YHM4204

4-Bits Auto-Bidirectional Voltage Level Translators

V1.02 Preliminary

Features

- V_{CC} Range:
  - V_{CCA}: 1.2V to 5.5V
  - V_{CCB}: 1.65V to 5.5V
- Maximum Data Rate:
  - Push Pull: 100Mbps
  - Open Drain: 1.1Mbps
- Support V_{CC} isolation function.
- Ultra-Low I_Q On Each V_{CC}: 5μA
- OE referenced to V_{CCA}.
- Support Partial Power Down Mode.
- Working Temperature Range: - 40°C to + 85°C
- Package:
  - 12-bump 1.8mm x 1.4mm FCLGA
  - 14-Pin 3.5mm x 3.5mm TQFN
  - 12-Pin 1.8mm x 1.8mm UQFN

Applications

- Portable device
- GPIO
- I2C/SMBUS
- UART/SPI

General Description

The YHM4204 is an auto-bidirectional voltage level translators family to support 4/6/8 bits applications. This device A port tracks the V_{CCA} voltage and its range is from 1.2V to 5.5V. B port tracks the V_{CCB} voltage and its range is from 1.65V to 5.5V.

When the output-enable (OE) input is low, all outputs are placed in the high-impedance (Hi-Z) state. And if either one of V_{CC} is absent and pull to GND, the outputs are also placed in Hi-Z state. And OE input circuit is reference to V_{CCA}. To ensure the Hi-Z state during power-up or power-down periods, tie OE to GND through a pull-down resistor.

The YHM4204 is fully specified for partial-power-down applications using I_{OFF}. The I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

The YHM4204 operates over an ambient temperature range of - 40°C to + 85°C.

Typical Application

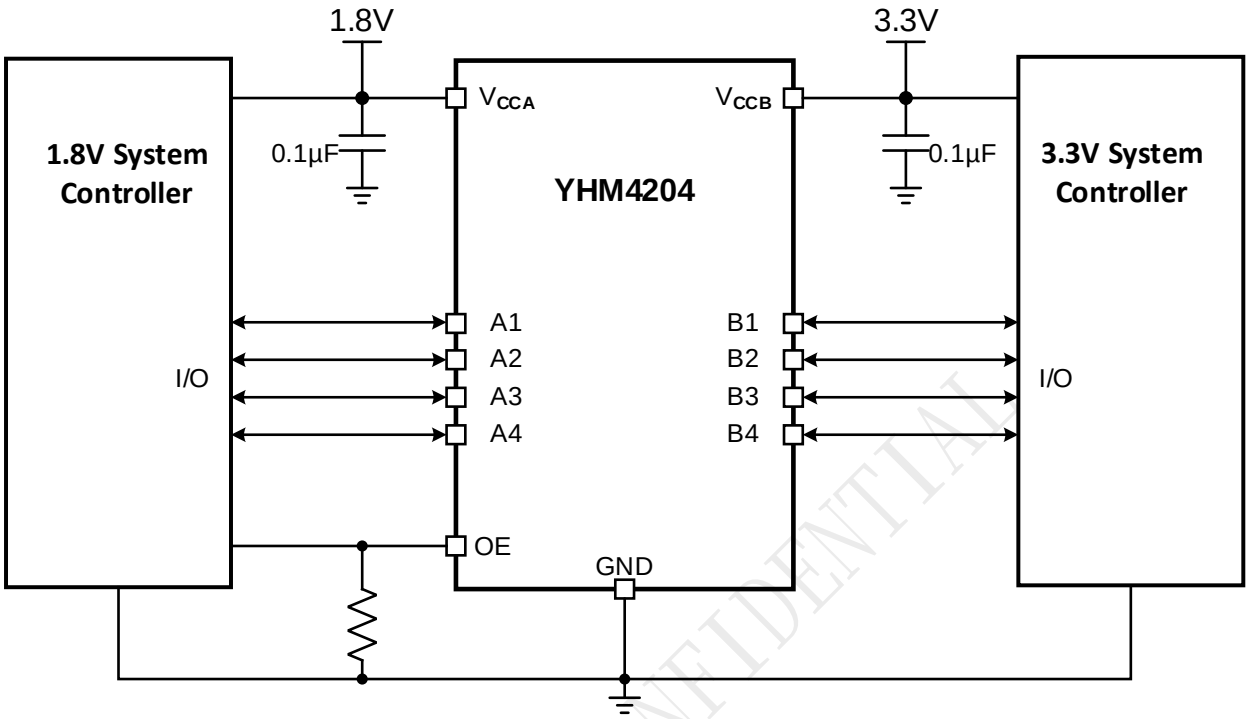


Figure 1. YHM4204 Application Diagram

Pin Configurations

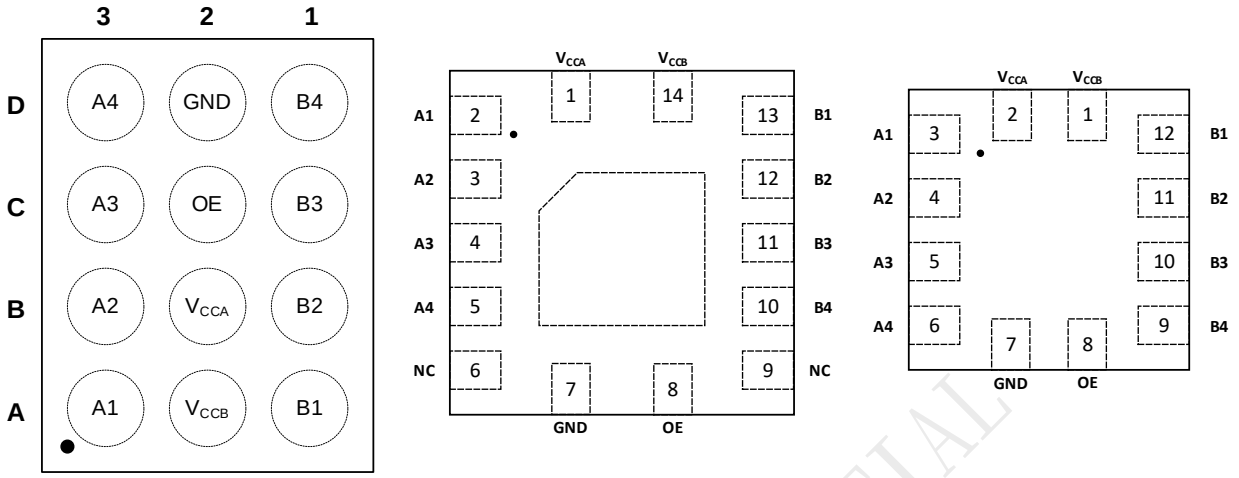


Figure 2. YHM4204 Pin Assignment. (Top View)

YHM4204 Pin Descriptions

FCLGA	TQFN	UQFN	Name	Description
A1	13	12	B1	Input/output 1. Referenced to V_{CCB}
A2	14	1	V_{CCB}	B port power supply. 1.65V ≤ V_{CCB} ≤ 5.5V and V_{CCA} ≤ V_{CCB}
A3	2	3	A1	Input/output 1. Referenced to V_{CCA}
B1	12	11	B2	Input/output 2. Referenced to V_{CCB}
B2	1	2	V_{CCA}	A port power supply. 1.2V ≤ V_{CCA} ≤ 5.5V
B3	3	4	A2	Input/output 2. Referenced to V_{CCA}
C1	11	10	B3	Input/output 3. Referenced to V_{CCB}
C2	8	8	OE	Output enable pin. Active high. Pull OE low to place all outputs in tri-state mode. Referenced to V_{CCA}.
C3	4	5	A3	Input/output 3. Referenced to V_{CCA}
D1	10	9	B4	Input/output 4. Referenced to V_{CCB}
D2	7	7	GND	Ground
D3	5	6	A4	Input/output 4. Referenced to V_{CCA}
-	6,9		NC	No Connection

1 Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter		Min.	Max.	Unit
V_{CCA},V_{CCB}	V_{CCA}, V_{CCB} to GND		-0.3	6	V
V_I	Input Voltage Range, Port A, Port B		-0.3	6	V
V_O	Output Voltage Range for the High-Impendence or Power Off States, Port A, Port B.		-0.3	6	V
V_O	Output Voltage Range for the High or Low States, Port A		-0.3	V_{CCA}	V
V_O	Output Voltage Range for the High or Low States, Port B		-0.3	V_{CCB}	V
I_{IK}	Input Clamp Current, V_I < 0			50	mA
I_{OK}	Output Clamp Current, V_O < 0			-50	mA
I_C	Continuous Current through V_{CCA}, V_{CCB}, or GND		-100	100	mA
T_J	Maximum Junction Temperature			+150	°C
ESD	Human Body Model, ANSI/ESDA/JEDEC JS-001-2012	All Pins	5		KV
		Port B	13		
	Charged Device Model, JESD22-C101	All Pins	2		

Note 1. Refer to JEDEC JESD51-7, use a 4-layerboard.

2 Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance.

Parameters		Min.	Max.	Unit
Voltage Supply: V_{CCA}		1.2	5.5	V
Voltage Supply: V_{CCB}		1.65	5.5	V
High Level Input Voltage: V_{IH} (Note 1)	Data Port	0.85 x V_{CCI}	V_{CCI}	V
	OE	0.85 x V_{CCA}	5.5	V
Low Level Input Voltage: V_{IL} (Note 1)	Data Port	0	0.15	V
	OE	0	0.15	V
Input Transition Rise or Fall Rate: Δt/ΔV	A Port (Push-Pull)		10	ns/V
	B Port (Push-Pull)		10	ns/V
Operating Ambient Temperature Range		-40	85	°C

3 Electrical Characteristics

Condition: T_A = -40°C to +85°C. Typical values are at T_A = 25°C, unless otherwise noted.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Port A Output High Voltage	V_{OHA}	I_{OH} = -20μA, T_A = 25°C V_{IB} ≥ V_{CCB} - 0.4V	0.9* V_{CCA}			V
Port A Output Low Voltage	V_{OLA}	V_{CCA} = 3V, V_{CCB} = 3.3V. I_{OL} = 400μA, T_A = 25°C, V_{IB} ≤ 0.15V			0.55	V
Port B Output High Voltage	V_{OHB}	I_{OH} = -20μA, T_A = 25°C, V_{IA} ≥ V_{CCA}-0.2V	0.9* V_{CCB}			V
Port Output Low Voltage	V_{OLB}	V_{CCA} = 3.3V, V_{CCB} = 4.5V. I_{OH} = 620μA, T_A = 25°C, V_{IA} ≤ 0.15V			0.55	V

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Input Leakage Current	I_{OE}	OE = V_{CCA} or GND, V_{CCA} = 1.2V to 5.5V, V_{CCB} = 1.65V to 5.5V			±1	μA
High Impendence Output Leakage Current	I_{OZ}	Port A or Port B, OE = GND, V_{CCA} = 1.2V to 5.5V, V_{CCB} = 1.65V to 5.5V		±1	±2	μA
V_{CCA} Quiescent Current	I_{CCA}	V_I = V_{CCI} or GND, V_O = Open, I_O = 0			5	μA
V_{CCB} Quiescent Current	I_{CCB}	V_I = V_{CCI} or GND, V_O = Open, I_O = 0			5	μA
Combined Quiescent Current	I_{CCA}+I_{CCB}	V_I = V_{CCI} or GND, V_O = Open, I_O = 0			10	μA
High Impendence V_{CCA} Supply Current	I_{CCZA}	V_I = V_O = Open, I_O = 0, OE = GND			5	μA
High Impendence V_{CCB} Supply Current	I_{CCZB}	V_I = V_O = Open, I_O = 0, OE = GND			5	μA
OE Input Capacitance (Note 1)	C_I	V_{CCA} = 1.2V to 5.5V, V_{CCB} = 1.65V to 5.5V		3		pF
Port Capacitance (Note 1)	C_{IO}	V_{CCA} = 1.2V to 5.5V, V_{CCB} = 1.65V to 5.5V		5		pF
Resistor of NMOS between A port and B port	R_{PASS}	OE is logic high, I = 10mA, V_I = 0.15V, V_{CCA} = 1.8V, V_{CCB} = 3.3V		500		Ω

Note 1: Guarantee by design.

4 Timing Requirements

Condition: T_A = 25°C, unless otherwise noted.

Parameter		Symbol	V_{CCB} = 1.8V	V_{CCB} = 2.5V	V_{CCB} = 3.3V	V_{CCB} = 5V	Unit
V_{CCA} = 1.2V							
			TYP.	**TYP.**	**TYP.**	**TYP.**	
Data Rate	Push-Pull		100	100	100	100	Mbps
	OD		2	2	2	2	
Pulse Duration	Push-Pull	tw	10	10	10	10	ns
	OD		500	500	500	500	
V_{CCA} = 1.5V							
Data Rate	Push-Pull		100	100	100	100	Mbps
	OD		2	2	2	2	
Pulse Duration	Push-Pull	tw	10	10	10	10	ns
	OD		500	500	500	500	
V_{CCA} = 1.8V							
			Min.	**Min.**	**Min.**	**Min.**	
Data Rate	Push-Pull		100	100	100	100	Mbps
	OD		2	2	2	2	
Pulse Duration	Push-Pull	tw	10	10	10	10	ns
	OD		500	500	500	500	
V_{CCA} = 2.5V							
Data Rate	Push-Pull		-	100	100	100	Mbps
	OD		-	2	2	2	

Parameter		Symbol	V_{CCB} = 1.8V	V_{CCB} = 2.5V	V_{CCB} = 3.3V	V_{CCB} = 5V	Unit
Pulse Duration	Push-Pull	t_W	-	10	10	10	ns
	OD		-	500	500	500	
V_{CCA} = 3.3V							
Data Rate	Push-Pull		-	-	100	100	Mbps
	OD		-	-	2	2	
Pulse Duration	Push-Pull	t_W	-	-	10	10	ns
	OD		-	-	500	500	
V_{CCA} = 5V							
Data Rate	Push-Pull		-	-	-	100	Mbps
	OD		-	-	-	2	
Pulse Duration	Push-Pull	t_W	-	-	-	10	ns
	OD		-	-	-	500	

5 Switching Characteristics

Condition: T_A = 25°C, unless otherwise noted.

Parameter	Symbol	Condition		V_{CCB} = 1.8V TYP.	V_{CCB} = 2.5V TYP.	V_{CCB} = 3.3V TYP.	V_{CCB} = 5V TYP.	Unit
V_{CCA} = 1.2V								
Propagation Delay (High to Low output)	t_{PHL}	A to B	Push-Pull	10.1	9.4	8.6	9.76	ns
			OD	15	10	10	10	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	14.3	10.3	8.4	7.6	
			OD	180	160	105	83	
Propagation Delay (High to Low output)	t_{PHL}	B to A	Push-Pull	14.3	13.2	13.1	13.6	ns
			OD	10	10	17	10	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	18.4	14.6	13.4	13.2	
			OD	10	10	10	10	
Enable Time	t_{EN}	OE to A or B	Push-Pull	200	200	200	200	ns
Disable Time	t_{DIS}		Push-Pull	20	20	20	20	
Output Rising Time	t_{RA}	A Port	Push-Pull	2.98	2.98	2.98	2.98	ns
			OD	1400	960	850	490	
Output Falling Time	t_{FA}		Push-Pull	2.87	2.87	2.87	2.87	
			OD	8	10	10	10	
Output Rising Time	t_{RB}	B Port	Push-Pull	4.24	3	2.44	1.64	ns
			OD	1010	730	560	316	
Output Falling Time	t_{FB}		Push-Pull	1.13	0.91	0.9	0.81	
			OD	10	10	10	10	
Channel to Channel Skew	t_{SK}		Push-Pull	1	1	1	1	ns
V_{CCA} = 1.8V								

Parameter	Symbol	Condition		V_{CCB} = 1.8V TYP.	V_{CCB} = 2.5V TYP.	V_{CCB} = 3.3V TYP.	V_{CCB} = 5V TYP.	Unit
Propagation Delay (High to Low output)	t_{PHL}	A to B	Push-Pull	5.9	4.3	3.8	3.2	ns
			OD	10	6.6	6.5	6.5	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	10.9	6.7	5	3.6	
			OD	70	66	50	65	
Propagation Delay (High to Low output)	t_{PHL}	B to A	Push-Pull	6	5.5	5.5	4.9	ns
			OD	10	10	10	10	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	11.1	7.7	6.5	5.1	
			OD	10	10	10	10	
Enable Time	t_{EN}	OE to A or B	Push-Pull	200	200	200	200	ns
Disable Time	t_{DIS}		Push-Pull	20	20	20	20	
Output Rising Time	t_{RA}	A Port	Push-Pull	3.6	3.6	3.6	3.6	ns
			OD	1400	1120	900	560	
Output Falling Time	t_{FA}		Push-Pull	3	3	3	3	
			OD	10	10	10	10	
Output Rising Time	t_{RB}	B Port	Push-Pull	4.3	2.9	2.3	1.6	ns
			OD	1360	1048	665	492	
Output Falling Time	t_{FB}		Push-Pull	0.9	0.8	0.7	0.7	
			OD	10	13	10	10	
Channel to Channel Skew	t_{SK}		Push-Pull	1	1	1	1	ns
V_{CCA} = 2.5V								
Propagation Delay (High to Low output)	t_{PHL}	A to B	Push-Pull	-	3.3	2.9	2.2	ns
			OD	-	6	5	5	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	-	6	4	2.9	
			OD	-	124	110	70	
Propagation Delay (High to Low output)	t_{PHL}	B to A	Push-Pull	-	3.5	3.4	3.2	ns
			OD	-	10	10	10	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	-	5.7	4.2	2.7	
			OD	-	10	10	10	
Enable Time	t_{EN}	OE to A or B	Push-Pull	-	200	200	200	ns
Disable Time	t_{DIS}		Push-Pull	-	20	20	20	
Output Rising Time	t_{RA}	A Port	Push-Pull	-	2.9	2.9	2.9	ns
			OD	-	1327	966	660	
Output Falling Time	t_{FA}		Push-Pull	-	3.3	2.6	2.1	
			OD	-	10	10	10	
Output Rising Time	t_{RB}	B Port	Push-Pull	-	3.6	2.5	1.5	ns
			OD	-	1250	938	622	
Output Falling Time	t_{FB}		Push-Pull	-	0.98	0.87	0.78	
			OD	-	11	9	12	
Channel to Channel	t_{SK}		Push-Pull	-	1	1	1	ns

Parameter	Symbol	Condition		V_{CCB} = 1.8V TYP.	V_{CCB} = 2.5V TYP.	V_{CCB} = 3.3V TYP.	V_{CCB} = 5V TYP.	Unit
Skew								
V_{CCA} = 3.3V								
Propagation Delay (High to Low output)	t_{PHL}	A to B	Push-Pull	-	-	2.3	1.8	ns
			OD	-	-	5.4	3.7	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	-	-	3.8	2.4	
			OD	-	-	10	35	
Propagation Delay (High to Low output)	t_{PHL}	B to A	Push-Pull	-	-	2.3	2.9	ns
			OD	-	-	5	5	
Propagation Delay (High to Low output)	t_{PLH}		Push-Pull	-	-	3.6	2.3	
			OD	-	-	10	10	
Enable Time	t_{EN}	OE to A or B	Push-Pull	-	-	200	200	ns
Disable Time	t_{DIS}		Push-Pull	-	-	20	20	
Output Rising Time	t_{RA}	A Port	Push-Pull	-	-	2.8	2.8	ns
			OD	-	-	1000	750	
Output Falling Time	t_{FA}		Push-Pull	-	-	2.8	2.8	
			OD	-	-	10	10	
Output Rising Time	t_{RB}	B Port	Push-Pull	-	-	2.6	1.6	ns
			OD	-	-	1000	708	
Output Falling Time	t_{FB}		Push-Pull	-	-	0.87	0.81	
			OD	-	-	12	10	
Channel to Channel Skew	t_{SK}		Push-Pull	-	-	1	1	ns

6 Parameter Measurement Circuit

6.1 Waveform

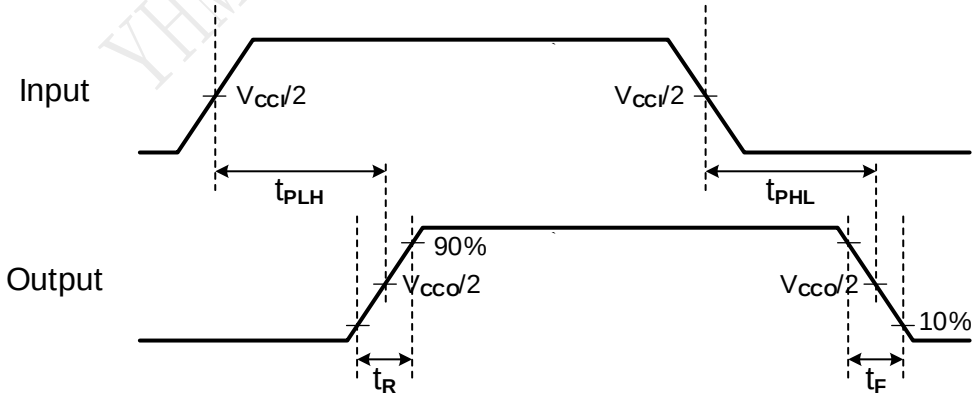


Figure 3. Propagation Delay, rising time, falling time

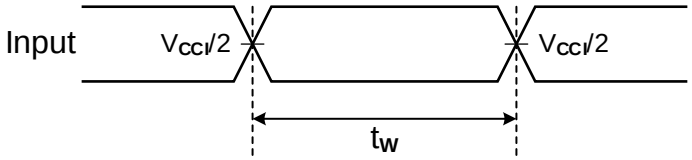


Figure 4.Pulse Duration (Push-Pull)

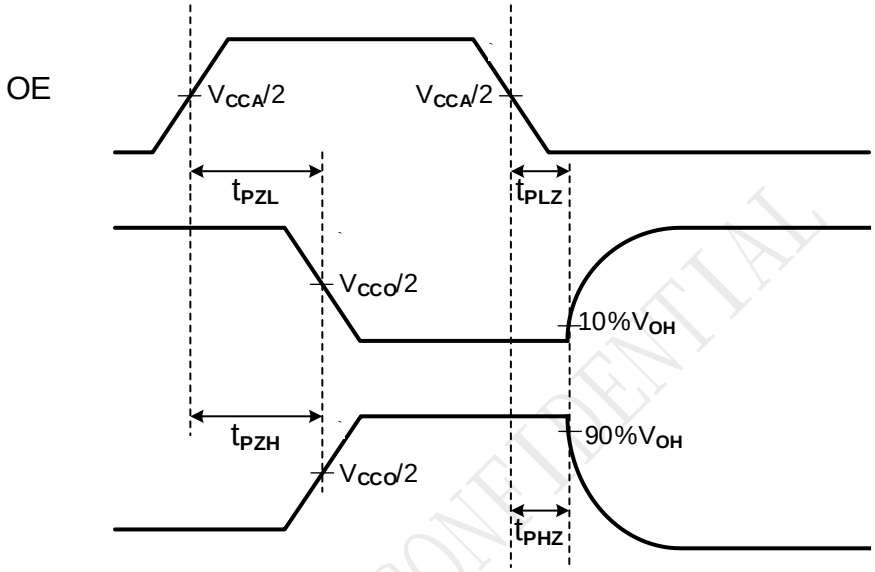


Figure 5. Enable and Disable Time

Output 1 waveform is for an output with internal that the output is high except when OE=1.

Output 2 waveform is for an output with internal that the output is low except when OE=0.

6.2 Load Circuit

Figure 10 shows the push-pull driver circuit used for measuring data rate, pulse duration, propagation delay, output rise-time and fall-time. Figure 11 shows the open-drain driver circuit used for measuring data rate, pulse duration, propagation delay, output rise-time and fall-time.

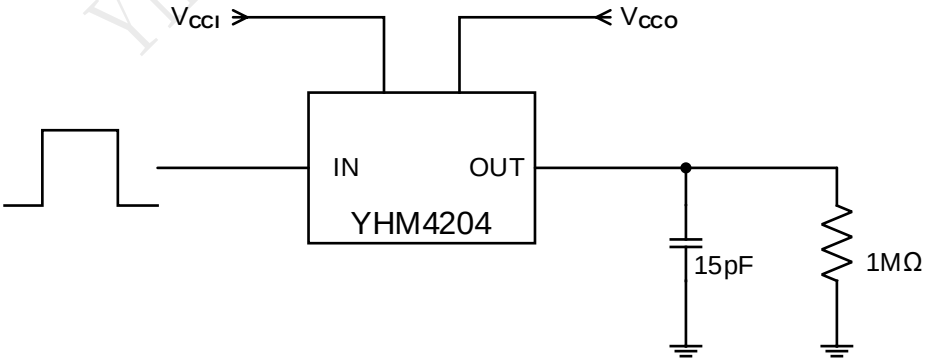


Figure 6. Push-Pull Input Load Circuit

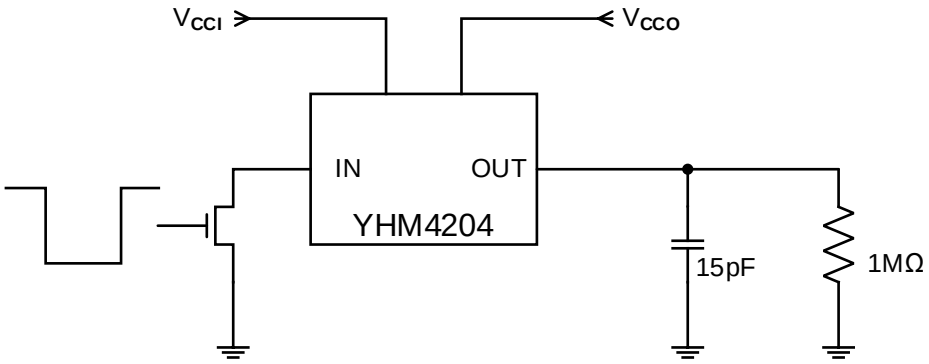


Figure 7. Open Drain Load Circuit

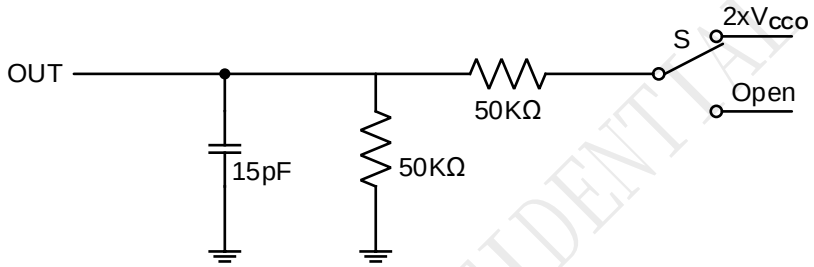


Figure 8. Load Circuit for Enable Time and Disable Time Measurement

Test	S
t_{PZL}, t_{PLZ} (t_{DIS})	2 x V_{CCO}
t_{PZH}, t_{PHZ} (t_{EN})	Open

7 Typical Operating Characteristics

TBD

8 Detailed Description

8.1 General Introduction

The YHM4204 is an auto-direction voltage level translator which designed for translating logic voltage levels. The port A support voltage range from 1.2V to 5.5V and port B support voltage range from 1.65 to 5.5V. The device uses pass gate architecture with edge accelerator to improve the data rate. The pull up resistors have been integrated for open drain applications and external resistor is not needs. The device can translate push-pull CMOS logic outputs and open drain outputs.

8.2 Feature Description

8.2.1 Architecture

Figure 13 describes YHM4204 one cell architecture design. This application requires for both push-pull and open drain mode. This application uses edge-rate accelerator circuitry, a high-on-resistance N-channel pass-gate transistor and pull-up resistors to meet these requirements. This design needs no direction control signal. The resulting implementation supports both low-speed open-drain operation as well as high-speed push-pull operation.

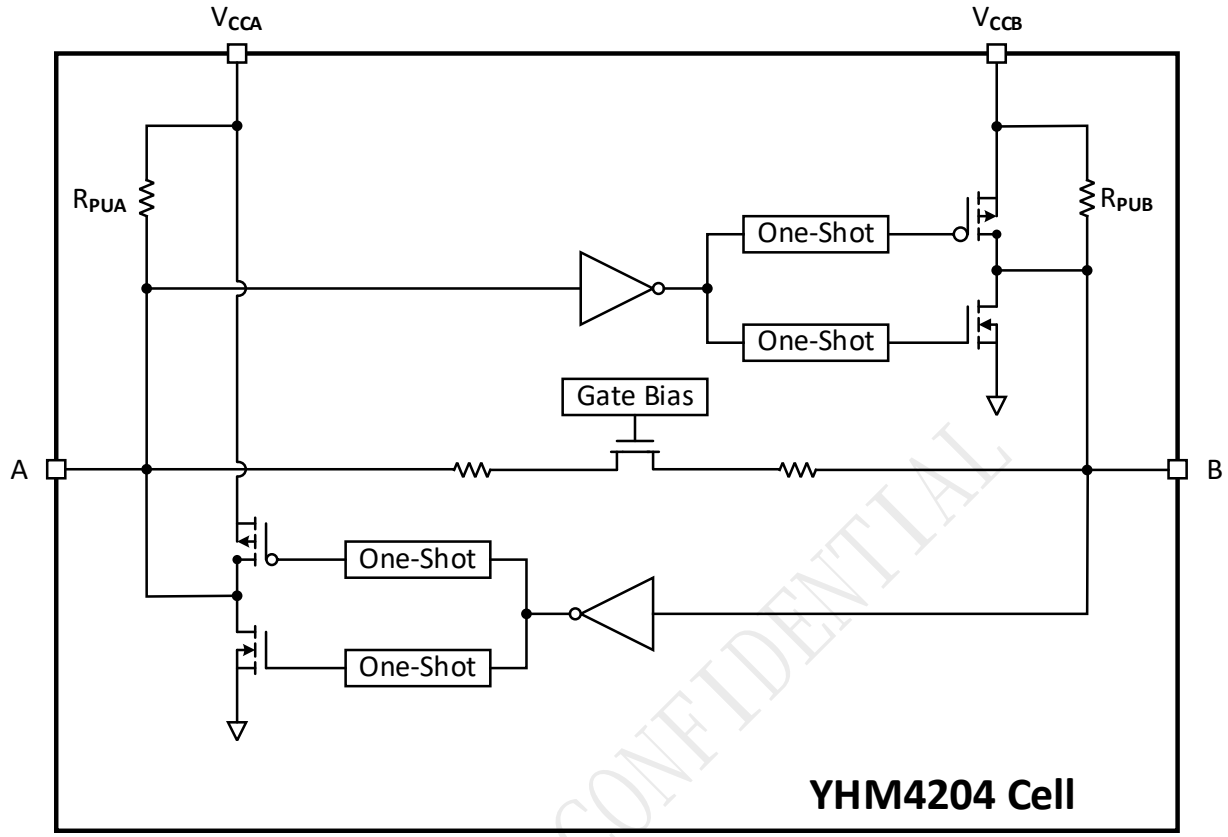


Figure 9. YHM4204 Cell Architecture

When transmitting data from A ports to B ports, during a rising edge the one-shot circuit turns on the PMOS transistor for a short-duration which reduces the low-to-high transition time. During a falling edge, the one-shot circuit turns on the N-channel MOSFET transistor for a short-duration which speeds up the high-to-low transition. Similarly, when transmitting data from B ports to A ports, during a rising edge the one-shot circuit turns on the PMOS transistor for a short-duration which reduces the low-to-high transition time. During a falling edge, the one-shot circuit turns on NMOS transistor for a short-duration and this speeds up the high-to-low transition.

8.2.2 Input Driver Requirements

The fall time (t_F) of a signal depends on the edge-rate and output impedance of the external device driving YHM4204 data I/Os, as well as the capacitive loading on the data lines. Similarly, the t_{PHL} and maximum data rates also depend on the output impedance of the external driver. The values for t_F, t_{PHL}, and maximum data rates in the data sheet assume that the output impedance of the external driver is less than 50Ω.

8.2.3 Output Load Considerations

Careful PCB layout practices with short PCB trace lengths to avoid excessive capacitive loading and to ensure that proper one-shot triggering takes place. PCB signal trace-lengths should be kept short enough so that the round trip delay is less than the one-shot duration. This improves signal integrity by ensuring that any reflection sees a low impedance at the driver. The one-shot circuits have been designed to stay on for approximately 50 ns. The maximum capacitance of the lumped load that can be driven also depends directly on the one-shot duration. With very heavy capacitive loads, the one-shot can time-out before the signal is driven fully to the positive rail. The one-shot duration has been set to best optimize trade-offs between dynamic I_{CC}, load driving capability, and maximum bit-rate considerations. Both PCB trace length and connectors add to the capacitance of the YHM4204 output.

8.2.4 Enable and Disable

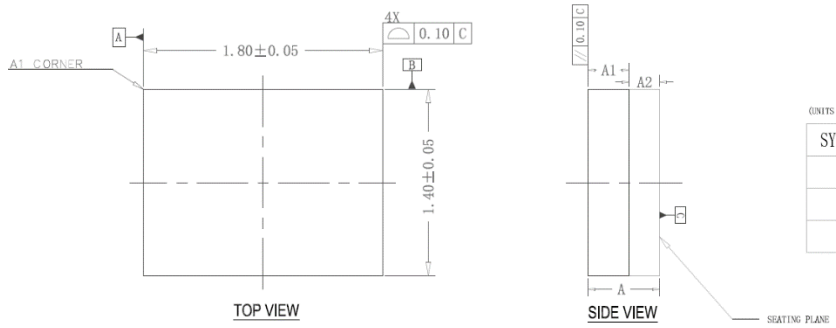
The YHM4204 has an OE pin input that is used to disable the device by setting the OE pin low, which places all I/Os in the Hi-Z state. The disabled time (t_{DIS}) indicates the delay between the time when the OE pin goes low and when the outputs get disabled (Hi-Z). The enable time (t_{EN}) indicates the amount of time the design must allow for the one-shot circuitry to become operational after the OE pin goes high.

8.2.5 Pull-up or Pull-down Resistors on I/O Lines

The YHM4204 has the smart pull-up resistors dynamically change value based on whether a low or a high is being passed through the I/O line. Each A-port I/O has a pull-up resistor (R_{PUA}) to V_{CCA} and each B-port I/O has a pull-up resistor (R_{PUB}) to V_{CCB}. R_{PUA} and R_{PUB} have a value of 40KΩ when the output is driving low. R_{PUA} and R_{PUB} have a value of 4KΩ when the output is driving high. R_{PUA} and R_{PUB} are disabled when OE = Low. This feature provides lower static power consumption and supports lower V_{OL} values for the same size pass-gate transistor and helps improve simultaneous switching performance.

9 Package Dimensions

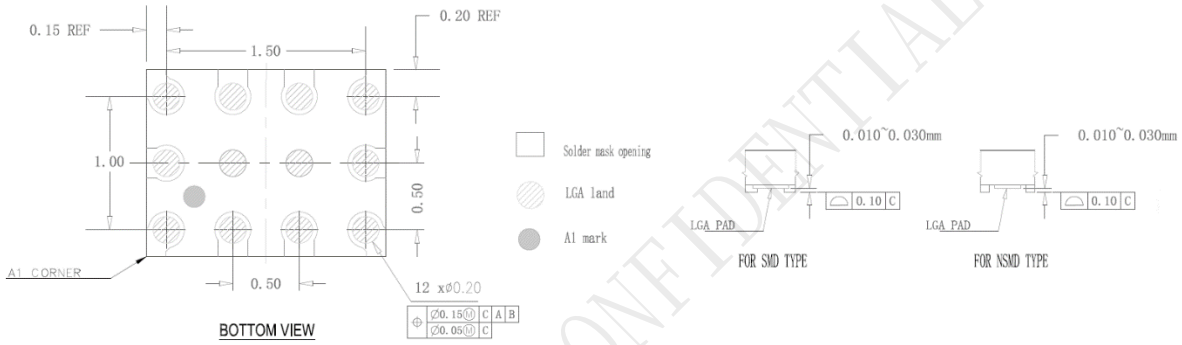
1.8mm x 1.4mm FCLGA-12



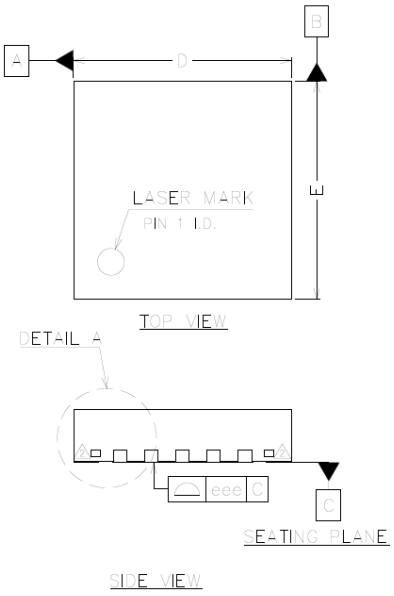
COMMON DIMENSIONS

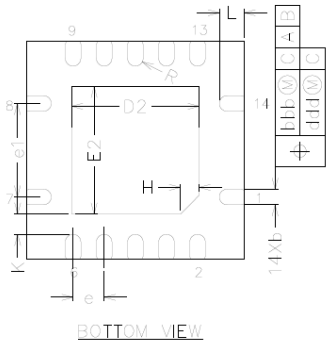
UNITS OF MEASURE=MILLIMETER

SYMBOL	MINIMUM	NOMINAL	MAXIMUM
A	0.490	0.540	0.590
A1	0.270	0.310	0.350
A2	0.200	0.230	0.260



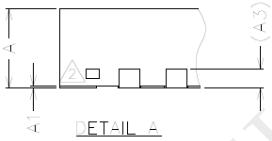
3.5mm x 3.5mm TQFN-14





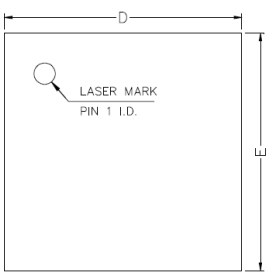
COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.80	0.85	0.90
A1	0	0.02	0.05
A3		0.20REF	
b	0.20	0.25	0.30
D	3.40	3.50	3.60
E	3.40	3.50	3.60
D2	1.95	2.05	2.15
E2	1.95	2.05	2.15
e		0.50BSC	
e1		1.50BSC	
H		0.30REF	
K	0.225	0.325	0.425
L	0.30	0.40	0.50
R	0.09	–	–
bbb		0.10	
ddd		0.05	
eee		0.08	

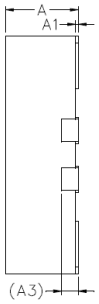


NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD MO-220
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

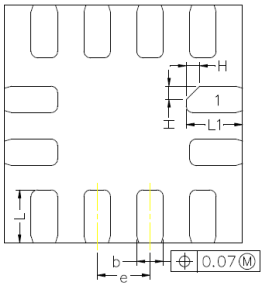
1.8mm x 1.8mm UQFN-12



TOP VIEW



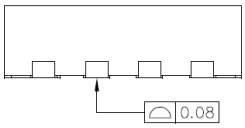
SIDE VIEW



BOTTOM VIEW

COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	0.50	0.55	0.60
A1	0.00	0.02	0.05
A3		0.127REF	
b	0.15	0.20	0.25
D	1.75	1.80	1.85
E	1.75	1.80	1.85
e	0.35	0.40	0.45
L	0.35	0.40	0.45
L1	0.375	0.425	0.475
H		0.10REF	



SIDE VIEW

NOTES:
ALL DIMENSIONS DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

10 Ordering Information

Part Number	Package	Top Mark(Note 1)	MOQ
YHM4204LBT	12 FCLGA	4204 YYWW	3000
YHM4204QCT	14 QFN(3.5mm x 3.5mm)	YHM4204 YYWW xxxxxxx	3000
YHM4204QBT	12 QFN(1.8mm x 1.8mm)	Y4204 YYWW xxxx	3000

T = Tape and reel.

Note 1:

YY: Production year; WW: Production week.

xxxx or xxxxxxx: Lot Number.

11 Datasheet Change History

Rev	Date	Changes
1.01	Feb./2024	Initial Version