用于开漏和推挽应用的4路双向电平转换器

4-Bit Bidirectional Voltage-Level Translator for Open-Drain and Push-Pull Applications

■ FEATURES

- Bidirectional translator, No Direction-Control Signal Needed
- Data Rates
  24Mbps (Push-Pull); 2Mbps (Open-Drain)
- 1.65V ~ 5.5V on A Port, 2.3V to 5.5V on B Port (VCCA≤VCCB)
- VCC Isolation: Either VCCA or VCCB is at GND, all ports will be in Hi-Z State
- No Power-Supply Sequencing Required: Either VCCA or VCCB can be Ramped First

- 双向电平转换，无需方向控制信号
- 最大数据速率
  推拉24Mbps，开漏2Mbps
- A端口:1.65V~5.5V电压，B端口: 2.3V~5.5V电压 (VCCA ≤ VCCB)
- VCC隔离：任一电源拉到地，则端口呈现高阻态
- 无电源时序要求: VCCA 或 VCCB 均可优先斜升

■ APPLICATIONS

- I^2C
- UART
- GPIO
- SPI
- JTAG
- I^2C
- SMBus
- MDIO

■ DESCRIPTION

HT0104 is a quad channel bidirectional translator with two separate power supply VCCA and VCCB. The low voltage signal present on A port with operating voltage from 1.65V to 5.5V referenced to VCCA, and the high voltage signal present on B port with operating voltage from 2.3V to 5.5V referenced to VCCB.

HT0104 enters a low current consumption mode with all IOs places in Hi-Z, once the OE pin is pulled low.

HT0104是一款4路双向电平转换器，其使用两个独立的供电VCCA和VCCB。电压较低的电平信号接入A端口，支持1.65V~5.5V电压，其对应VCCA；电压较高的电平信号接入B端口，支持2.3V~5.5V电压，其对应VCCB。

当OE脚拉低时，HT0104进入低功耗模式，所用IO进入高阻状态。

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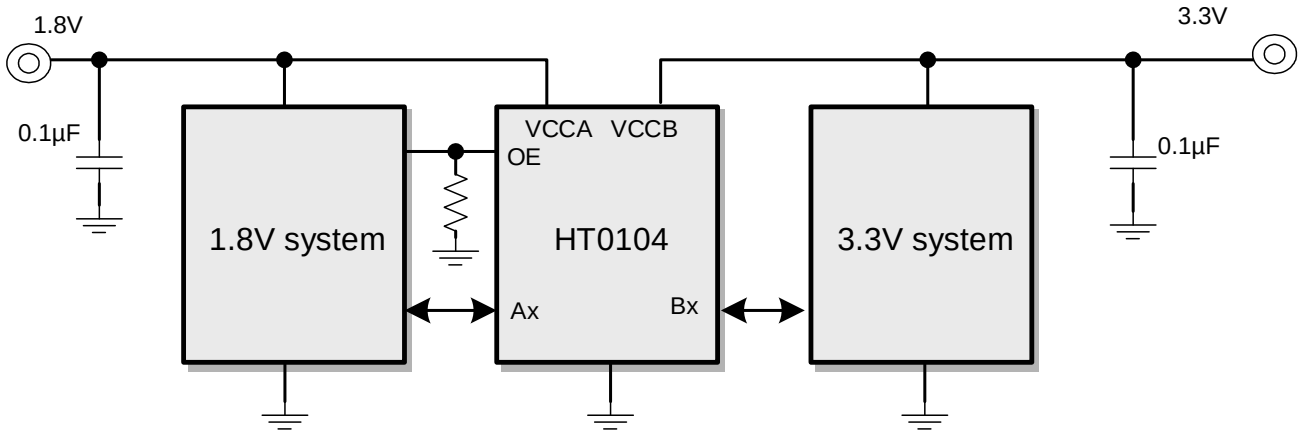
■ TYPICAL APPLICATION



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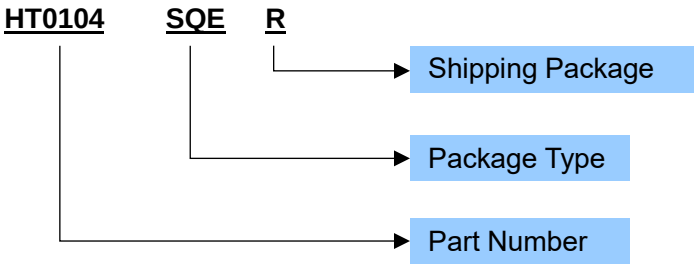
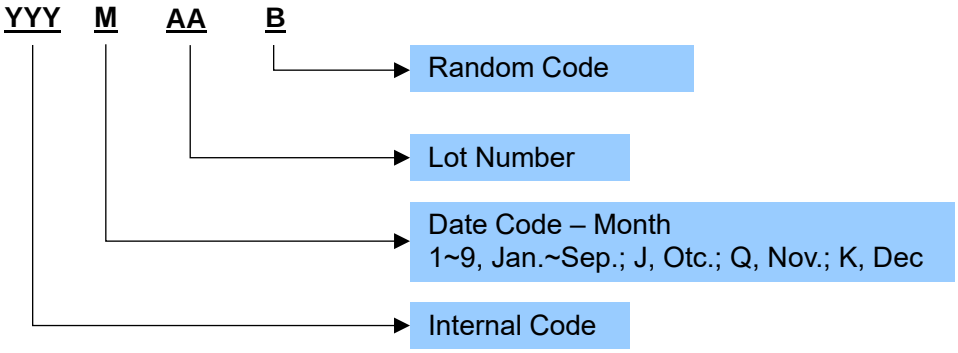
■ ORDERING INFORMATION

Ordering Number	Package Type	Marking	Operating Temperature Range	Shipping Package / MOQ
HT0104SQER	QFN14L-3.5×3.5 (SQE)	HT0104 YYYMAAB[1]	-40℃～85℃	Tape and Reel / 5000pcs
HT0104MTNR	TSSOP14L (MTN)	HT0104 YYYMAAB	-40℃～85℃	Tape and Reel / 3000pcs

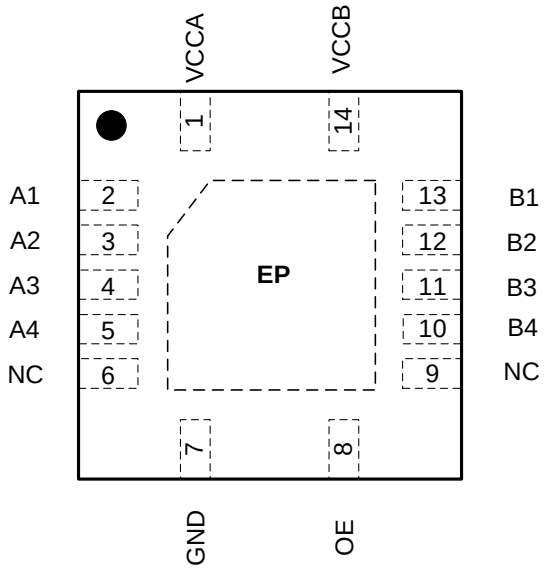
Ordering Number

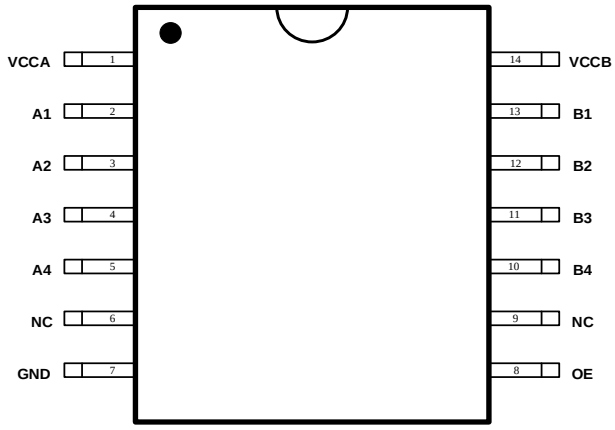


Production Tracking Code



■ TERMINAL CONFIGURATION





■ TERMINAL FUNCTION

Terminal No.		Name	I/O	Description
SQE	MTN			
1	1	VCCA	-	A port power supply, 1.65V≤VCCA≤5.5V and VCCA≤ VCCB
2	2	A1	I/O	Input/Output A1, referenced to VCCA
3	3	A2	I/O	Input/Output A2, referenced to VCCA
4	4	A3	I/O	Input/Output A3, referenced to VCCA
5	5	A4	I/O	Input/Output A4, referenced to VCCA
6	6	NC	-	No connection
7	7	GND	-	Ground
8	8	OE	I	Pull OE low to place all outputs in Hi-Z.
9	9	NC	-	No connection
10	10	B4	I/O	Input/Output B4, referenced to VCCB
11	11	B3	I/O	Input/Output B3, referenced to VCCB
12	12	B2	I/O	Input/Output B2, referenced to VCCB
13	13	B1	I/O	Input/Output B1, referenced to VCCB
14	14	VCCB	-	B port power supply, 2.3V≤VCCB≤5.5V
EP	-	NC	-	No connection

■ SPECIFICATIONS[1]

● Absolute Maximum Ratings [2]

PARAMETER	Symbol	MIN	TYP	MAX	UNIT
Supply voltage range	VCCA	-0.5		6.5	V
Supply voltage range	VCCB	-0.5		6.5	V
Input voltage range[3] (A ports, B ports, OE)	V_I	-0.5		6.5	V
Voltage range applied to any output in the high-impedance or power-off state	V_O	-0.5		6.5	V
Voltage range applied to any output in the high or low state		-0.5		V_{CCx} + 0.5	V
Input clamp current, VI < 0	I_{IK}			－50	mA
Output clamp current, V_O < 0	I_{OK}			-50	mA
Continuous output current	I_O			±50	mA
Continuous current through VCCx or GND				±100	mA
Storage Temperature	T_{STG}	-65		150	℃
Junction Temperature				150	℃
ESD (HBM)			2		kV
ESD (CDM)			1		kV

● Recommended Operating Conditions

Over operating free-air temperature range, unless otherwise specified.

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
Power supply voltage	VCCA		1.65		5.5	V
Power supply voltage	VCCB		2.3		5.5	V
Input voltage	V_I		0		5.5	V
High-level input voltage	V_{IH}	A port, VCCA=1.65~1.95V VCCB = 2.3~5.5V	V_{CCI}[4] – 0.2		V_{CCI}	V
		A port, VCCA=2.3~5.5V VCCB = 2.3~5.5V	V_{CCI} - 0.4		V_{CCI}	V
		B port, VCCA=2.3~5.5V VCCB = 2.3~5.5V	V_{CCI} - 0.4		V_{CCI}	V
		OE, VCCA=2.3~5.5V VCCB = 2.3~5.5V	V_{CCA}× 0.65		5.5	V
Low-level input voltage	V_{IL}	A port, VCCA=2.3~5.5V VCCB = 2.3~5.5V	0		0.15	V
		B port, VCCA=2.3~5.5V VCCB = 2.3~5.5V	0		0.15	V
		OE, VCCA=2.3~5.5V VCCB = 2.3~5.5V	0		V_{CCA}× 0.35	V
Input transition rise or fall rate	Δt/Δv	A port, push-pull			10	ns/V
		B port, push-pull			10	
		Control input			10	
Operating free-air temperature	T_A		-40		85	℃

[1] Depending on parts and PCB layout, characteristics may be changed.

[2] Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

[3] The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

[4] V_{CCI} is the supply voltage associated with the input port.

● Electrical Characteristics

Over operating free-air temperature range, unless otherwise specified.

PARAMETER	Symbol	CONDITION	MIN	TYP	MAX	UNIT
A ports output high voltage	V_{OHA}	I_{OH} = –20 μA, V_{IB}≥V_{CCB}-0.4 V	V_{CCA}× 0.8			V
A ports output low voltage	V_{OLA}	I_{OL} = 1mA, V_{IB}≤0.15V			0.4	V
B ports output high voltage	V_{OHB}	I_{OH} = –20 μA, V_{IB}≥V_{CCB}-0.2 V	V_{CCB}× 0.8			V
B ports output low voltage	V_{OLB}	I_{OL} = 1mA, V_{IB}≤0.15V			0.4	V
Input leakage current	I_L	VI = VCCI or GND	-2		2	μA
High-impedance state output current	I_{OZ}	OE = L	-2		2	μA
Quiescent current of VCCA	I_{CCA}	VI = VO = Open, IO = 0, VCCA=1.65V~VCCB VCCB=2.3V~5.5V			2.4	μA
		VI = VO = Open, IO = 0, VCCA=3.6V, VCCB=0V			2.2	μA
		VI = VO = Open, IO = 0, VCCA=0V, VCCB=5.5V			-1	μA
Quiescent current of VCCB	I_{CCB}	VI = VO = Open, IO = 0, VCCA=1.65V~VCCB VCCB=2.3V~5.5V			12	μA
		VI = VO = Open, IO = 0, VCCA=3.6V, VCCB=0V			-1	μA
		VI = VO = Open, IO = 0, VCCA=0V, VCCB=5.5V			1	μA
Total quiescent current	I_{CCA} + I_{CCB}	VI = VO = Open, IO = 0			14.4	μA
Input capacitance	C_I	VCCA = 3.3V, VCCB = 3.3V		2.5		pF
Input-to-output internal capacitance	C_{IO}	VCCA = 3.3V, VCCB = 3.3V, A ports		5		pF
		VCCA = 3.3V, VCCB = 3.3V, B ports		12		pF

● Timing Requirements

Ta = 25℃, unless otherwise specified

PARAMETER	Symbol	CONDITION	VCCB			UNIT
			2.5V	3.3V	5V	
VCCA = 1.8V						
Maximum Data Rate		Push Pull	24	24	24	Mbps
		Open Drain	2	2	2	Mbps
Minimum Pulse duration	t_w	Push Pull, data inputs	41	41	41	ns
		Open Drain, data inputs	500	500	500	ns
VCCA = 2.5V						
Maximum Data Rate		Push Pull	24	24	24	Mbps
		Open Drain	2	2	2	Mbps
Minimum Pulse duration	t_w	Push Pull, data inputs	41	41	41	ns
		Open Drain, data inputs	500	500	500	ns
VCCA = 3.3V						
Maximum Data Rate		Push Pull	24	24	24	Mbps
		Open Drain	2	2	2	Mbps
Minimum Pulse duration	t_w	Push Pull, data inputs	41	41	41	ns
		Open Drain, data inputs	500	500	500	ns

● Switching Characteristics

Ta = 25℃, unless otherwise specified.

PARAMETER	FROM (INPUT)	TO(OUTPUT)	VCCB	Condition	VCCA = 1.8V			UNIT
					MIN	TYP	MAX	
t_{PHL}	A	B	5.0V	Push-pull		4.3		ns
				Open-drain		26.7		
			3.3V	Push-pull		3.0		
				Open-drain		26.3		
			2.5V	Push-pull		2.4		
				Open-drain		26		
t_{PLH}	A	B	5.0V	Push-pull		3.5		ns
				Open-drain		110		
			3.3V	Push-pull		3.6		
				Open-drain		145		
			2.5V	Push-pull		4.0		
				Open-drain		175		
t_{PHL}	B	A	5.0V	Push-pull		2.1		ns
				Open-drain		26.2		
			3.3V	Push-pull		1.9		
				Open-drain		26.1		
			2.5V	Push-pull		2.0		
				Open-drain		26		
t_{PLH}	B	A	5.0V	Push-pull		1.4		ns
				Open-drain		51		
			3.3V	Push-pull		1.5		
				Open-drain		69		
			2.5V	Push-pull		1.7		
				Open-drain		133		
t_{EN}	OE	A or B	5.0V			18		ns
			3.3V			20		
			2.5V			24		
t_{DIS}	OE	A or B	5.0V			1200		ns
			3.3V			1200		
			2.5V			1200		
t_{rA}	Port A rise time		5.0V	Push-pull		5.4		ns
				Open-drain		10		
			3.3V	Push-pull		5.8		
				Open-drain		31		
			2.5V	Push-pull		6.6		
				Open-drain		89		
t_{rB}	Port B rise time		5.0V	Push-pull		3.9		ns
				Open-drain		58		
			3.3V	Push-pull		4.6		
				Open-drain		98		
			2.5V	Push-pull		5.6		
				Open-drain		128		
t_{fA}	Port A fall time		5.0V	Push-pull		2.6		ns
				Open-drain		1.6		
			3.3V	Push-pull		2.7		
				Open-drain		1.7		
			2.5V	Push-pull		2.9		

			Open-drain	1.9	
t_{fB}	Port B fall time	5.0V	Push-pull	8.0	ns
			Open-drain	2.9	
		3.3V	Push-pull	5.9	
			Open-drain	2.3	
		2.5V	Push-pull	4.6	
			Open-drain	2.3	
t_{SK}	Channel to Channel skew time, output	5.0V		0.5	ns
		3.3V		0.5	
		2.5V		0.5	
	Maximum data rate	5.0V	Push-pull	24	Mbps
			Open-drain	2	
		3.3V	Push-pull	24	
			Open-drain	2	
		2.5V	Push-pull	24	
			Open-drain	2	

PARAMETER	FROM (INPUT)	TO(OUTPUT)	VCCB	Condition	VCCA = 2.5V			UNIT
					MIN	TYP	MAX	
t_{PHL}	A	B	5.0V	Push-pull		4.8		ns
				Open-drain		26.7		
			3.3V	Push-pull		3.3		
				Open-drain		26.4		
			2.5V	Push-pull		2.7		
				Open-drain		26.2		
t_{PLH}	A	B	5.0V	Push-pull		2.3		ns
				Open-drain		110		
			3.3V	Push-pull		2.4		
				Open-drain		144		
			2.5V	Push-pull		2.6		
				Open-drain		169		
t_{PHL}	B	A	5.0V	Push-pull		2.4		ns
				Open-drain		26.5		
			3.3V	Push-pull		2.3		
				Open-drain		26.4		
			2.5V	Push-pull		2.4		
				Open-drain		26.3		
t_{PLH}	B	A	5.0V	Push-pull		1.8		ns
				Open-drain		55		
			3.3V	Push-pull		1.9		
				Open-drain		118		
			2.5V	Push-pull		2.0		
				Open-drain		165		
t_{EN}	OE	A or B	5.0V			16		ns
			3.3V			19		
			2.5V			23		
t_{DIS}	OE	A or B	5.0V			1200		ns
			3.3V			1200		
			2.5V			1200		
t_{rA}	Port A rise time		5.0V	Push-pull		2.6		ns
				Open-drain		10		
			3.3V	Push-pull		2.8		

			Open-drain	70	
		2.5V	Push-pull	3.2	
			Open-drain	120	
t_{rB}	Port B rise time	5.0V	Push-pull	2.6	ns
			Open-drain	62	
		3.3V	Push-pull	3.4	
			Open-drain	96	
		2.5V	Push-pull	4.5	
			Open-drain	122	
t_{fA}	Port A fall time	5.0V	Push-pull	4.8	ns
			Open-drain	1.7	
		3.3V	Push-pull	5.0	
			Open-drain	1.9	
		2.5V	Push-pull	4.9	
			Open-drain	2.0	
t_{fB}	Port B fall time	5.0V	Push-pull	8.3	ns
			Open-drain	2.7	
		3.3V	Push-pull	6.1	
			Open-drain	2.1	
		2.5V	Push-pull	4.8	
			Open-drain	1.9	
t_{SK}	Channel to Channel skew time, output	5.0V		0.5	ns
		3.3V		0.5	
		2.5V		0.5	
	Maximum data rate	5.0V	Push-pull	24	Mbps
			Open-drain	2	
		3.3V	Push-pull	24	
			Open-drain	2	
		2.5V	Push-pull	24	
			Open-drain	2	

PARAMETER	FROM (INPUT)	TO(OUTPUT)	VCCB	Condition	VCCA = 3.3V			UNIT
					MIN	TYP	MAX	
t_{PHL}	A	B	5.0V	Push-pull		4.9		ns
				Open-drain		26.7		
			3.3V	Push-pull		3.5		
				Open-drain		26.3		
t_{PLH}	A	B	5.0V	Push-pull		2.0		ns
				Open-drain		104		
			3.3V	Push-pull		2.2		
				Open-drain		133		
t_{PHL}	B	A	5.0V	Push-pull		3.2		ns
				Open-drain		26.8		
			3.3V	Push-pull		3.0		
				Open-drain		26.6		
t_{PLH}	B	A	5.0V	Push-pull		1.7		ns
				Open-drain		83		
			3.3V	Push-pull		1.8		
				Open-drain		132		
t_{EN}	OE	A or B	5.0V			15		ns
			3.3V			18		
t_{DIS}	OE	A or B	5.0V			1200		ns

		3.3V		1200	
t_{rA}	Port A rise time	5.0V	Push-pull	2.0	ns
			Open-drain	36	
		3.3V	Push-pull	2.2	
			Open-drain	87	
t_{rB}	Port B rise time	5.0V	Push-pull	2.3	ns
			Open-drain	56	
		3.3V	Push-pull	2.9	
			Open-drain	87	
t_{fA}	Port A fall time	5.0V	Push-pull	5.8	ns
			Open-drain	2.0	
		3.3V	Push-pull	6.2	
			Open-drain	2.3	
t_{fB}	Port B fall time	5.0V	Push-pull	8.2	ns
			Open-drain	2.5	
		3.3V	Push-pull	6.5	
			Open-drain	2.0	
t_{SK}	Channel to Channel skew time, output	5.0V		0.5	ns
		3.3V		0.5	
	Maximum data rate	5.0V	Push-pull	24	Mbps
			Open-drain	2	
		3.3V	Push-pull	24	
			Open-drain	2	

■ Parameter Measurement Information

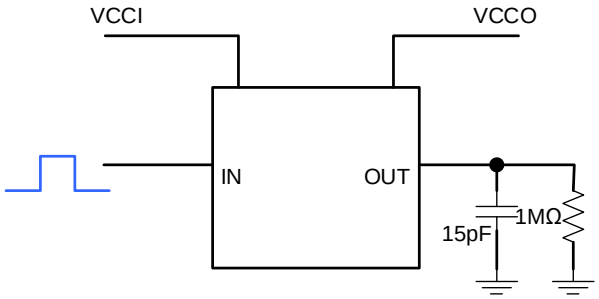


Figure 1 Data Rate, Pulse Duration, Propagation Delay, Output Rise and Fall Time Measurement

Using a Push-pull Driver

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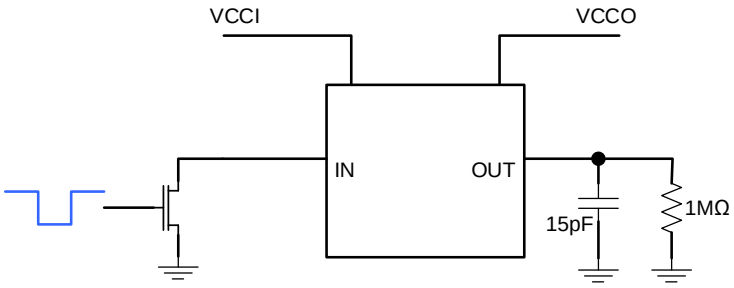


Figure 2 Data Rate, Pulse Duration (t_W), Propagation Delay (t_{PHL}, t_{PLH}), Output Rise (t_r) and Fall Time (t_f) Measurement

Using an Open-Driver

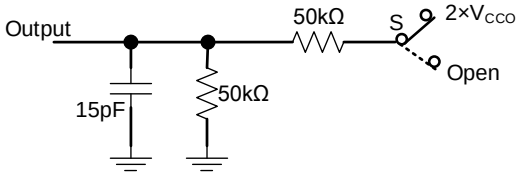


Figure 3 Load Circuit for Enable and Disable Time (t_{EN}, t_{DIS}) Measurement

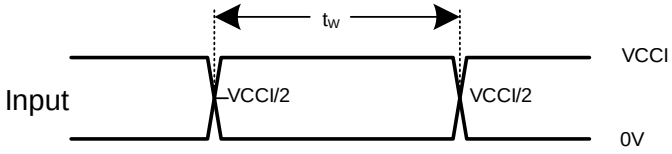


Figure 4 Pulse Duration

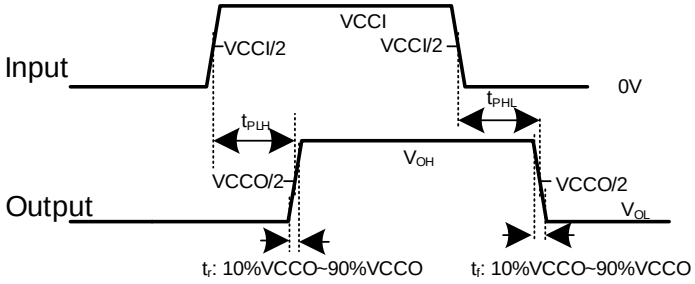


Figure 5 Propagation Delay Time, Output Rise and Fall Time

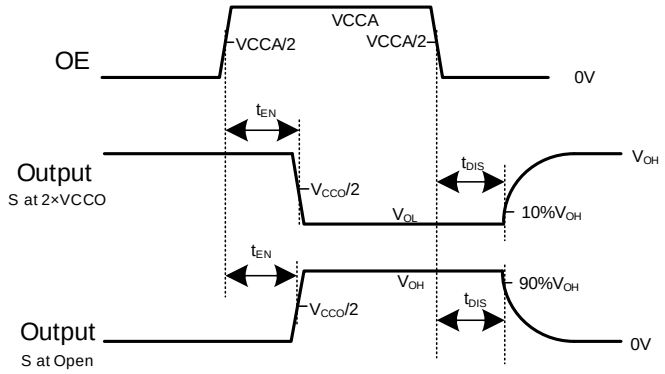


Figure 6 Enable and Disable Time

NOTES:
A. C_L includes probe and jig capacitance.
B. All input pulses are supplied by generators having the following characteristics: PRR <10 MHz, Z_O = 50Ω, dv/dt > 1V/ns.
C. The outputs are measured one at a time, with one input transition per measurement.
D. All parameters and waveforms are not applicable to all devices.

■ DEAILED DESCRIPTION

1 Overview

HT0104 is a quad channel bidirectional translator with two separate power supply VCCA and VCCB. The low voltage signal present on A port with operating voltage from 1.65V to 5.5V referenced to VCCA, and the high voltage signal present on B port with operating voltage from 2.3V to 5.5V referenced to VCCB.

HT0104 enters a low current consumption mode with all IOs places in Hi-Z, once the OE pin is pulled low.

HT0104 是一款 4 路双向电平转换器，其使用两个独立的供电 VCCA 和 VCCB。电压较低的电平信号接入 A 端口，支持 1.65V~5.5V 电压，其对应 VCCA；电压较高的电平信号接入 B 端口，支持 2.3V~5.5V 电压，其对应 VCCB。

当 OE 脚拉低时，HT0104 进入低功耗模式，所用 IO 进入高阻状态。

2 Application and Implementation

HT0104 is a bidirectional translator that can automatically detect the direction of data flow from port A to port B or from port B to port A. Therefore, each IO can be configured as input or output.

Each port A IO has an internal 10k ohm resistor pulled up to VCCA, and each port B IO has an internal 10k ohm resistor pulled up to VCCB. An external resistor can be added in parallel with the internal 10k ohm resistor to get a smaler vlue of pullup resistor.

The fall time (t_{fA}, t_{fB}), the high-to-low output delay time (t_{PHL}) and the maximum data rates depend on the output impedence of the external device.

When powering up, either VCCA or VCCB can be ramped up first. However, during normal opeartion, VCCA≤VCCB all the time.

Once OE terminal is pulled low, all IOs will be palced into Hi-Z.

HT0104 是一个双路电平转换器，能够自动检测信号方向，从端口 A 到端口 B，或从端口 B 到端口 A。因此，每个 IO 口均可作为输入或输出端口。

每个 A 端口均有一个内置 10k 欧姆的电阻上拉到 VCCA，每个 B 端口均有一个内置 10k 欧姆的电阻上拉到 VCCB。当需要更小的上拉电阻时，可在外部并联一个上拉电阻。

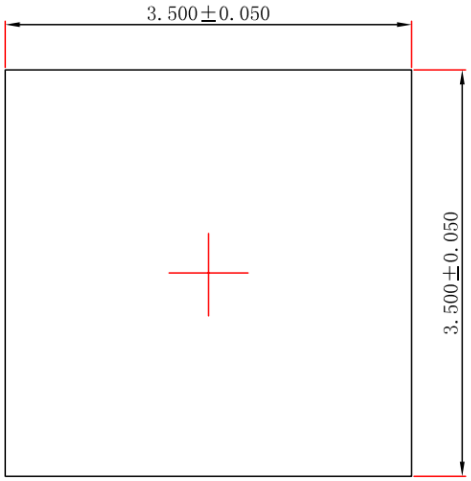
t_{fA}, t_{fB} 和 t_{PHL} 取决于外部驱动器的输出阻抗。

上电时，VCCA 和 VCCB 无需时序要求，VCCA 或 VCCB 均可优先斜升。但是在正常工作过程中，需 VCCA≤VCCB。

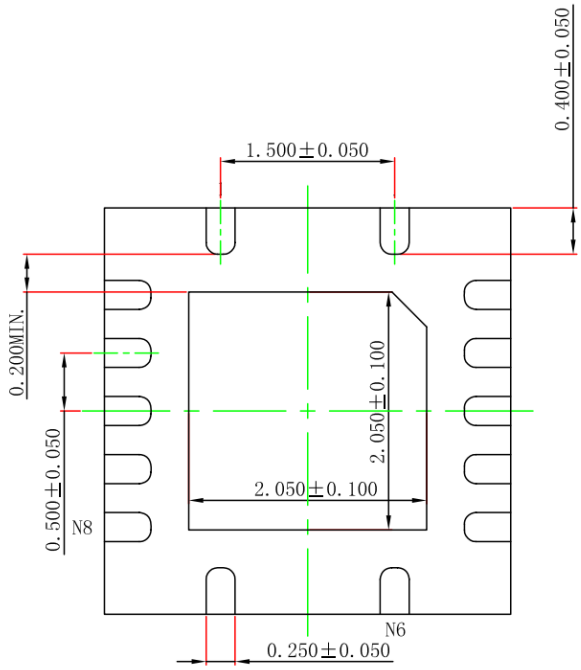
OE 脚拉低时，所有 IO 进入高阻状态。

■ PACKAGE OUTLINE

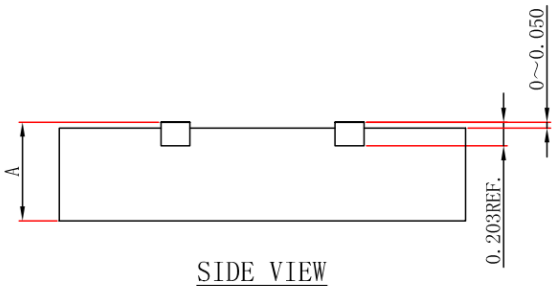
SQE (QFN14L-3.5×3.5), Dimensions in Millimeters



TOP VIEW
[顶视图]



BOTTOM VIEW
[背视图]



SIDE VIEW
[侧视图]

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.700	0.750	0.800