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QUAD ±100V 2.5A 5-LEVEL ULTRASOUND PULSER

Rev.2.0_00

The ABLIC Inc. HDL6V5541HF is a quad, five-level RTZ, high-voltage, ultra high-speed pulser.
The HDL6V5541HF consists of logic interfaces, level translators, MOSFET gate drive buffers, and high-voltage, high-current MOSFETs.

Functions

- Quad 5-level pulser with 3-input per channel

Features

- 0 to ±100V output voltage
- ±2.5A source and sink peak current for the 1st and 2nd high-voltage pulses ($V_{PP}1/V_{NN}1$, $V_{PP}2/V_{NN}2$)
- ±1.0A source and sink peak current for active ground clamp
- 500Ω (±50mA) active ground clamp without blocking diode for anti-leakage (Analog SW type)
- 15V/ns output slew rate
- Up to 100MHz CMOS clock (transparent mode available)
- Symmetrical positive and negative pulse waveforms for low 2nd order harmonic distortion
- 1.8V to 5V CMOS logic interface
- Noise-cut diodes at each high-voltage output
- Embedded high-voltage clamp diodes
- 4-mode output current control for the 2nd high-voltage rail
- Automatic thermal protection with indicator
- Latch-up free, low crosstalk between channels by SOI CMOS technology
- 64-lead 9x9mm QFN package (RoHS compliant)

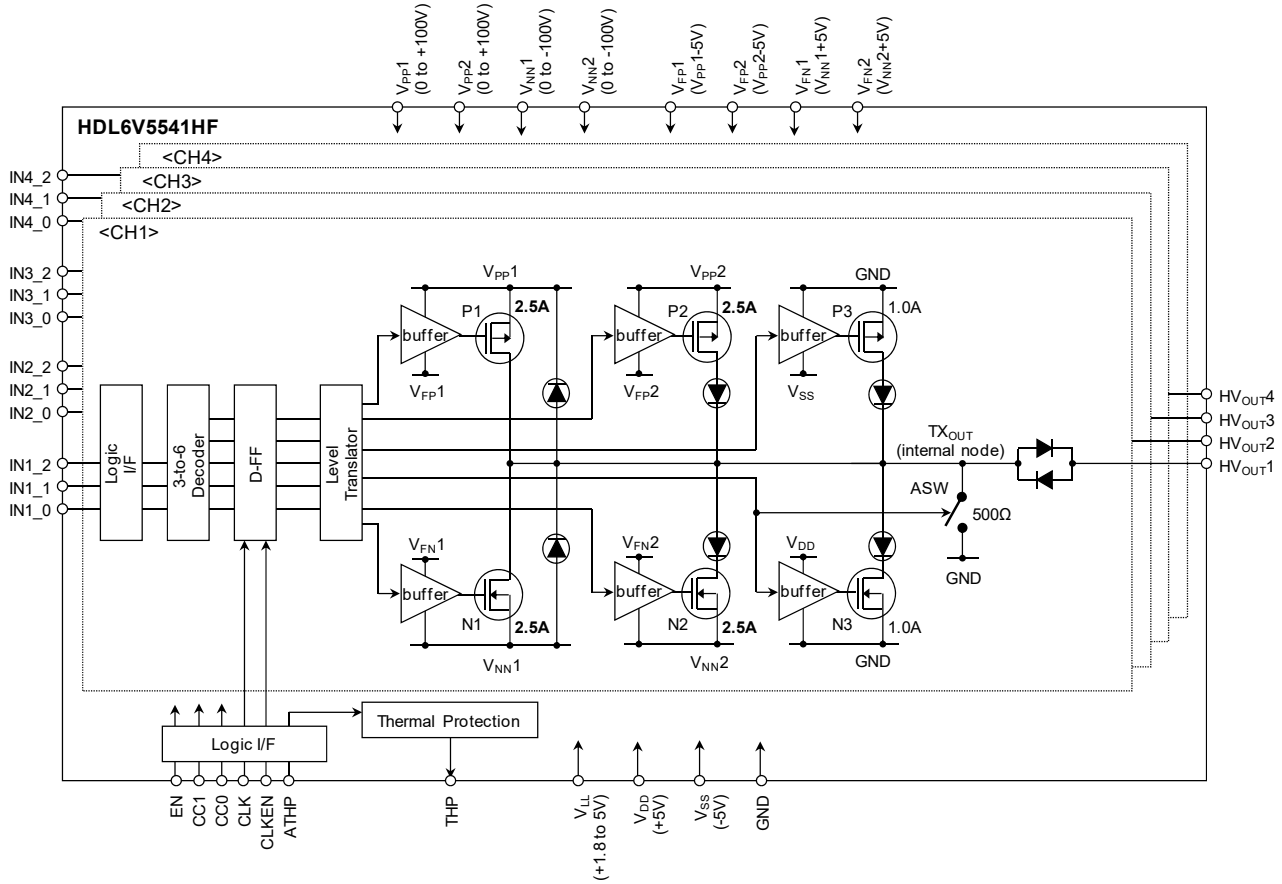


Fig.1 Block diagram

1. Absolute Maximum Ratings

T_A=25°C unless otherwise noted.

Table 1 Absolute Maximum Ratings

No.	Items	Symbol	Value	Units	Condition
1	Logic supply voltage	V_{LL}	-0.4 to +7	V	
2	Positive supply voltage	V_{DD}	-0.4 to +7	V	
3	Negative supply voltage	V_{SS}	-7 to +0.4	V	
4	Positive high-voltage supplies	$V_{PP}1$, $V_{PP}2$	-0.5 to +105	V	
5	Negative high-voltage supplies	$V_{NN}1$, $V_{NN}2$	-105 to +0.5	V	
6	Positive high-voltage difference	($V_{PP}1$-$V_{PP}2$)	-0.5 to +105	V	INx_[2:0]='001'
			-105 to +105	V	Other than above
7	Negative high-voltage difference	($V_{NN}1$-$V_{NN}2$)	-105 to +0.5	V	INx_[2:0]='101'
			-105 to +105	V	Other than above
8	High-voltage outputs (x=1~4)	$HV_{OUT}x$	-105 to +105	V	
9	Gate drive floating voltages	($V_{PP}1$- $V_{FP}1$), ($V_{PP}2$- $V_{FP}2$), ($V_{FN}1$- $V_{NN}1$), ($V_{FN}2$- $V_{NN}2$)	-0.4 to +7	V	
10	THP (Thermal Protection) output	THP	-0.4 to +7	V	
11	All Logic input voltages (x=1~4)	INx_[2:0], EN, CLK, CLKEN, CC1, CC0, ATHP	-0.4 to +7	V	
12	Operating junction temperature	T_{Jop}	-20 to +150	°C	
13	Storage temperature	T_{STG}	-55 to +150	°C	
14	Maximum power dissipation	P_{Dmax}	4	W	

NOTE: Stresses beyond the absolute maximum ratings may cause permanent damage to the product.

2. Operating Supply Voltages, Temperature, Logic Inputs, and Power sequencing

2.1 Operating Supply Voltages and Temperature

Table 2 Operating Supply Voltages and Temperature

No	Items	Symbol	Min	Typ	Max	Units	Condition
1	Logic supply voltage	V_{LL}	2.4	2.5 to 5	V_{DD}	V	CLK mode (CLK≤80MHz)
			2.6	2.7 to 5	V_{DD}	V	CLK mode (CLK≤100MHz)
			1.7	1.8 to 5	V_{DD}	V	TP mode (f_{OUT}≤20MHz)
			2.4	2.5 to 5	V_{DD}	V	TP mode (f_{OUT}≥20MHz)
2	Positive supply voltage	V_{DD}	4.75	5	5.25	V	
3	Negative supply voltage	V_{SS}	-5.25	-5	-4.75	V	
4	Positive high-voltage supplies	$V_{PP}1$, $V_{PP}2$	0	-	100	V	
5	Negative high-voltage supplies	$V_{NN}1$, $V_{NN}2$	-100	-	0	V	
6	Positive high-voltage difference	($V_{PP}1$-$V_{PP}2$)	0	-	100	V	
7	Negative high-voltage difference	($V_{NN}1$-$V_{NN}2$)	-100	-	0	V	

Table 2 Operating Supply Voltages and Temperature (continued)

No	Items	Symbol	Min	Typ	Max	Units	Condition
8	P1 gate drive floating voltage	$V_{FP}1$	$V_{PP}1$-5.25	$V_{PP}1$-5	$V_{PP}1$-4.75	V	
9	P2 gate drive floating voltage	$V_{FP}2$	$V_{PP}2$-5.25	$V_{PP}2$-5	$V_{PP}2$-4.75	V	
10	N1 gate drive floating voltage	$V_{FN}1$	$V_{NN}1$+4.75	$V_{NN}1$+5	$V_{NN}1$+5.25	V	
11	N2 gate drive floating voltage	$V_{FN}2$	$V_{NN}2$+4.75	$V_{NN}2$+5	$V_{NN}2$+5.25	V	
12	IC substrate voltage *	V_{SUB}	-	0	-	V	
13	$V_{PP}x$, $V_{NN}x$ slew rate (x=1,2)	SR_{MAX}	-	-	25	V/ms	
14	Operating Free-air Temperature	T_A	0	25	75	°C	

NOTE: * The package exposed pad internally connected to the IC substrate must be soldered to the ground.

2.2 Logic Inputs

There are two modes, transparent(TP) and clock(CLK) mode, to deal with the logic inputs INx_[2:0] (x=1~4).

TP mode:
Set CLKEN=1, CLK=0. INx_[2:0] are decoded, level-translated, then sent to high-voltage output stage. See table 3 for all the logic inputs.

CLK mode:
Set CLKEN=0. INx_[2:0] are decoded, clocked, level-translated, then sent to high-voltage output stage. See table 3 for all the logic inputs.

Table 3 Logic Inputs

No	Items	Symbol	Min	Typ	Max	Units	Condition
1	High-level logic input voltage	V_{IH}	0.8V_{LL}	-	V_{LL}	V	
2	Low-level logic input voltage	V_{IL}	0	-	0.2V_{LL}	V	
3	Logic input capacitance	C_{IN}	-	2	-	pF	
4	Logic input high current *1	I_{IH}	-10	-	10	μA	
5	Logic input low current *2	I_{IL}	-10	-	10	μA	
6	Logic input pulse width	t_{PW}	10	-	-	ns	
7	Input rise/fall time	t_r, t_f	-	-	2.0	ns	10% to 90% CLK, INx_[2:0] CLK mode, CLK≤100MHz
8	Input clock frequency	f_{CLK}	-	-	100	MHz	CLK mode, CLK
9	Duty cycle	D	40	50	60	%	D=τ/T, See Fig.2
10	Data setup time	t_{SU}	0.8	-	-	ns	CLK mode INx_[2:0], See Fig.2
11	Data hold time	t_{HLD}	2.8	-	-	ns	

NOTE:
*1) ATHP has 50μA leak at V_{LL}=2.5V due to 50kΩ internal pull-down resistor.
*2) EN, CC[1:0], and CLKEN have 50μA leak at V_{LL}=2.5V due to 50kΩ internal pull-up resistor.

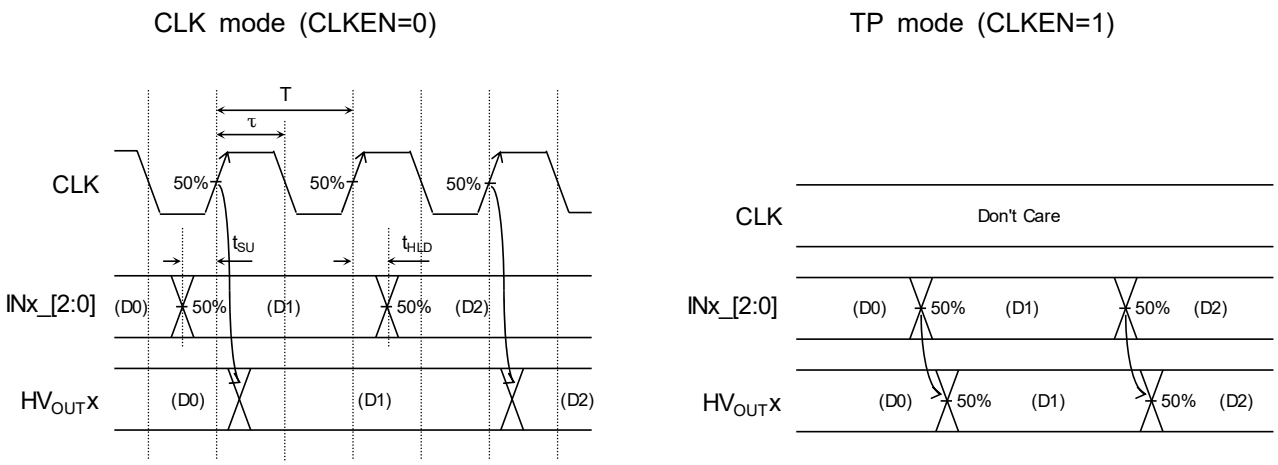


Fig.2 Setup/Hold Time

2.3 Power Supply Sequencing

Table 4 Power Supply Sequencing

Power-Up Sequence

1	V_{LL}
2	V_{DD}, V_{SS}
3	Set EN=1 ($HV_{OUT}x$=HiZ)
4	($V_{PP}1$-$V_{FP}1$), ($V_{PP}2$-$V_{FP}2$), ($V_{FN}1$-$V_{NN}1$), ($V_{FN}2$-$V_{NN}2$)
5	$V_{PP}1$, $V_{PP}2$, $V_{NN}1$, $V_{NN}2$
6	Logic control signals

Power-Down Sequence

1	Set EN=1 ($HV_{OUT}x$=HiZ)
2	$V_{PP}1$, $V_{PP}2$, $V_{NN}1$, $V_{NN}2$
3	($V_{PP}1$-$V_{FP}1$), ($V_{PP}2$-$V_{FP}2$), ($V_{FN}1$-$V_{NN}1$), ($V_{FN}2$-$V_{NN}2$)
4	V_{DD}, V_{SS}
5	V_{LL}

High-voltage Change Sequence during operation

1	Set EN=1 ($HV_{OUT}x$=HiZ)
2	Change $V_{PP}1$, $V_{PP}2$, $V_{NN}1$, $V_{NN}2$
3	Logic control signals

NOTE: It is indispensable to avoid the occurrence of the excessive voltage beyond the maximum rating in applying and cutting of the power supplies.

3. Typical Application Circuit

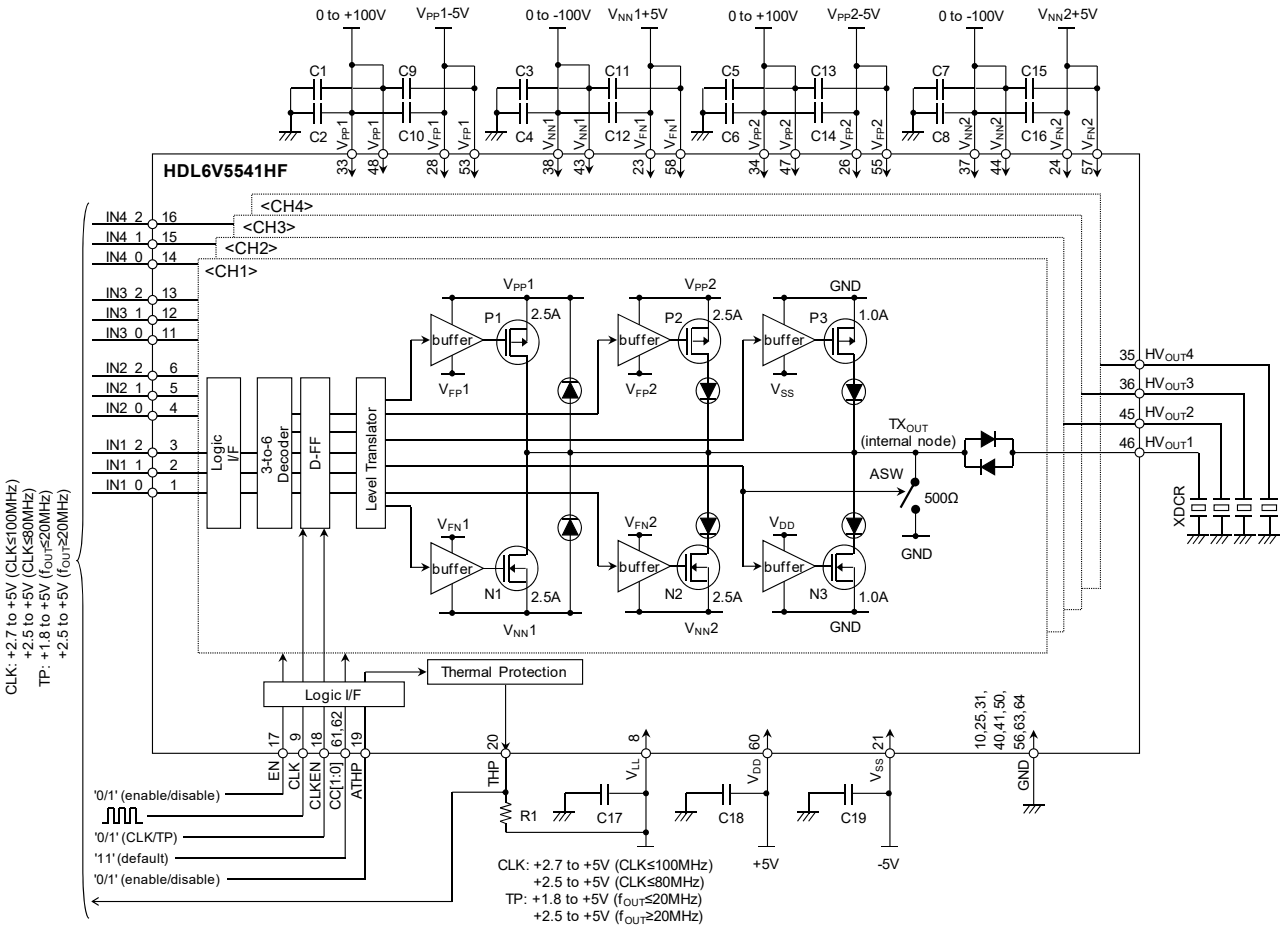


Fig. 3 Typical Application Circuit

NOTE:

1. High-voltage power supply pins, $V_{PP}x/V_{NN}x$ (x=1,2), can draw fast transient currents up to ±2.5A. Therefore, ceramic capacitors of ≥200V 0.1µF to 1µF (C1~8) should be connected as close to the pins as possible for bypassing purpose.
2. Ceramic capacitors of ≥16V 0.1µF to 1µF (C9~19) also should be connected between high-voltage power supply pins and corresponding floating voltage pins, $V_{FP}x/V_{FN}x$, and low-voltage power supply pins for bypassing purpose. Connect those as close to the pins as possible.
3. It is also important to minimize the trace length and to have enough trace width of those high voltage and floating voltage lines.
4. The thermal tab on the bottom of the package must be soldered to the GND.

4. Electrical Characteristics

4.1 Operating Supply Currents

Table 5 Operating Supply Currents

V_{LL}=2.5V, V_{DD}=5V, V_{SS}=-5V, $V_{FP}x=V_{PP}x$-5V, $V_{FN}x=V_{NN}x$+5V, T_A=25ºC, CLK=100MHz/0(CLKEN=0/1), ATHP=0, HV_{OUT} load=220pF//200Ω, unless otherwise specified.

No.	Items		Symbol	Spec			Units	Conditions
				Min	Typ	Max		
1	V_{LL} current	TP mode	I_{LLQD}	-	0	-	μA	Quiescent current-1 EN=1(Disable) INx_[2:0]='000' Current mode 4 (CC[1:0]='11') $V_{PP}1/V_{NN}1$=+/-100V $V_{PP}2/V_{NN}2$=+/-100V
		CLK mode		-	0.7	-	mA	
2	V_{DD} current	TP mode	I_{DDQD}	-	0.7	-	mA	
		CLK mode		-	12	-	mA	
3	V_{SS} current		I_{SSQD}	-	0.10	-	mA	
4	$V_{PP}1$ current		I_{PP1QD}	-	0	-	μA	
5	$V_{NN}1$ current		I_{NN1QD}	-	0	-	μA	
6	$V_{PP}2$ current		I_{PP2QD}	-	0.13	-	mA	
7	$V_{NN}2$ current		I_{NN2QD}	-	0.10	-	mA	
8	$V_{FP}1$ current		I_{FP1QD}	-	0	-	μA	
9	$V_{FP}2$ current		I_{FP2QD}	-	0.07	-	mA	
10	$V_{FN}1$ current		I_{FN1QD}	-	0	-	μA	
11	$V_{FN}2$ current		I_{FN2QD}	-	0.04	-	mA	
12	V_{LL} current	TP mode	I_{LLQE}	-	0.06	-	mA	Quiescent current-2 EN=0(Enable) INx_[2:0]='000' Current mode 4 (CC[1:0]='11') $V_{PP}1/V_{NN}1$=+/-100V $V_{PP}2/V_{NN}2$=+/-100V
		CLK mode		-	0.75	-	mA	
13	V_{DD} current	TP mode	I_{DDQE}	-	0.7	-	mA	
		CLK mode		-	12	-	mA	
14	V_{SS} current		I_{SSQE}	-	0.10	-	mA	
15	$V_{PP}1$ current		I_{PP1QE}	-	0	-	μA	
16	$V_{NN}1$ current		I_{NN1QE}	-	0	-	μA	
17	$V_{PP}2$ current		I_{PP2QE}	-	0.13	-	mA	
18	$V_{NN}2$ current		I_{NN2QE}	-	0.10	-	mA	
19	$V_{FP}1$ current		I_{FP1QE}	-	0	-	μA	
20	$V_{FP}2$ current		I_{FP2QE}	-	0.07	-	mA	
21	$V_{FN}1$ current		I_{FN1QE}	-	0	-	μA	
22	$V_{FN}2$ current		I_{FN2QE}	-	0.04	-	mA	

Table 5 Operating Supply Currents (continued)

No.	Items		Symbol	Spec			Units	Conditions
				Min	Typ	Max		
23	V_{LL} current	TP mode	I_{LLPW}	-	0.06	-	mA	PW Operating current EN=0 Current mode 4 (CC[1:0]='11') 4-channel active Bipolar 3-level 2-cycle f=5MHz, PRT=200µs $V_{PP}1/V_{NN}1$=+/-60V $V_{PP}2/V_{NN}2$=+/-60V
		CLK mode		-	0.75	-	mA	
24	V_{DD} current	TP mode	I_{DDPW}	-	2.5	-	mA	
		CLK mode		-	14	-	mA	
25	V_{SS} current		I_{SSPW}	-	2.1	-	mA	
26	$V_{PP}1$ current		I_{PP1PW}	-	2.2	-	mA	
27	$V_{NN}1$ current		I_{NN1PW}	-	2.5	-	mA	
28	$V_{PP}2$ current		I_{PP2PW}	-	0.13	-	mA	
29	$V_{NN}2$ current		I_{NN2PW}	-	0.10	-	mA	
30	$V_{FP}1$ current		I_{FP1PW}	-	0.08	-	mA	
31	$V_{FP}2$ current		I_{FP2PW}	-	0.07	-	mA	
32	$V_{FN}1$ current		I_{FN1PW}	-	0.05	-	mA	
33	$V_{FN}2$ current		I_{FN2PW}	-	0.04	-	mA	
34	V_{LL} current	TP mode	I_{LLCW4}	-	0.25	-	mA	CW Operating current-1 EN=0 Current mode 4 (CC[1:0]='11') 4-channel active Bipolar 3-level Continuous f=5MHz $V_{PP}1/V_{NN}1$=+/-5V $V_{PP}2/V_{NN}2$=+/-5V
		CLK mode		-	1.3	-	mA	
35	V_{DD} current	TP mode	I_{DDCW4}	-	7	-	mA	
		CLK mode		-	19	-	mA	
36	V_{SS} current		I_{SSCW4}	-	4.8	-	mA	
37	$V_{PP}1$ current		I_{PP1CW4}	-	0	-	µA	
38	$V_{NN}1$ current		I_{NN1CW4}	-	0	-	µA	
39	$V_{PP}2$ current		I_{PP2CW4}	-	170	-	mA	
40	$V_{NN}2$ current		I_{NN2CW4}	-	158	-	mA	
41	$V_{FP}1$ current		I_{FP1CW4}	-	0	-	µA	
42	$V_{FP}2$ current		I_{FP2CW4}	-	30	-	mA	
43	$V_{FN}1$ current		I_{FN1CW4}	-	0	-	µA	
44	$V_{FN}2$ current		I_{FN2CW4}	-	18	-	mA	
45	V_{LL} current	TP mode	I_{LLCW3}	-	0.25	-	mA	CW Operating current-2 EN=0 Current mode 3 (CC[1:0]='10') 4-channel active Bipolar 3-level Continuous f=5MHz $V_{PP}1/V_{NN}1$=+/-5V $V_{PP}2/V_{NN}2$=+/-5V
		CLK mode		-	1.3	-	mA	
46	V_{DD} current	TP mode	I_{DDCW3}	-	7.2	-	mA	
		CLK mode		-	19	-	mA	
47	V_{SS} current		I_{SSCW3}	-	5.7	-	mA	
48	$V_{PP}1$ current		I_{PP1CW3}	-	0	-	µA	
49	$V_{NN}1$ current		I_{NN1CW3}	-	0	-	µA	
50	$V_{PP}2$ current		I_{PP2CW3}	-	150	-	mA	
51	$V_{NN}2$ current		I_{NN2CW3}	-	143	-	mA	
52	$V_{FP}1$ current		I_{FP1CW3}	-	0	-	µA	
53	$V_{FP}2$ current		I_{FP2CW3}	-	22	-	mA	
54	$V_{FN}1$ current		I_{FN1CW3}	-	0	-	µA	
55	$V_{FN}2$ current		I_{FN2CW3}	-	14	-	mA	

Table 5 Operating Supply Currents (continued)

No.	Items		Symbol	Spec			Units	Conditions
				Min	Typ	Max		
56	V_{LL} current	TP mode	I_{LLCW2}	-	0.26	-	mA	CW Operating current-3 EN=0 Current mode 2 (CC[1:0]='01') 4-channel active Bipolar 3-level Continuous f=5MHz $V_{PP}1/V_{NN}1$=+/-5V $V_{PP}2/V_{NN}2$=+/-5V
		CLK mode		-	1.3	-	mA	
57	V_{DD} current	TP mode	I_{DDCW2}	-	7.2	-	mA	
		CLK mode		-	19	-	mA	
58	V_{SS} current		I_{SSCW2}	-	4.7	-	mA	
59	$V_{PP}1$ current		I_{PP1CW2}	-	0	-	µA	
60	$V_{NN}1$ current		I_{NN1CW2}	-	0	-	µA	
61	$V_{PP}2$ current		I_{PP2CW2}	-	133	-	mA	
62	$V_{NN}2$ current		I_{NN2CW2}	-	130	-	mA	
63	$V_{FP}1$ current		I_{FP1CW2}	-	0	-	µA	
64	$V_{FP}2$ current		I_{FP2CW2}	-	15	-	mA	
65	$V_{FN}1$ current		I_{FN1CW2}	-	0	-	µA	
66	$V_{FN}2$ current		I_{FN2CW2}	-	10	-	mA	
67	V_{LL} current	TP mode	I_{LLCW1}	-	0.31	-	mA	CW Operating current-4 EN=0 Current mode 1 (CC[1:0]='00') 4-channel active Bipolar 3-level Continuous f=5MHz $V_{PP}1/V_{NN}1$=+/-5V $V_{PP}2/V_{NN}2$=+/-5V
		CLK mode		-	1.4	-	mA	
68	V_{DD} current	TP mode	I_{DDCW1}	-	7.2	-	mA	
		CLK mode		-	19	-	mA	
69	V_{SS} current		I_{SSCW1}	-	4.7	-	mA	
70	$V_{PP}1$ current		I_{PP1CW1}	-	0	-	µA	
71	$V_{NN}1$ current		I_{NN1CW1}	-	0	-	µA	
72	$V_{PP}2$ current		I_{PP2CW1}	-	111	-	mA	
73	$V_{NN}2$ current		I_{NN2CW1}	-	111	-	mA	
74	$V_{FP}1$ current		I_{FP1CW1}	-	0	-	µA	
75	$V_{FP}2$ current		I_{FP2CW1}	-	7.9	-	mA	
76	$V_{FN}1$ current		I_{FN1CW1}	-	0	-	µA	
77	$V_{FN}2$ current		I_{FN2CW1}	-	5.3	-	mA	

4.2 Static Characteristics

Table 6 Static Characteristics

V_{LL}=2.5V, V_{DD}=5V, V_{SS}=-5V, $V_{FP}x=V_{PP}x$-5V, $V_{FN}x=V_{NN}x$+5V, T_A=25ºC, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Conditions
			Min	Typ	Max		
1	Output voltage range	$HV_{OUT}x$	-100	-	100	V	
2	High-side output peak current	I_{OH}	-	2.5	-	A	P1 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V
			-	2.5	-	A	P2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 4 (CC[1:0]='11')
			-	1.88	-	A	P2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 3 (CC[1:0]='10')
			-	1.25	-	A	P2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 2 (CC[1:0]='01')
			-	0.63	-	A	P2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 1 (CC[1:0]='00')
3	High-side GND clamp peak current	I_{OHCL}	-	1.0	-	A	N3 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V
4	Low-side output peak current	I_{OL}	-	2.5	-	A	N1 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V
			-	2.5	-	A	N2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 4 (CC[1:0]='11')
			-	1.88	-	A	N2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 3 (CC[1:0]='10')
			-	1.25	-	A	N2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 2 (CC[1:0]='01')
			-	0.63	-	A	N2 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V Current mode 1 (CC[1:0]='00')
5	Low-side GND clamp peak current	I_{OLCL}	-	1.0	-	A	P3 active, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V
6	High-side output on-resistance	R_{ONH}	-	9	-	Ω	P1 active, I_{OH}=100mA
			-	11	-	Ω	P2 active, I_{OH}=100mA Current mode 4 (CC[1:0]='11')
			-	13	-	Ω	P2 active, I_{OH}=100mA Current mode 3 (CC[1:0]='10')
			-	15	-	Ω	P2 active, I_{OH}=100mA Current mode 2 (CC[1:0]='01')
			-	23	-	Ω	P2 active, I_{OH}=100mA Current mode 1 (CC[1:0]='00')
7	High-side GND clamp on-resistance	R_{ONHCL}	-	17	-	Ω	N3 active, I_{OHCL}=100mA
8	Low-side output on-resistance	R_{ONL}	-	9	-	Ω	N1 active, I_{OL}=100mA
			-	11	-	Ω	N2 active, I_{OL}=100mA Current mode 4 (CC[1:0]='11')
			-	13	-	Ω	N2 active, I_{OL}=100mA Current mode 3 (CC[1:0]='10')
			-	15	-	Ω	N2 active, I_{OL}=100mA Current mode 2 (CC[1:0]='01')
			-	23	-	Ω	N2 active, I_{OL}=100mA Current mode 1 (CC[1:0]='00')
9	Low-side GND clamp on-resistance	R_{ONLCL}	-	17	-	Ω	P3 active, I_{OLCL}=100mA
10	Output off-capacitance	C_{HVOFF}	-	10	-	pF	$TX_{OUT}x$=HiZ

4.3 Dynamic Characteristics

Table 7 Dynamic Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=+/-5V, $V_{FP}x=V_{PP}x$-5V, $V_{FN}x=V_{NN}x$+5V, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-60V, T_A=25ºC, CC[1:0]='11', EN=0, ATHP=0, CLK=100MHz/0 (CLKEN=0/1), HV_{OUT} load=220pF//200Ω, unless otherwise specified.

No.	Items		Symbol	Spec			Units	Conditions	
				Min	Typ	Max			
1	Output frequency		f_{OUT}	-	20	-	MHz	Bipolar, TP mode	
2	Output slew rate	P1/N1 drive	SR_{rP-P}, SR_{fP-P}	15	-	-	V/ns	50Ω load	$V_{PP}1/V_{NN}1$=±30V $V_{PP}2/V_{NN}2$=±30V Bipolar, 1-cyc f_{OUT}=20MHz See Fig.4
				4.5	-	-		220pF//200Ω load	
		P2/N2 drive		12	-	-		50Ω load	
				3.3	-	-		220pF//200Ω load	
		P1/N1 drive	SR_{r0-P}, SR_{f0-P}	6	-	-		50Ω load	
				2	-	-		220pF//200Ω load	
		P2/N2 drive		6	-	-		50Ω load	
				2	-	-		220pF//200Ω load	
3	Output rise time	P1/N1 drive	t_r	-	2	-	ns	50Ω load	
				-	6	-		220pF//200Ω load	
		P2/N2 drive		-	2	-		50Ω load	
				-	6	-		220pF//200Ω load	
4	Output fall time	P1/N1 drive	t_f	-	2	-	ns	50Ω load	
				-	6	-		220pF//200Ω load	
		P2/N2 drive		-	2	-		50Ω load	
				-	6	-		220pF//200Ω load	
5	Output rise propagation delay	TP mode	t_{dr}	-	56	-	ns	$V_{PP}1/V_{NN}1$=±30V $V_{PP}2/V_{NN}2$=±30V Bipolar, 1-cyc f_{OUT}=20MHz See Fig.4	
		CLK mode		-	61	-	ns		
6	Output fall propagation delay	TP mode	t_{df}	-	56	-	ns		
		CLK mode		-	61	-	ns		
7	Output rise propagation delay clamp	TP mode	t_{drCL}	-	56	-	ns		
		CLK mode		-	61	-	ns		
8	Output fall propagation delay clamp	TP mode	t_{dfCL}	-	56	-	ns		
		CLK mode		-	61	-	ns		
9	Propagation delay matching		Δt_d	-	±1	±3	ns		
10	Second harmonic distortion		HD2	-	-40	-	dBc	Bipolar, 2-cyc, f_{OUT}=5MHz See Fig.5	
11	Pulse cancellation		HDPC	-	-40	-	dBc		
			HDPC2	-	-40	-	dBc		
12	RMS output jitter		t_J	-	10	-	ps	Bipolar CW, f_{OUT}=5MHz $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=+/-5V	
13	Output enable time		t_{EN}	-	61	-	ns	See Fig.6	
14	Output disable time		t_{DS}	-	61	-	ns		
15	Clock mode enable time		t_{CLKEN}	-	61	-	ns		
16	Clock mode disable time		t_{CLKDS}	-	61	-	ns		

4.4 Integrated Peripheral Circuits Characteristics

Analog Switch

Table 8 Analog Switch Characteristics

T_A=25ºC

No.	Items	Symbol	Spec			Units	Conditions
			Min	Typ	Max		
1	ASW on-resistance	R_{ONASW}	-	500	-	Ω	

HV Blocking Diode

Table 9 Output HV Blocking Diode Characteristics

T_A=25ºC

No.	Items	Symbol	Spec			Units	Conditions
			Min	Typ	Max		
1	Forward voltage	V_{FDHV}	-	1.0	-	V	I_F=100mA
2	Reverse voltage	V_{RDHV}	200	-	-	V	I_R=1μA

LV Noise-cut Diode

Table 10 Output LV Noise-cut Diode Characteristics

T_A=25ºC

No.	Items	Symbol	Spec			Units	Conditions
			Min	Typ	Max		
1	Forward voltage	V_{FDNC}	-	0.85	-	V	I_F=100mA

Thermal Protection

Table 11 Thermal Protection Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=+/-5V, T_A=25ºC, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Conditions
			Min	Typ	Max		
1	THP pull-up voltage	V_{PUTHP}	-	-	5.25	V	Open drain
2	THP output current	I_{THP}	-	1.0	-	mA	
3	THP output low voltage	V_{OLTHP}	-	-	1.0	V	THP active, V_{LL}=3.3V, I_{THP}=1mA
4	THP temperature threshold	T_{THP}	90	110	130	ºC	
5	THP reset hysteresis	T_{HYSTHP}	-	10	-	ºC	

5. Switching Time Diagram

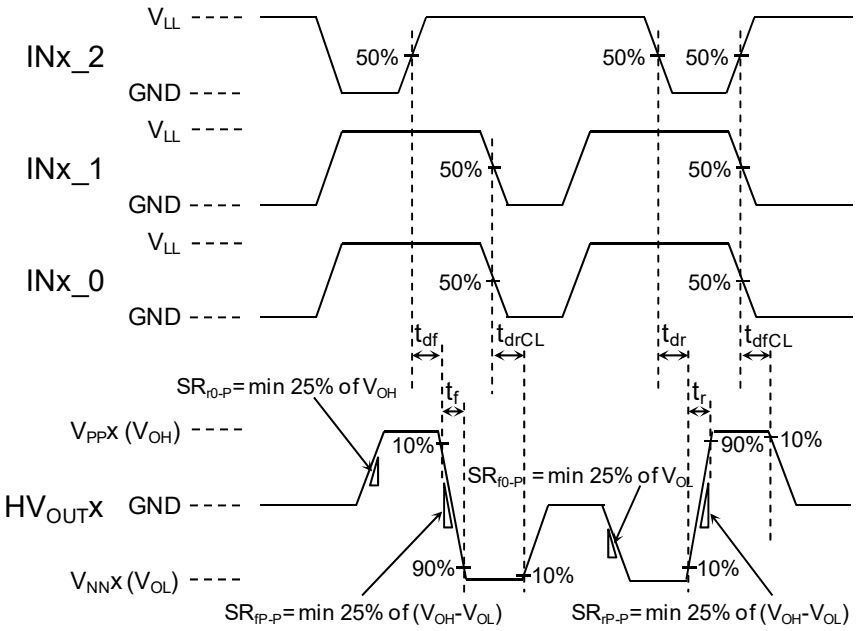
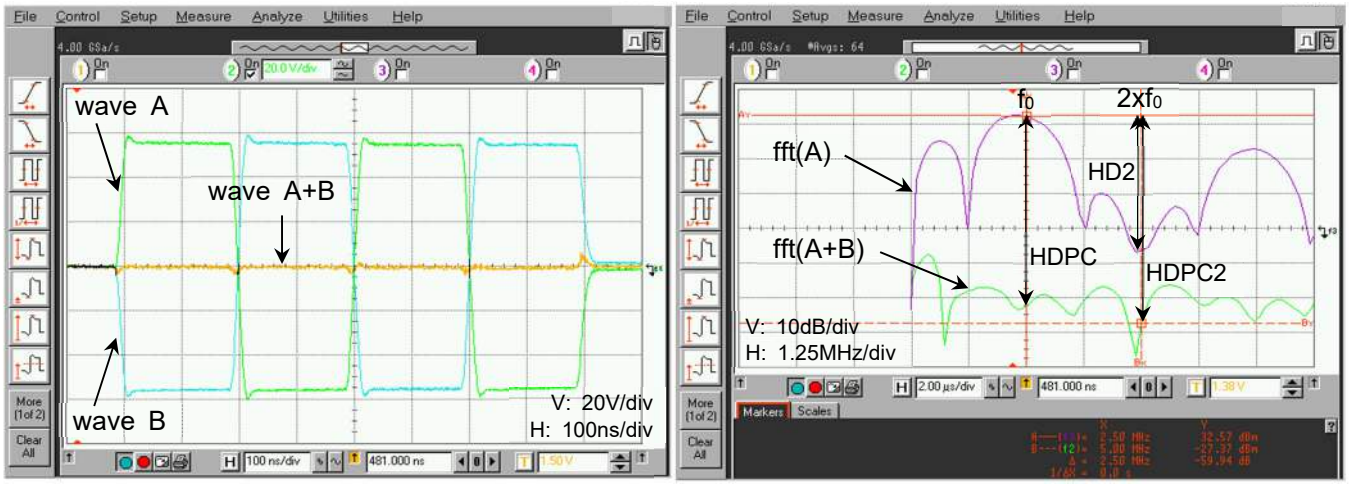


Fig. 4 Propagation delay and Output rise/fall time



Example waveforms: VPP/VNN=+/-60V, f_0=2.5MHz, 2-cycle, HV_{OUT} load=220pF//200Ω

Fig.5 2nd harmonic distortion and Pulse cancellation

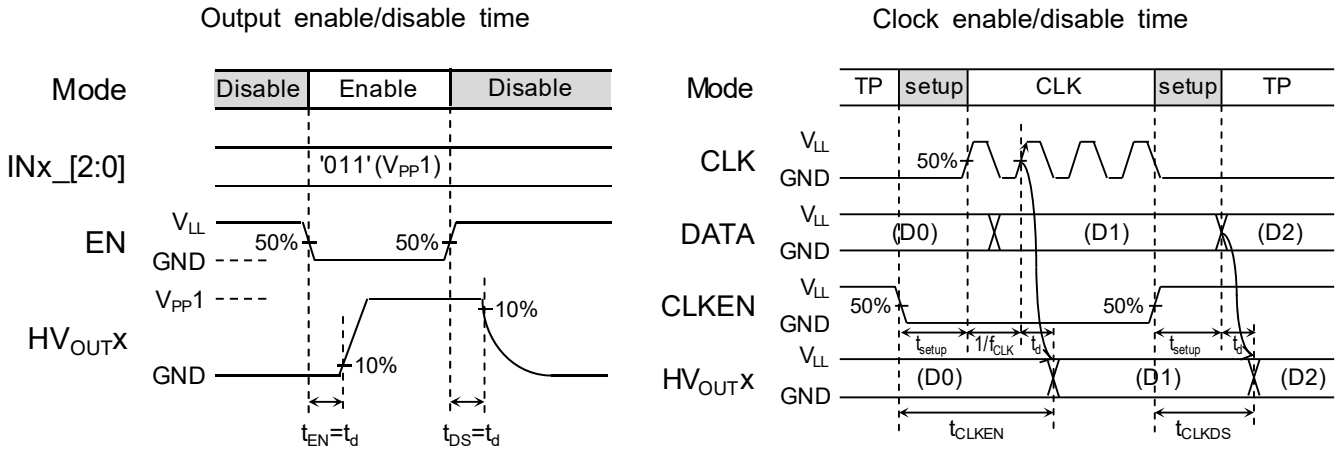


Fig.6 Output enable/disable and Clock enable/disable time

6. Truth Table and Current Mode Control

6.1 Truth Table

Table 12 Truth table

Logic Inputs				Internal MOSFET state							Output state
EN	**INx_2**	**INx_1**	**INx_0**	**P1**	**N1**	**P2**	**N2**	**P3**	**N3**	**ASW**	**$TX_{OUT}x$**
				+HV1	-HV1	+HV2	-HV2	GND	GND	GND	(internal node)
0	0	0	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF	HiZ
0	0	0	1	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	+HV2
0	0	1	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF	HiZ
0	0	1	1	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	+HV1
0	1	0	0	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	GND
0	1	0	1	OFF	OFF	OFF	**ON**	OFF	OFF	OFF	-HV2
0	1	1	0	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	GND
0	1	1	1	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	-HV1
1	X	X	X	OFF	OFF	OFF	OFF	OFF	OFF	OFF	HiZ

NOTE:
- $V_{PP}1$/ $V_{NN}1$=+/-HV1, $V_{PP}2$/ $V_{NN}2$=+/-HV2
- x=1~4

6.2 Current Mode Control

Table 13 P2/N2 Drive current mode control

			Iout [A]	
Current Mode	CC1	CC0	P2	N2
1	0	0	0.63	0.63
2	0	1	1.25	1.25
3	1	0	1.88	1.88
4	1	1	2.5	2.5

NOTE:
Recommended mode is as follows:
- Current mode 3 or 4 for high-amplitude short-cycle pulse waveforms, or for driving heavy load
- Current mode 1 or 2 for low-amplitude long pulse train waveforms (e.g. CW), or for driving light load

7. Pin Configuration

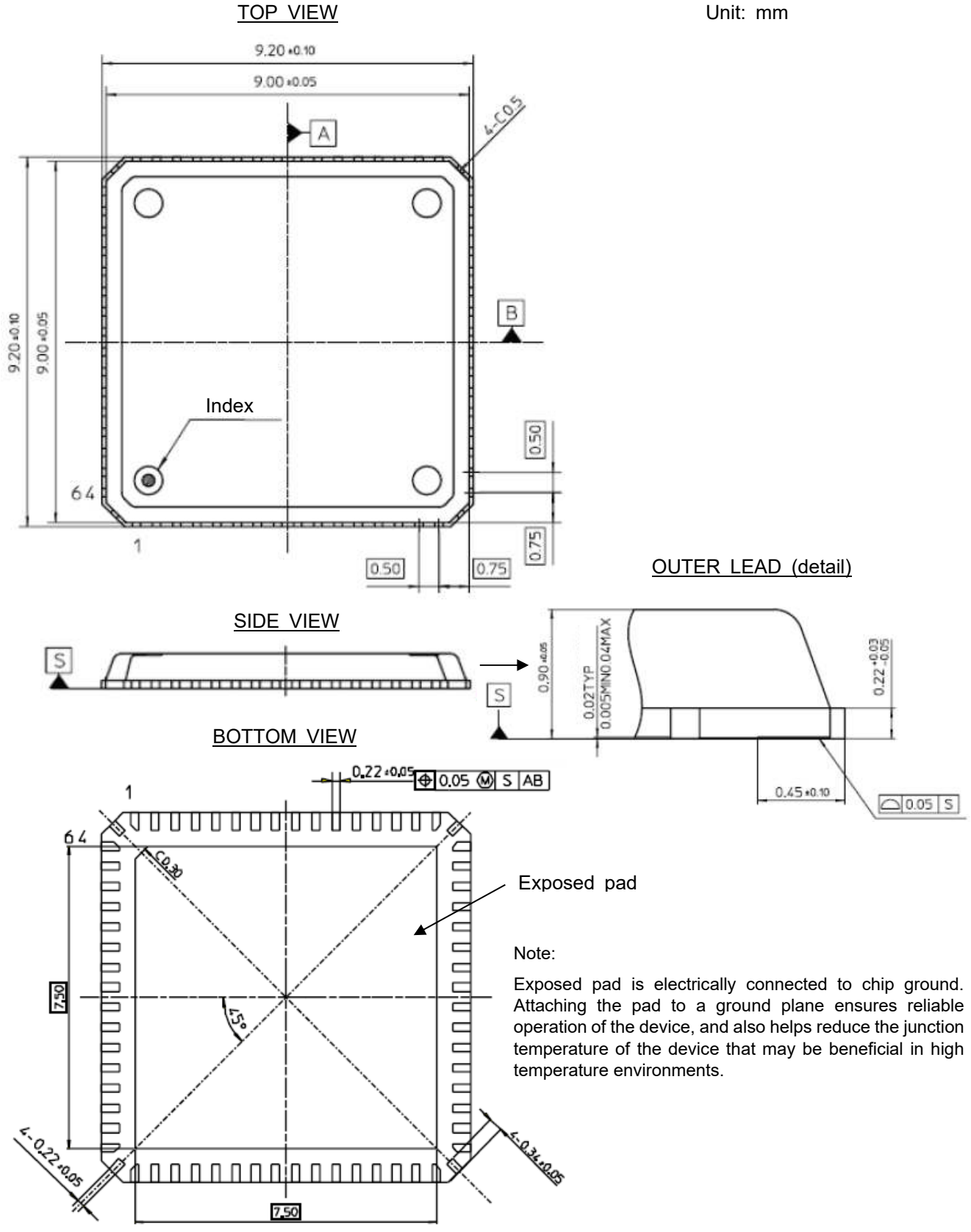
Table 14 Pin Configuration

Pin#	Pin Name	I/O	Function
1	IN1_0	I	Input logic control of the least significant bit of channel 1, HV2 control
2	IN1_1	I	Input logic control of 2nd significant bit of channel 1, HV1 control
3	IN1_2	I	Input logic control of the most significant bit of channel 1, polarity control
4	IN2_0	I	Input logic control of the least significant bit of channel 2, HV2 control
5	IN2_1	I	Input logic control of 2nd significant bit of channel 2, HV1 control
6	IN2_2	I	Input logic control of the most significant bit of channel 2, polarity control
7	NC	-	No connection
8	VLL	-	Positive voltage supply of low voltage interface (+3.3V)
9	CLK	I	Clock Input (100MHz)
10	GND	-	Drive power ground (0V)
11	IN3_0	I	Input logic control of the least significant bit of channel 3, HV2 control
12	IN3_1	I	Input logic control of 2nd significant bit of channel 3, HV1 control
13	IN3_2	I	Input logic control of the most significant bit of channel 3, polarity control
14	IN4_0	I	Input logic control of the least significant bit of channel 4, HV2 control
15	IN4_1	I	Input logic control of 2nd significant bit of channel 4, HV1 control
16	IN4_2	I	Input logic control of the most significant bit of channel 4, polarity control
17	EN	I	Control of drive output enable, Hi=off, Low=on (50kΩ internal pull-up resistor)
18	CLKEN	I	Control of clock enable, Hi=clock disable, Low=clock enable (50kΩ internal pull-up resistor)
19	ATHP	I	Control of active THP enable, Hi=disable, Low=enable (50kΩ internal pull-down resistor)
20	THP	O	Thermal protection output, open N-MOS drain
21	VSS	-	Negative low voltage power supply (-5V)
22	NC	-	No connection
23	VFN1	-	N-MOS (N1) floating gate drive power supply (VNN1+5V)
24	VFN2	-	N-MOS (N2) floating gate drive power supply (VNN2+5V)
25	GND	-	Drive power ground (0V)
26	VFP2	-	P-MOS (P2) floating gate drive power supply (VPP2-5V)
27	NC	-	No connection
28	VFP1	-	P-MOS (P1) floating gate drive power supply (VPP1-5V)
29	NC	-	No connection
30	NC	-	No connection
31	GND	-	Drive power ground (0V)
32	NC	-	No connection

Table 14 Pin Configuration (continued)

Pin#	Pin Name	I/O	Function
33	VPP1	-	Positive high voltage power supply 1 for channel 3,4 (0 to +100V)
34	VPP2	-	Positive high voltage power supply 2 for channel 3,4 (0 to +100V, VPP2<VPP1)
35	HVOUT4	O	Output high voltage for channel 4
36	HVOUT3	O	Output high voltage for channel 3
37	VNN2	-	Negative high voltage power supply 2 for channel 3,4 (0 to -100V, VNN2>VNN1)
38	VNN1	-	Negative high voltage power supply 1 for channel 3,4 (0 to -100V)
39	NC	-	No connection
40	GND	-	Drive power ground (0V)
41	GND	-	Drive power ground (0V)
42	NC	-	No connection
43	VNN1	-	Negative high voltage power supply 1 for channel 1,2 (0 to -100V)
44	VNN2	-	Negative high voltage power supply 2 for channel 1,2 (0 to -100V, VNN2>VNN1)
45	HVOUT2	O	Output high voltage for channel 2
46	HVOUT1	O	Output high voltage for channel 1
47	VPP2	-	Positive high voltage power supply 2 for channel 1,2 (0 to +100V)
48	VPP1	-	Positive high voltage power supply 1 for channel 1,2 (0 to +100V)
49	NC	-	No connection
50	GND	-	Drive power ground (0V)
51	NC	-	No connection
52	NC	-	No connection
53	VFP1	-	P-MOS (P1) floating gate drive power supply (VPP1-5V)
54	NC	-	No connection
55	VFP2	-	P-MOS (P2) floating gate drive power supply (VPP2-5V)
56	GND	-	Drive power ground (0V)
57	VFN2	-	N-MOS (N2) floating gate drive power supply (VNN2+5V)
58	VFN1	-	N-MOS (N1) floating gate drive power supply (VNN1+5V)
59	NC	-	No connection
60	VDD	-	Positive low voltage power supply (+5V)
61	CC0	I	Control of drive current mode 0 (50kΩ internal pull-up resistor)
62	CC1	I	Control of drive current mode 1 (50kΩ internal pull-up resistor)
63	GND	-	Drive power ground (0V)
64	GND	-	Drive power ground (0V)

8. Package Outline

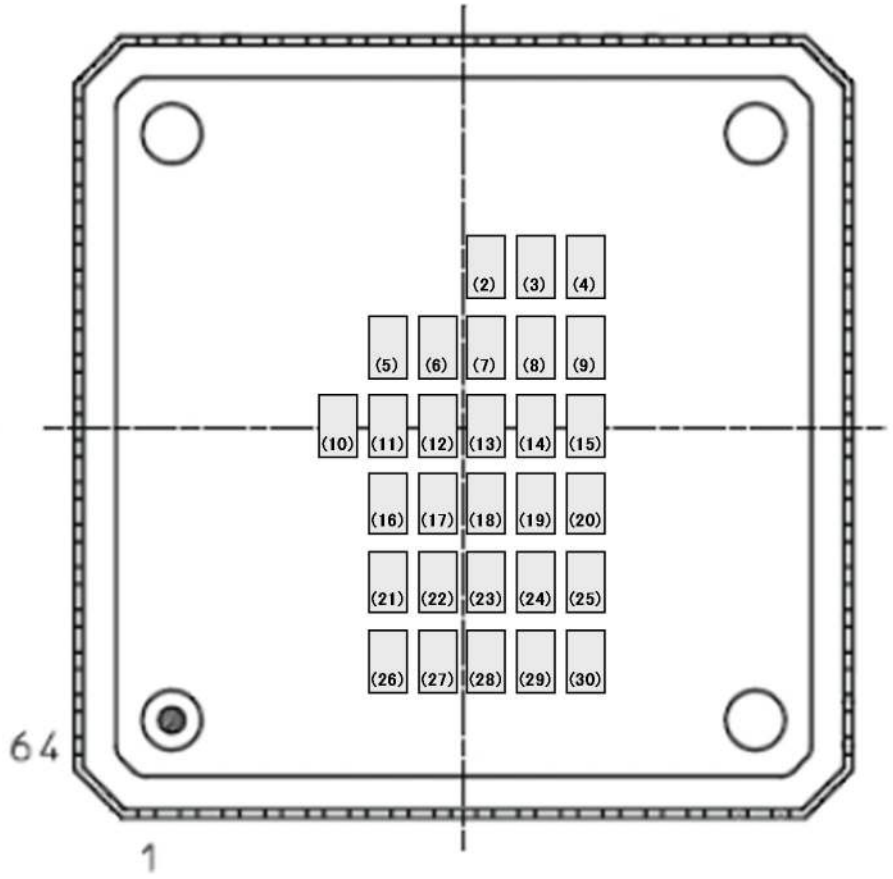


Note:

Exposed pad is electrically connected to chip ground. Attaching the pad to a ground plane ensures reliable operation of the device, and also helps reduce the junction temperature of the device that may be beneficial in high temperature environments.

Fig.7 Package Outline (64-Lead QFN Package)

9. Package Marking



No.	Code
(2)	Year sealed : the last one digit of the year
(3)	Month sealed : A~M (exc "I") in the order of Jan. to Dec.
(4)	Week sealed : 1~5
(5)~(15)	HDL6V5541HF (product name)
(16)~(25)	Quality control code
(26)~(30)	Country of origin

Fig.8 Package Marking

10. Transport Media, Quantity

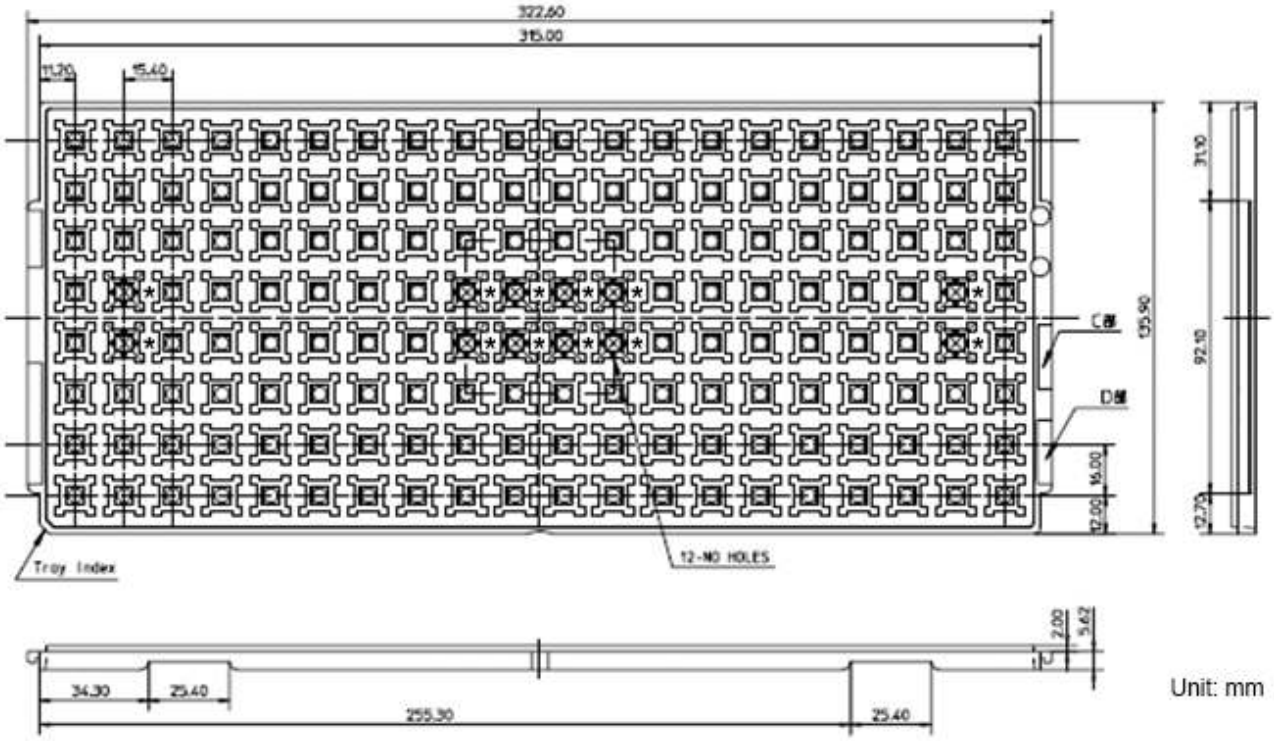
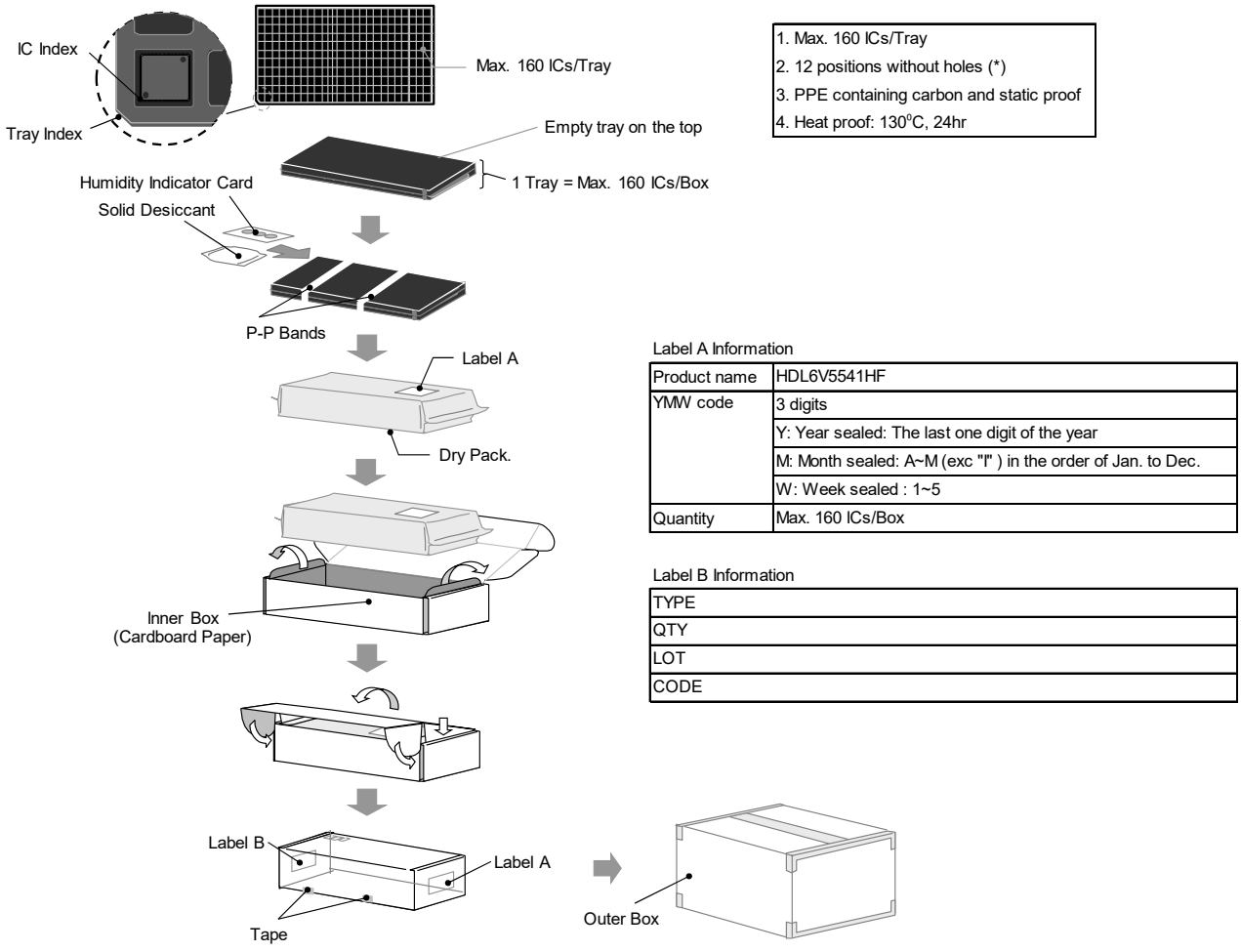


Fig.9 IC Tray Outline



1. Max. 160 ICs/Tray
2. 12 positions without holes (*)
3. PPE containing carbon and static proof
4. Heat proof: 130°C, 24hr

Label A Information

Product name	HDL6V5541HF
YMW code	3 digits
	Y: Year sealed: The last one digit of the year
	M: Month sealed: A~M (exc "I") in the order of Jan. to Dec.
	W: Week sealed : 1~5
Quantity	Max. 160 ICs/Box

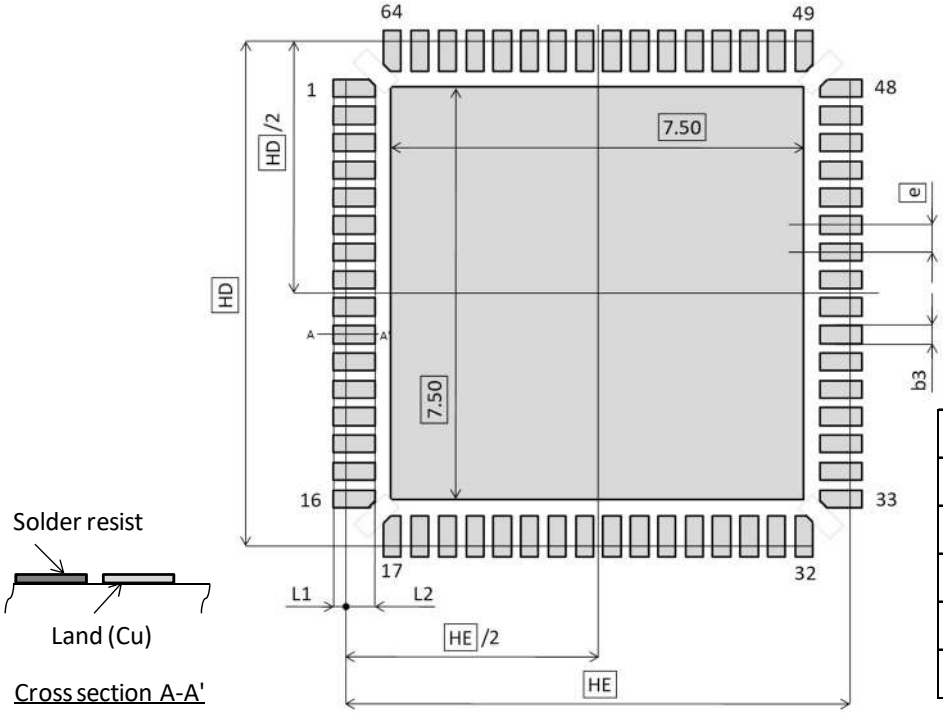
Label B Information

TYPE
QTY
LOT
CODE

Fig.10 Transport Media, Quantity

11. Mounting, Storage

11.1 Mounting Pad Design Example



Unit: mm

HD	9.20
HE	9.20
e	0.50
b3	0.32 ± 0.05
L2	0.55 ± 0.05
L1	0.20 ± 0.05

Fig.11 Mounting Pad Design Example

11.2 Storage Conditions

11.2.1 The storage location should be kept at 5 to 35 ºC and 40 to 70% relative humidity. Keeping in a dry box is recommended. Moisture-proof property is assured for 12 months from delivery date for sealed moisture-proof packing, while it is guaranteed for 7 days from unpacked date under the condition above.

11.2.2 When the storage conditions do not conform to those above or other conditions occur indicating moisture exposure, the ICs should be dried to avoid package cracks. A baking process at 125 ºC lasting for 24 hours results in sufficient dehumidification. The baking is not allowed more than twice, and the ICs should be mounted within 7 days after initial baking or within 10 days of total exposure after the second dehumidification.

11.3 Reflow Conditions

Typical full heating methods such as Infrared (IR), Hot air, and N2 reflow process are applicable.
IR/Air reflow heating conditions are shown below.

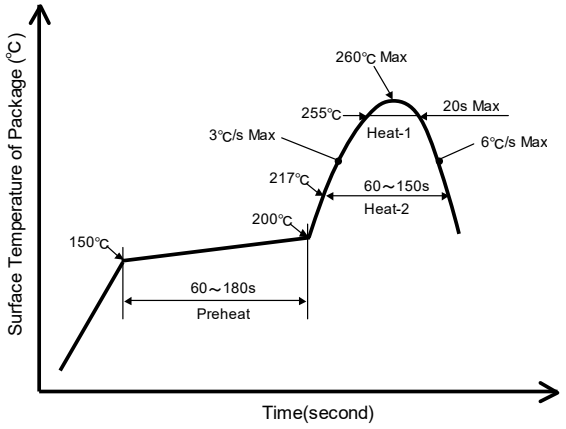


Fig.12 IR/Air Reflow Heating Conditions

12. Inspection

Hundred percent inspections shall be conducted on electrical characteristics.

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14. Cautions

14.1 Customers are advised to follow the cautions below to protect products from damage caused by electrical static discharge (ESD).

14.1.1 Material of container or any device to carry products should be free from ESD, which may be caused by vibration while transportation. It is recommended that electric-conductive container or aluminum sheet be used as an effective countermeasure.

14.1.2 Those what touch products such as work platform, machine, measurement/test equipment should be grounded.

14.1.3 Those who deal with products should be grounded through a large series impedance around 100kΩ to 1MΩ.

14.1.4 Prevent friction with other materials made with high polymer.

14.1.5 Prevent vibration or friction when carrying the printed circuit board (PCB) where products are mounted. To short circuit terminals is a recommended countermeasure to keep the same electric potential on the PCB.

14.1.6 Avoid dealing with or storing products in an extremely arid environment.

14.2 “Absolute maximum ratings” should never be exceeded during use regardless of any change in external conditions. Otherwise, products may be damaged or destroyed. In no event shall ABLIC Inc. be liable for any failure in products or any secondary damage resulting from use at a value exceeding the absolute maximum ratings.

14.3 Products may experience failures due to accident or unexpected surge voltages. Accordingly, adopt safe design features, such as redundancy or prevention of erroneous action, to avoid extensive damage in the event of a failure. (If a semiconductor device fails, there may be cases in which the semiconductor device, wiring or wiring pattern will emit smoke or cause a fire or in which the semiconductor device will burst.)

14.4 Products may experience failures or malfunction in poor surroundings, such as electrical leakage in products due to long-term use in high humidity, malfunctioning or permanent damage due to chemical reaction of products in corrosive environment or due to discharge by strongly charged object near products or due to excessive mechanical shock. To use products in radiation environment is not assumed. To use products near material easy to ignite may cause a fire due to its flammable package. Avoid using products in such environment or take appropriate countermeasures depending on the environment.

14.5 Products are not designed, manufactured, or warranted to be suitable for use where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment). Inclusion of products in such application shall be fully at the risk of customers. ABLIC Inc. assumes no liability for applications assistance, customer product design, or performance.

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   The entire system in which the products are used must be sufficiently evaluated and judged whether the products are allowed to apply for the system on customer's own responsibility.
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2.4-2019.07