,N_W -COM (Including surge voltage)	-4	---	4	V

Time charts of IPM Protection Function

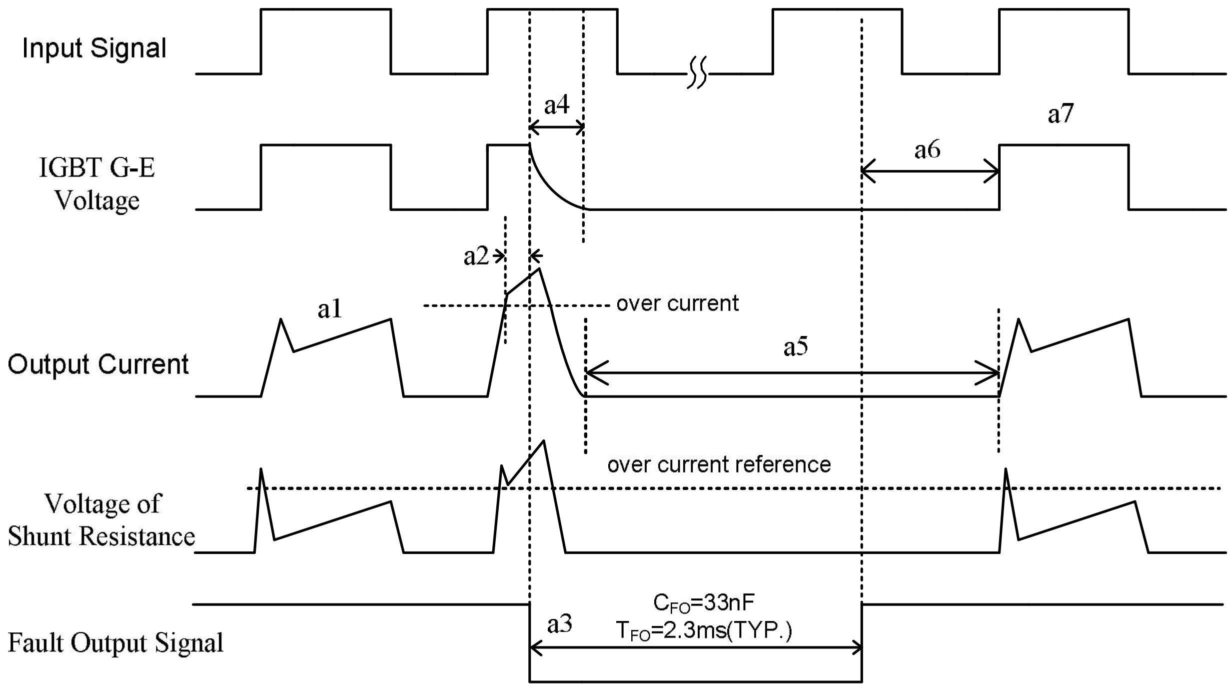


Fig 5.Over Current Protection

（Low-side only ,with the external shunt resistance and RC filter）

a1 Normal operation: IGBT ON and carrying current
a2 Over current detection and filter
a3 Fault output timer operation starts: The pulse width of the V_{FO} is set by the external capacitor C_{FO}
a4 IGBT turns off softly
a5 IGBT OFF state
a6 V_{FO} finishes output,but IGBTs don't turn on until inputting next ON signal.
a7 Normal operation: IGBT ON and outputs current by next ON signal(L→H).

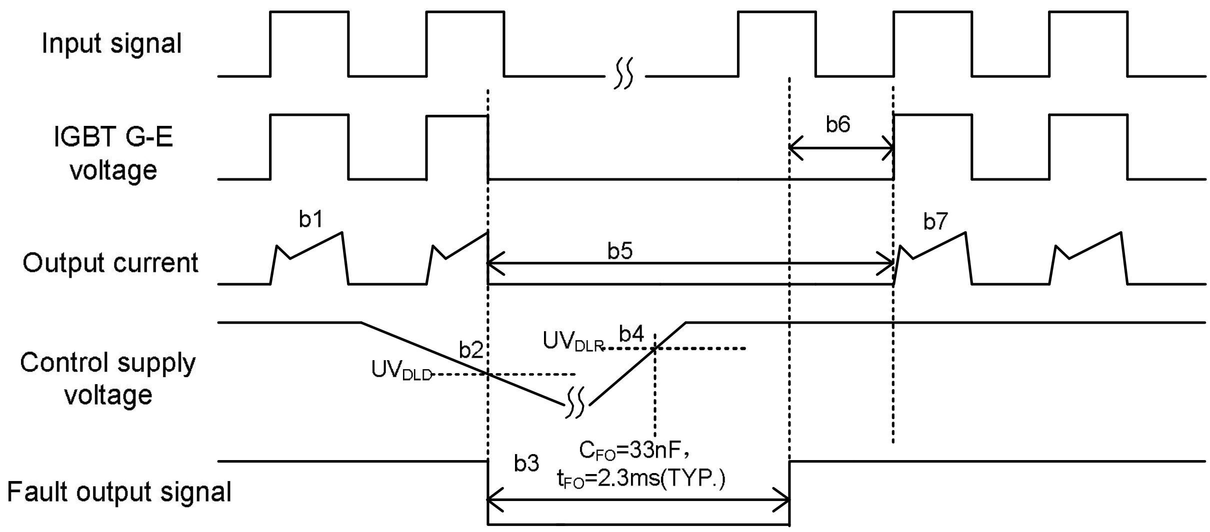


Fig 6.Under-Voltage Protection of Low-side

b1 Normal operation: IGBT ON and carrying current
b2 Under voltage detection（UV_{DLD}）
b3 Fault output timer operation starts: The pulse width of the V_{FO} is set by the external capacitor C_{FO}
b4 Under voltage reset（UV_{DLR}）
b5 IGBT OFF state
b6 VFO finishes output,but IGBTs don't turn on until inputting next ON signal.
b7 Normal operation: IGBT ON and outputs current by next ON signal(L→H).

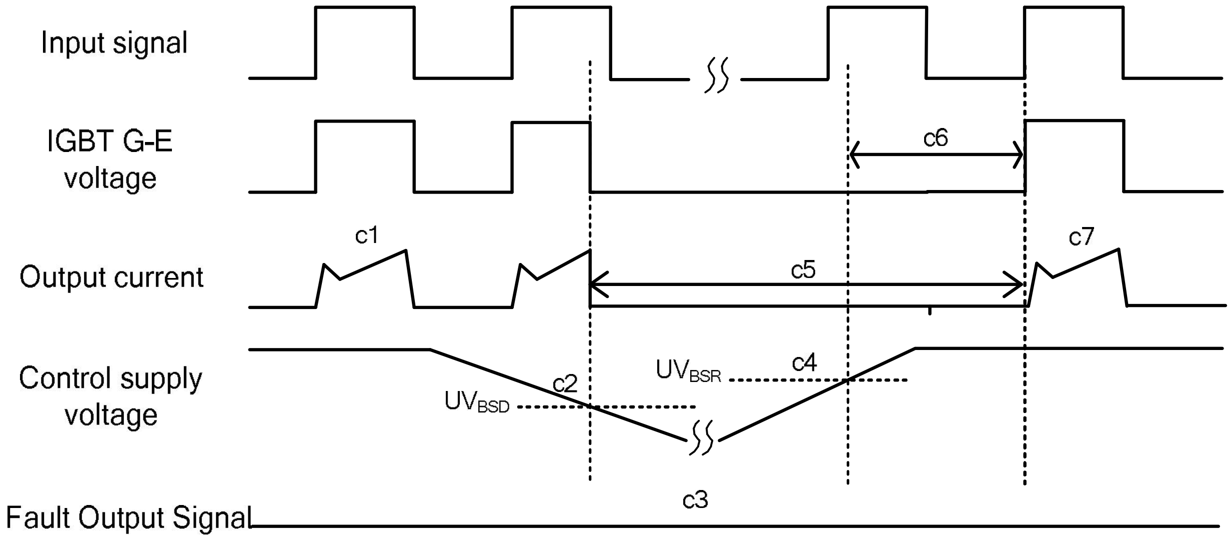


Fig 7.Under-Voltage Protection of High-side

c1 Normal operation: IGBT ON and carrying current
c2 Under voltage detection（UV_{BSD}）
c3 No fault output signal
c4 Under voltage reset（UV_{BSR}）
c5 IGBT OFF state
c6 Under voltage reset,but IGBTs don't turn on until inputting next ON signal.
c7 Normal operation: IGBT ON and outputs current by next ON signal(L→H).

Internal Equivalent Circuit and Input/Output Pins

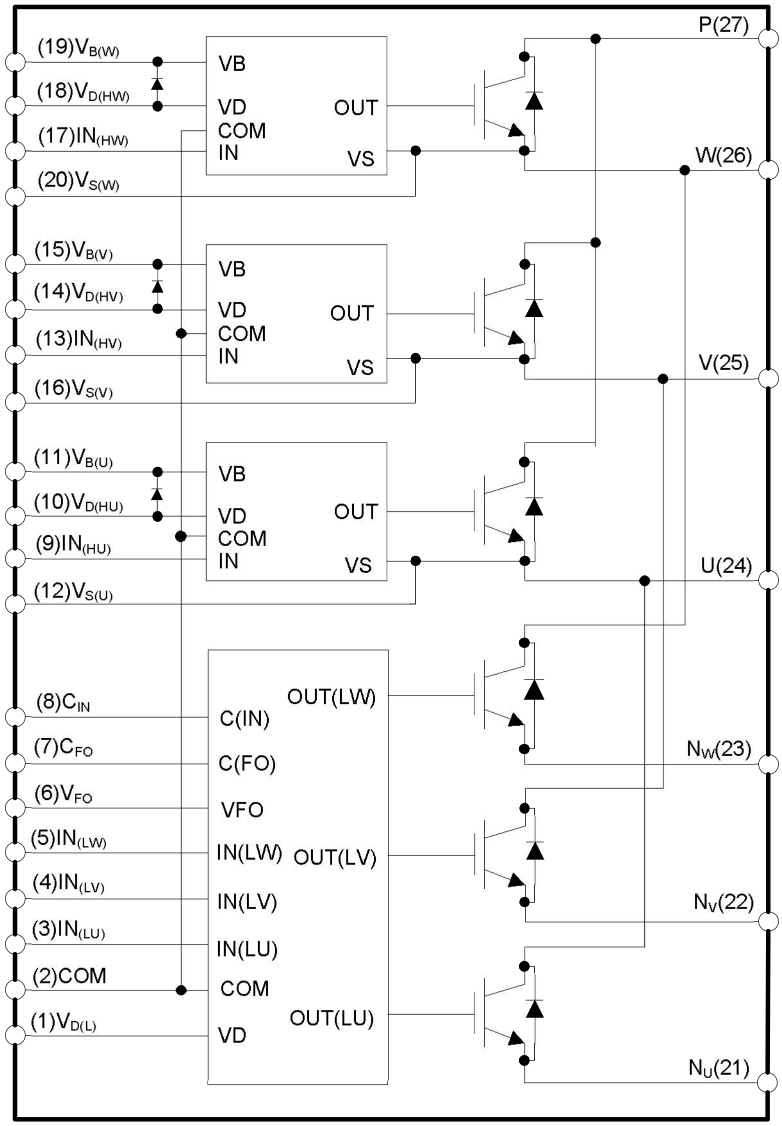


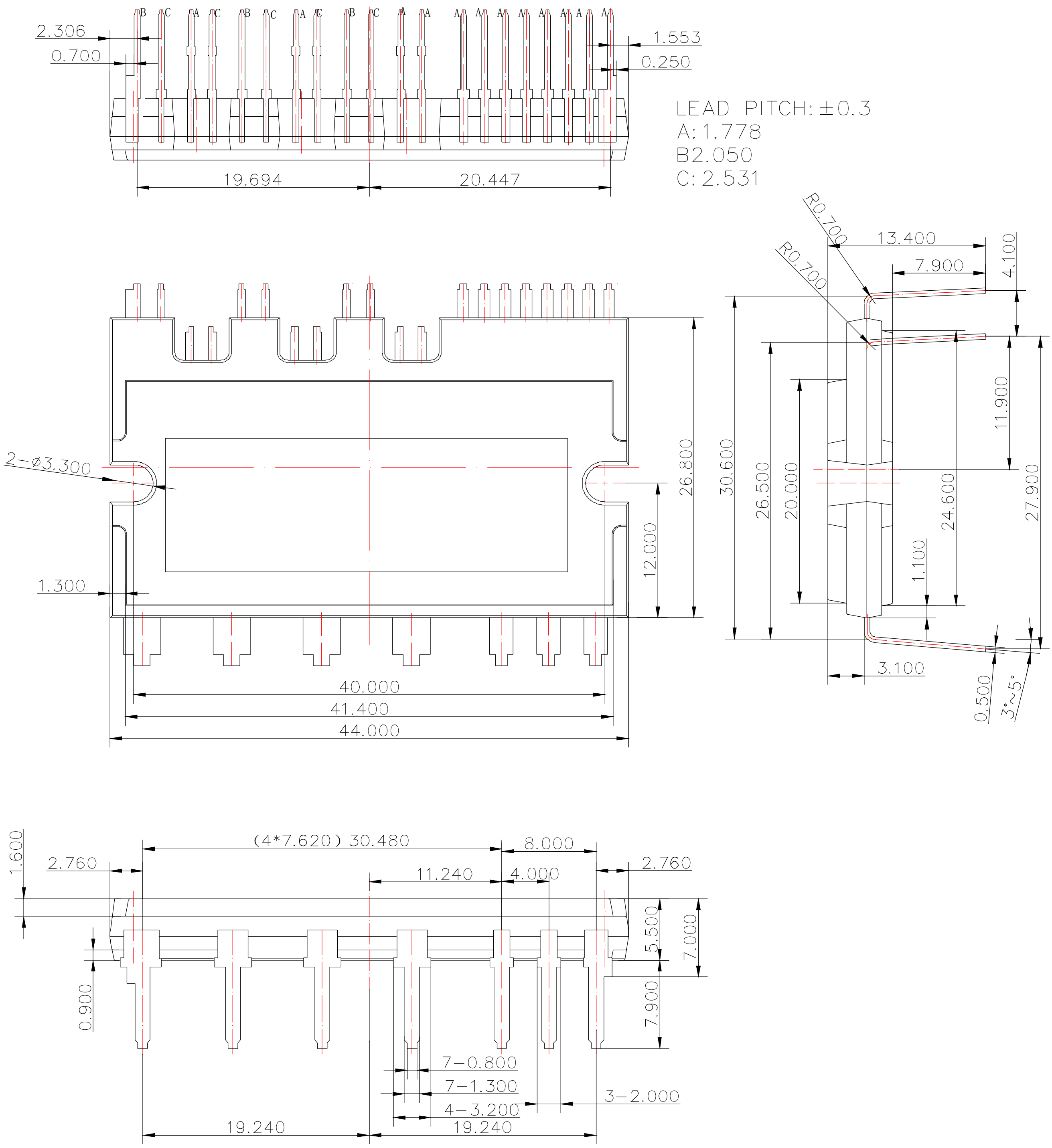
Fig 8. Internal Equivalent Circuit and Input/Output Pins

Note:

1. Inverter low-side is composed of three IGBTs, freewheeling diodes for each IGBT and one control IC. It has gate drive and protection functions
2. Inverter power side is composed of four inverter dc-link input terminals and three inverter output terminals
3. Inverter high-side is composed of three IGBTs, freewheeling diodes, bootstrap diodes and three drive ICs for each IGBT

Detailed Package Outline Drawings (Unit: mm)

Package:BIP27-4426



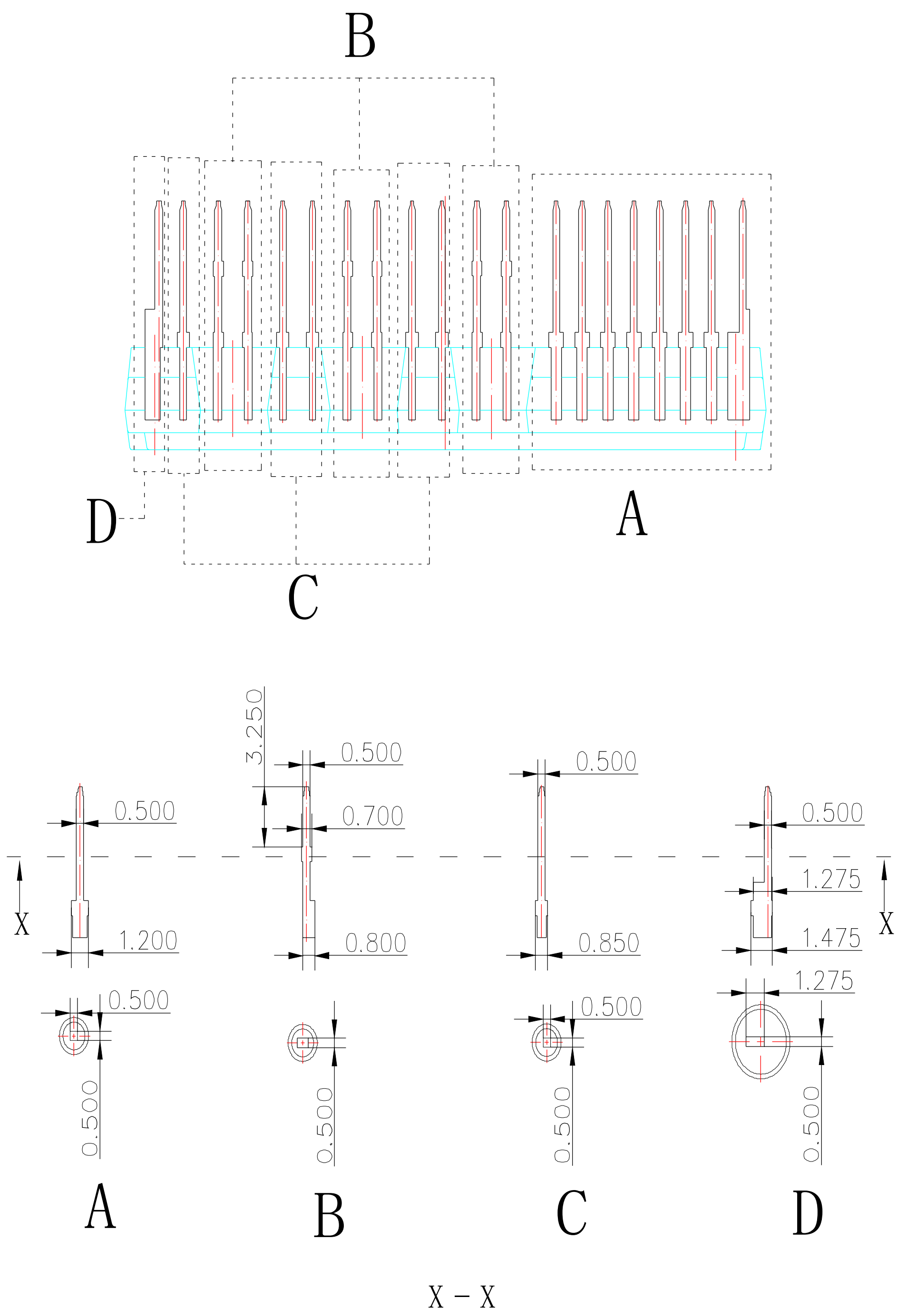


Fig 9.Detailed Package Outline Drawings

Packing

package	pcs/tube	tube/ inner box	inner box/ carton	pcs/carton
tube	10	7	5	350

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