S-UM5588

OCTAL PROGRAMMABLE 5-LEVEL HIGH-VOLTAGE ULTRASOUND TRANSMIT BEAMFORMER

Rev.1.0_00

S-UM5588 is a Octal programmable 5-level high-voltage ultrasound transmit beam-former.
The S-UM5588 comprises control logic, waveform memory, delay calculator, level translators, gate drive buffers with floating voltage regulators, high-voltage, high-current MOSFETs, and active T/R switches.

■ Functions

- Octal programmable 5-level transmit beam-former with active T/R-switch

■ Features

- 0 to ±100V output voltage
- ±2A source and sink current for the 1st and 2nd high-voltage pulses ($V_{PP}1/V_{NN}1$, $V_{PP}2/V_{NN}2$)
- 2-mode output current control for the 2nd high-voltage rail
- ±1A source and sink peak current for active ground clamp
- 250Ω active ground clamp without blocking diode for anti-leakage
- 20MHz output frequency at ±60V output, 220pF load
- Symmetrical positive and negative pulse waveforms for low 2nd order harmonic distortion
- 1.8V to 3.3V LVCMOS logic interface
- Waveform memory and registers with 100MHz Write / 50MHz Read SPI
- 0.2µs to 41µs common delay time range from TRIG signal
- 0 to 1.275µs channel-to-channel delay time range
- 5ns channel-to-channel delay time resolution with dual-edge 100MHz LVDS/LVCMOS clock
- Minimum 10ns pulse width with 5ns time resolution with dual-edge 100MHz LVDS/LVCMOS clock
- 15Ω active T/R switch
- Noise-cut diodes at each high-voltage output
- High-voltage clamp diodes between each high-voltage output and power rails
- Automatic thermal protection with indicator
- Power-up/down reset function for free power sequencing and for fail-safe in abrupt power drop
- Latch-up free, low crosstalk between channels by SOI CMOS technology
- QFN-68(1010)B: 68-lead 10×10mm QFN package (RoHS compliant)

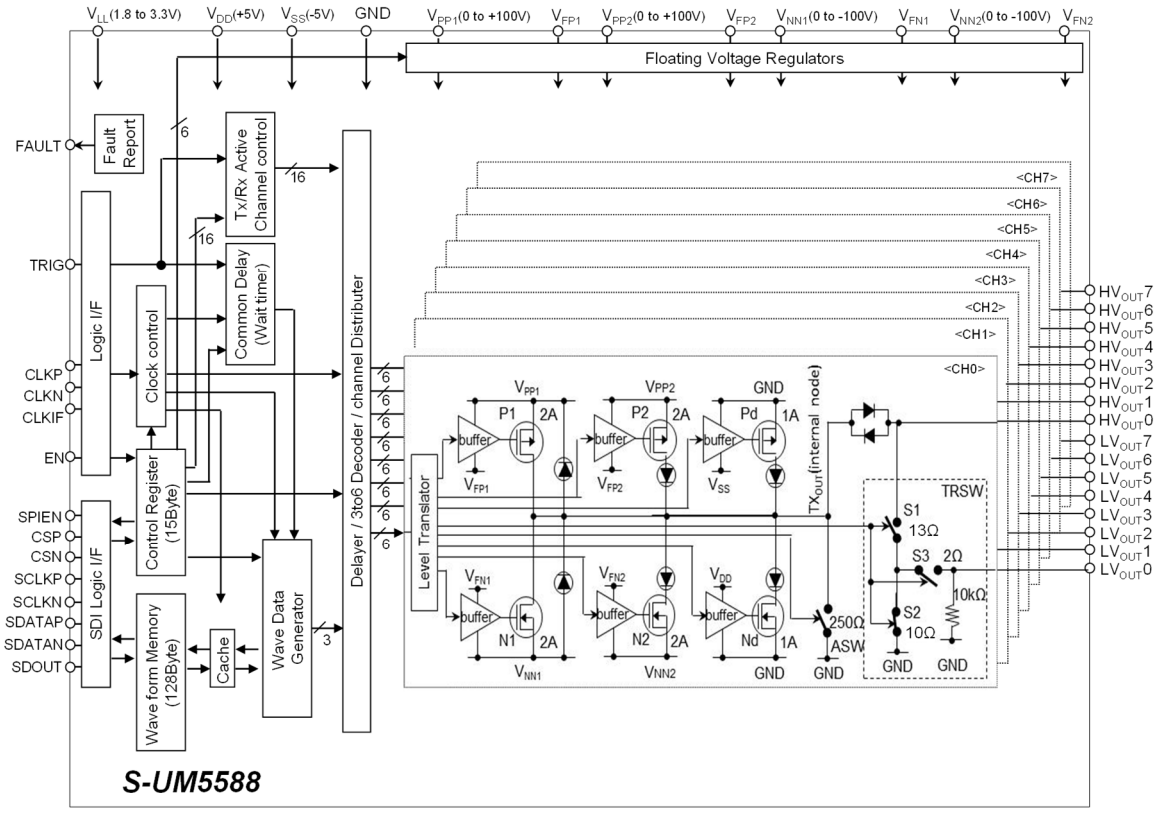

Figure 1 Block Diagram

■ Absolute Maximum Ratings

T_A=25°C unless otherwise specified.

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_{PP1}, V_{PP2}	-0.5 to +105	V	
5	Negative high-voltage supplies	V_{NN1},V_{NN2}	-105 to +0.5	V	
6	High-voltage outputs (x=0 to 7)	$HV_{OUT}x$	-105 to +105	V	
7	Low-voltage outputs (x=0 to 7)	$LV_{OUT}x$	-1 to +1	V	
8	Logic output voltage	SDOUT, FAULT	-0.4 to +7	V	
9	Logic input voltages	EN, CLKIF, CLKP, CLKN, TRIG, SPIEN, CSP, CSN, SCLKP, SCLKN, SDATAP, SDATAN	-0.4 to +7	V	
10	Operating junction temperature	T_{Jop}	-20 to +125	°C	
11	Storage temperature	T_{STG}	-55 to +150	°C	
12	Maximum power dissipation	P_{Dmax}	4	W	

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

■ Operating Supply Voltages and Logic Inputs

1. Operating supply voltage and temperature

Table 2 Operating Supply Voltage and Temperature

No.	Items	Symbol	Min.	Typ.	Max.	Units	Condition
1	Logic supply voltage	V_{LL}	1.71	1.8 to 3.3	3.6	V	
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_{PP1}, V_{PP2}	0	–	100	V	
5	Negative high-voltage supplies	V_{NN1}, V_{NN2}	-100	–	0	V	
6	IC substrate voltage *1	V_{SUB}	–	0	–	V	
7	$V_{PP\_}$, $V_{NN\_}$ slew rate	SR_{MAX}	–	–	25	V/ms	
8	Operating free-air Temperature	T_a	0	–	75	°C	

***1**. The package exposed pad internally connected to the chip substrate must be soldered to the ground.

2. Logic inputs and outputs

2.1 LVDS differential logic inputs

Table 3 CLKP/CLKN, CSP/CSN, SCLKP/SCLKN, SDATAP/SDATAN

No.	Items	Symbol	Min.	Typ.	Max.	Units	Condition
1	High-level input voltage	V_{IH}	1.265	–	–	V	V_{IHCMR}(Typ)+V_{DIFF}(Min)/2
2	Low-level input voltage	V_{IL}	–	–	1.135	V	V_{IHCMR}(Typ)-V_{DIFF}(Min)/2
3	Differential input voltage range	$V_{DIFF(range)}$	0.13	0.35	0.49	±V	Same as voltage swing
4	Differential input voltage peak to peak swing	$V_{DIFF(p-p)}$	0.26	0.7	0.98	V_{pp}	Differential peak-to-peak absolute voltage swing
5	Input voltage common mode range	V_{IHCMR}	0.84	1.2	1.56	V	
6	High-level input current	I_{IH}	–	–	5.8	mA	
7	Low-level input current	I_{IL}	–	–	5.8	mA	
8	Input rise/fall time	t_r, t_f	–	–	600	ps	20% to 80% of V_{DIFF}
9	Input clock frequency (Tx)	f_{CLK}	–	–	100	MHz	CLKP/CLKN, SCLKP/SCLKN
	Input clock frequency (SPI)	f_{SCLK}	–	–	100	MHz	SCLKP/SCLKN (Write mode)
			–	–	50	MHz	SCLKP/SCLKN (Read mode)
10	Clock duty cycle	D_{CLK}	48	50	52	%	CLKP/CLKN
		D_{SCLK}	45	50	55	%	SCLKP/SCLKN
11	CS setup time	t_{SU_CS}	2.5	–	–	ns	CS to SCLK rise
12	CS hold time	t_{HLD_CS}	2.5	–	–	ns	CS to SCLK rise
13	CS width	t_{W_CS}	$1043T_{SCLK}$	–	–	ns	Data write to memory
			$1050T_{SCLK}$	–	–	ns	Data read from memory
			$75T_{SCLK}$	–	–	ns	Data Write to 7Byte register
			$82T_{SCLK}$	–	–	ns	Data read from 7Byte register
			$147T_{SCLK}$	–	–	ns	Data write to 16Byte register
			$154T_{SCLK}$	–	–	ns	Data read from 16Byte register
			$26T_{SCLK}$	–	–	ns	Data read of other register
14	SDATA setup time	t_{SU_SDATA}	2.5	–	–	ns	SDATA to SCLK rise
15	SDATA hold time	t_{HLD_SDATA}	2.5	–	–	ns	SDATA to SCLK rise

Remark External termination Resister (100Ω) is necessary for LVDS I/F differential inputs.

2.2 CMOS logic inputs & outputs

Table 4 CLKP/CLKN, CSP/CSN, SCLKP/SCLKN, SDATAP/SDATAN*3 EN, CLKIF, TRIG, SPIEN, SDOUT

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}	–	3	–	pF	
4	Logic input high current *1	I_{IH}	-10	–	10	µA	
5	Logic input low current *2	I_{IL}	-10	–	10	µA	
6	Input rise/fall time	t_r , t_f	–	–	2.0	ns	10% to 90% of signal
7	TRIG fall to clock rise setup time	$t_{SU\_TRFtoCKR}$	1.5	–	–	ns	LVDS clock
			1.5	–	–		CMOS clock
8	TRIG fall to clock rise hold time	$t_{HLD\_TRFtoCKR}$	1.5	–	–	ns	LVDS clock
			1.5	–	–		CMOS clock
9	TRIG width	t_{W_TRIG}	$3T_{CLK}$	–	–	ns	
10	High-level logic output voltage	V_{OH}	$0.8V_{LL}$	–	V_{LL}	V	SDOUT
11	Low-level logic output voltage	V_{OL}	0	–	$0.2V_{LL}$	V	SDOUT
12	Logic output off leak current	$I_{OFFLEAK}$	-10	–	10	µA	SDOUT Hi-Z output
13	SDOUT propagation delay	t_{D_SDOUT}	8	12	18	ns	V_{LL}=1.8V, 10pF load
			7	11	17	ns	V_{LL}=2.5V, 10pF load
			6	10	16	ns	V_{LL}=3.3V, 10pF load

***1.** CLKIF has 50µA leakage at V_{LL}=2.5V due to 50kΩ internal pull-down resistor.

***2.** EN, SPIEN has 50µA leakage at V_{LL}=2.5V due to 50kΩ internal pull-up resistor.

***3.** Differential CMOS or Single-ended CMOS is also available for CLKP/N, CSP/N, SCLKP/N and SDATAP/N.
In case of single-ended CMOS, N-terminals (CLKN, CSPN, SCLKN and SDATAN) need to be connected to half of V_{LL} (V_{LL}/2).

2.3 Open drain output

Table 5 FAULT

No.	Items	Symbol	Min.	Typ.	Max.	Units	Condition
1	Pull-up voltage	$V_{PUFAULT}$	–	–	V_{LL}	V	Connected to V_{LL} with R1
2	Output low voltage	$V_{OLFAULT}$	–	–	0.5	V	Active, V_{LL}=2.5V, R1=2.5kΩ
3	Output current	I_{FAULT}	–	1.0	–	mA	V_{LL}=2.5V, R1=2.5kΩ
4	Off leak current	$I_{OFFLEAK}$	-10	–	10	µA	Disabled (Hi-Z)

2.4 Logic inputs timing chart

2.4.1 LVDS clock inputs

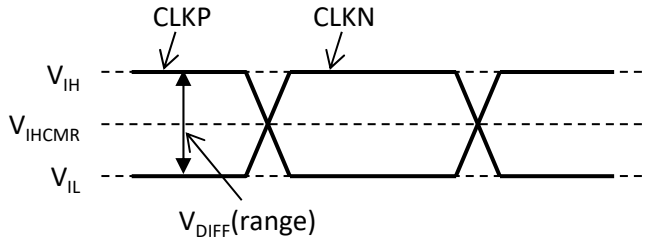

Figure 2 Differential Input Voltage Range (V_{DIFF}(range))

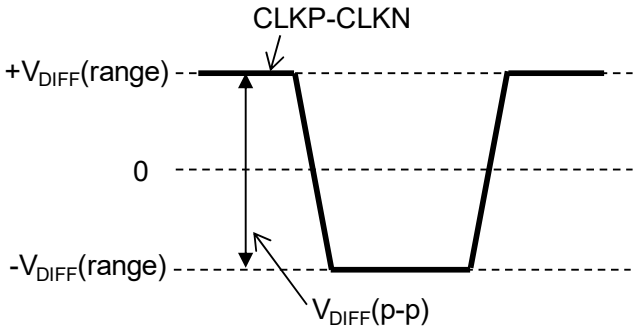

Figure 3 Differential Input Voltage Peak to Peak Swing ($V_{DIFF(p-p)}$)

2.4.2 TRIG and setup/hold time

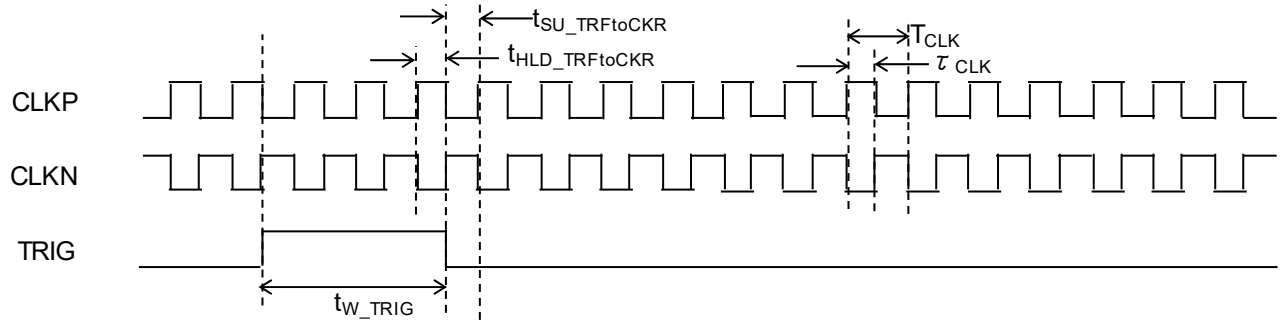

Figure 4

2.4.3 SPI inputs and setup/hold time

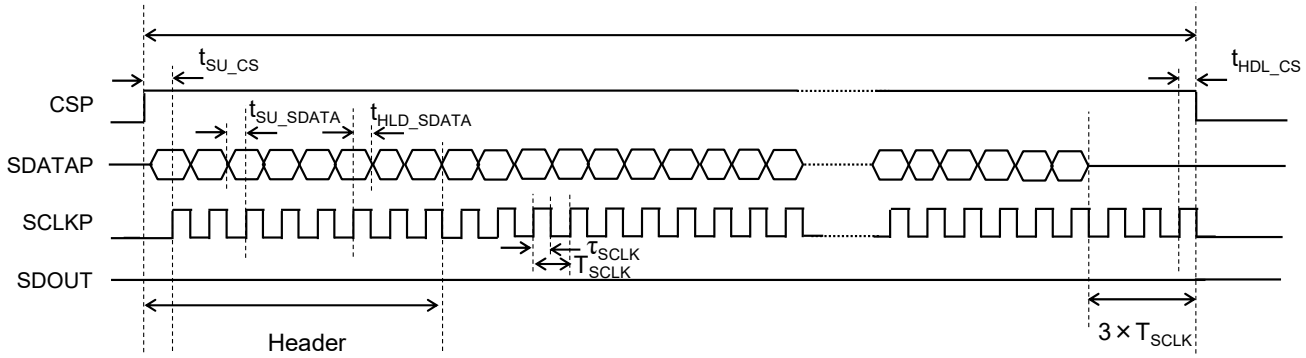

Figure 5 Write Data to Waveform Memory or Registers

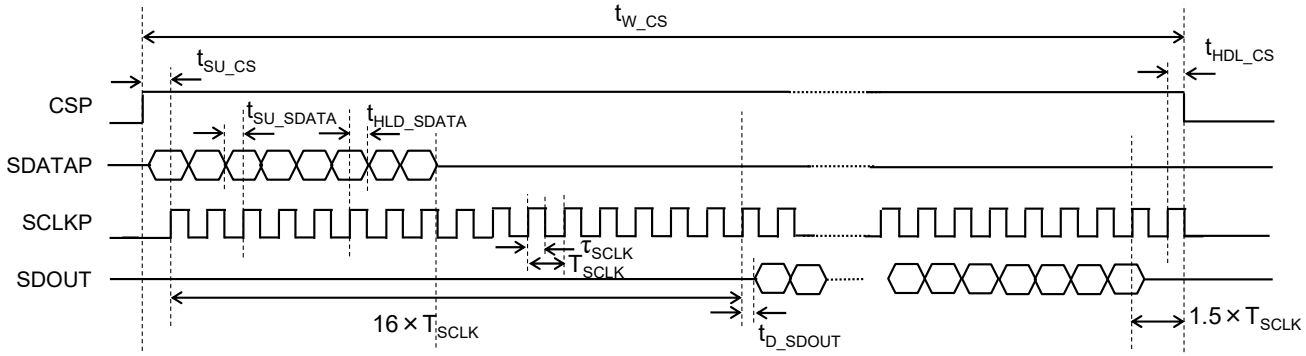

Figure 6 Read Data from Waveform Memory or Registers

2.4.4 Note on CSP rise timing

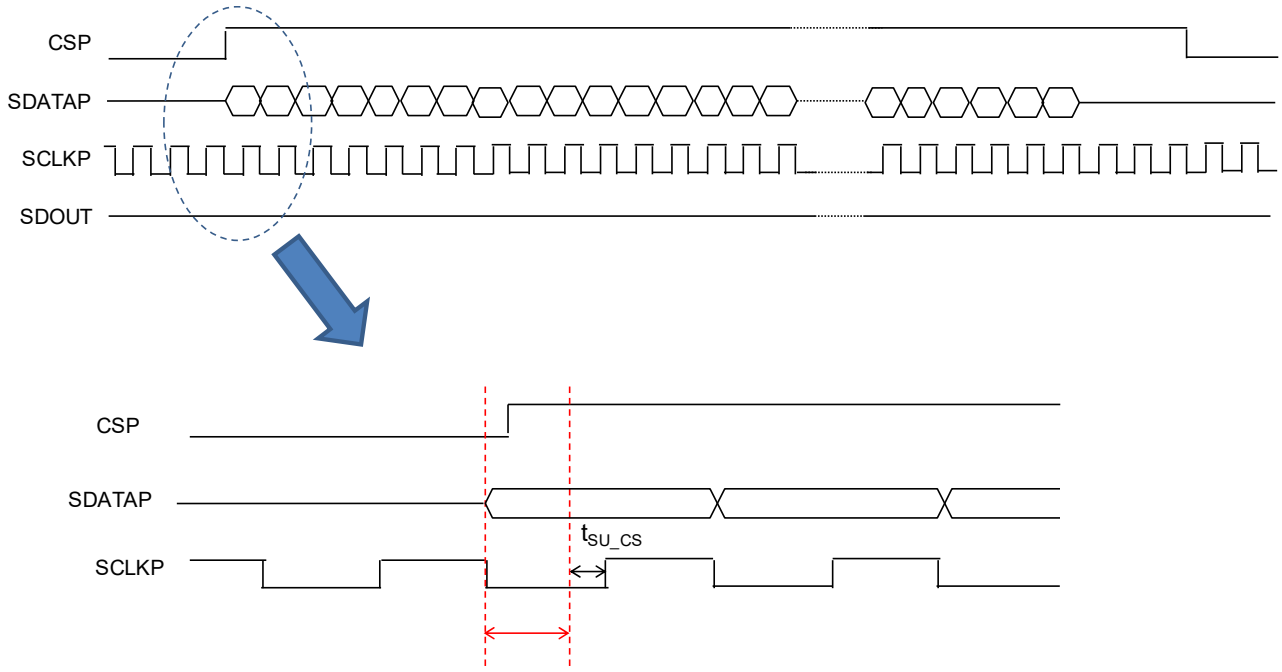

Figure 7 Note on CSP rise timing in case that SCLKP operates before CSP rising as following.

In case that SCLKP operates before CSP rising, CSP has to rise during SCLKP is “low” except for setup time “t_{SU_CS}”.

■ Typical Application Circuit

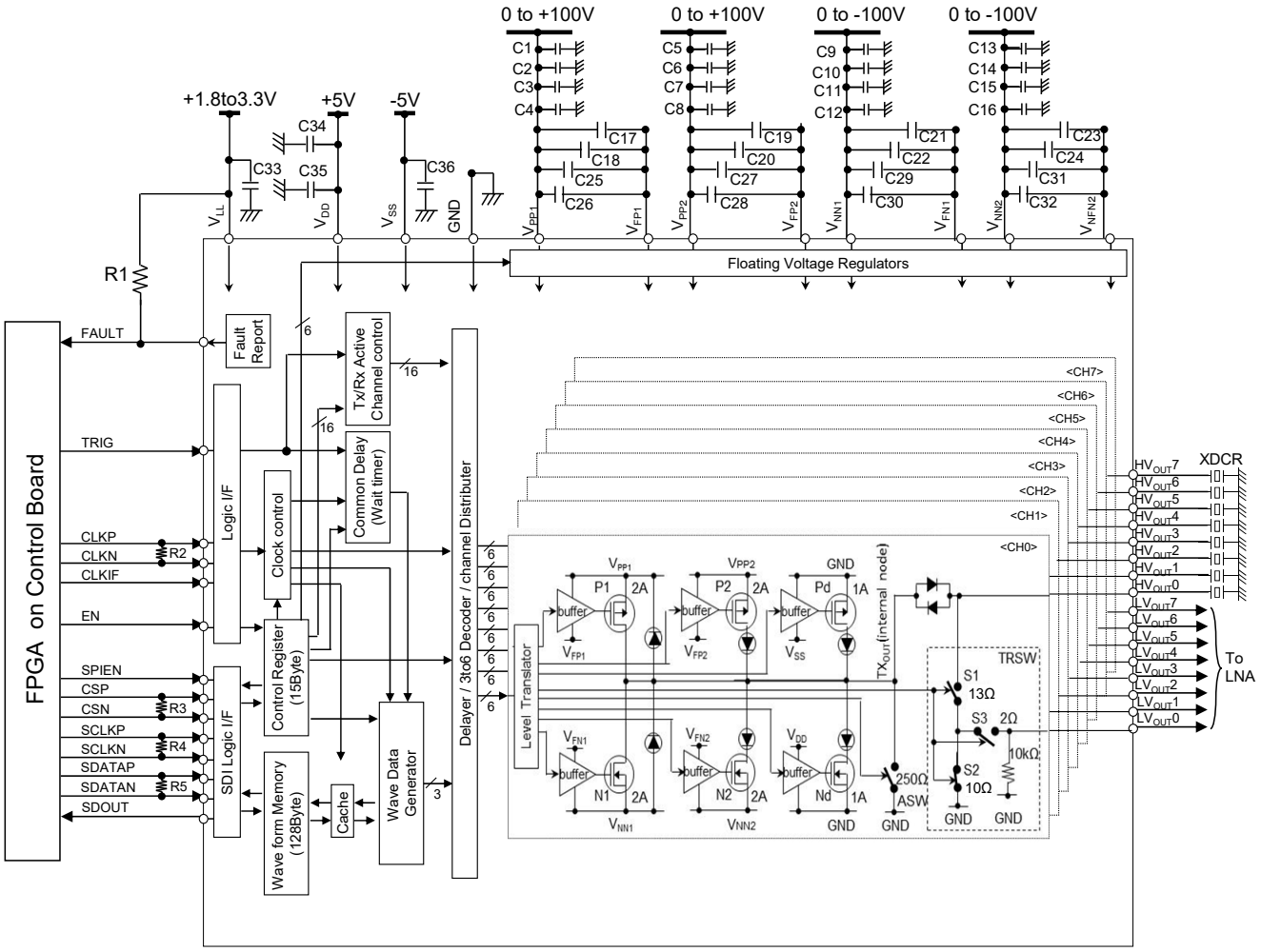

Figure 8 Typical Application Circuit

Remark C1 to C16: Ceramic capacitors of ≥200V 0.1μF to 1μF
C17 to C24: Ceramic capacitors of ≥16V 10μF
C25 to C36: Ceramic capacitors of ≥16V 0.1μF
R1: 2.5kΩ
R2 to R5: 100Ω (for LVDS)

Note:

1. High-voltage power supply pins, VPP/VNN, can draw fast transient currents up to ±2.0A. Therefore, ceramic capacitors of ≥200V 0.1μF to 1μF (C1 to 16) should be connected as close to the pins as possible for bypassing purpose.
2. Ceramic capacitors of ≥16V 10μF (C17 to 24), and ≥16V 0.1μF (C25 to 36) should also be connected between high-voltage power supply pins and corresponding floating voltage pins VFP/VFN, 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.
5. External 100Ω should be connected between differential LVDS inputs of SPI and Clock.

■ Electrical Characteristics

1. Operating supply currents

Table 6 Operating Supply Currents（1/2）

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, CLKP/CLKN=100MHz, HV_{OUT} load=220pF//200Ω, LV_{OUT} load=47pF//200Ω, unless otherwise specified.

No.	Items		Symbol	Spec			Units	Conditions
				Min.	Typ.	Max.		
1	V_{LL} current	SPIEN=H	I_{LLQD}	–	0.05	–	mA	Quiescent current-1 EN=1(Disable) Current mode 1 (CC='1') V_{PP1}/V_{NN1}=±100V V_{PP2}/V_{NN2}=±100V
		SPIEN=L		–	0.1	–	mA	
2	V_{DD} current	SPIEN=H	I_{DDQD}	–	5.5	–	mA	
		SPIEN=L		–	13.5	–	mA	
3	V_{SS} current		I_{SSQD}	–	1	–	mA	
4	V_{PP1} current		I_{PP1QD}	–	0.1	–	mA	
5	V_{PP2} current		I_{PP2QD}	–	0.1	–	mA	
6	V_{NN1} current		I_{NN1QD}	–	0.1	–	mA	
7	V_{NN2} current		I_{NN2QD}	–	0.1	–	mA	
8	V_{LL} current	SPIEN=H	I_{LLQE}	–	0.1	–	mA	Quiescent current-2 EN=0(Enable) Current mode 1 (CC='1') V_{PP1}/V_{NN1}=±100V V_{PP2}/V_{NN2}=±100V
		SPIEN=L		–	0.15	–	mA	
9	V_{DD} current	SPIEN=H, CLKIF=H(CMOS)	I_{DDQE}	–	12	–	mA	
		SPIEN=H, CLKIF=L(LVDS)		–	14	–	mA	
		SPIEN=L, CLKIF=H(CMOS)		–	20	–	mA	
		SPIEN=L, CLKIF=L(LVDS)		–	22	–	mA	
10	V_{SS} current		I_{SSQE}	–	1	–	mA	
11	V_{PP1} current		I_{PP1QE}	–	0.3	–	mA	
12	V_{PP2} current		I_{PP2QE}	–	0.3	–	mA	
13	V_{NN1} current		I_{NN1QE}	–	0.3	–	mA	
14	V_{NN2} current		I_{NN2QE}	–	0.3	–	mA	
15	V_{LL} current	SPIEN=H	I_{LLPW}	–	0.1	–	mA	PW operating current EN=0 Current mode 1 (CC='1') 8-channel active Bipolar 3-level 2-cycle f=5MHz, PRT=200µs V_{PP1}/V_{NN1}=±60V V_{PP2}/V_{NN2}=±5V
		SPIEN=L		–	0.15	–	mA	
16	V_{DD} current	SPIEN=H, CLKIF=H(CMOS)	I_{DDPW}	–	15	–	mA	
		SPIEN=H, CLKIF=L(LVDS)		–	17	–	mA	
		SPIEN=L, CLKIF=H(CMOS)		–	23	–	mA	
		SPIEN=L, CLKIF=L(LVDS)		–	25	–	mA	
17	V_{SS} current		I_{SSPW}	–	2	–	mA	
18	V_{PP1} current		I_{PP1PW}	–	4	–	mA	
19	V_{PP2} current		I_{PP2PW}	–	0.3	–	mA	
20	V_{NN1} current		I_{NN1PW}	–	4	–	mA	
21	V_{NN2} current		I_{NN2PW}	–	0.3	–	mA	

Table 6 Operating Supply Currents（2/2）

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, CLKP/CLKN=100MHz, HV_{OUT} load=220pF//200Ω, LV_{OUT} load=47pF//200Ω unless otherwise specified.

No.	Items		Symbol	Spec			Units	Conditions
				Min.	Typ.	Max.		
16	V_{LL} current	SPIEN=H	I_{LLCW1}	–	0.1	–	mA	CW operating current-1 EN=0, CKDIV[1:0]=10 Current mode 1 (CC='1') 8-channel active Bipolar 3-level Continuous f=5MHz V_{PP1}/V_{NN1}=±60V V_{PP2}/V_{NN2}=±5V
		SPIEN=L		–	0.15	–	mA	
17	V_{DD} current	SPIEN=H, CLKIF=H(CMOS)	I_{DDCW1}	–	108	–	mA	
		SPIEN=H, CLKIF=L(LVDS)		–	110	–	mA	
		SPIEN=L, CLKIF=H(CMOS)		–	116	–	mA	
		SPIEN=L, CLKIF=L(LVDS)		–	118	–	mA	
18	V_{SS} current		I_{SSCW1}	–	24	–	mA	
19	V_{PP1} current		I_{PP1CW1}	–	0.3	–	mA	
20	V_{PP2} current		I_{PP2CW1}	–	190	–	mA	
21	V_{NN1} current		I_{PP2CW1}	–	0.3	–	mA	
22	V_{NN2} current		I_{NN2CW1}	–	200	–	mA	
23	V_{LL} current	SPIEN=H	I_{LLCW2}	–	0.1	–	mA	CW operating current-2 EN=0, CKDIV[1:0]=10 Current mode 0 (CC='0') 8-channel active Bipolar 3-level Continuous f=5MHz V_{PP1}/V_{NN1}=±60V V_{PP2}/V_{NN2}=±5V
		SPIEN=L		–	0.15	–	mA	
24	V_{DD} current	SPIEN=H, CLKIF=H(CMOS)	I_{DDCW2}	–	105	–	mA	
		SPIEN=H, CLKIF=L(LVDS)		–	107	–	mA	
		SPIEN=L, CLKIF=H(CMOS)		–	113	–	mA	
		SPIEN=L, CLKIF=L(LVDS)		–	115	–	mA	
25	V_{SS} current		I_{SSCW2}	–	21	–	mA	
26	V_{PP1} current		I_{PP1CW2}	–	0.24	–	mA	
27	V_{PP2} current		I_{PP2CW2}	–	175	–	mA	
28	V_{NN1} current		I_{NN1CW2}	–	0.24	–	mA	
29	V_{NN2} current		I_{NN2CW2}	–	185	–	mA	

2. Static characteristics

Table 7 Static Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, VFP[2:0]=VFN[2:0]=000, DRVPADJ=DRVNADJ=0, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	$HV_{OUT}x$ output voltage range	$HV_{OUT}x$	-100	–	+100	V	
2	$HV_{OUT}x$ high-side peak current	I_{OH}	–	2.0	–	A	P1 active, V_{PP1}/V_{NN1}=±60V
			–	2.0	–	A	P2 active, V_{PP2}/V_{NN2}=±60V, CC=1
			–	1.0	–	A	P2 active, V_{PP2}/V_{NN2}=±60V, CC=0
3	$HV_{OUT}x$ high-side GND clamp peak current	I_{OHCL}	–	1.0	–	A	Nd active, $V_{PP1}/V_{NN1}=V_{PP2}/V_{NN2}$=±60V
4	$HV_{OUT}x$ low-side peak current	I_{OL}	–	2.0	–	A	N1 active, V_{PP}/V_{NN}=±60V
			–	2.0	–	A	N2 active, V_{PP}/V_{NN}=±60V, CC=1
			–	1.0	–	A	N2 active, V_{PP}/V_{NN}=±60V, CC=0
5	$HV_{OUT}x$ low-side GND clamp peak current	I_{OLCL}	–	1.0	–	A	Pd active, $V_{PP1}/V_{NN1}=V_{PP2}/V_{NN2}$=±60V
6	$HV_{OUT}x$ high-side on-resistance	R_{ONH}	–	15	–	Ω	I_{OH}=100mA, P1 active
			–	15	–	Ω	I_{OH}=100mA, P2 active, CC=1
			–	23	–	Ω	I_{OH}=100mA, P2 active, CC=0
7	$HV_{OUT}x$ high-side GND clamp on-resistance	R_{ONHCL}	–	20	–	Ω	I_{OHCL}=100mA, Pd active
8	$HV_{OUT}x$ low-side on-resistance	R_{ONL}	–	15	–	Ω	I_{OL}=100mA, N1 active
			–	15	–	Ω	I_{OL}=100mA, N2 active, CC=1
			–	23	–	Ω	I_{OL}=100mA, N2 active, CC=0
9	$HV_{OUT}x$ low-side GND clamp on-resistance	R_{ONLCL}	–	20	–	Ω	I_{OLCL}=100mA, Nd active
10	$HV_{OUT}x$ off-capacitance	C_{HVOFF}	–	34	–	pF	$TX_{OUT}x$=GND, TRSW=off

3. Dynamic characteristics

Table 8 Dynamic Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, CLKP/CLKN=100MHz,VFPCTL[2:0]=VFNCTL[2:0]='000', HV_{OUT} load=220pF//200Ω, LV_{OUT} load=47pF//200Ω, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	Output frequency	f_{OUT}	–	20	–	MHz	
2	Output rise propagation delay	t_{dr}	–	40	–	ns	
3	Output fall propagation delay	t_{df}	–	40	–	ns	
4	Output rise propagation delay clamp	t_{drCL}	–	40	–	ns	
5	Output fall propagation delay clamp	t_{dfCL}	–	40	–	ns	
6	Propagation delay matching	Δt_d	–	±1	±3	ns	
7	Output rise time	t_r	–	18	–	ns	P1 active
			–	18	–	ns	P2 active, CC=1
			–	33	–	ns	P2 active, CC=0
		t_{rCL}	–	15	–	ns	Pd active
8	Output fall time	t_f	–	18	–	ns	N1 active
			–	18	–	ns	N2 active, CC=1
			–	33	–	ns	N2 active, CC=0
		t_{fCL}	–	15	–	ns	Nd active
9	2nd harmonic distortion	HD2	–	-40	–	dBc	Bipolar, 2-cycle, f_{OUT}=5MHz
10	Pulse cancellation	HDPC	–	-40	–	dBc	
		HDPC2	–	-40	–	dBc	
11	RMS output jitter	t_J	–	10	–	ps	Bipolar CW, f_{OUT}=5MHz, V_{PP}/V_{NN}=±5V, HV_{OUT} load=50Ω
12	Crosstalk between channels	X_{TLK}	–	-70	–	dB	f_{OUT}=5MHz, $10V_{p-p}$, HV_{OUT} load=50Ω

4. Integrated peripheral circuits characteristics

4. 1 T/R Switch characteristics

Table 9 T/R Switch Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, $V_{PP}1/V_{NN}1=V_{PP}2/V_{NN}2$=±60V, T_A=25°C, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	$LV_{OUT}x$ output voltage range	$LV_{OUT}x$	-0.85	–	+0.85	V	
2	TRSW on-resistance	R_{ONTR}	–	15	–	Ω	$HV_{OUT}x$=100mV, $LV_{OUT}x$=0V
3	TRSW on-capacitance	C_{ONTR}	–	15	–	pF	$LV_{OUT}x$=0V
4	TRSW off-resistance on HVOUTx	$R_{OFFTRHV}$	1	-	–	MΩ	
5	TRSW off-resistance on LVOUTx	$R_{OFFTRLV}$	8	10	12	kΩ	
6	Spike voltage on $HV_{OUT}x$ and $LV_{OUT}x$	V_{TRN}	–	–	110	mV_{PP}	220pF//200Ω load on $HV_{OUT}x$ 47pF//200Ω load on $LV_{OUT}x$
7	TRSW turn-on time	t_{dTRON}	–	300	–	ns	Logic input-to-ready for Rx signal See Fig.15
8	TRSW turn-off time	t_{dTROFF}	–	50	100	ns	See Fig.15

4. 2 Analog Switch

Table 10 Analog Switch Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	ASW on-resistance	R_{ONASW}	–	250	–	Ω	

4. 3 HV Blocking Diode

Table 11 HV Blocking Diode Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	Forward voltage	V_{FHVD}	–	1.0	–	V	I_F=100mA
			–	1.2	–	V	I_F=200mA
2	Reverse voltage	V_{RHVD}	200	–	–	V	I_R=1μA

4. 4 LV Noise-cut Diode

Table 12 LV Noise-cut Diode Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	Forward voltage	V_{FLVD}	–	1.1	–	V	I_F=100mA
			–	1.25	–	V	I_F=200mA

4. 5 Thermal Protection

Table 13 Thermal Protection Characteristics

V_{LL}=2.5V, V_{DD}/V_{SS}=±5V, T_A=25°C, unless otherwise specified.

No.	Items	Symbol	Spec			Units	Condition
			Min.	Typ.	Max.		
1	THP temperature threshold	T_{THP}	90	110	120	°C	THPCTL[1:0]=00
			120	130	140	°C	THPCTL[1:0]=01
			140	150	160	°C	THPCTL[1:0]=10
			–	Disabled	–	°C	THPCTL[1:0]=11 (THP is disabled)
2	THP reset hysteresis	T_{HYSTHP}	5	10	20	°C	

■ Operation Mode

Table 14 Operation Mode

Section	EN	CSP	SPIEN*2	TRIG	Tx Pattern Signal	SPI LVDS Receiver	Memory Write	Memory Read	Register Write	Register Read	Tx	Rx	Operation mode
A	1	0	0	×	×	Bias on	–	–	–	–	–	–	IC disabled
			1			Bias off							
B	1	1	0	×	×	Bias on	✓	✓	–	✓	–	–	IC disabled, W/R of Memory and Read of Register
			1			Bias off	–	–	–	–			
C	0	1	0	×	×	Bias on	✓	✓	✓	✓	–	✓*1	Rx, W/R of Memory or Register, Reset of Tx Operation
			1			Bias off	–	–	–	–			
D	0	0	0	1	×	Bias on	–	–	–	–	–	✓*1	Rx & Reset of Tx Operation
			1			Bias off							
E	0	0	0	0	Generated	Bias on	–	–	–	–	✓*1	–	Tx
			1			Bias off							
F	0	0	0	0	none	Bias on	–	–	–	–	–	✓*1	Rx
			1			Bias off							

***1.** Individual register parameter on Tx/Rx active channel (TXACT[x] and RXACT[x]) is necessary to be set "1".
***2.** SPIEN Signal is used to reduce the bias current of SPI LVDS Receiver when SPI is not used. (Power on/off time of LVDS receiver is <300ns/<100ns.)

Remark ✓: Available
–: Not available
×: Don't care

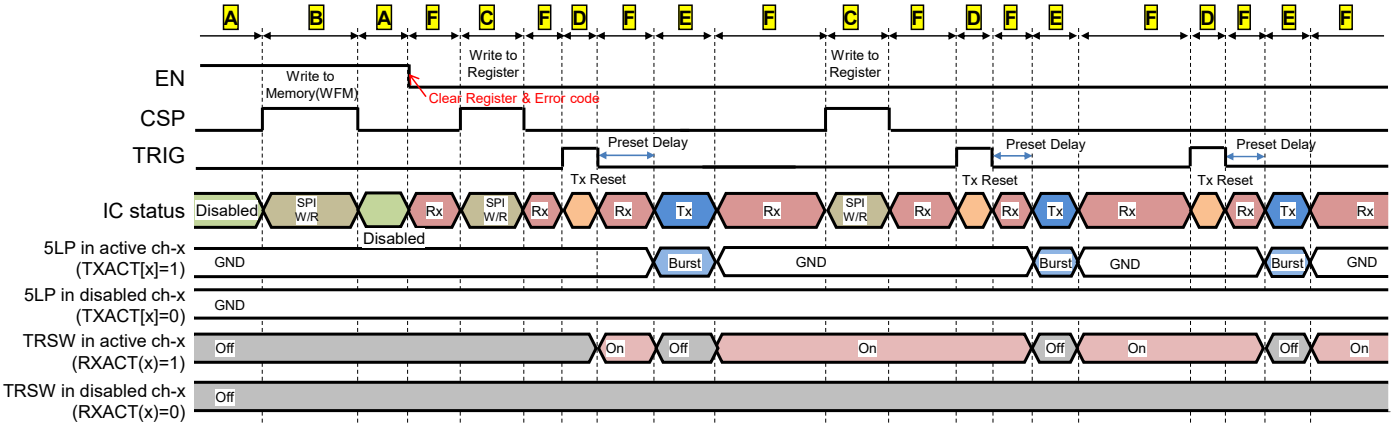

Figure 9 An Example of Operating Sequence

■ SPI Header Configuration

Table 15 SPI Operation Table

SDATA Control Header (First 1Byte of SDATA)								SPI Operation
D7 (MSB)	D6	D5	D4	D3	D2	D1	D0 (LSB)	
0	0	0	0	0000 (Reserved)				Write to the first 7Byte (R#0 to R#6) Control Registers and CRC[7:0]
0	1	0	0					Write to all 16Byte Control Registers and CRC[7:0]
1	0	0	0					N/A
1	1	0	0					Write to Memory and CRC[7:0]
0	0	0	1					Read from the first 7Byte (R#0 to R#6) Control Registers and CRC[7:0]
0	1	0	1					Read from all 16Byte Control Registers and CRC[7:0]
1	0	0	1					N/A
1	1	0	1					Read from Memory and CRC[7:0] through SDOUT pin
×	×	1	0					Read from ERROR[7:0] through SDOUT pin
×	×	1	1					Read from DSUM[7:0] through SDOUT pin

< 8bit CRC Conditions>
CRC initial value = 00000000
CRC Polynomial equation is $X^8+X^5+X^4+1$

Remark ×: Don't care

■ Access to Memory or Registers with SPI

1. SPI write to memory or registers operation

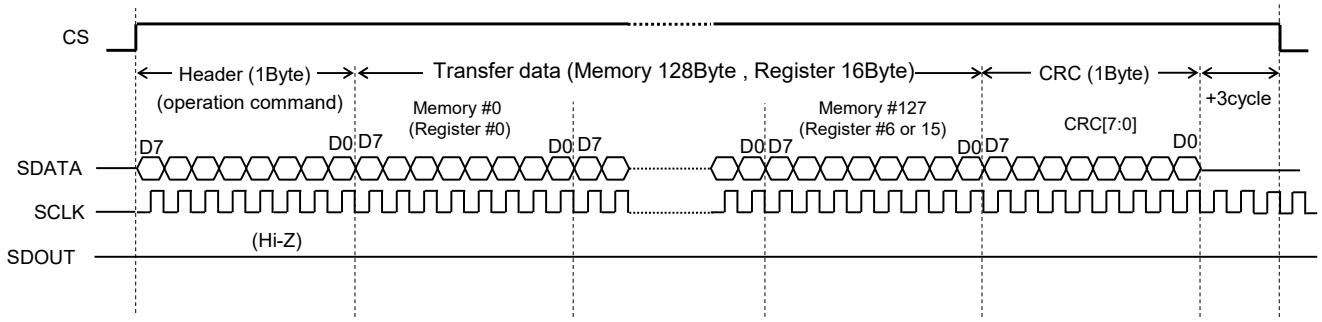

Figure 10 Sequence of Writing to Memory or Registers with SPI

Remark <CRC Conditions>
CRC initial value = 00000000
CRC Polynomial equation is $X^8+X^5+X^4+1$

In SPI “WRITE” operation, internal logic circuit also calculates the CRC ,and writes it to internal Register DSUM[7:0]. If CRC[7:0] matches DSUM[7:0], ERROR[0] = 0. If unmatched, ERROR[0] = 1 and FAULT pin reports, unless fault report is released.

2. Read back form memory or registers operation

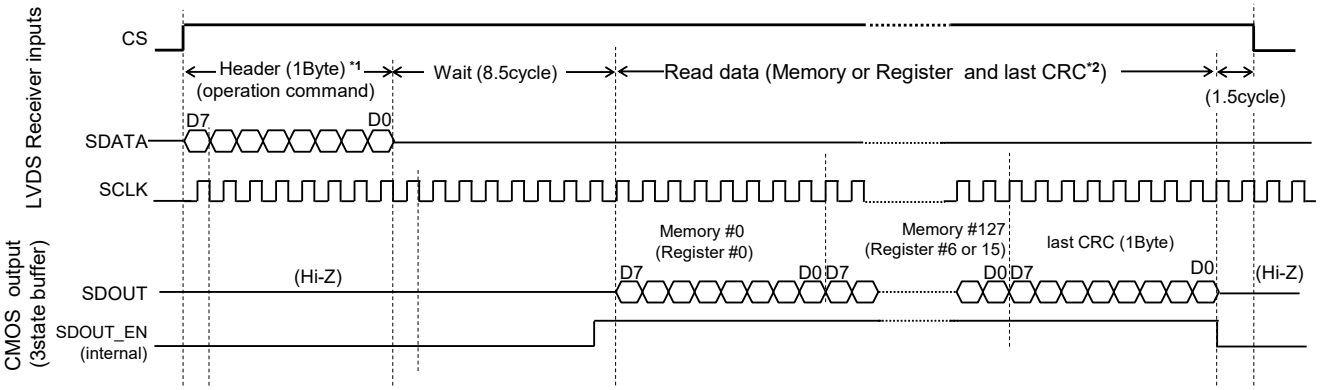

Figure 11 Sequence of Reading from Memory or Registers with SPI

***1.** In case of "READ" operation, SDATA inputs except for Header are ignored. (CRC error detection is disabled).
***2.** Last CRC is the received CRC data from FPGA in previous "WRITE" operation to Memory or Register.

■ 5LP+TRSW Operation Example

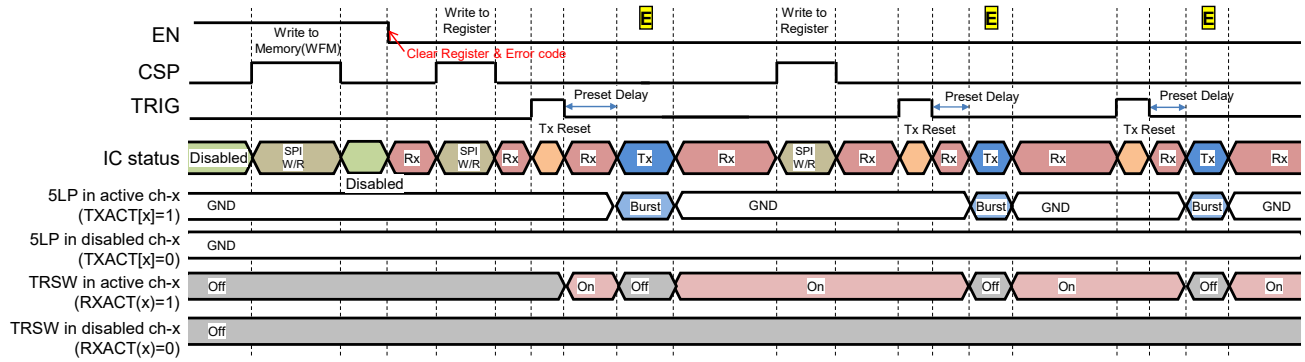

Figure 12 An Example of IC State Timing Diagram and 5LP Operation

E Tx starts from TRIG fall edge with preset delay time.
TRSW turns on except for Tx Burst period or IC-disabled.

Generating Tx WF Pattern

CODE_[1:0] = output state (±HV, GND) see **Truth Table**
Pulse width = 5ns × (W_[4:0]+2) (decimal, 10ns to 165ns)
START [6:0] = starting address
STOP [6:0] = stopping address
Repeat count(s) = 1, 1×REPEAT[7:0], 16×REPEAT[7:0], CW
CW mode ends with CS = 1 or TRIG = 1.

Generating Tx Delay (8ch)

CHx delay time form TRIG fall edge = BASE-DELAY + CHx-DELAY
BASE-DELAY(common) = 160ns×(BASEDL[7:0])+200ns
(decimal, 0.2µs to 41µs)
CHx-DELAY(/ch) = 5ns*(CHxDL[7:0])
(x=0 to 7, decimal, 0 to 1.275µs)
Delay time resolution = 5ns

WFM

START[6:0]
STOP[6:0]

M#	Item	D7	D6	D5	D4	D3	D2	D1	D0
0	Pulse #0	CODE0 [2]	CODE0 [1]	CODE0 [0]	W0 [4]	W0 [3]	W0 [2]	W0 [1]	W0 [0]
1	Pulse #1	CODE1 [2]	CODE1 [1]	CODE1 [0]	W1 [4]	W1 [3]	W1 [2]	W1 [1]	W1 [0]
2	Pulse #2	CODE2 [2]	CODE2 [1]	CODE2 [0]	W2 [4]	W2 [3]	W2 [2]	W2 [1]	W2 [0]
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
127	Pulse #127	CODE127 [2]	CODE127 [1]	CODE127 [0]	W127 [4]	W127 [3]	W127 [2]	W127 [1]	W127 [0]

Register

R#	D7	D6	D5	D4	D3	D2	D1	D0
0	reserved	START[6]	START[5]	START[4]	START[3]	START[2]	START[1]	START[0]
1	reserved	STOP[6]	STOP[5]	STOP[4]	STOP[3]	STOP[2]	STOP[1]	STOP[0]
2	INV	MUL-RPT	reserved	CC	CKDIV[1]	CKDIV[0]	THPCTL[1]	THPCTL[0]
3	REPEAT[7]	REPEAT[6]	REPEAT[5]	REPEAT[4]	REPEAT[3]	REPEAT[2]	REPEAT[1]	REPEAT[0]
4	DRVPADJ	VFP[2]	VFP[1]	VFP[0]	DRVNADJ	VFN[2]	VFN[1]	VFN[0]
5	TXACT[7]	TXACT[6]	TXACT[5]	TXACT[4]	TXACT[3]	TXACT[2]	TXACT[1]	TXACT[0]
6	RXACT[7]	RXACT[6]	RXACT[5]	RXACT[4]	RXACT[3]	RXACT[2]	RXACT[1]	RXACT[0]
7	BASEDL[7]	BASEDL[6]	BASEDL[5]	BASEDL[4]	BASEDL[3]	BASEDL[2]	BASEDL[1]	BASEDL[0]
8	CH0DL[7]	CH0DL[6]	CH0DL[5]	CH0DL[4]	CH0DL[3]	CH0DL[2]	CH0DL[1]	CH0DL[0]
9	CH1DL[7]	CH1DL[6]	CH1DL[5]	CH1DL[4]	CH1DL[3]	CH1-DL[2]	CH1DL[1]	CH1DL[0]
10	CH2DL[7]	CH2DL[6]	CH2DL[5]	CH2DL[4]	CH2DL[3]	CH2DL[2]	CH2DL[1]	CH2DL[0]
11	CH3DL[7]	CH3DL[6]	CH3DL[5]	CH3DL[4]	CH3DL[3]	CH3DL[2]	CH3DL[1]	CH3DL[0]
12	CH4DL[7]	CH4DL[6]	CH4DL[5]	CH4DL[4]	CH4DL[3]	CH4DL[2]	CH4DL[1]	CH4DL[0]
13	CH5DL[7]	CH5DL[6]	CH5DL[5]	CH5DL[4]	CH5DL[3]	CH5DL[2]	CH5DL[1]	CH5DL[0]
14	CH6DL[7]	CH6DL[6]	CH6DL[5]	CH6DL[4]	CH6DL[3]	CH6DL[2]	CH6DL[1]	CH6DL[0]
15	CH7DL[7]	CH7DL[6]	CH7DL[5]	CH7DL[4]	CH7DL[3]	CH7DL[2]	CH7DL[1]	CH7DL[0]

■ Truth Table

Table 16 Truth Table

	IC status		External singal			Internal Tx-PT(x)	Control Register		WFM CODE[2:0]			Control Register	CHx 5LP MOSFET/ASW/TRSW status								CHx Output state	
	mode	SPI	EN	CS	TRIG		TXACT	RXACT	[2]	[1]	[0]	INV	P1	N1	P2	N2	Pd	Nd	250Ω ASW	TRSW	$TXOUT_x$	$LVOUT_x$
A	IC disabled	no op.	1	0	×	none	×	×	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
B		Mem. W	1	1	×	none	×	×	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
C	Rx & Tx Reset by SPI W/R	Memory W/R or Register W/R	0	1	×	none	0	0	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	1	×	none	0	1	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**	GND	$HVOUT_x$
			0	1	×	none	1	0	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	1	×	none	1	1	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**	GND	$HVOUT_x$
D	Rx & Tx Reset By TRIG	no op.	0	0	1	none	0	0	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	0	1	none	0	1	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**	GND	$HVOUT_x$
			0	0	1	none	1	0	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	0	1	none	1	1	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**	GND	$HVOUT_x$
E	Tx	no op.	0	0	0	Gen.	1	×	0	0	0	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	0	0	Gen.	1	×	0	0	1	0	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	+HV1	10kΩ
			0	0	0	Gen.	1	×	0	0	1	1	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	-HV1	10kΩ
			0	0	0	Gen.	1	×	0	1	0	0	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	-HV1	10kΩ
			0	0	0	Gen.	1	×	0	1	0	1	**ON**	OFF	OFF	OFF	OFF	OFF	OFF	OFF	+HV1	10kΩ
			0	0	0	Gen.	1	×	0	1	1	×	N/A								N/A	
			0	0	0	Gen.	1	×	1	0	0	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	0	0	Gen.	1	×	1	0	1	0	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	+HV2	10kΩ
			0	0	0	Gen.	1	×	1	0	1	1	OFF	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	-HV2	10kΩ
			0	0	0	Gen.	1	×	1	1	0	0	OFF	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	-HV2	10kΩ
			0	0	0	Gen.	1	×	1	1	0	1	OFF	OFF	**ON**	OFF	OFF	OFF	OFF	OFF	+HV2	10kΩ
			0	0	0	Gen.	1	×	1	1	1	×	N/A								N/A	
F	Rx	no op.	0	0	0	none	×	0	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	OFF	GND	10kΩ
			0	0	0	none	×	1	×	×	×	×	OFF	OFF	OFF	OFF	**ON**	**ON**	**ON**	**ON**	GND	$HVOUT_x$

Remark ×: Don't care

Table 17 Truth Table

DRVP ADJ	DRVN ADJ	I_{OUT}[A]	
		P1	N1
0	0	2	2
0	1	2	2.1
1	0	2.1	2
1	1	2.1	2.1

Table 18 Truth Table

Current mode	CC	I_{OUT}[A]	
		P2	N2
0	0	1	1
1	1	2	2

Table 19 Truth Table

VFPCTL			VPP1-VFP1 [V]	VPP2-VFP2 [V]
[2]	[1]	[0]		
0	0	0	5	5
0	0	1	5.15	5.15
0	1	0	5.3	5.3
0	1	1	5.45	5.45
1	0	0	5	5
1	0	1	4.85	4.85
1	1	0	4.7	4.7
1	1	1	4.55	4.55

Table 20 Truth Table

VFNCTL			VFN1-VNN1 [V]	VFN2-VNN2 [V]
[2]	[1]	[0]		
0	0	0	5	5
0	0	1	5.15	5.15
0	1	0	5.3	5.3
0	1	1	5.45	5.45
1	0	0	5	5
1	0	1	4.85	4.85
1	1	0	4.7	4.7
1	1	1	4.55	4.55

■ Timing Chart

Control Registers
START[6:0] = n
STOP[6:0] = n+1

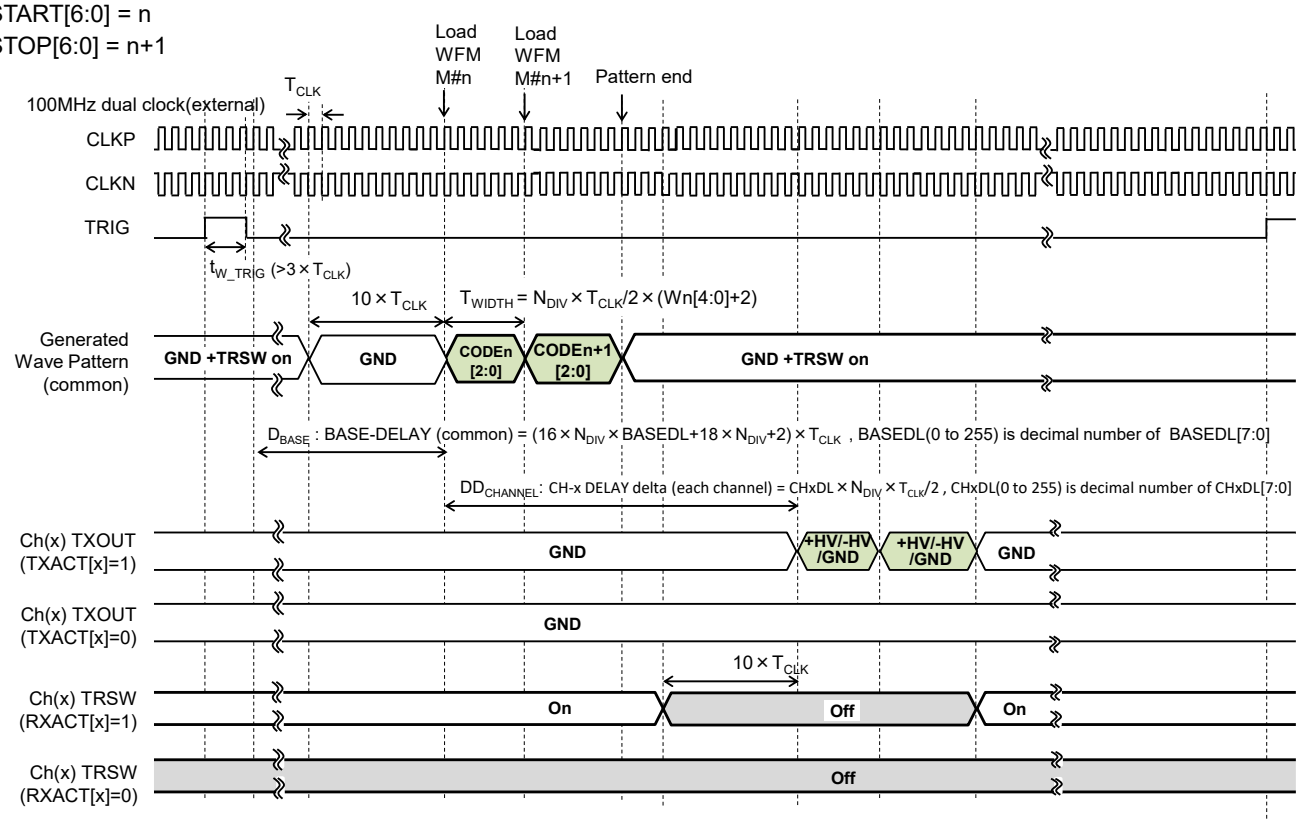

Figure 13 An Example of 5LP State Timing Diagram with Register TXACT[x] & RXACT[x] (x=0 to 15)

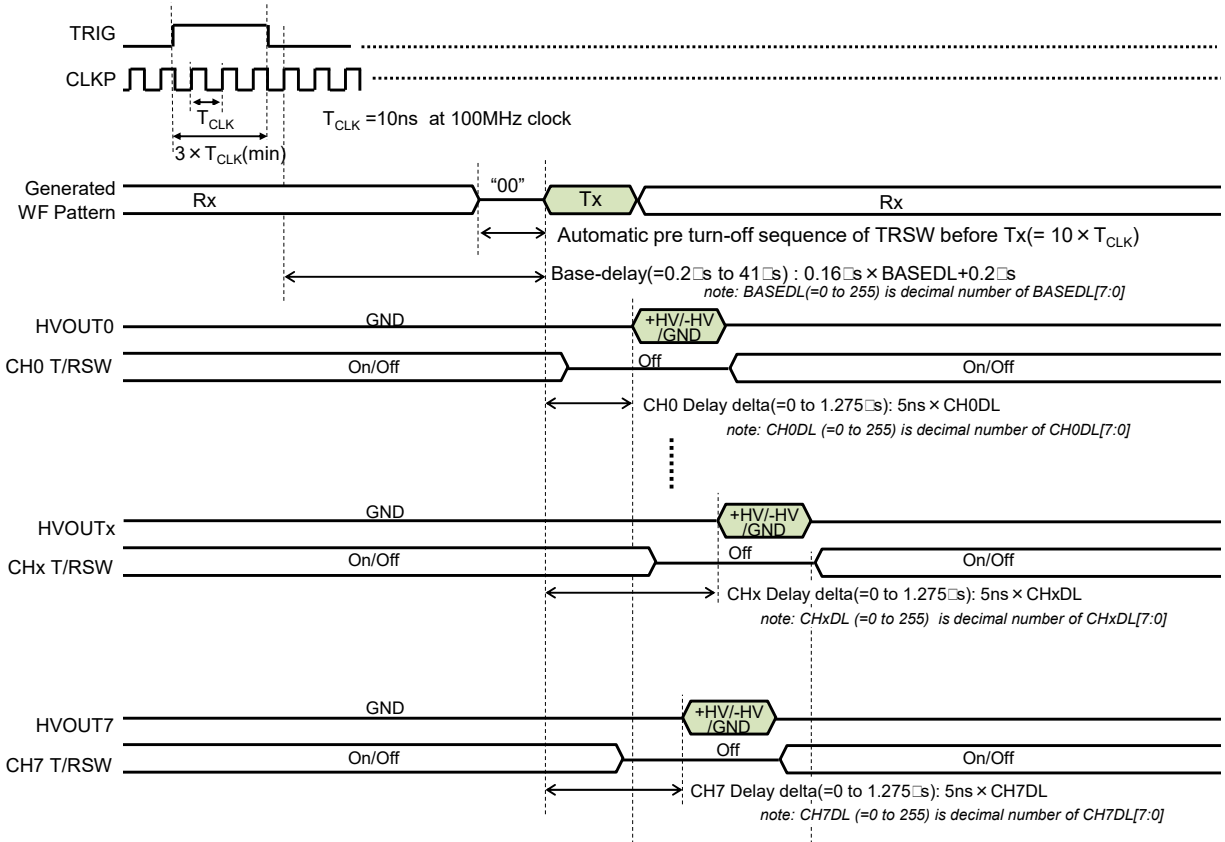

Figure 14 An Example of 5LP State Timing Diagram with Register BASEDL[7:0] & CHxDL[8:0] (x=0 to 15)

■ Tx Propagation Delay and Rise/Fall Time Definition

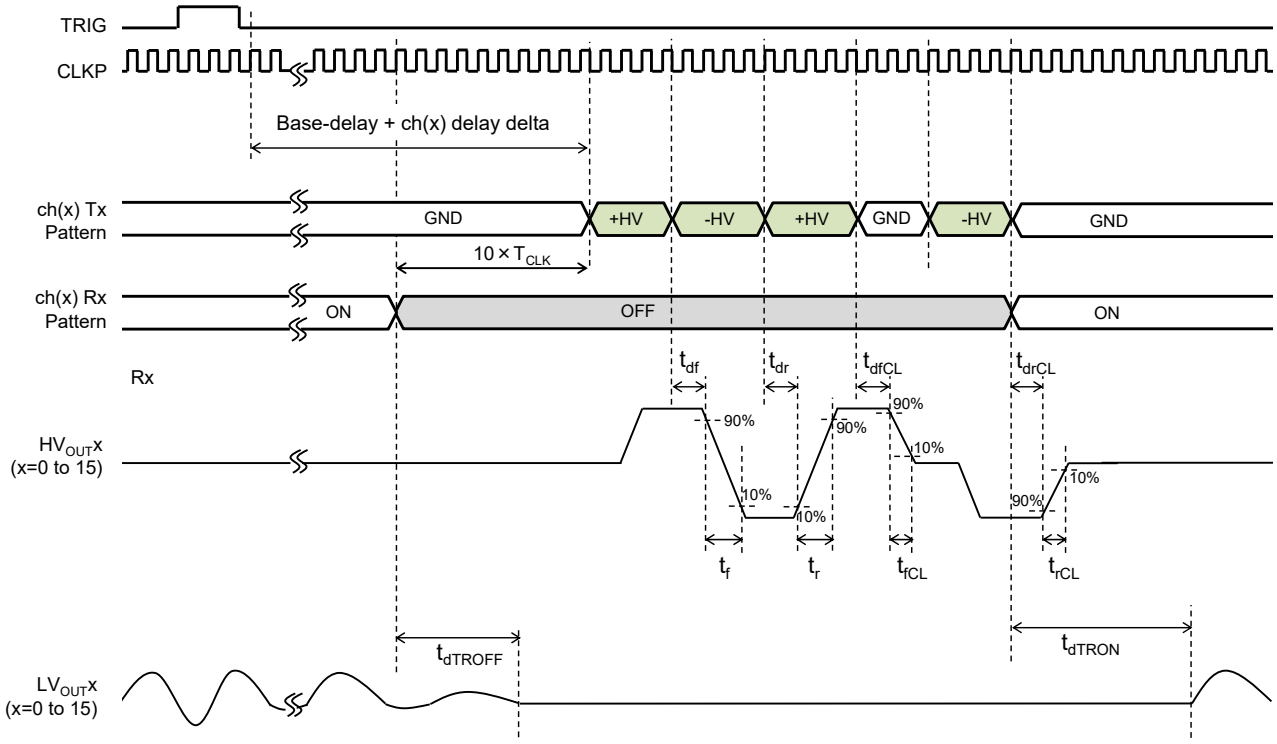

Fig.15 Tx propagation Delay and Rise/Fall Time

■ Tx Pulse Width and Delay Control Table

Table 21 Tx Pulse Width and Delay Control Table

Clock frequency = 100MHz (T_{CLK}=10ns)

No.	Items		Symbol	Spec			Units	Note
				Min.	Typ.	Max.		
1	Tx pulse width	N_{DIV}=1	T_{WIDTH}	10	–	165	ns	T_{WIDTH} [ns] = N_{DIV} ×T_{CLK}/2 × (WIDTHx + 2) WIDTHx(=0 to 31) is decimal number of WIDTHx[4:0] in memory #x, x=0 to 127
		N_{DIV}=2		20	–	330		
		N_{DIV}=4		40	–	660		
2	Tx pulse width resolution	N_{DIV}=1	ΔT_{WIDTH}	–	5	–	ns	ΔT_{WIDTH}=N_{DIV}×T_{CLK}/2
		N_{DIV}=2		–	10	–		
		N_{DIV}=4		–	20	–		
3	Base delay range	N_{DIV}=1	D_{BASE}	0.2	–	41	µs	D_{BASE}=(16×N_{DIV}×BASEDL+18×N_{DIV}+2)×T_{CLK} BASEDL(=0 to 255) is decimal number of BASEDL[7:0]
		N_{DIV}=2		0.38	–	81.98		
		N_{DIV}=4		0.74	–	163.94		
4	Base delay resolution	N_{DIV}=1	ΔD_{BASE}	–	0.16	–	µs	ΔD_{BASE}=16×N_{DIV}×T_{CLK}
		N_{DIV}=2		–	0.32	–		
		N_{DIV}=4		–	0.64	–		
5	CHx delay delta range (x=0 to 15)	N_{DIV}=1	$DD_{CHANNEL}$	0	–	1275	ns	$DD_{CHANNEL}$= N_{DIV}×T_{CLK}/2×CHxDL CHxDL(=0 to 255) is decimal number of CHxDL[7:0] x=0 to 7
		N_{DIV}=2		0	–	2550		
		N_{DIV}=4		0	–	5100		
6	CHx delay delta resolution (x=0 to 15)	N_{DIV}=1	$\Delta DD_{CHANNEL}$	–	5	–	ns	$\Delta DD_{CHANNEL}$=N_{DIV}×T_{CLK}/2
		N_{DIV}=2		–	10	–		
		N_{DIV}=4		–	20	–		

Remark N_{DIV}(=1,2,4) is internal clock dividing factor with Register CKDIV[1:0].
CKDIV[1:0]=00: N_{DIV} =1
CKDIV[1:0]=01: N_{DIV} =2
CKDIV[1:0]=10,11: N_{DIV} =4

■ Memory MAP

Table 22 Memory Map

Memory #	D7	D6	D5	D4	D3	D2	D1	D0
0	CODE0[2:0]			WIDTH0[4:0]				
1	CODE1[2:0]			WIDTH1[4:0]				
2	CODE2[2:0]			WIDTH2[4:0]				
3	CODE3[2:0]			WIDTH3[4:0]				
: : :	: : :			: : :				
124	CODE124[2:0]			WIDTH124[4:0]				
125	CODE125[2:0]			WIDTH125[4:0]				
126	CODE126[2:0]			WIDTH126[4:0]				
127	CODE127[2:0]			WIDTH127[4:0]				

Remark 1. In Memory Map, each 1-byte code consists of upper 3-bit CODEx[3:0] and lower 5-bit WIDTHx[4:0]. Suffix "x" corresponds to 1-byte Memory number (x=0 to 127).

2. CODEx[2:0] stands for an output state of Tx burst as shown in Truth Table.

3. WIDTHx[4:0] expresses the pulse width (T_{WIDTH}) which is calculated as follows.

T_{WIDTH} [ns] = $N_{DIV} \times T_{CLK}/2 \times$ (WIDTHx + 2)

4. Where, T_{CLK} is the CLKP/CLKN clock period, WIDTHx(=0 to 31) is decimal number of WIDTHx[4:0] and N_{DIV}(=1,2,4) is internal clock dividing factor with Register CKDIV[1:0].

5. In case of 100MHz CLK,

CKDIV[1:0]=00 : N_{DIV}=1, T_{WIDTH} [ns] is 10ns to 165ns (5ns step).

CKDIV[1:0]=01 : N_{DIV}=2, T_{WIDTH} [ns] is 20ns to 330ns (10ns step).

CKDIV[1:0]=10, 11 : N_{DIV}=4, T_{WIDTH} [ns] is 40ns to 660ns (20ns step).

■ Register Parameter Function

Table 23 Register Parameter Function

Items	Register	type	function
WFM Read Address(start)	START [6:0]	common	Starting address of the Waveform Memory for generating the Tx waveform pattern
WFM Read Address(stop)	STOP [6:0]	common	Stop address of the Waveform Memory for generating the Tx waveform pattern
TX Waveform control	INV	common	Inversion control of generating Tx waveform pattern
Wave generation Repeat control(1)	MUL-RPT	common	Multiplying factor selection for REPEAT[7:0] (1: 1×REPEAT[7:0], 0: 16×REPEAT[7:0])
Tx driver current control	CC	common	P2/N2 Tx driver current control (0=1A, 1=2A)
Tx clock dividing	CKDIV [1:0]	common	Internal clock dividing factor "N_{DIV}" selection (00:N_{DIV}=1, 01:N_{DIV}=2, 10 or 11 :N_{DIV}=4)
P1 Driver adjusment	DRVPADJ	common	P1 driver current, 0:2A , 1:2.1A
N1 Driver adjusment	DRVNADJ	common	N1 driver current, 0:2A , 1:2.1A
Built-in power supply control for P1	VFP[2:0]	common	VFP[2]=0: VPP1-VFP1 (=5 to 5.45) : 5+0.15×VFP, VFP is decimal number of VFP[1:0] VFP[2]=1: VPP1-VFP1(=4.55 to 5) : 5-0.15×VFP, VFP is decimal number of VFP[1:0]
Built-in power supply control for N1	VFN[2:0]	common	VFN[2]=0: VFN1-VNN1 (=5 to 5.45) : 5+0.15×VFN, VFN is decimal number of VFN[1:0] VFN[2]=1: VFN1-VNN1(=4.55 to 5) : 5-0.15×VFN, VFN is decimal number of VFN[1:0]
THP detection control	THPCTL[1:0]	common	THP detection control (00:110deg , 01:130deg , 10:150deg, 11:Disabled)
Wave generation Repeat control (2)	REPEAT[7:0]	common	Repeat counts control of Tx waveform pattern generation
Active channel control for Tx	TXACT [7:0]	/channel	Active channel control in Tx, TXACT[x] corresponds to ch(x) in Tx
Active channel control for Rx	RXACT [7:0]	/channel	Active channel control of T/R-SW, RXACT[x] corresponds to TRSW of ch(x)
TX delay control (1)	BASEDL[7:0]	common	Tx offset delay (common to all channel) : (16×N_{DIV}×BASEDL+14×N_{DIV}+2)×T_{CLK} BASEDL(=0 to 255) is decimal number of BASEDL[7:0], T_{CLK} is external clock period.
TX delay control (2)	CHxDL [7:0]	/channel	Tx delay for each channel x (x=0 to 7) : N_{DIV}×T_{CLK}/2×CHxDL CHxDL(=0 to 255) is decimal number of CHxDL[7:0], T_{CLK} is external clock period.

REPEAT[7:0] (Repeat counts control of Tx waveform pattern generation)
REPEAT[7:0]=00000000 : repeat count = 1
REPEAT[7:0]=00000001 to 11111110 : repeat count = 1(or 16)×REPEAT[7:0]
REPEAT[7:0]=11111111 : continuous

■ Register MAP

Table 24 Tx Control Register MAP

R#	D7	D6	D5	D4	D3	D2	D1	D0
0	reserved	START[6]	START[5]	START[4]	START[3]	START[2]	START[1]	START[0]
1	reserved	STOP[6]	STOP[5]	STOP[4]	STOP[3]	STOP[2]	STOP[1]	STOP[0]
2	INV	MUL-RPT	reserved	CC	CKDIV[1]	CKDIV[0]	THPCTL[1]	THPCTL[0]
3	REPEAT[7]	REPEAT[6]	REPEAT[5]	REPEAT[4]	REPEAT[3]	REPEAT[2]	REPEAT[1]	REPEAT[0]
4	DRVPADJ	VFP[2]	VFP[1]	VFP[0]	DRVNADJ	VFN[2]	VFN[1]	VFN[0]
5	TXACT[7]	TXACT[6]	TXACT[5]	TXACT[4]	TXACT[3]	TXACT[2]	TXACT[1]	TXACT[0]
6	RXACT[7]	RXACT[6]	RXACT[5]	RXACT[4]	RXACT[3]	RXACT[2]	RXACT[1]	RXACT[0]
7	BASEDL[7]	BASEDL[6]	BASEDL[5]	BASEDL[4]	BASEDL[3]	BASEDL[2]	BASEDL[1]	BASEDL[0]
8	CH0DL[7]	CH0DL[6]	CH0DL[5]	CH0DL[4]	CH0DL[3]	CH0DL[2]	CH0DL[1]	CH0DL[0]
9	CH1DL[7]	CH1DL[6]	CH1DL[5]	CH1DL[4]	CH1DL[3]	CH1-DL[2]	CH1DL[1]	CH1DL[0]
10	CH2DL[7]	CH2DL[6]	CH2DL[5]	CH2DL[4]	CH2DL[3]	CH2DL[2]	CH2DL[1]	CH2DL[0]
11	CH3DL[7]	CH3DL[6]	CH3DL[5]	CH3DL[4]	CH3DL[3]	CH3DL[2]	CH3DL[1]	CH3DL[0]
12	CH4DL[7]	CH4DL[6]	CH4DL[5]	CH4DL[4]	CH4DL[3]	CH4DL[2]	CH4DL[1]	CH4DL[0]
13	CH5DL[7]	CH5DL[6]	CH5DL[5]	CH5DL[4]	CH5DL[3]	CH5DL[2]	CH5DL[1]	CH5DL[0]
14	CH6DL[7]	CH6DL[6]	CH6DL[5]	CH6DL[4]	CH6DL[3]	CH6DL[2]	CH6DL[1]	CH6DL[0]
15	CH7DL[7]	CH7DL[6]	CH7DL[5]	CH7DL[4]	CH7DL[3]	CH7DL[2]	CH7DL[1]	CH7DL[0]

■ CRC and ERROR Register

Table 25 CRC, Calculated CRC and ERROR Register MAP

Register	D7	D6	D5	D4	D3	D2	D1	D0
CRC	CRC[7:0]							
Calculated CRC	DSUM[7:0]							
Error	ERROR[7:0]							

Table 26 CRC, Calculated CRC and ERROR Register Function

CRC[7:0]	Transferred CRC data in SDATA CRC initial value = 00000000 CRC polynomial equation is $X^8+X^5+X^4+1$
DSUM[7:0]	Calculated CRC values with transferred SDATA signal
ERROR[7:0]	When Error has occurred, ERROR register corresponding to error type is set to be “1”. ERROR[7:3] : Not used. ERROR[2]: Threshold over of the junction temperature set in advance. ERROR[1]: Start and stop address for Tx waveform pattern generation are same. ERROR[0]: SPI transfer error (CRC un-match) has occurred.

Remark Error[7:0] are cleared when IC is powered on or “EN” becomes form “high” to “low” (fall edge).

■ Pin Configuration

Table 27 Pin Configuration (1/2)

Pin#	Pin Name	Function
1	LVOUT1	Low voltage output of channel 1
2	LVOUT0	Low voltage output of channel 0
3	HGND	channel 0 to channel 3 Drive power ground (0V)
4	GND	Logic power ground (0V)
5	GND	Logic power ground (0V)
6	EN	Control of chip enable, H=disable, L=enable (50kΩ internal pull-up)
7	FAULT	Fault output flag, open N-MOS drain
8	VDD	Positive low voltage power supply (+5V)
9	CLKP	Positive LVDS/CMOS clock input (up to 100MHz)
10	CLKN	Negative LVDS/CMOS clock Input (up to 100MHz)
11	GND	Logic power ground (0V)
12	TRIG	Tx Trigger signal
13	VLL	Positive low voltage power supply (+2.5 to 3.3V)
14	CLKIF	I/F selection for CLKP/CLKN, H:CMOS L:LVDS (50kΩ internal pull-down)
15	HGND	channel 4 to channel 7 Drive power ground (0V)
16	LVOUT7	Low voltage output of channel 7
17	LVOUT6	Low voltage output of channel 6
18	VFP1	Built-in power supply for channel 4 to channel 7 P-MOS (P1) gate drive
19	HVOUT7	High voltage output of channel 7
20	VPP1	Positive high voltage power supply (0 to +100V) for channel 4 to channel 7 P-MOS (P1) Driver
21	VPP1	Positive high voltage power supply (0 to +100V) for channel 4 to channel 7 P-MOS (P1) Driver
22	HVOUT6	High voltage output of channel 6
23	VPP2	Positive high voltage power supply (0 to +100V) for channel 4 to channel 7 P-MOS (P2) Driver
24	VPP2	Positive high voltage power supply (0 to +100V) for channel 4 to channel 7 P-MOS (P2) Driver
25	VFP2	Built-in power supply for channel 4 to channel 7 P-MOS (P2) gate drive
26	HGND	channel 4 to channel 7 Drive power ground (0V)
27	VFN2	Built-in power supply for channel 4 to channel 7 N-MOS (N2) gate drive
28	VNN2	Negative high voltage power supply (0 to -100V) channel 4 to channel 7 N-MOS (N2) Driver
29	VNN2	Negative high voltage power supply (0 to -100V) channel 4 to channel 7 N-MOS (N2) Driver
30	HVOUT5	High voltage output of channel 5
31	VNN1	Negative high voltage power supply (0 to -100V) channel 4 to channel 7 N-MOS (N1) Driver
32	VNN1	Negative high voltage power supply (0 to -100V) channel 4 to channel 7 N-MOS (N1) Driver
33	HVOUT4	High voltage output of channel 4
34	VFN1	Built-in power supply for channel 4 to channel 7 N-MOS (N1) gate drive
35	LVOUT5	Low voltage output of channel 5
36	LVOUT4	Low voltage output of channel 4
37	HGND	channel 4 to channel 7 Drive power ground (0V)
38	SDOUT	SPI serial output data (CMOS)
39	SPIEN	Control of SPI Reciver Enable, H=disable, L=enable (50kΩ internal pull-up)
40	SDATAP	SPI positive serial input data (LVDS/CMOS)
41	SDATAN	SPI negative serial input data (LVDS/CMOS)
42	VDD	Positive low voltage power supply (+5V)
43	GND	Logic power ground (0V)
44	VSS	Negative low voltage power supply (-5V)
45	SCLKP	SPI Positive LVDS/CMOS clock input (up to 100MHz)
46	SCLKN	SPI negative LVDS/CMOS clock Input (up to 100MHz)
47	CSP	SPI positive chip select signal (LVDS/CMOS)
48	CSN	SPI negative chip select signal (LVDS/CMOS)
49	HGND	channel 0 to channel 3 Drive power ground (0V)
50	LVOUT3	Low voltage output of channel 3
51	LVOUT2	Low voltage output of channel 2

Table 27 Pin Configuration (2/2)

Pin#	Pin Name	Function
52	VFN1	Built-in power supply for channel 0 to channel 3 N-MOS (N1) gate drive
53	HVOUT3	High voltage output of channel 3
54	VNN1	Negative high voltage power supply (0 to -100V) channel 0 to channel 3 N-MOS (N1) Driver
55	VNN1	Negative high voltage power supply (0 to -100V) channel 0 to channel 3 N-MOS (N1) Driver
56	HVOUT2	High voltage output of channel 2
57	VNN2	Negative high voltage power supply (0 to -100V) channel 0 to channel 3 N-MOS (N2) Driver
58	VNN2	Negative high voltage power supply (0 to -100V) channel 0 to channel 3 N-MOS (N2) Driver
59	VFN2	Built-in power supply for channel 0 to channel 3 N-MOS (N2) gate drive
60	HGND	channel 0 to channel 7 Drive power ground (0V)
61	VFP2	Built-in power supply for channel 0 to channel 3 P-MOS (P2) gate drive
62	VPP2	Positive high voltage power supply (0 to +100V) for channel 0 to channel 3 P-MOS (P2) Driver
63	VPP2	Positive high voltage power supply (0 to +100V) for channel 0 to channel 3 P-MOS (P2) Driver
64	HVOUT1	High voltage output of channel 1
65	VPP1	Positive high voltage power supply (0 to +100V) for channel 0 to channel 3 P-MOS (P1) Driver
66	VPP1	Positive high voltage power supply (0 to +100V) for channel 0 to channel 3 P-MOS (P1) Driver
67	HVOUT0	High voltage output of channel 0
68	VFP1	Built-in power supply for channel 0 to channel 3 P-MOS (P1) gate drive

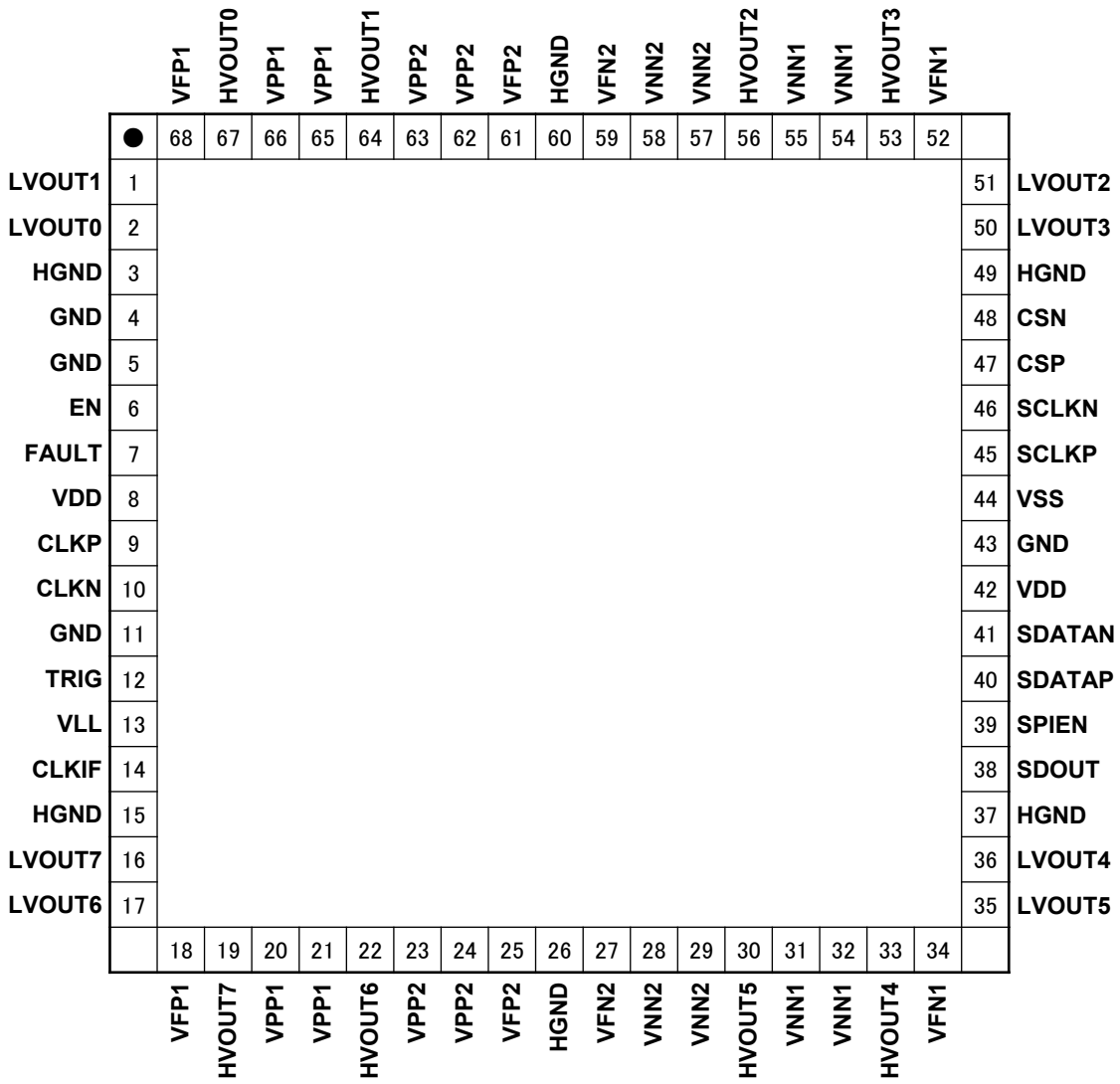

Figure 16 Pin Configuration

■ Package

Table 28 Package Drawing Codes

Package Name	Dimension	Tray	Marking	Land	Packing
QFN-68(1010)B	QN068-B-P	QN068-B-T	QN068-B-M	QN068-B-L	QN068-B-K

■ Storage, Mounting

1. Storage Conditions

1. 1 The storage location should be kept at 5 to 35 °C 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.

1. 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 °C 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.

2. Reflow soldering

The temperature rise may be different in the resin and a terminal part due to the reflow soldering.
It is necessary to check the package surface temperature (resin) before setting the temperature profile.
Figure 17 shows the resistance to soldering heat condition for package (Reflow method).
Confirm the heat resistance of the package shown below. (Based on JEDEC J-STD-020).

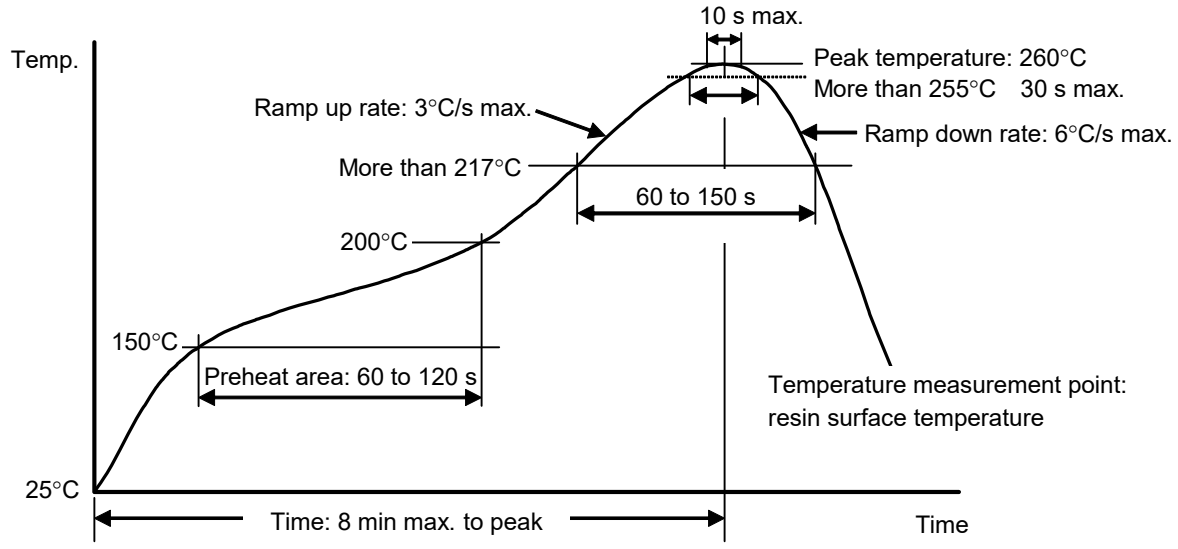

Figure 17 Resistance to soldering heat condition for package (Reflow method)

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■ Cautions

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

   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.

   1. 2 Those what touch products such as work platform, machine, measurement/test equipment should be grounded.

   1. 3 Those who deal with products should be grounded through a large series impedance around 100kΩ to 1MΩ.

   1. 4 Prevent friction with other materials made with high polymer.

   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.

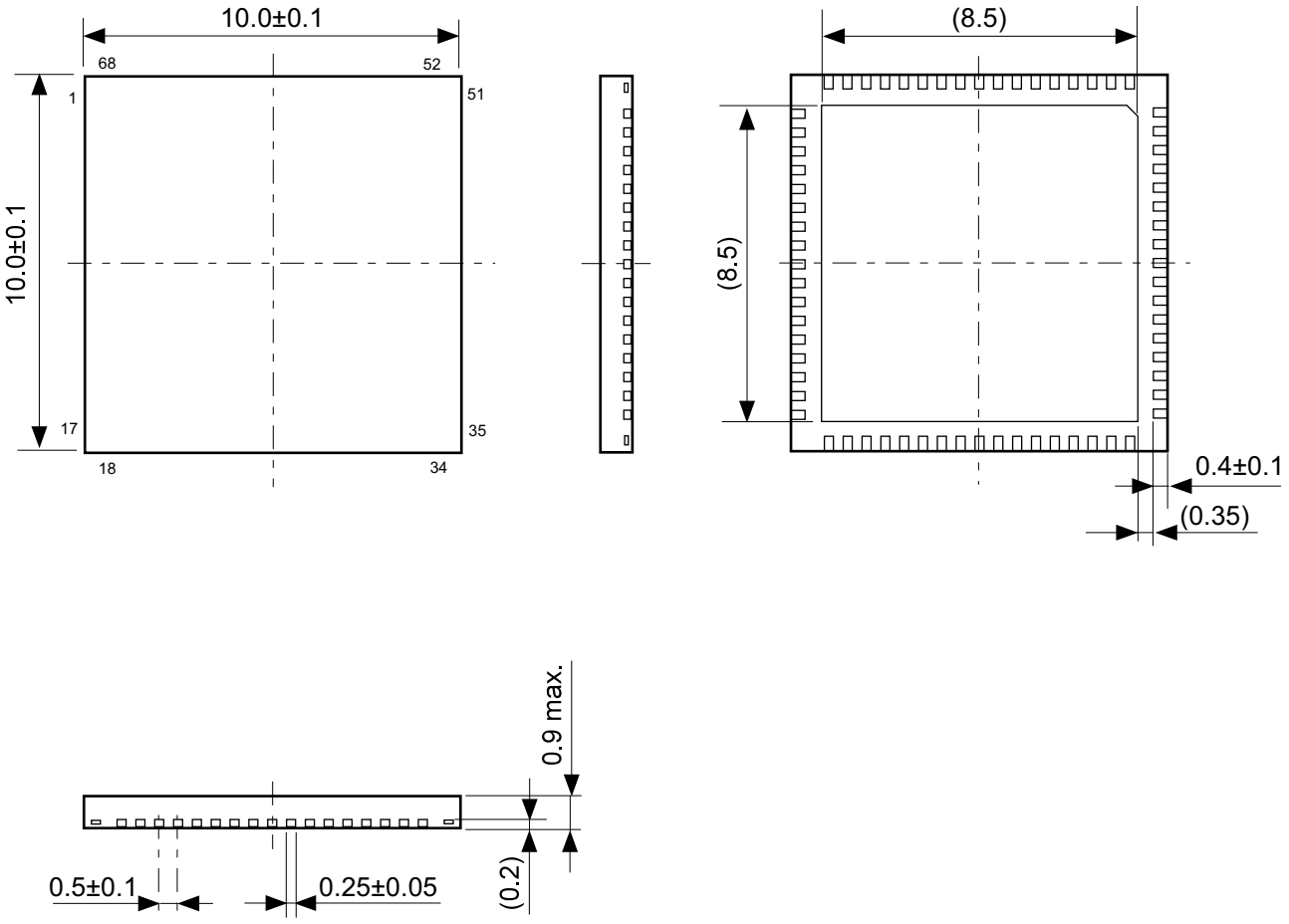
   1. 6 Avoid dealing with or storing products in an extremely arid environment.

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.

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.)

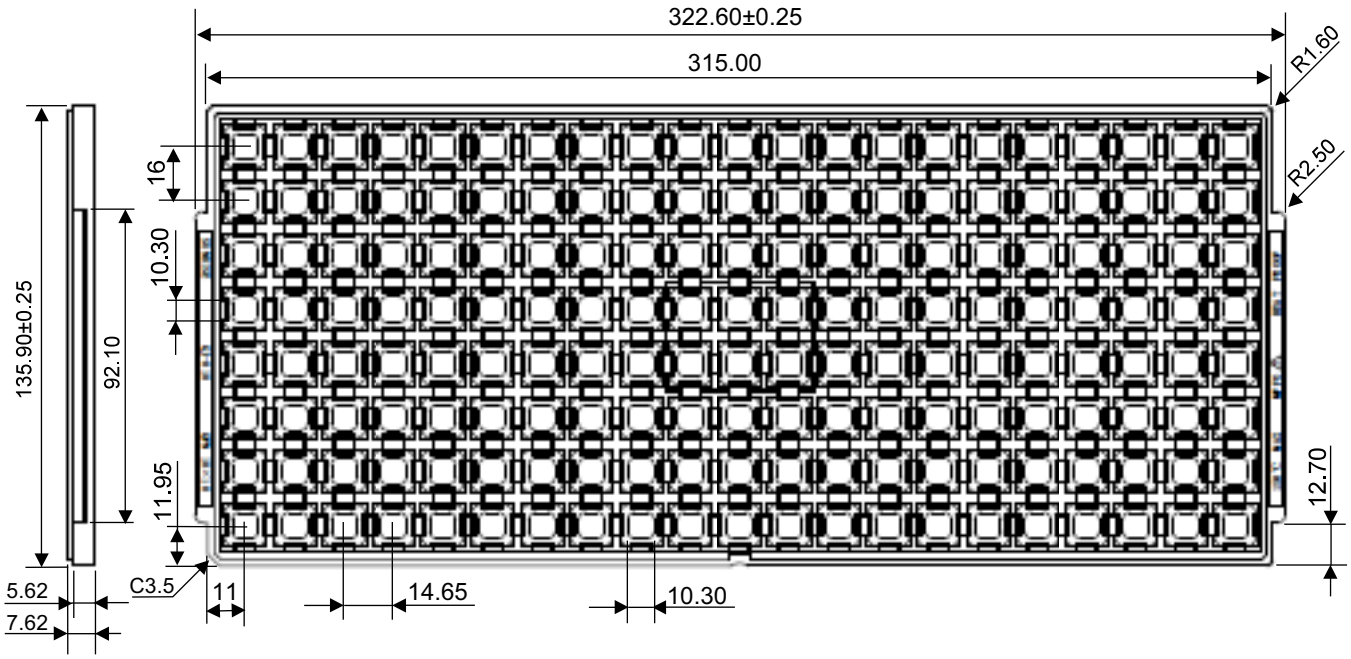
4. Products may experience failures or malfunction in poor surroundings, such as electrical leakage in products due to long-term use in high humidity, malfunctioning or permanent damage due to chemical reaction of products in corrosive environment or due to discharge by strongly charged object near products 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.

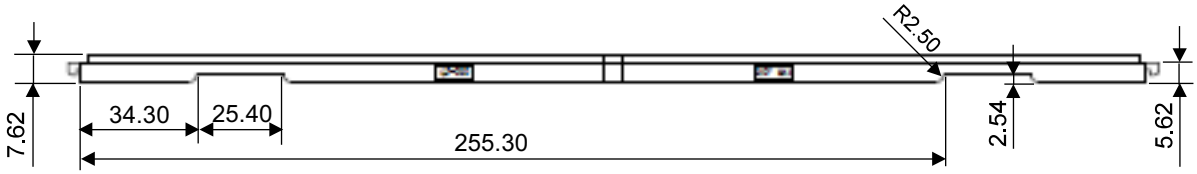
5. Products are not designed, manufactured, or warranted to be suitable for use where extremely high reliability is required (such as use in nuclear power control, aerospace and aviation, traffic equipment, life-support-related medical equipment, fuel control equipment and various kinds of safety equipment). 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.



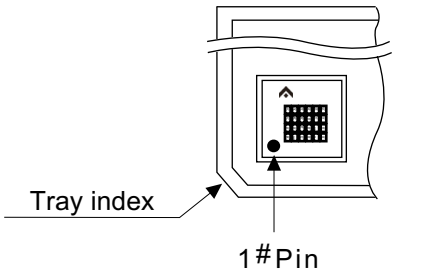
No. QN068-B-P-SD-1.0

TITLE	QFN68-B-PKG Dimensions
No.	QN068-B-P-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	



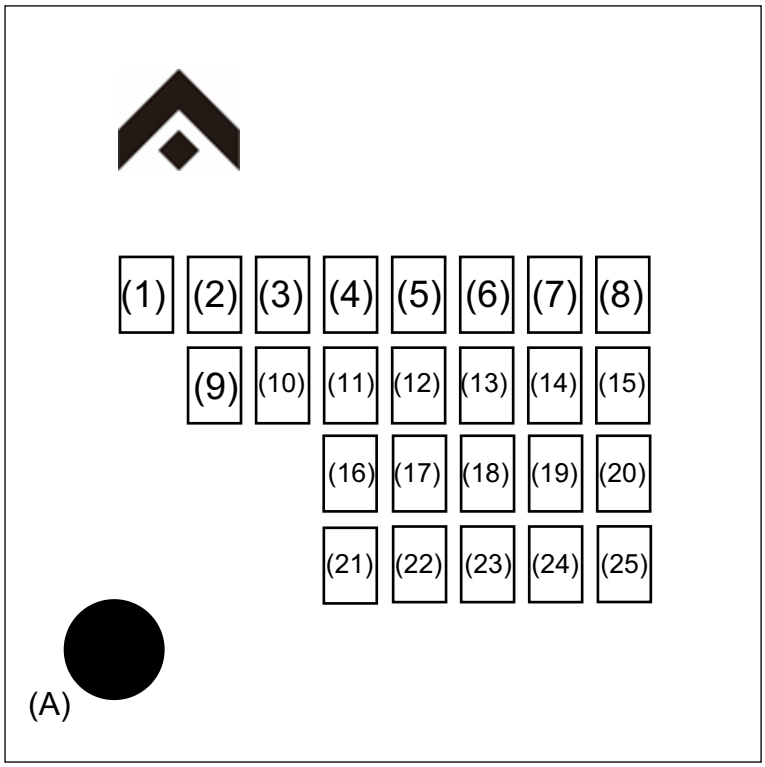


(Direction of IC in tray)



No. QN068-B-T-SD-1.0

TITLE	QFN68-B-Tray		
No.	QN068-B-T-SD-1.0		
ANGLE		QTY.	168
UNIT	mm		
ABLIC Inc.			



(1) to (10) : Product code

(11) , (12) : Quality control code

(13) : Year of assembly

(14) : Month of assembly

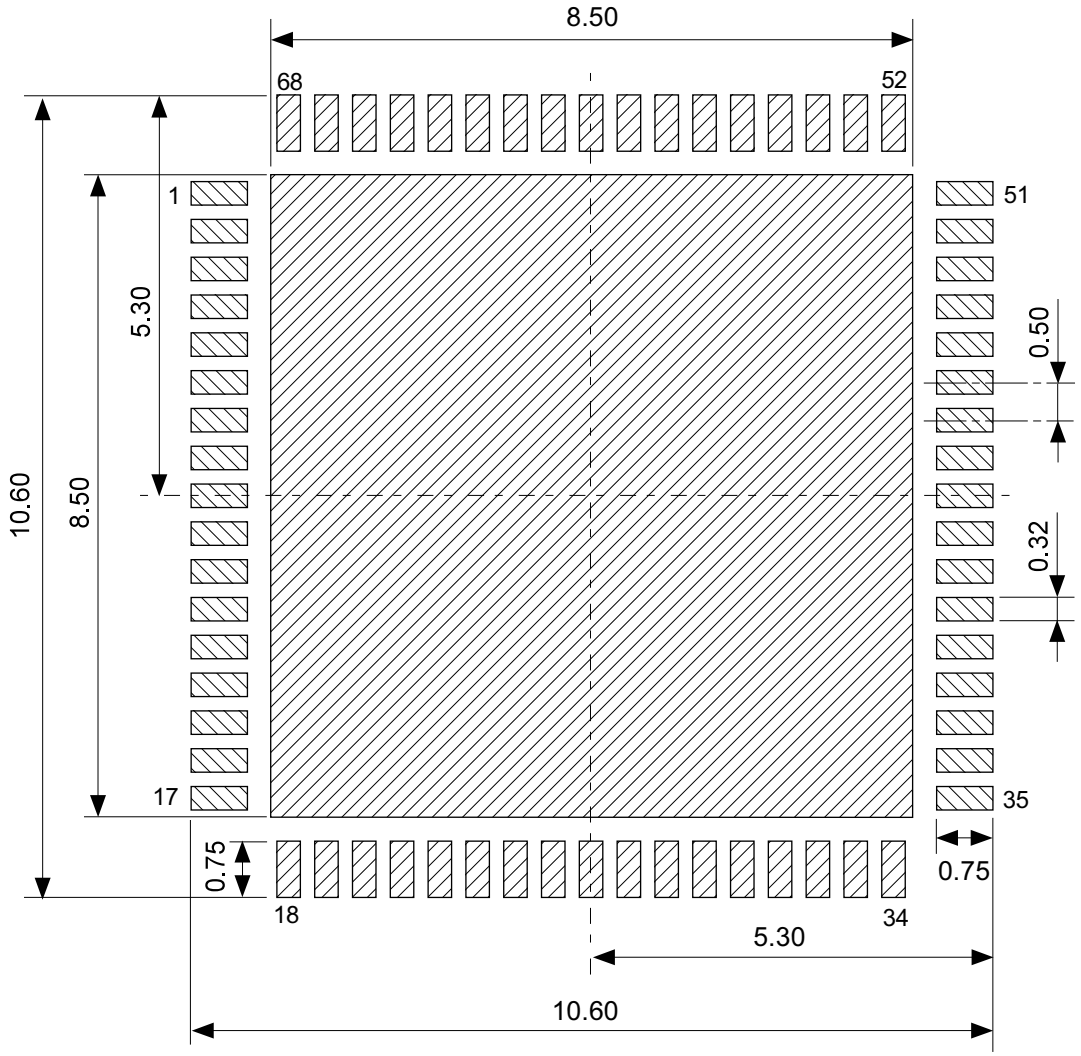
(15) : Week of assembly

(16) to (25) : Quality control code

(A) : 1-pin mark

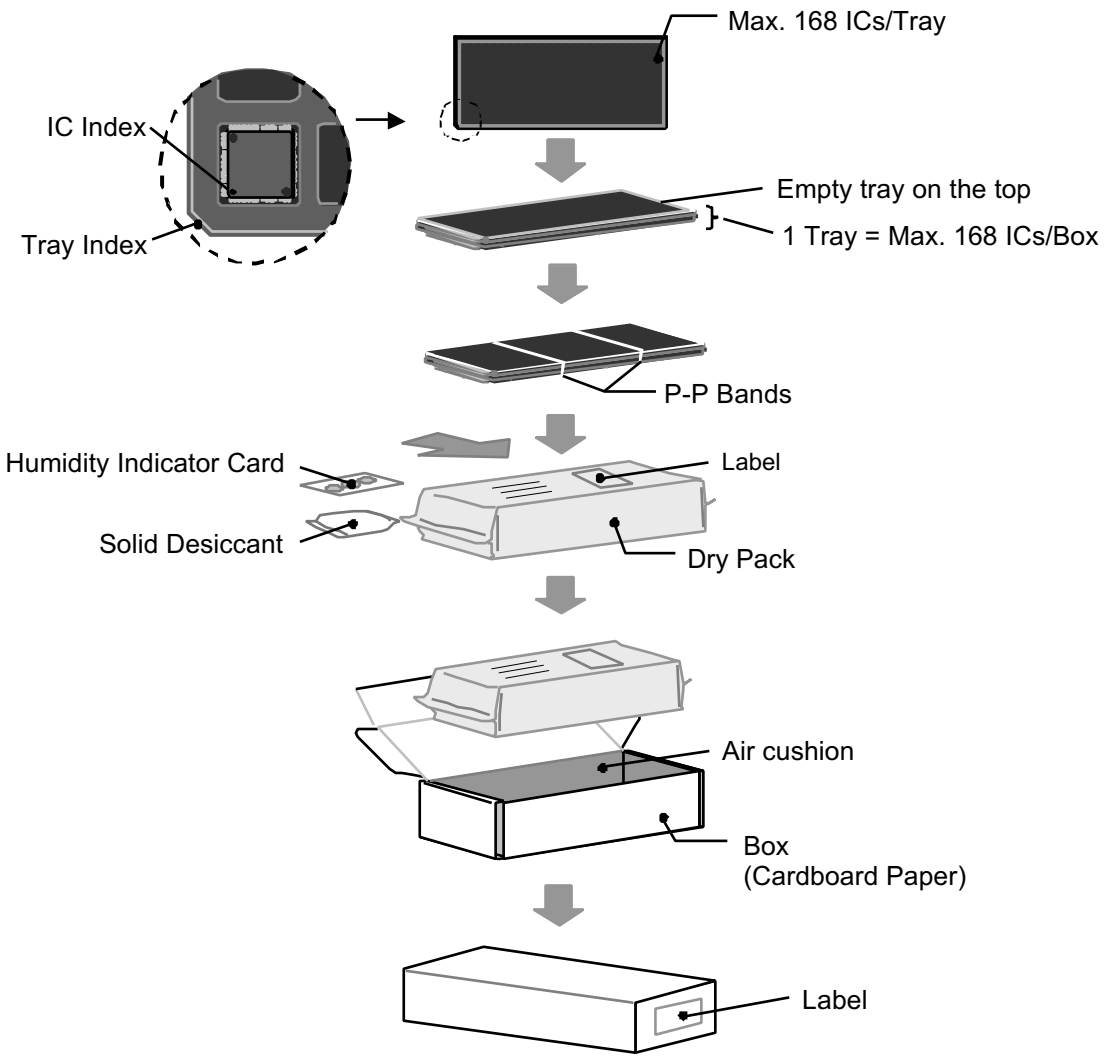
No. QN068-B-M-S1-1.0

TITLE	QFN68-B-Markings		
No.	QN068-B-M-S1-1.0		
ANGLE			
UNIT		TYPE	LASER
ABLIC Inc.			



No. QN068-B-L-SD-1.0

TITLE	QFN68-B -Land Recommendation
No.	QN068-B-L-SD-1.0
ANGLE	
UNIT	mm
ABLIC Inc.	



TITLE	QFN68-B -Packing Procedure
No.	QN068-B-K-SD-2.0
ANGLE	
UNIT	
ABLIC Inc.	

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