

HDMI Switch ICs

1 for input 1 output buffer (Sync with OE)



BU16025MUV

No.11063EAT06

●Description

BU16025MUV is HDMI Buffer IC for Source, Sink, and repeater equipment. Each TMDS input has internal 50ohm resistor. These resistors can be turned off by OE pin control. And BU16025MUV has selectable equalizer circuit and DDC active buffer to isolate capacitor between input and output.

●Features

- 1) Support 480i/p, 720p, and 1080i/p 12bit deep color and 2.70Gbps data rate
- 2) 5V Tolerance to all DDC and HPD_SINK Inputs
- 3) Integrated active DDC buffer
- 4) Integrated DDC data line delay mode to get hold margin
- 5) Integrated Switchable 50Ω Receiver Termination
- 6) Integrated Low TMDS output swing mode for High speed signal
- 7) High Impedance Outputs When Disabled
- 8) TMDS Inputs and output HBM ESD Protection Exceeds 8kV
- 9) Support AC coupling input (TMDS input common mode voltage is 3.3V)
- 10) Selectable Receiver Equalization
- 11) Integrated I²C Identification Data for HDMI/DVI distinction (Display port translator mode)
- 12) 48-Pin VQFN Package
- 13) ROHS Compatible

●Applications

Digital TV, DVD player, set-top box, AV receiver, Digital projector, Desktop/Note book PC

●Absolute maximum ratings

Parameter	Ratings	Unit
Input Voltage	-0.3~+4.5	V
DDC, HPD_SINK input voltage	-0.3~+5.5	V
Differential pin input voltage	+2.5~+4.0	V
PRE, I2C_ONB, SELREF, OEB, EQ, DDC_TI, DDCEN, HDMID_EN, HPDINV input voltage	-0.3~+4.0	V
Power Dissipation rating	2123(*1)	mW
Storage temperature	-55~+125	°C

*1 ROHM standard substrate When it's used by than Ta=25°C, it's reduced by 21.2mW/°C

●Operating conditions

Parameter	Symbol	Ratings			Unit
		Min.	Typ.	Max.	
Supply Voltage	V _{CC}	3.0	3.3	3.6	V
Operating free-air temperature	T _A	0	-	70	°C
TMDS DIFFERENTIAL PINS (A/B)					
Input differential voltage range	V _{ID}	150	-	1560	mVp-p
Input common voltage range	V _{IC}	1.5	-	V _{CC} +0.01	V
Current control resistor	REXT	1.18	1.2	1.22	kΩ
TMDS output voltage range	AV _{CC}	3	3.3	3.6	V
Termination Resistor	R _T	45	50	55	Ω
Signal rate	-	-	-	2.70	Gbps
CONTROL PINS (PRE, I2C_ONB, OEB, SELREF, EQ, DDC_TI, DDCEN, HDMID_EN, HPDINV)					
H level input voltage	V _{IH}	0.7 × V _{CC}	-	V _{CC}	V
L level input voltage	V _{IL}	-0.3	-	0.3 × V _{CC}	V
DDC I/O PINS (SCLx, SCLy, SDAx, SDAy)					
I ² C data rate	d _{R(I2C)}	-	-	100	kHz
SDAx, SCLx					
H level input voltage	V _{IH}	2.1	-	5.5	V
L level input voltage	V _{IL}	-0.3	-	0.35	V
SDAy, SCLy					
H level input voltage	V _{IH}	2.1	-	5.5	V
L level input voltage	V _{IL}	-0.3	-	1.5	V
STATUS PINS (HPD_SINK)					
H level input voltage	V _{IH}	2.1	-	5.5	V
L level input voltage	V _{IL}	-0.3	-	0.8	V

●Electrical characteristics(Unless Otherwise noted Ta=25°C, Vcc=3.3V)

Parameter	Symbol	Limits			Unit	Conditions	
		Min.	Typ.	Max.			
Stand by Current (DDC_EN= “L”)	Ist	-	-	10	μA	OEB = “Vcc”, V _{IL} = “0V”, V _{IH} =”Vcc”	
Stand by Current2 (DDC_EN= “H”)	Ist2	-	1.8	3.0	mA	OEB = “Vcc”, V _{IL} = “0V”, V _{IH} =”Vcc”	
Circuit Current	I _{cc}	-	68+32 ^{*(1)}	84+32 ^{*(1)}	mA	V _{IH} = Vcc, V _{IL} = Vcc-0.4V, REXT=1.2kΩ , R _T = 50 Ω , AVcc = 3.3V, PRE=0V Am/Bm =2.25 Gbps HDMI data pattern, m = 2,3,4, A1/B1 = 225 MHz clock	
Power Consumptions	P _D	-	-	381	mW	V _{IH} = Vcc, V _{IL} = Vcc-0.4V REXT=1.2kΩ , R _T = 50 Ω , AVcc = 3.3V, PRE=0V Am/Bm = 2.25Gbps HDMI data pattern, m = 2,3,4, A1/B1 = 225 MHz clock	
TMDS DIFFERENTIAL PINS (A/B; Y/Z)							
H level output voltage	V _{OH}	AVcc-10	-	AVcc+10	mV	AVcc = 3.3V, R _T = 50 Ω , PRE = 0V	
L level output voltage	V _{OL}	AVcc-600	-	AVcc-400	mV		
Swing voltage	V _{SWING}	400	-	600	mV		
Swing voltage2 (Low TMDS output swing mode)	V _{SWING 2}	600	-	920	mVp-p	PRE = Vcc, Am/Bm =225 Mbps HDMI data pattern, m = 2,3,4, A1/B1 = 225 MHz clock	
TMDS internal Resistor	R _{INT}	45	50	55	Ω	V _{IN} = 2.9V	
Output leak current	V _{off}	-10	0	10	μA	AVcc = 3.3V, Vcc=0V	
DDC Input and output							
SDAx, SCLx							
Input leak current	I _{IH1}	-10	-	10	μA	V _I = 5.5V	
Input leak current	I _{IH2}	-10	-	10	μA	V _I = Vcc	
H level output current	I _{OHT}	-10	-	10	μA	V _O = 5.5V	
L level output current	I _{IL}	-10	-	10	μA	V _{IL} = GND	
L level output voltage	V _{OLT}	0.43	-	0.57	V	RL = 4.7kΩ	SELREF = “L”
		0.52	-	0.87			SELREF = “H”
L level input voltage below output voltage	V _{OLT-V_{IL}}	-	100	-	mV		SELREF = “L”
		-	400	-			SELREF = “H”
SDAy , SCLy							
Input leak current	I _{IH1}	-10	-	10	μA	V _I = 5.5V	
Input leak current	I _{IH2}	-10	-	10	μA	V _I = Vcc	
H level output current	I _{OH}	-10	-	10	μA	V _O = 5.5V	
L level output current	I _{OL}	-10	-	10	μA	V _{IL} = GND	
L level output voltage	V _{OL}	-	-	0.2	V	I _{OUT} = 4mA	
STATUS PINS (HPD)							
H level output voltage	V _{OH}	2.4	-	Vcc	V	I _{OH} = - 8mA	
L level output voltage	V _{OL}	0	-	0.4	V	I _{OL} = 8mA	
CONTROL PINS (PRE, OEB, DDCEN, HPDINV)							
H level input current	I _{IH}	-10	-	10	μA	V _{IH} = Vcc	
L level input current	I _{IL}	-10	-	10	μA	V _{IL} = GND	
CONTROL PINS (SELREF, EQ, DDC_TI)							
H level input current	I _{IH}	50	-	150	μA	V _{IH} = Vcc	
L level input current	I _{IL}	-10	-	10	μA	V _{IL} = GND	
CONTROL PINS (I2C_ONB, HDMIID_EN)							
H level input current	I _{IH}	-10	-	10	μA	V _{IH} = Vcc	
L level input current	I _{IL}	-150	-	50	μA	V _{IL} = GND	

(*) 32mA is the current through TMDS internal resistor

●AC Characteristic (Unless Otherwise noted Ta=25°C, Vcc=3.3V)

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
TMDS Output Differential pin (Y/Z)						
Differential output rise time (20%-80%)	t _{R_tmds}	-	110	-	ps	AV _{CC} = 3.3V, R _T = 50 Ω , PRE ="H"
Differential output rise time (20%-80%)	t _{F_tmds}	-	110	-	ps	
Differential intra pair skew (Fig9)	t _{sk(D)}	-	35	-	ps	
DDC I/O Pin (SCLx, SCLy, SDAx, SDAy)						
Propagation delay (L to H) SCLx to SCLy	t _{PLH1}	-	30	-	ns	R _L = 4.7K Ω C _L = 10pF DDC_TI = "H"
Propagation delay (H to L) SCLx to SCLy	t _{PHL1}	-	10	-	ns	
Propagation delay (L to H) SCLy to SCLx	t _{PLH2}	-	40	-	ns	
Propagation delay (H to L) SCLy to SCLx	t _{PHL2}	-	20	-	ns	
Propagation delay (L to H) SDAx to SDAy	t _{PLH3}	-	570	-	ns	R _L = 4.7K Ω C _L = 10pF DDC_TI = "H"
Propagation delay (H to L) SDAx to SDAy	t _{PHL3}	-	570	-	ns	
Propagation delay (L to H) SDAy to SDAx	t _{PLH4}	-	370	-	ns	
Propagation delay (H to L) SDAyto SDAx	t _{PHL4}	-	370	-	ns	
Propagation delay (L to H) SDAx/SCLx to SDAy/SCLy	t _{PLH5}	-	30	-	ns	R _L = 4.7K Ω C _L = 10pF DDC_TI = "L"
Propagation delay (H to L) SDAx/SCLx to SDAy/SCLy	t _{PHL5}	-	10	-	ns	
Propagation delay (L to H) SDAy/SCLy to SDAx/SCLx	t _{PLH6}	-	40	-	ns	
Propagation delay (H to L) SDAy/SCLy to SDAx/SCLx	t _{PHL6}	-	20	-	ns	
SDAx/SCLx output rise time	t _{R1}	-	80	-	ns	R _L = 4.7K Ω C _L = 10pF
SDAx/SCLx output rise time	t _{F1}	-	5	-	ns	
SDAy/SCLy output rise time	t _{R2}	-	95	-	ns	
SDAy/SCLy output rise time	t _{F2}	-	5	-	ns	
STATUS PINS(HPD)						
Propagation delay time (L to H)	t _{PLH(HPD)}	-	100	-	ns	C _L =10pF
Propagation delay time (H to L)	t _{PHL(HPD)}	-	100	-	ns	C _L =10pF

●Electrical characteristic curves (Reference data)

Unless Otherwise noted Ta=25°C, Vcc=3.3V

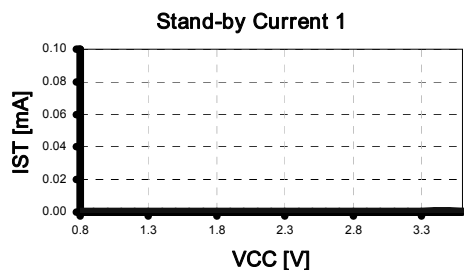


Fig.1 Stand-by Current 1(Ist)
OEB = "Vcc", DDC_EN= "0V"

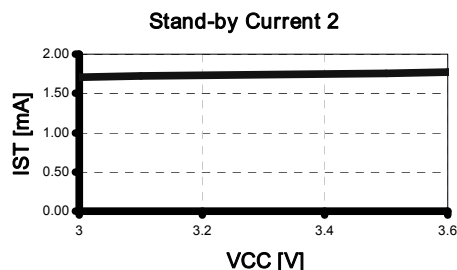


Fig.2 Stand-by Current 2(Ist2)
OEB = "Vcc", DDC_EN= "Vcc"

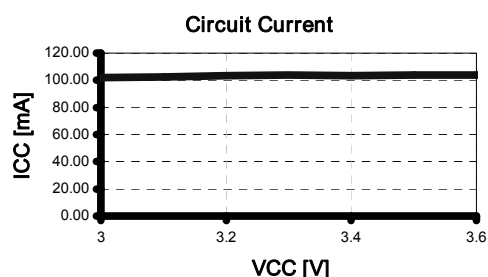


Fig.3 Circuit Current(Vcc + AVcc) (Icc)
OEB = "Vcc", DDC_EN= "0V"

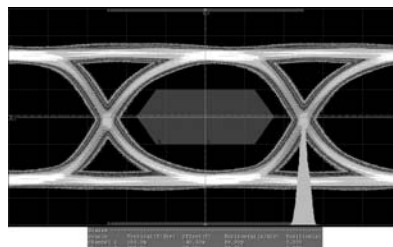


Fig.4 Eye Diagram of BU16025MUV
2.25Gbps Data rate when PRE = "L",
Test Equipment DTG5334(tektronix),
DSA80000B(Agilent)

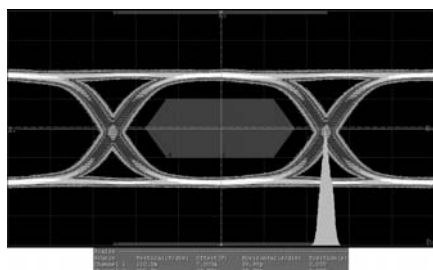


Fig.5 Eye Diagram of BU16025MUV
2.25Gbps Data rate when PRE = "H",
Test Equipment DTG5334(tektronix),
DSA80000B(Agilent)

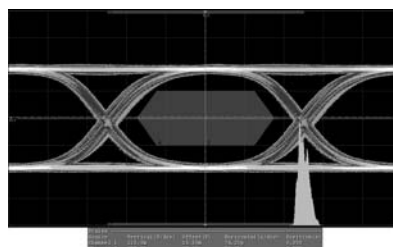


Fig.6 Eye Diagram of BU16025MUV
2.7Gbps Data rate when PRE = "H",
Test Equipment DTG5334(tektronix),
DSA80000B(Agilent)

●Measurement symbol and circuit diagram

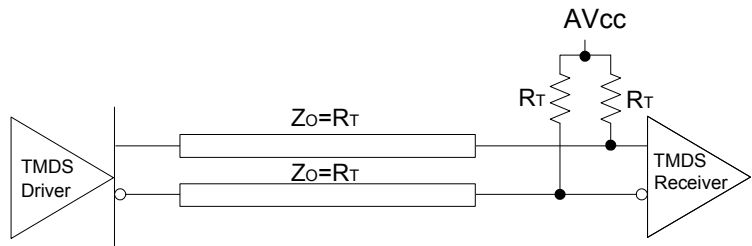


Fig 7 TMD5 Output driver

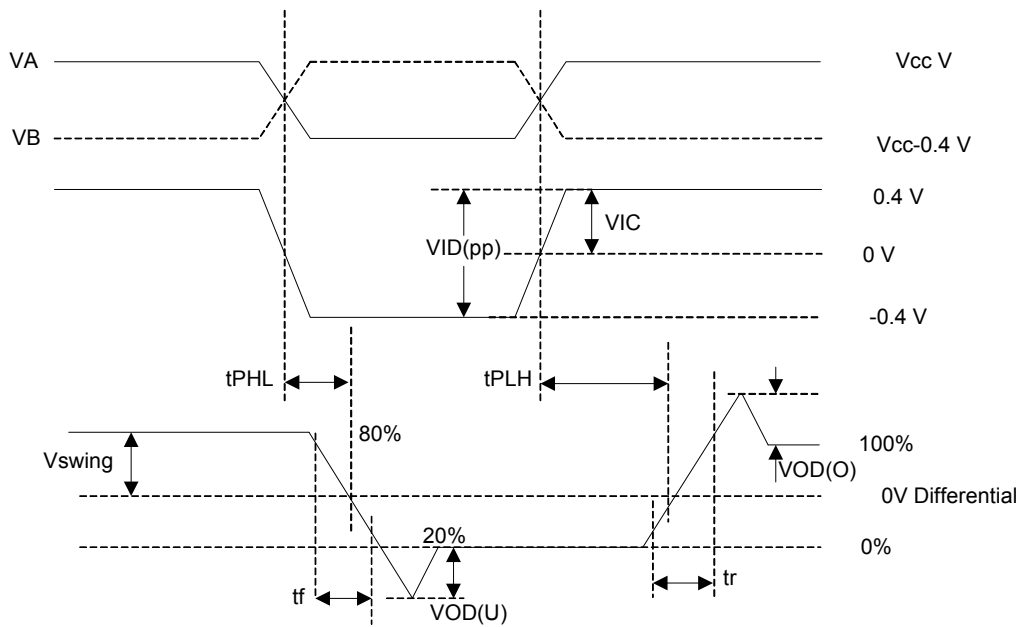
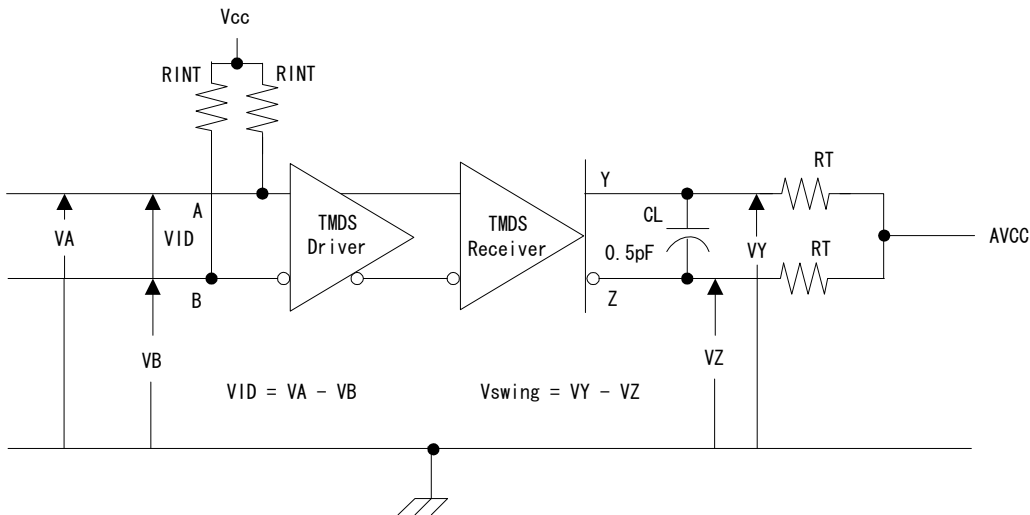


Fig8 Test circuit and definition

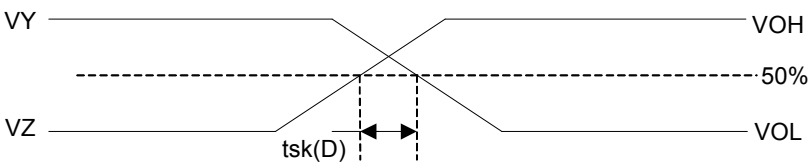


Fig9 Definition of differential intra pair skew

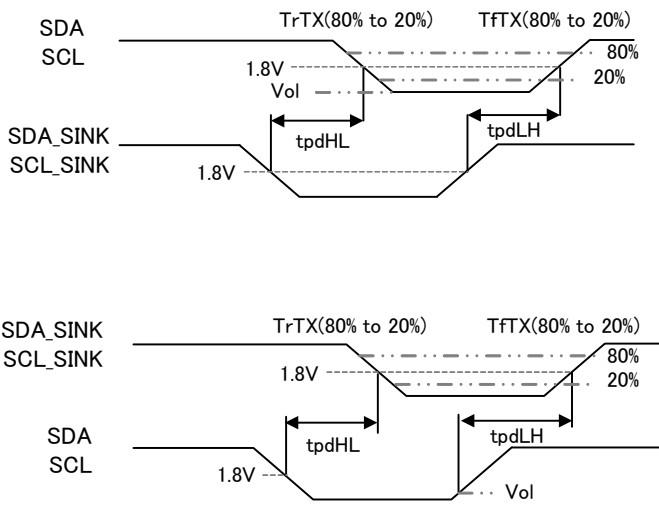


Fig10 DDC timing definitions

●Block diagram and pin configuration

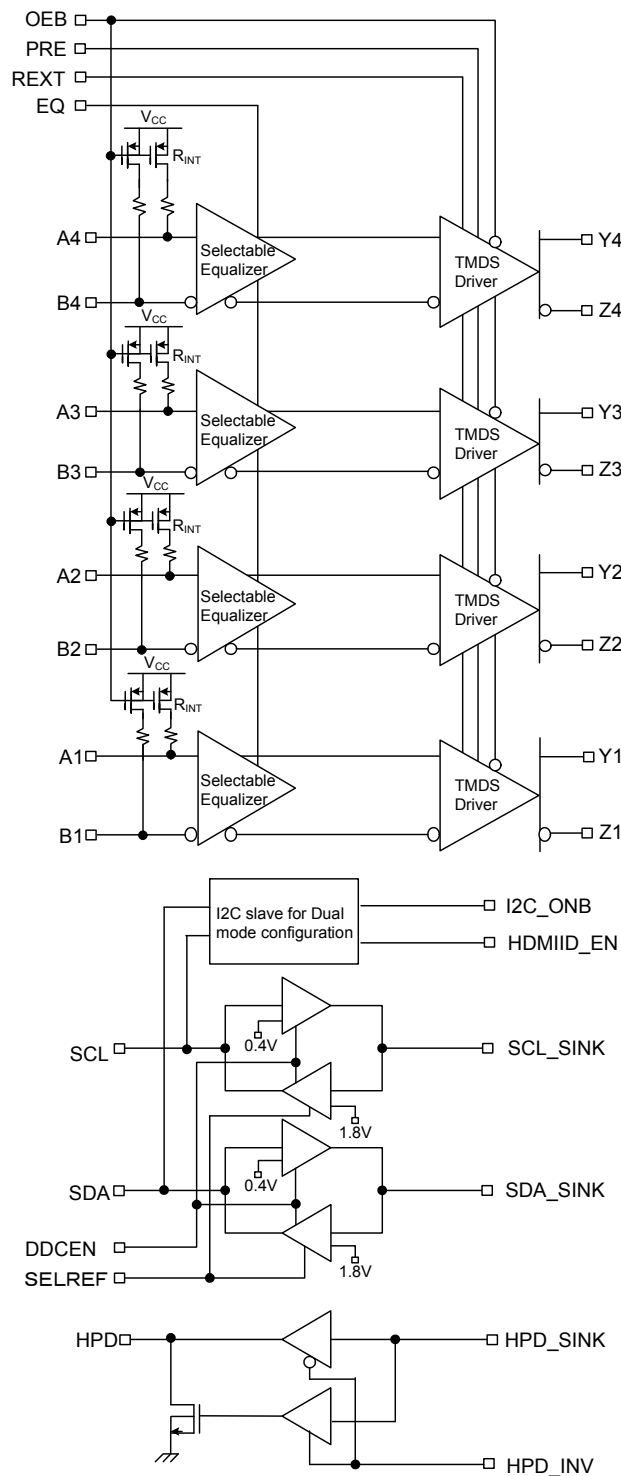
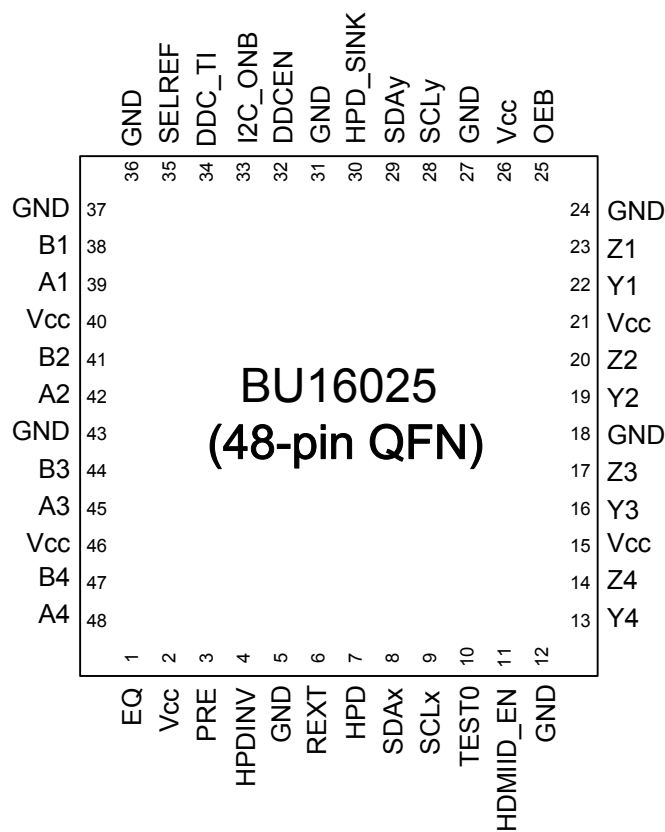


Fig.11 Block Diagram of BU16025MUV

●Pin Explanation

Pin		I/O	Explanations
Name	Number		
B1, B2, B3, B4	38, 41, 44, 47	Input	TMDS Negative input
A1, A2, A3, A4	39, 42, 45, 48	Input	TMDS Positive input
Z1, Z2, Z3, Z4	23, 20, 17, 14	Output	TMDS Negative input
Y1, Y2, Y3, Y4	22, 19, 16, 13	Output	TMDS Positive input
EQ	1	Input	Equalizer gain setting(40k Ω internal pull down) “L” 5dB “H” 15dB
PRE	3	Input	TMDS Low output swing mode(Recommend High) Low : OFF High : ON
HPDINV	4	Input	HPD output select switch Low : non-invert High : Invert and open drain output
REXT	6	Input	TMDS Current control pin(via 1.2k Ω to GND)
HPD	7	Output	Hot plug detect output ^{(*)1}
SDAx	8	Inout	DDC Data line(*2 Vol = 0.5V)
SCLx	9	Inout	DDC Clock line(*2 Vol = 0.5V)
TEST0	10	Input	Open or Gnd
HDMIID_EN	11	Input	HDMI ID Enable(40k Ω internal pull up) ^{(*)3} Low : 0xFF(DVI) High : ASCII (HDMI)
OEB	25	Input	TMDS line internal resistor and output enable switch Low : ON(Enable) High : High-Z
SCLy	28	Inout	DDC Clock line ^{(*)2}
SDAy	29	Inout	DDC Data line ^{(*)2}
HPD_SINK	30	Input	Hot plug detect input(10k Ω internal pull down)
DDCEN	32	Input	I ² C Repeater Enable Low : High-Z High : Enable
I2C_ONB	33	Input	Built-in I ² C Slave Enable Switch(90k Ω internal pull up) ^{(*)3} Low : ON High : OFF
DDC_TI	34	Input	DDC Data hold margin setting (40k Ω internal pull down) ^{(*)4} DDC_TI = “L” Delay from SDAx to SDAY = 570nsec, Delay from SCLx to SCLy = 20nsec Delay from SDAY to SDAx = 370nsec, Delay from SCLy to SCLx = 20nsec DDC_TI = “H” Delay from SDAx to SDAY = 20nsec, Delay from SCLx to SCLy = 20nsec Delay from SDAY to SDAx = 20nsec, Delay from SCLy to SCLx = 20nsec
SELREF	35	Input	SCLx/SDAx L level output voltage select (40k Ω internal pull down)
V _{CC}	2, 15, 21, 26, 40, 46	-	Power
GND	5, 12, 18, 24, 27, 31, 36, 37, 43	-	Ground

(*)1 HPD_OFF mode sets Hot plug detect output to High impedance. Except HPD_OFF mode, HPD is always active.

(*)2 SDAx/SCLx, SDAY/SCLy have different L level input and output voltage. Please refer recommended operating condition in detail

(*)3 HDMIID_EN, I2C_ONB don't need to be Enable except using internal I²C slave.

(*)4 Data hold time increases when DDC_TI= “L”. But Data setup time and holdtime of Start condition decrease.

●Look up table of I2C_ONB and HDMIID_EN pin

Name	Pin setting				Output state			
	OEB	DDCEN	I2C_ONB	HDMI ID_EN	I ² C Buffer	Internal I ² C slave	HPD	TMDS Internal R
Normal mode (recommend)	L	L	H	H	OFF	OFF	active	ON
	L	H	H	H	active	OFF	active	ON
HPD_OFF mode	L	L	H	L	OFF	OFF	High Impedance	ON
	L	H	H	L	active	OFF	High Impedance	ON
TMDS_OFF mode	H	L	H	H	OFF	OFF	active	OFF
	H	H	H	H	active	OFF	active	OFF
HPD_TMDS_OFF mode	H	L	H	L	OFF	OFF	High Impedance	OFF
	H	H	H	L	active	OFF	High Impedance	OFF
Display Port Translator mode (HDMI)	-	H	L	H	active	(HDMI)	active	OFF
Display Port Translator mode (DVI)	-	H	L	L	active	(DVI) 0xFF	active	OFF
None	-	L	L	-	OFF	OFF	active	OFF

Display Port Translator mode

DisplayPort Translator mode are used to access internal I2C slave. I2C Slave register stores value like below. The ASCII code of this value is "DP-HDMI ADAPTOR<EOT>

Please read from address 0x00 to 0x0F at the read cycle.

Slave adr : 7'b100_0000

I2C_ONB	HDMIID_EN	Acknowledge (from slave)	Address	0x00	0x01	0x02	0x03	0x04	0x05	0x06	0x07	0x08	0x09	0x0A	0x0B	0x0C	0x0D	0x0E	0x0F
L	H : HDMI Connect	Occur	Data	0x44	0x50	0x2D	0x48	0x44	0x4D	0x49	0x20	0x41	0x44	0x41	0x50	0x54	0x4F	0x52	0x04
	L : DVI Connect	Occur	Data	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF
H	-	None	Data	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF	0xFF

When I2C_ONB=1, slave adr 7'b100_0000 is disabled

I²C Slave Read access to register block

step 1	0	S : Start Condition
I ² C Start(Master)	S	

step 2	7	6	5	4	3	2	1	0
I ² C Device Address Write(Master)	1	0	0	0	0	0	0	0

Write

step 3	9	A : Acknowledge
I ² C Acknowledge(Slave)	A	

step 4	7	6	5	4	3	2	1	0
I ² C Logic Address(Master)	0	0	0	0	0	0	0	0

step 5	9	A
I ² C Acknowledge(Slave)	A	

step 6	0	P : Stop Condition
I ² C Stop(Master)	P	

step 7	0	S
I ² C Start(Master)	S	

step 8	7	6	5	4	3	2	1	0
I ² C General Address Read(Master)	1	0	0	0	0	0	0	1

Read

step 9	9	A
I ² C Acknowledge(Slave)	A	

step 10	7	6	5	4	3	2	1	0
I ² C Read Data(Slave)	Data	Data	Data	Data	Data	Data	Data	Data

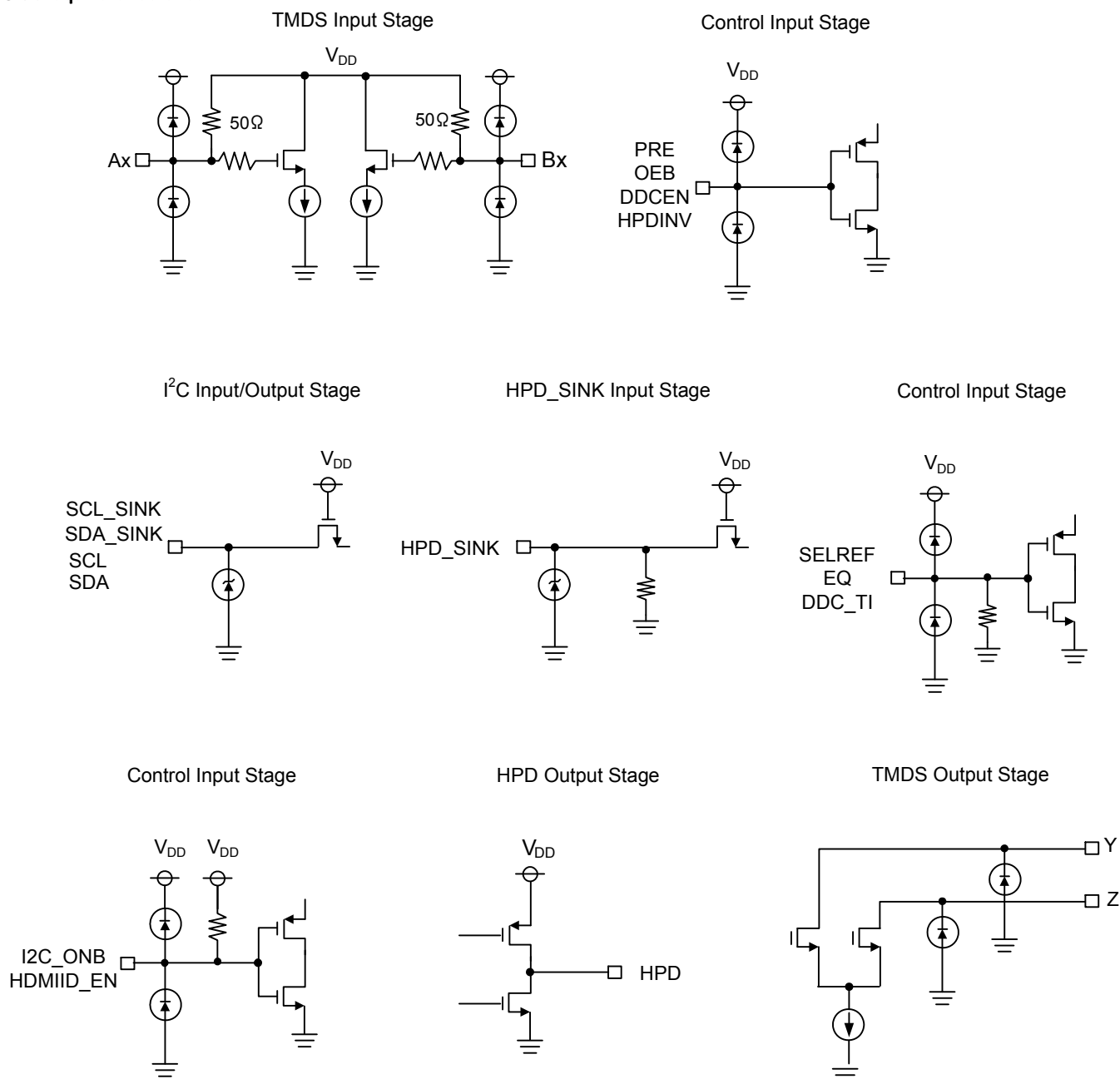
step 11	9	X : A (Acknowledge) or ~A (Not-Acknowledge)
I ² C Not-Acknowledge(Master)	X	

When X =A, Address pointer is incremented and repeat step10.

When X =~ A, I²C slave reg stops and moves to step12.

step 12	0	P
I ² C Stop(Master)	P	

● I/O equivalence circuit



●Notes for use

1)Internal Resistor about HPD_SINK

For the reason HPD_SINK pin have internal resistor of 10kohm like below, don't put external resistor.

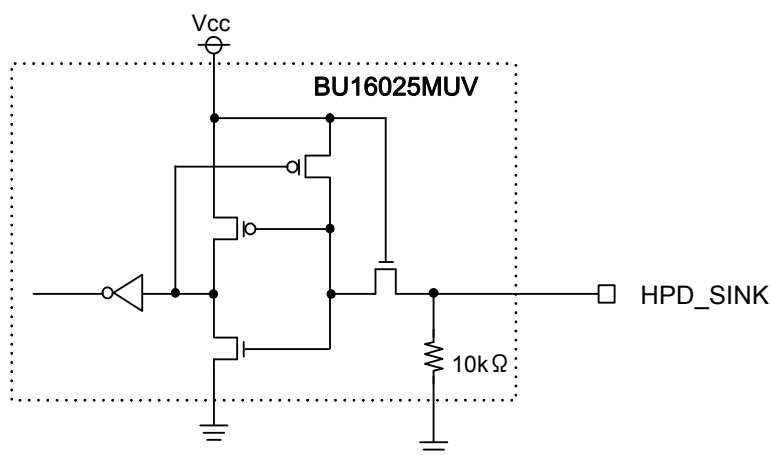


Fig12 HPD_SINK I/O schematic

2)About unused input pin

a. Unused inputs of TMDS recommend to OPEN

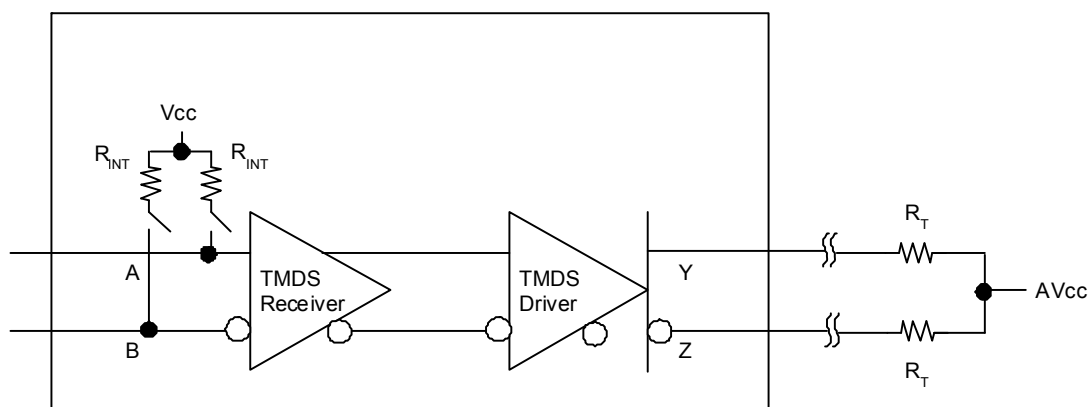


Fig 13 TMDS Input Recommendation

b. Unused inputs of DDC recommend to pull up.

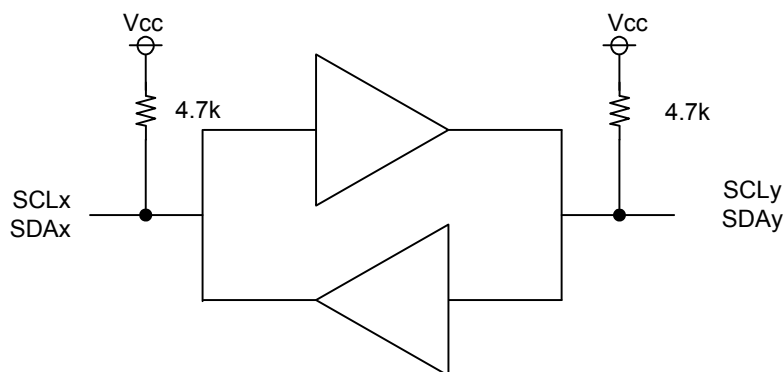


Fig 14 Unused DDC Buffers of R side

c. Unused input of HPD recommends to open

3) Serial connection of TMDS differential line

The serial connections of TMDS differential line like fig15 decrease the jitter tolerant characteristic. Especially when system needs 1080p (12bit) data rate, deterioration of Jitter tolerance is outstanding. This problem also depends on receiver IC characteristic. When 1080p (12bit) is required, Rohm doesn't recommend cascade connect application.

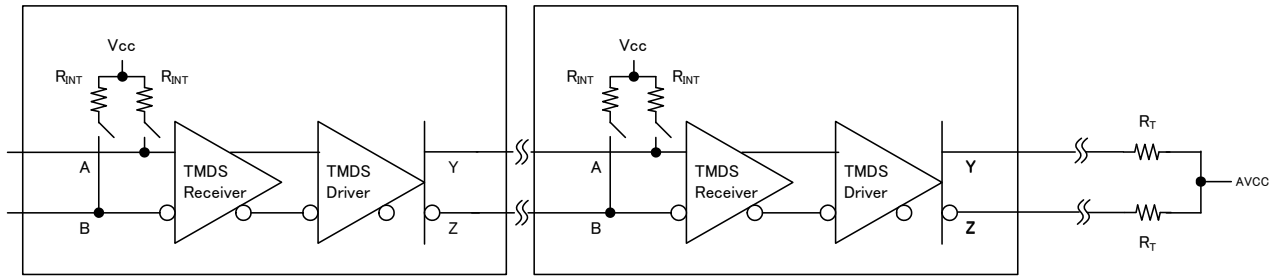


Fig 15 cascade connection notice

4) DDC line connections

DDC buffer of SDAx/SCLx and SDAy/SCLy have different low threshold level. Connect like below

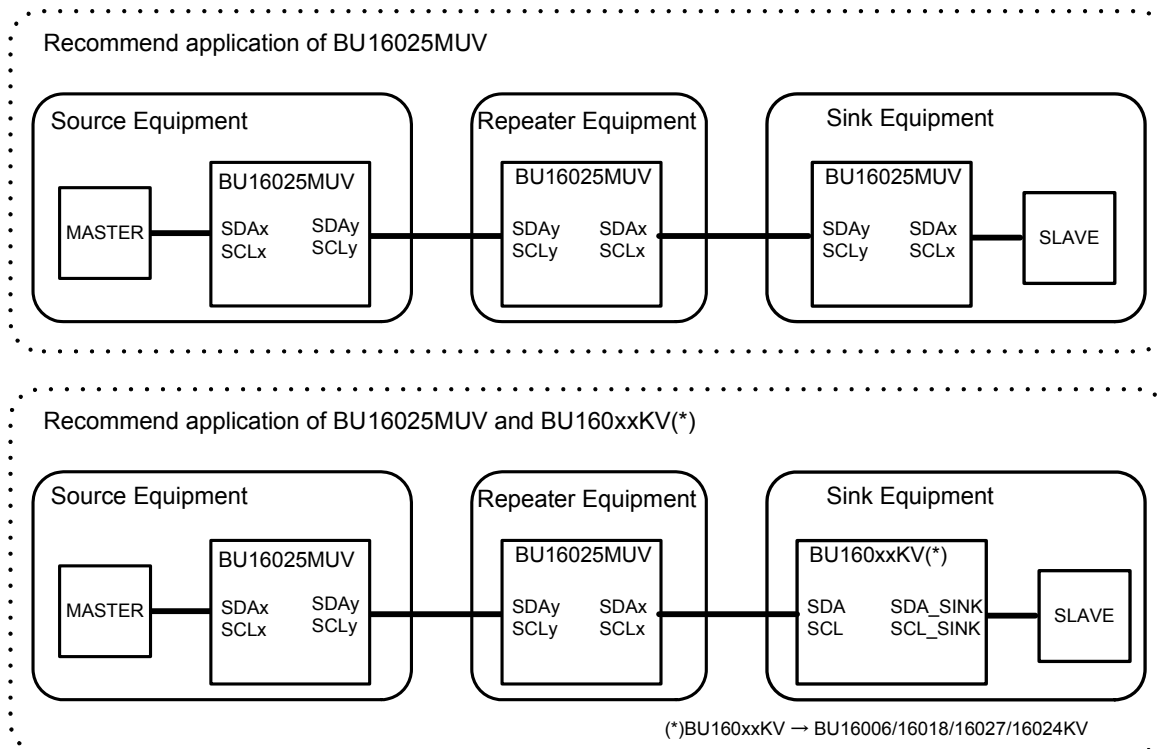


Fig 16 DDC connection notice

5) AC Coupling

This IC can also communicate using AC coupling capacitor with TMDS line. But even connecting AC coupling capacitor, AC current may flow if input common mode voltage between two devices is different. This AC current may damage the lower common mode voltage devices like PCIe or DisplayPort.

6) TMDS output offset voltage

Offset voltage may appear to TMDS output when there is no signal to TMDS input differential line. OE should be set to "H" to avoid it.

●Thermal Derating Curve

Rohm standard 4layer board

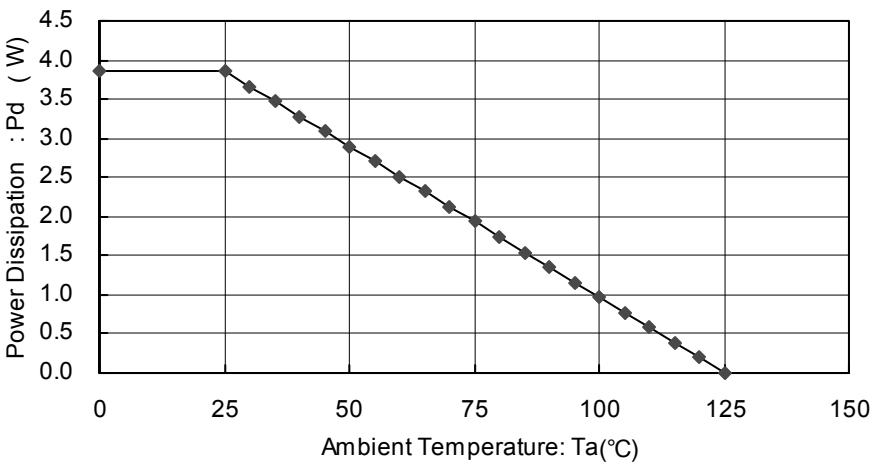
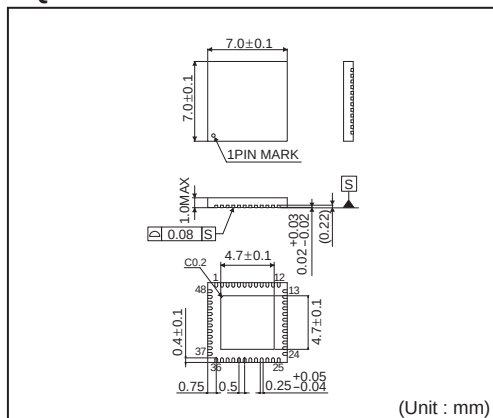


Fig.17 Thermal Derating Curve

●Ordering part number

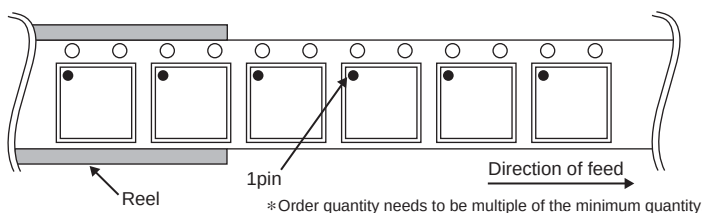
B	U	1	6	0	2	5	M	U	V	-	E	2
Part No.		Part No.					Package MUV: VQFN48AV7070			Packaging and forming specification E2: Embossed tape and reel		

VQFN048AV7070



<Tape and Reel information>

Tape	Embossed carrier tape
Quantity	1500pcs
Direction of feed	E2 (The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand)



Notes

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