NEC

MOS INTEGRATED CIRCUIT

μPD160083

480-OUTPUT TFT-LCD SOURCE DRIVER (COMPATIBLE WITH 256-GRAY SCALES)

DESCRIPTION

The μPD160083 is a source driver for TFT-LCDs capable of dealing with displays with 256-gray scales. Data input is based on digital input configured as 8 bits by 3 dots (1 pixel) with double clock edge, which can realize a full-color display of 16,777,216 colors by output of 256 values γ-corrected by an internal D/A converter and 9-by-2 external power modules. Because the output dynamic range is as large as V_{SS2} + 0.1 V to V_{DD2} – 0.1 V, level inversion operation of the LCD's common electrode is rendered unnecessary. Also, to be able to deal with dot-line inversion, n-line inversion and column line inversion when mounted on a single side, this source driver is equipped with a built-in 8-bit D/A converter circuit whose odd output pins and even output pins respectively output gray scale voltages of differing polarity. Assuring a clock frequency of 85 MHz when driving at 3.0 V, this driver is applicable to UXGA-standard (1600×1200), SXGA-standard (1280×1024) TFT-LCD panels.

FEATURES

- RSDS™ (Reduced Swing Differential Signaling) interface
- 480 outputs
- Input of 8 bits (gradation data) by 3 dots with double clock edge sampling
- Capable of outputting 256 values by means of 9-by-2 external power modules (18 units) and a D/A converter
- Logic power supply voltage (V_{DD1}): 2.7 to 3.6 V
- Driver power supply voltage (V_{DD2}): 10.5 to 13.5 V
- Output dynamic range: V_{SS2} + 0.1 V to V_{DD2} – 0.1 V
- High-speed data transfer: f_{CLK} = 85MHz MAX. (Internal data transfer speed when operating at V_{DD1} = 3.0 V)
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output Voltage polarity inversion function (POL)
- Input data inversion function (INV)
- ControIable output short function (MODE1 to MODE3)

Remark RSDS™ is a trademark of National Semiconductor Corporation.

ORDERING INFORMATION

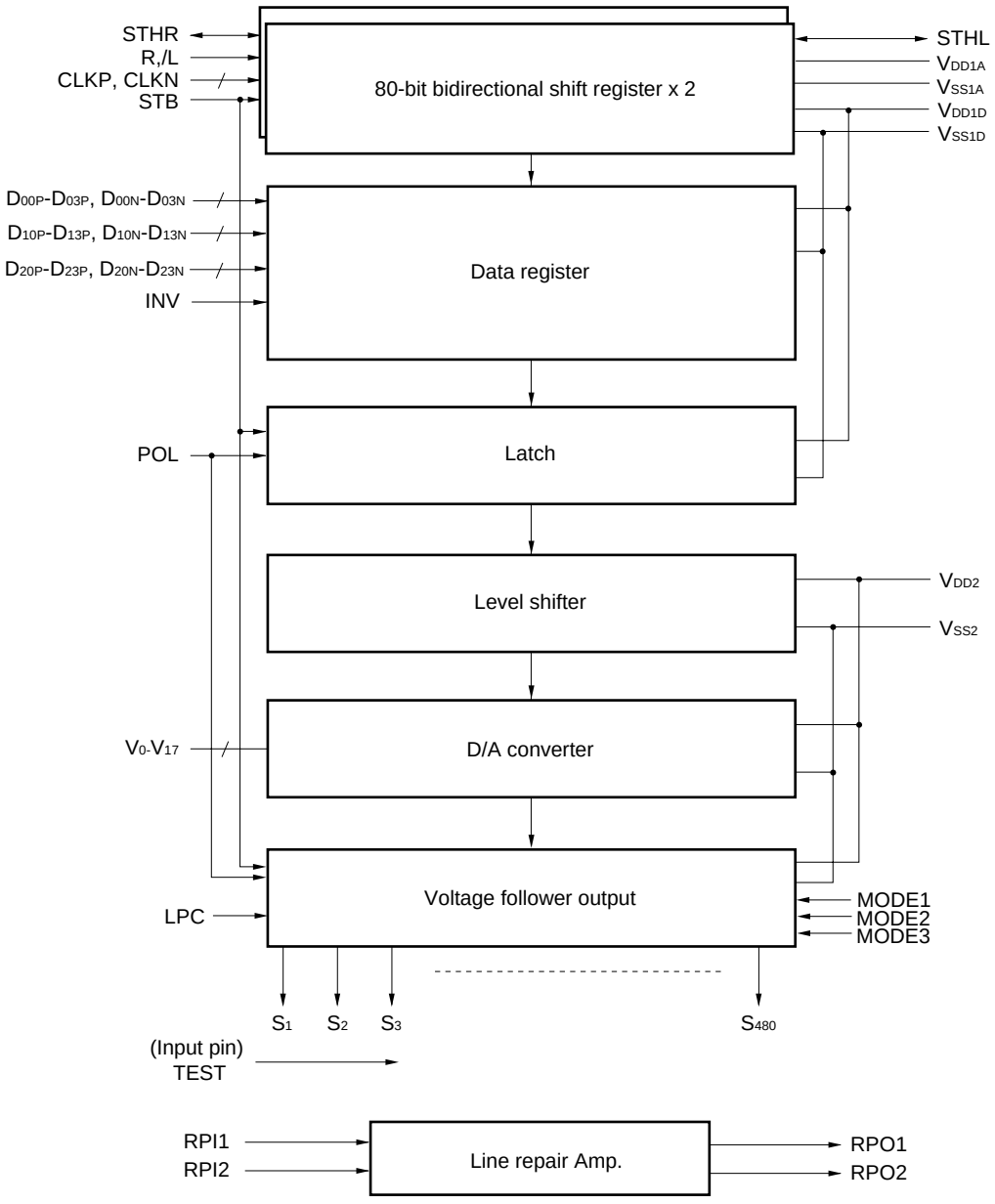
Part Number	Package
μPD160083N-xxx	TCP (TAB package)
μPD160083NL-xxx	COF (COF package)

Remark The TCP/COF's external shape is customized. To order the required shape, so please contact one of our sales representatives

The information contained in this document is being issued in advance of the production cycle for the product. The parameters for the product may change before final production or NEC Electronics Corporation, at its own discretion, may withdraw the product prior to its production.
Not all products and/or types are availabe in every country. Please check with an NEC Electronics sales representative for availability and additional information.

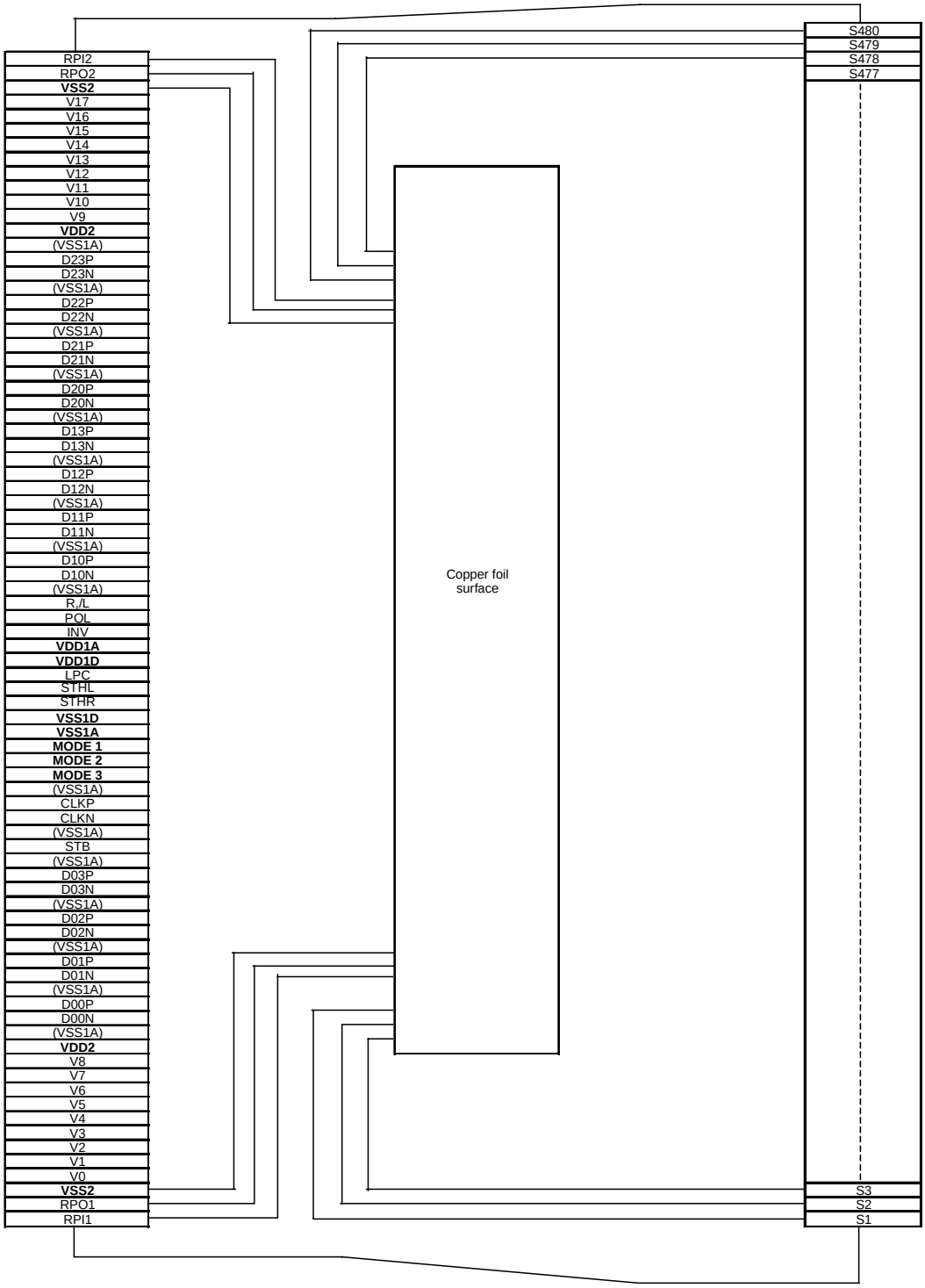
Document S16450EJ1V0PM00
Date Published May 2003 CP(K)
Printed in Japan

1. BLOCK DIAGRAM



Remark /xxx indicates active low signal.

2. PIN CONFIGURATION (μPD160083N-×××: TCP) (Copper foil surface, face-up)



Remark 1. This figure does not specify the TCP package.

2. (V_{SS1A}) is recommended to connect to analog GND on PCB for the return current of transmission line. And please don't use these pins for power supply terminal with dynamic current.

3. PIN FUNCTIONS

(1/2)

Pin Symbol	Pin Name	I/O	Description
S_1 to S_{480}	Driver	Output	The D/A converted 256-gray-scale analog voltage is output.
D_{00P} to D_{03P}, D_{00N} to D_{03N} D_{10P} to D_{13P}, D_{10N} to D_{13N} D_{20P} to D_{23P}, D_{20N} to D_{23N}	Display data (RSDS)	Input	The display data is input with a width of 12 bits by double edge, viz., the gray scale data (8 bits) by 3 dots (1 pixel).
R,/L (CMOS)	Shift direction control	Input	These refer to the start pulse input/output pins when driver ICs are connected in cascade. The shift directions of the shift registers are as follows. R,/L = H (V_{DD1} level): STHR input, $S_1 \rightarrow S_{480}$, STHL output R,/L = L (V_{SS1} level): STHL input, $S_{480} \rightarrow S_1$, STHR output
STHR (CMOS)	Right shift start pulse	I/O	R,/L = H (V_{DD1} level): Becomes the start pulse input pin. R,/L = L (V_{SS1} level): Becomes the start pulse output pin.
STHL (CMOS)	Left shift start	I/O	R,/L = H (V_{DD1} level): Becomes the start pulse output pin. R,/L = L (V_{SS1} level): Becomes the start pulse input pin.
CLKP, CLKN (RSDS)	Shift clock	Input	Refers to the shift register's shift clock input. The display data is incorporated into the data register at both of rising and falling edge. At the falling edge of the 160th clock after the start pulse input, the start pulse output reaches the high level, thus becoming the start pulse of the next-level driver.
STB (CMOS)	Latch	Input	The contents of the data register are transferred to the latch circuit at the rising edge. And the output timing and output short function are controlled by MODE1 to MODE3. Please refer to **8. RELATIONSHIP BETWEEN STB, POL, MODE1 to MODE3 AND OUTPUT WAVEFORM** for more detail. It is necessary to ensure input of one pulse per horizontal period.
POL (CMOS)	Polarity	Input	POL = H (V_{DD1} level): The S_{2n-1} output uses V_0-V_8 as the reference supply. The S_{2n} output uses V_9-V_{17} as the reference supply. POL = L (V_{SS1} level): The S_{2n-1} output uses V_9-V_{17} as the reference supply. The S_{2n} output uses V_0-V_8 as the reference supply. S_{2n-1} indicates the odd output: and S_{2n} indicates the even output. Input of the POL signal is allowed the setup time ($t_{POL-STB}$) with respect to STB's rising edge.
INV (CMOS)	Data inversion	Input	Data inversion can invert when display data is loaded. INV = H (V_{DD1} level): Data inversion loads display data after inverting it. INV = L (V_{SS1} level): Data inversion does not invert input data. Please input DC signal. For details, refer to **6. DATA INVERSION.**
LPC	Low power control	Input	LPC = L or open: Normal mode (default) LPC = H: Low power mode (35% lower than noamal mode) This pin is pulled down to the V_{SS1D} inside the IC.
MODE1 to MODE3	Output short contro	Input	This pin controls the output short function.

MODE1	MODE2	MODE3	Output Short	Remark
H or open	X	X	Non-active	Output short circuit OFF
L	H or open	X	Active	During STB = H
	L	H or open	H or open	During 34 CLK after STB falling
		L	L	During 68 CLK after STB falling

Remark X: H or L

Output short function works only when POL signal is changed from previous line. This pin is pulled up to V_{DD1D} inside the IC.

(2/2)

Pin Symbol	Pin Name	I/O	Description
RPI1, RPI2	Line-repair Amp.	Input	The driver-ability of the line-repair amp is around twice of the normal analog output S_1 to S_{480}. And these outputs are changed at the rising edge of STB and don't have Hi-Z (High impedance) period. RPI1 (RPI2) → impedance changed → RPO1 (RPO2)
RPO1, RPO2		Output	
TEST	Test	Input	TEST = H or open: Normal operation mode TEST = L: Test mode
V_0-V_{17}	γ-corrected power supplies	–	Input the γ-corrected power supplies from outside by using operational amplifier. Make sure to maintain the following relationships. During the gray scale voltage output, be sure to keep the gray scale level power supply at a constant level. $V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 \geq 0.5\ V_{DD2}$ $0.5\ V_{DD2} \geq V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_5 > V_{16} > V_{17} \geq V_{SS2} + 0.1\ V$
$V_{DD1D/A}$	Logic power supply	–	2.7 to 3.6 V
V_{DD2}	Driver power supply	–	10.5 to 13.5 V
$V_{SS1D/A}$	Logic ground	–	Grounding
V_{SS2}	Driver ground	–	Grounding

Cautions 1. The power on sequence must be V_{DD1D}, V_{DD1A}, logic input, and V_{DD2} and V_0-V_{17} in that order. Reverse this sequence to shut down (Simultaneous power application to V_{DD2} and V_0-V_{17} is possible.).

2. To stabilize the supply voltage, please be sure to insert a 0.1 μF bypass capacitor between V_{DD1D}, V_{DD1A}-V_{SS1D}, V_{DD1A} and V_{DD2}-V_{SS2}. Furthermore, for increased precision of the D/A converter, insertion of a bypass capacitor of about 0.01 μF is also advised between the γ-corrected power supply pins (V_0, V_1, V_2, ⋯, V_{17}) and V_{SS2}.

3. Because of the large power consumption of this driver IC, it is necessary to pay attention to the driver IC's temperature for the Junction Temperature. So, it should be considered to use the suitable mechanical design for the heat spreading and use the LPC function and the output reset function for the power reduction. Especially, it is recommended to measure the temperature of the driver IC surface.

4. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT VOLTAGE VALUE

The μPD160083 incorporates a 8-bit D/A converter whose odd output pins and even output pins output respectively gray scale voltages of differing polarity with respect to the LCD's counter electrode (common electrode) voltage. The D/A converter consists of ladder resistors and switches. The ladder resistors (r0 to r255) are designed so that the ratio of LCD panel γ-compensated voltages to V_0'-V_{255}' and V_0"-V_{255}" is almost equivalent, therefore, each resistance value indicates figure 4–2. For the 2 sets of 9 γ-compensated power supplies, V_0-V_8 and V_9-V_{17}, respectively, input gray scale voltages of the same polarity with respect to the common voltage

Figure 4–1 shows the relationship between the driving voltages such as liquid-crystal driving voltages V_{DD2}, V_{SS2} and 0.5 V_{DD2}, and γ-corrected voltages V_0-V_{17} and the input data. Be sure to maintain the voltage relationships below.

$V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 \geq 0.5\ V_{DD2}$

$0.5\ V_{DD2} \geq V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} \geq V_{SS2} + 0.1\ V$

Figures 4–2 shows γ-corrected voltages and ladder resistors ratio and figure 4–3 shows relationship between the input data and the output voltage.

Figure 4–1. Relationship Between Input Data and γ-corrected Power Supply

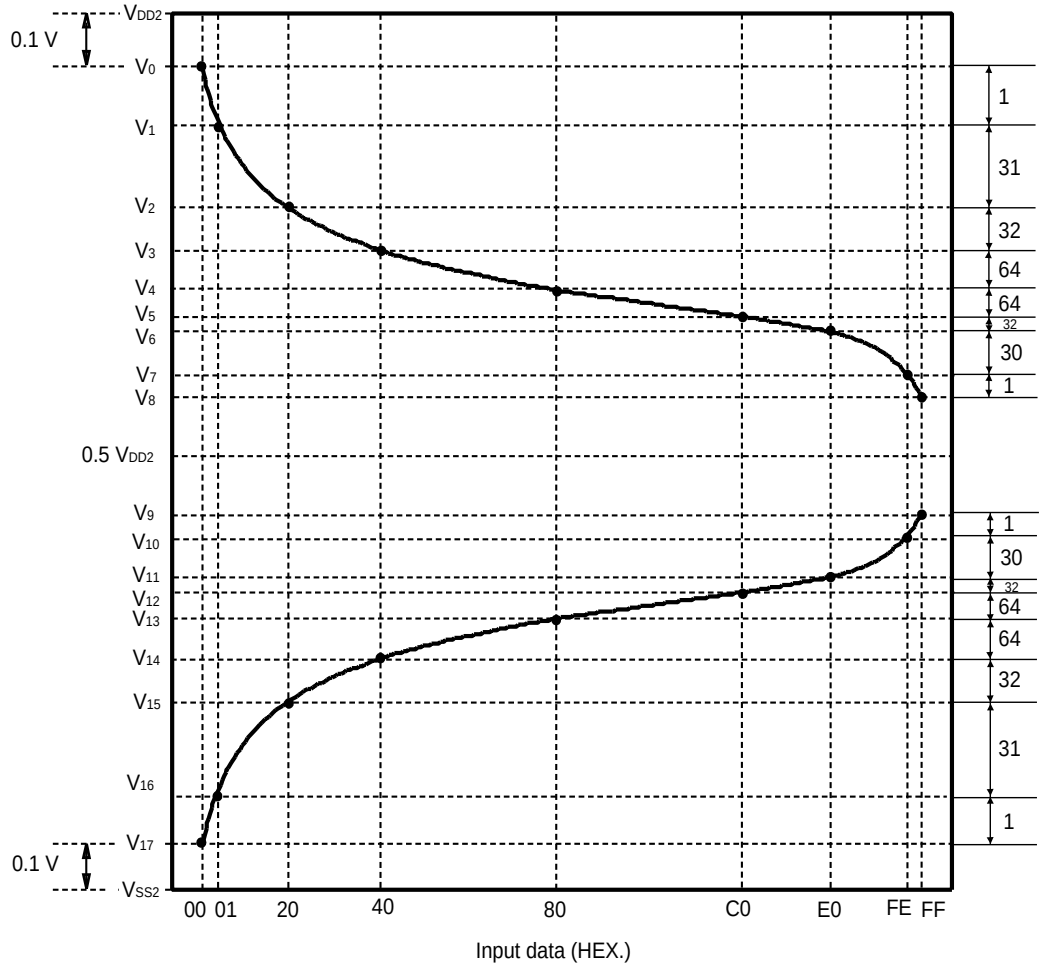
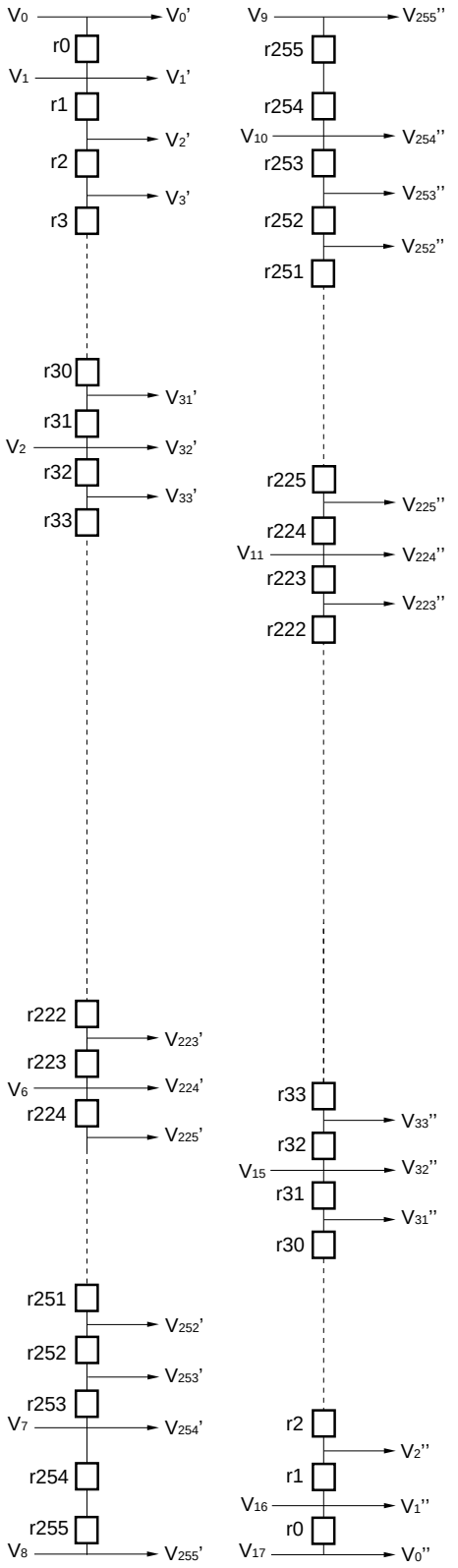


Figure 4–2. γ-corrected Voltages and Ladder Resistors Ratio



rn	Ratio	Value	rn	Ratio	Value	rn	Ratio	Value	rn	Ratio	Value
r0	31.50	630	r64	2.25	45	r128	1.00	20	r192	1.00	20
r1	27.50	550	r65	2.25	45	r129	1.00	20	r193	1.00	20
r2	24.00	480	r66	2.25	45	r130	1.00	20	r194	1.00	20
r3	21.50	430	r67	2.25	45	r131	1.00	20	r195	1.00	20
r4	19.00	380	r68	2.00	40	r132	1.00	20	r196	1.25	25
r5	17.50	350	r69	2.00	40	r133	1.00	20	r197	1.25	25
r6	16.50	330	r70	2.00	40	r134	1.00	20	r198	1.25	25
r7	15.00	300	r71	2.00	40	r135	1.00	20	r199	1.25	25
r8	14.00	280	r72	2.00	40	r136	1.00	20	r200	1.25	25
r9	13.00	260	r73	2.00	40	r137	1.00	20	r201	1.25	25
r10	12.00	240	r74	2.00	40	r138	1.00	20	r202	1.25	25
r11	11.00	220	r75	2.00	40	r139	1.00	20	r203	1.25	25
r12	10.00	200	r76	1.75	35	r140	1.00	20	r204	1.25	25
r13	9.50	190	r77	1.75	35	r141	1.00	20	r205	1.25	25
r14	9.50	190	r78	1.75	35	r142	1.00	20	r206	1.25	25
r15	9.00	180	r79	1.75	35	r143	1.00	20	r207	1.25	25
r16	8.50	170	r80	1.75	35	r144	1.00	20	r208	1.25	25
r17	8.00	160	r81	1.75	35	r145	1.00	20	r209	1.25	25
r18	7.50	150	r82	1.75	35	r146	1.00	20	r210	1.25	25
r19	7.50	150	r83	1.75	35	r147	1.00	20	r211	1.25	25
r20	7.00	140	r84	1.75	35	r148	1.00	20	r212	1.25	25
r21	6.50	130	r85	1.75	35	r149	1.00	20	r213	1.25	25
r22	6.50	130	r86	1.50	30	r150	1.00	20	r214	1.25	25
r23	6.00	120	r87	1.50	30	r151	1.00	20	r215	1.25	25
r24	6.00	120	r88	1.50	30	r152	1.00	20	r216	1.25	25
r25	5.50	110	r89	1.50	30	r153	1.00	20	r217	1.25	25
r26	5.50	110	r90	1.50	30	r154	1.00	20	r218	1.50	30
r27	5.50	110	r91	1.50	30	r155	1.00	20	r219	1.50	30
r28	5.00	100	r92	1.50	30	r156	1.00	20	r220	1.50	30
r29	5.00	100	r93	1.50	30	r157	1.00	20	r221	1.50	30
r30	5.00	100	r94	1.50	30	r158	1.00	20	r222	1.50	30
r31	4.50	90	r95	1.50	30	r159	1.00	20	r223	1.50	30
r32	4.50	90	r96	1.50	30	r160	1.00	20	r224	1.50	30
r33	4.50	90	r97	1.50	30	r161	1.00	20	r225	2.00	40
r34	4.00	80	r98	1.50	30	r162	1.00	20	r226	2.00	40
r35	4.00	80	r99	1.50	30	r163	1.00	20	r227	2.00	40
r36	4.00	80	r100	1.50	30	r164	1.00	20	r228	2.00	40
r37	4.00	80	r101	1.50	30	r165	1.00	20	r229	2.00	40
r38	3.75	75	r102	1.50	30	r166	1.00	20	r230	2.50	50
r39	3.75	75	r103	1.50	30	r167	1.00	20	r231	2.50	50
r40	3.50	70	r104	1.50	30	r168	1.00	20	r232	2.50	50
r41	3.50	70	r105	1.50	30	r169	1.00	20	r233	3.00	60
r42	3.50	70	r106	1.50	30	r170	1.00	20	r234	3.00	60
r43	3.50	70	r107	1.50	30	r171	1.00	20	r235	3.00	60
r44	3.25	65	r108	1.50	30	r172	1.00	20	r236	3.50	70
r45	3.25	65	r109	1.50	30	r173	1.00	20	r237	3.50	70
r46	3.00	60	r110	1.25	25	r174	1.00	20	r238	4.00	80
r47	3.00	60	r111	1.25	25	r175	1.00	20	r239	4.00	80
r48	3.00	60	r112	1.25	25	r176	1.00	20	r240	4.50	90
r49	3.00	60	r113	1.25	25	r177	1.00	20	r241	5.00	100
r50	3.00	60	r114	1.25	25	r178	1.00	20	r242	5.00	100
r51	3.00	60	r115	1.25	25	r179	1.00	20	r243	5.50	110
r52	2.75	55	r116	1.25	25	r180	1.00	20	r244	6.00	120
r53	2.75	55	r117	1.25	25	r181	1.00	20	r245	6.50	130
r54	2.75	55	r118	1.25	25	r182	1.00	20	r246	7.00	140
r55	2.75	55	r119	1.25	25	r183	1.00	20	r247	7.50	150
r56	2.50	50	r120	1.25	25	r184	1.00	20	r248	8.00	160
r57	2.50	50	r121	1.25	25	r185	1.00	20	r249	8.50	170
r58	2.50	50	r122	1.25	25	r186	1.00	20	r250	9.00	180
r59	2.50	50	r123	1.25	25	r187	1.00	20	r251	9.50	190
r60	2.50	50	r124	1.25	25	r188	1.00	20	r252	10.50	210
r61	2.50	50	r125	1.25	25	r189	1.00	20	r253	11.50	230
r62	2.25	45	r126	1.00	20	r190	1.00	20	r254	12.50	250
r63	2.25	45	r127	1.00	20	r191	1.00	20	r255	25.00	500

Caution There is no connection between V_8 and V_9 pin inside the IC.

Figure 4–3. Relationship between Input Data and Output Voltage (1/2)

(Output voltage 1) V_{DD2} – 0.1 V ≥ V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 ≥ 0.5 V_{DD2}

Data	Output Voltage		Data	Output Voltage		Data	Output Voltage		Data	Output Voltage	
00H	V0	V0	40H	V64	V3	80H	V128	V4	C0H	V192	V5
01H	V1	V1	41H	V65	V3+(V4-V3) X 45 / 2010	81H	V129	V4+(V5-V4) X 20 / 1280	C1H	V193	V5+(V6-V5) X 20 / 810
02H	V2	V1+(V2-V1) X 550 / 6570	42H	V66	V3+(V4-V3) X 90 / 2010	82H	V130	V4+(V5-V4) X 40 / 1280	C2H	V194	V5+(V6-V5) X 40 / 810
03H	V3	V1+(V2-V1) X 1030 / 6570	43H	V67	V3+(V4-V3) X 135 / 2010	83H	V131	V4+(V5-V4) X 60 / 1280	C3H	V195	V5+(V6-V5) X 60 / 810
04H	V3	V1+(V2-V1) X 1460 / 6570	44H	V68	V3+(V4-V3) X 180 / 2010	84H	V132	V4+(V5-V4) X 80 / 1280	C4H	V196	V5+(V6-V5) X 80 / 810
05H	V5	V1+(V2-V1) X 1840 / 6570	45H	V69	V3+(V4-V3) X 220 / 2010	85H	V133	V4+(V5-V4) X 100 / 1280	C5H	V197	V5+(V6-V5) X 105 / 810
06H	V6	V1+(V2-V1) X 2190 / 6570	46H	V70	V3+(V4-V3) X 260 / 2010	86H	V134	V4+(V5-V4) X 120 / 1280	C6H	V198	V5+(V6-V5) X 130 / 810
07H	V7	V1+(V2-V1) X 2520 / 6570	47H	V71	V3+(V4-V3) X 300 / 2010	87H	V135	V4+(V5-V4) X 140 / 1280	C7H	V199	V5+(V6-V5) X 155 / 810
08H	V8	V1+(V2-V1) X 2820 / 6570	48H	V72	V3+(V4-V3) X 340 / 2010	88H	V136	V4+(V5-V4) X 160 / 1280	C8H	V200	V5+(V6-V5) X 180 / 810
09H	V9	V1+(V2-V1) X 3100 / 6570	49H	V73	V3+(V4-V3) X 380 / 2010	89H	V137	V4+(V5-V4) X 180 / 1280	C9H	V201	V5+(V6-V5) X 205 / 810
0AH	V10	V1+(V2-V1) X 3360 / 6570	4AH	V74	V3+(V4-V3) X 420 / 2010	8AH	V138	V4+(V5-V4) X 200 / 1280	CAH	V202	V5+(V6-V5) X 230 / 810
0BH	V11	V1+(V2-V1) X 3600 / 6570	4BH	V75	V3+(V4-V3) X 460 / 2010	8BH	V139	V4+(V5-V4) X 220 / 1280	CBH	V203	V5+(V6-V5) X 255 / 810
0CH	V12	V1+(V2-V1) X 3820 / 6570	4CH	V76	V3+(V4-V3) X 500 / 2010	8CH	V140	V4+(V5-V4) X 240 / 1280	CCH	V204	V5+(V6-V5) X 280 / 810
0DH	V13	V1+(V2-V1) X 4020 / 6570	4DH	V77	V3+(V4-V3) X 535 / 2010	8DH	V141	V4+(V5-V4) X 260 / 1280	CDH	V205	V5+(V6-V5) X 305 / 810
0EH	V14	V1+(V2-V1) X 4210 / 6570	4EH	V78	V3+(V4-V3) X 570 / 2010	8EH	V142	V4+(V5-V4) X 280 / 1280	CEH	V206	V5+(V6-V5) X 330 / 810
0FH	V15	V1+(V2-V1) X 4400 / 6570	4FH	V79	V3+(V4-V3) X 605 / 2010	8FH	V143	V4+(V5-V4) X 300 / 1280	CFH	V207	V5+(V6-V5) X 355 / 810
10H	V16	V1+(V2-V1) X 4580 / 6570	50H	V80	V3+(V4-V3) X 640 / 2010	90H	V144	V4+(V5-V4) X 320 / 1280	D0H	V208	V5+(V6-V5) X 380 / 810
11H	V17	V1+(V2-V1) X 4750 / 6570	51H	V81	V3+(V4-V3) X 675 / 2010	91H	V145	V4+(V5-V4) X 340 / 1280	D1H	V209	V5+(V6-V5) X 405 / 810
12H	V18	V1+(V2-V1) X 4910 / 6570	52H	V82	V3+(V4-V3) X 710 / 2010	92H	V146	V4+(V5-V4) X 360 / 1280	D2H	V210	V5+(V6-V5) X 430 / 810
13H	V19	V1+(V2-V1) X 5060 / 6570	53H	V83	V3+(V4-V3) X 745 / 2010	93H	V147	V4+(V5-V4) X 380 / 1280	D3H	V211	V5+(V6-V5) X 455 / 810
14H	V20	V1+(V2-V1) X 5210 / 6570	54H	V84	V3+(V4-V3) X 780 / 2010	94H	V148	V4+(V5-V4) X 400 / 1280	D4H	V212	V5+(V6-V5) X 480 / 810
15H	V21	V1+(V2-V1) X 5350 / 6570	55H	V85	V3+(V4-V3) X 815 / 2010	95H	V149	V4+(V5-V4) X 420 / 1280	D5H	V213	V5+(V6-V5) X 505 / 810
16H	V22	V1+(V2-V1) X 5480 / 6570	56H	V86	V3+(V4-V3) X 850 / 2010	96H	V150	V4+(V5-V4) X 440 / 1280	D6H	V214	V5+(V6-V5) X 530 / 810
17H	V23	V1+(V2-V1) X 5610 / 6570	57H	V87	V3+(V4-V3) X 880 / 2010	97H	V151	V4+(V5-V4) X 460 / 1280	D7H	V215	V5+(V6-V5) X 555 / 810
18H	V24	V1+(V2-V1) X 5730 / 6570	58H	V88	V3+(V4-V3) X 910 / 2010	98H	V152	V4+(V5-V4) X 480 / 1280	D8H	V216	V5+(V6-V5) X 580 / 810
19H	V25	V1+(V2-V1) X 5850 / 6570	59H	V89	V3+(V4-V3) X 940 / 2010	99H	V153	V4+(V5-V4) X 500 / 1280	D9H	V217	V5+(V6-V5) X 605 / 810
1AH	V26	V1+(V2-V1) X 5960 / 6570	5AH	V90	V3+(V4-V3) X 970 / 2010	9AH	V154	V4+(V5-V4) X 520 / 1280	DAH	V218	V5+(V6-V5) X 630 / 810
1BH	V27	V1+(V2-V1) X 6070 / 6570	5BH	V91	V3+(V4-V3) X 1000 / 2010	9BH	V155	V4+(V5-V4) X 540 / 1280	DBH	V219	V5+(V6-V5) X 660 / 810
1CH	V28	V1+(V2-V1) X 6180 / 6570	5CH	V92	V3+(V4-V3) X 1030 / 2010	9CH	V156	V4+(V5-V4) X 560 / 1280	DCH	V220	V5+(V6-V5) X 690 / 810
1DH	V29	V1+(V2-V1) X 6280 / 6570	5DH	V93	V3+(V4-V3) X 1060 / 2010	9DH	V157	V4+(V5-V4) X 580 / 1280	DDH	V221	V5+(V6-V5) X 720 / 810
1EH	V30	V1+(V2-V1) X 6380 / 6570	5EH	V94	V3+(V4-V3) X 1090 / 2010	9EH	V158	V4+(V5-V4) X 600 / 1280	DEH	V222	V5+(V6-V5) X 750 / 810
1FH	V31	V1+(V2-V1) X 6480 / 6570	5FH	V95	V3+(V4-V3) X 1120 / 2010	9FH	V159	V4+(V5-V4) X 620 / 1280	DFH	V223	V5+(V6-V5) X 780 / 810
20H	V32	V2	60H	V96	V3+(V4-V3) X 1150 / 2010	A0H	V160	V4+(V5-V4) X 640 1280	E0H	V224	V6
21H	V33	V2+(V3-V2) X 90 / 2030	61H	V97	V3+(V4-V3) X 1180 / 2010	A1H	V161	V4+(V5-V4) X 660 / 1280	E1H	V225	V6+(V7-V6) X 30 / 2940
22H	V34	V2+(V3-V2) X 180 / 2030	62H	V98	V3+(V4-V3) X 1210 / 2010	A2H	V162	V4+(V5-V4) X 680 / 1280	E2H	V226	V6+(V7-V6) X 70 / 2940
23H	V35	V2+(V3-V2) X 260 / 2030	63H	V99	V3+(V4-V3) X 1240 / 2010	A3H	V163	V4+(V5-V4) X 700 / 1280	E3H	V227	V6+(V7-V6) X 110 / 2940
24H	V36	V2+(V3-V2) X 340 / 2030	64H	V100	V3+(V4-V3) X 1270 / 2010	A4H	V164	V4+(V5-V4) X 720 / 1280	E4H	V228	V6+(V7-V6) X 150 / 2940
25H	V37	V2+(V3-V2) X 420 / 2030	65H	V101	V3+(V4-V3) X 1300 / 2010	A5H	V165	V4+(V5-V4) X 740 / 1280	E5H	V229	V6+(V7-V6) X 190 / 2940
26H	V38	V2+(V3-V2) X 500 / 2030	66H	V102	V3+(V4-V3) X 1330 / 2010	A6H	V166	V4+(V5-V4) X 760 / 1280	E6H	V230	V6+(V7-V6) X 230 / 2940
27H	V39	V2+(V3-V2) X 575 / 2030	67H	V103	V3+(V4-V3) X 1360 / 2010	A7H	V167	V4+(V5-V4) X 780 / 1280	E7H	V231	V6+(V7-V6) X 280 / 2940
28H	V30	V2+(V3-V2) X 650 / 2030	68H	V104	V3+(V4-V3) X 1390 / 2010	A8H	V168	V4+(V5-V4) X 800 / 1280	E8H	V232	V6+(V7-V6) X 330 / 2940
29H	V41	V2+(V3-V2) X 720 / 2030	69H	V105	V3+(V4-V3) X 1420 / 2010	A9H	V169	V4+(V5-V4) X 820 / 1280	E9H	V233	V6+(V7-V6) X 380 / 2940
2AH	V42	V2+(V3-V2) X 790 / 2030	6AH	V106	V3+(V4-V3) X 1450 / 2010	AAH	V170	V4+(V5-V4) X 840 / 1280	EAH	V234	V6+(V7-V6) X 440 / 2940
2BH	V43	V2+(V3-V2) X 860 / 2030	6BH	V107	V3+(V4-V3) X 1480 / 2010	ABH	V171	V4+(V5-V4) X 860 / 1280	EBH	V235	V6+(V7-V6) X 500 / 2940
2CH	V44	V2+(V3-V2) X 930 / 2030	6CH	V108	V3+(V4-V3) X 1510 / 2010	ACH	V172	V4+(V5-V4) X 880 / 1280	ECH	V236	V6+(V7-V6) X 560 / 2940
2DH	V45	V2+(V3-V2) X 995 / 2030	6DH	V109	V3+(V4-V3) X 1540 / 2010	ADH	V173	V4+(V5-V4) X 900 / 1280	EDH	V237	V6+(V7-V6) X 630 / 2940
2EH	V46	V2+(V3-V2) X 1060 / 2030	6EH	V110	V3+(V4-V3) X 1570 / 2010	AEH	V174	V4+(V5-V4) X 920 / 1280	EEH	V238	V6+(V7-V6) X 700 / 2940
2FH	V47	V2+(V3-V2) X 1120 / 2030	6FH	V111	V3+(V4-V3) X 1595 / 2010	AFH	V175	V4+(V5-V4) X 940 / 1280	EFH	V239	V6+(V7-V6) X 780 / 2940
30H	V48	V2+(V3-V2) X 1180 / 2030	70H	V112	V3+(V4-V3) X 1620 / 2010	B0H	V176	V4+(V5-V4) X 960 / 1280	F0H	V240	V6+(V7-V6) X 860 / 2940
31H	V49	V2+(V3-V2) X 1240 / 2030	71H	V113	V3+(V4-V3) X 1645 / 2010	B1H	V177	V4+(V5-V4) X 980 / 1280	F1H	V241	V6+(V7-V6) X 950 / 2940
32H	V50	V2+(V3-V2) X 1300 / 2030	72H	V114	V3+(V4-V3) X 1670 / 2010	B2H	V178	V4+(V5-V4) X 1000 / 1280	F2H	V242	V6+(V7-V6) X 1050 / 2940
33H	V51	V2+(V3-V2) X 1360 / 2030	73H	V115	V3+(V4-V3) X 1695 / 2010	B3H	V179	V4+(V5-V4) X 1020 / 1280	F3H	V243	V6+(V7-V6) X 1150 / 2940
34H	V52	V2+(V3-V2) X 1420 / 2030	74H	V116	V3+(V4-V3) X 1720 / 2010	B4H	V180	V4+(V5-V4) X 1040 / 1280	F4H	V244	V6+(V7-V6) X 1260 / 2940
35H	V53	V2+(V3-V2) X 1475 / 2030	75H	V117	V3+(V4-V3) X 1745 / 2010	B5H	V181	V4+(V5-V4) X 1060 / 1280	F5H	V245	V6+(V7-V6) X 1380 / 2940
36H	V54	V2+(V3-V2) X 1530 / 2030	76H	V118	V3+(V4-V3) X 1770 / 2010	B6H	V182	V4+(V5-V4) X 1080 / 1280	F6H	V246	V6+(V7-V6) X 1510 / 2940
37H	V55	V2+(V3-V2) X 1585 / 2030	77H	V119	V3+(V4-V3) X 1795 / 2010	B7H	V183	V4+(V5-V4) X 1100 / 1280	F7H	V247	V6+(V7-V6) X 1650 / 2940
38H	V56	V2+(V3-V2) X 1640 / 2030	78H	V120	V3+(V4-V3) X 1820 / 2010	B8H	V184	V4+(V5-V4) X 1120 / 1280	F8H	V248	V6+(V7-V6) X 1800 / 2940
39H	V57	V2+(V3-V2) X 1690 / 2030	79H	V121	V3+(V4-V3) X 1845 / 2010	B9H	V185	V4+(V5-V4) X 1140 / 1280	F9H	V249	V6+(V7-V6) X 1960 / 2940
3AH	V58	V2+(V3-V2) X 1740 / 2030	7AH	V122	V3+(V4-V3) X 1870 / 2010	BAH	V186	V4+(V5-V4) X 1160 / 1280	FAH	V250	V6+(V7-V6) X 2130 / 2940
3BH	V59	V2+(V3-V2) X 1790 / 2030	7BH	V123	V3+(V4-V3) X 1895 / 2010	BBH	V187	V4+(V5-V4) X 1180 / 1280	FBH	V251	V6+(V7-V6) X 2310 / 2940
3CH	V60	V2+(V3-V2) X 1840 / 2030	7CH	V124	V3+(V4-V3) X 1920 / 2010	BCH	V188	V4+(V5-V4) X 1200 / 1280	FCH	V252	V6+(V7-V6) X 2500 / 2940
3DH	V61	V2+(V3-V2) X 1890 / 2030	7DH	V125	V3+(V4-V3) X 1945 / 2010	BDH	V189	V4+(V5-V4) X 1220 / 1280	FDH	V253	V6+(V7-V6) X 2710 / 2940
3EH	V62	V2+(V3-V2) X 1940 / 2030	7EH	V126	V3+(V4-V3) X 1970 / 2010	BEH	V190	V4+(V5-V4) X 1240 / 1280	FEH	V254	V7
3FH	V63	V2+(V3-V2) X 1985 / 2030	7FH	V127	V3+(V4-V3) X 1990 / 2010	BFH	V191	V4+(V5-V4) X 1260 / 1280	FFH	V255	V8

Figure 4–3. Relationship between Input Data and Output Voltage (2/2)

(Output voltage 2) 0.5 $V_{DD2} \geq V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} \geq V_{SS2}$ + 0.1 V

Data	Output Voltage		Data	Output Voltage		Data	Output Voltage		Data	Output Voltage	
00H	V0'	V17	40H	V64'	V14	80H	V128'	V13	C0H	V192'	V12
01H	V1"	V16	41H	V65'	V14+(V13-V14) X 45 / 2010	81H	V129'	V13+(V12-V13) X 20 / 1280	C1H	V193'	V12+(V11-V12) X 20 / 810
02H	V2'	V16+(V15-V16) X 550 / 6570	42H	V66'	V14+(V13-V14) X 90 / 2010	82H	V130'	V13+(V12-V13) X 40 / 1280	C2H	V194'	V12+(V11-V12) X 40 / 810
03H	V3'	V16+(V15-V16) X 1030 / 6570	43H	V67'	V14+(V13-V14) X 135 / 2010	83H	V131"	V13+(V12-V13) X 60 / 1280	C3H	V195'	V12+(V11-V12) X 60 / 810
04H	V4'	V16+(V15-V16) X 1460 / 6570	44H	V68'	V14+(V13-V14) X 180 / 2010	84H	V132'	V13+(V12-V13) X 80 / 1280	C4H	V196'	V12+(V11-V12) X 80 / 810
05H	V5'	V16+(V15-V16) X 1840 / 6570	45H	V69'	V14+(V13-V14) X 220 / 2010	85H	V133'	V13+(V12-V13) X 100 / 1280	C5H	V197'	V12+(V11-V12) X 105 / 810
06H	V6'	V16+(V15-V16) X 2190 / 6570	46H	V70'	V14+(V13-V14) X 260 / 2010	86H	V134'	V13+(V12-V13) X 120 / 1280	C6H	V198'	V12+(V11-V12) X 130 / 810
07H	V7'	V16+(V15-V16) X 2520 / 6570	47H	V71'	V14+(V13-V14) X 300 / 2010	87H	V135'	V13+(V12-V13) X 140 / 1280	C7H	V199'	V12+(V11-V12) X 155 / 810
08H	V8'	V16+(V15-V16) X 2820 / 6570	48H	V72'	V14+(V13-V14) X 340 / 2010	88H	V136'	V13+(V12-V13) X 160 / 1280	C8H	V200'	V12+(V11-V12) X 180 / 810
09H	V9'	V16+(V15-V16) X 3100 / 6570	49H	V73'	V14+(V13-V14) X 380 / 2010	89H	V137'	V13+(V12-V13) X 180 / 1280	C9H	V201'	V12+(V11-V12) X 205 / 810
0AH	V10'	V16+(V15-V16) X 3360 / 6570	4AH	V74'	V14+(V13-V14) X 420 / 2010	8AH	V138'	V13+(V12-V13) X 200 / 1280	CAH	V202'	V12+(V11-V12) X 230 / 810
0BH	V11"	V16+(V15-V16) X 3600 / 6570	4BH	V75'	V14+(V13-V14) X 460 / 2010	8BH	V139'	V13+(V12-V13) X 220 / 1280	CBH	V203'	V12+(V11-V12) X 255 / 810
0CH	V12'	V16+(V15-V16) X 3820 / 6570	4CH	V76'	V14+(V13-V14) X 500 / 2010	8CH	V140'	V13+(V12-V13) X 240 / 1280	CCH	V204'	V12+(V11-V12) X 280 / 810
0DH	V13'	V16+(V15-V16) X 4020 / 6570	4DH	V77'	V14+(V13-V14) X 535 / 2010	8DH	V141'	V13+(V12-V13) X 260 / 1280	CDH	V205'	V12+(V11-V12) X 305 / 810
0EH	V14'	V16+(V15-V16) X 4210 / 6570	4EH	V78'	V14+(V13-V14) X 570 / 2010	8EH	V142'	V13+(V12-V13) X 280 / 1280	CEH	V206'	V12+(V11-V12) X 330 / 810
0FH	V15'	V16+(V15-V16) X 4400 / 6570	4FH	V79'	V14+(V13-V14) X 605 / 2010	8FH	V143'	V13+(V12-V13) X 300 / 1280	CFH	V207'	V12+(V11-V12) X 355 / 810
10H	V16'	V16+(V15-V16) X 4580 / 6570	50H	V80'	V14+(V13-V14) X 640 / 2010	90H	V144'	V13+(V12-V13) X 320 / 1280	D0H	V208'	V12+(V11-V12) X 380 / 810
11H	V17'	V16+(V15-V16) X 4750 / 6570	51H	V81'	V14+(V13-V14) X 675 / 2010	91H	V145'	V13+(V12-V13) X 340 / 1280	D1H	V209'	V12+(V11-V12) X 405 / 810
12H	V18'	V16+(V15-V16) X 4910 / 6570	52H	V82'	V14+(V13-V14) X 710 / 2010	92H	V146'	V13+(V12-V13) X 360 / 1280	D2H	V210'	V12+(V11-V12) X 430 / 810
13H	V19'	V16+(V15-V16) X 5060 / 6570	53H	V83'	V14+(V13-V14) X 745 / 2010	93H	V147'	V13+(V12-V13) X 380 / 1280	D3H	V211'	V12+(V11-V12) X 455 / 810
14H	V20'	V16+(V15-V16) X 5210 / 6570	54H	V84'	V14+(V13-V14) X 780 / 2010	94H	V148'	V13+(V12-V13) X 400 / 1280	D4H	V212'	V12+(V11-V12) X 480 / 810
15H	V21'	V16+(V15-V16) X 5350 / 6570	55H	V85'	V14+(V13-V14) X 815 / 2010	95H	V149'	V13+(V12-V13) X 420 / 1280	D5H	V213'	V12+(V11-V12) X 505 / 810
16H	V22'	V16+(V15-V16) X 5480 / 6570	56H	V86'	V14+(V13-V14) X 850 / 2010	96H	V150'	V13+(V12-V13) X 440 / 1280	D6H	V214'	V12+(V11-V12) X 530 / 810
17H	V23'	V16+(V15-V16) X 5610 / 6570	57H	V87'	V14+(V13-V14) X 880 / 2010	97H	V151'	V13+(V12-V13) X 460 / 1280	D7H	V215'	V12+(V11-V12) X 555 / 810
18H	V24'	V16+(V15-V16) X 5730 / 6570	58H	V88'	V14+(V13-V14) X 910 / 2010	98H	V152'	V13+(V12-V13) X 480 / 1280	D8H	V216'	V12+(V11-V12) X 580 / 810
19H	V25'	V16+(V15-V16) X 5850 / 6570	59H	V89'	V14+(V13-V14) X 940 / 2010	99H	V153'	V13+(V12-V13) X 500 / 1280	D9H	V217'	V12+(V11-V12) X 605 / 810
1AH	V26'	V16+(V15-V16) X 5960 / 6570	5AH	V90'	V14+(V13-V14) X 970 / 2010	9AH	V154'	V13+(V12-V13) X 520 / 1280	DAH	V218'	V12+(V11-V12) X 630 / 810
1BH	V27'	V16+(V15-V16) X 6070 / 6570	5BH	V91'	V14+(V13-V14) X 1000 / 2010	9BH	V155'	V13+(V12-V13) X 540 / 1280	DBH	V219'	V12+(V11-V12) X 660 / 810
1CH	V28'	V16+(V15-V16) X 6180 / 6570	5CH	V92'	V14+(V13-V14) X 1030 / 2010	9CH	V156'	V13+(V12-V13) X 560 / 1280	DCH	V220'	V12+(V11-V12) X 690 / 810
1DH	V29'	V16+(V15-V16) X 6280 / 6570	5DH	V93'	V14+(V13-V14) X 1060 / 2010	9DH	V157'	V13+(V12-V13) X 580 / 1280	DDH	V221'	V12+(V11-V12) X 720 / 810
1EH	V30'	V16+(V15-V16) X 6380 / 6570	5EH	V94'	V14+(V13-V14) X 1090 / 2010	9EH	V158'	V13+(V12-V13) X 600 / 1280	DEH	V222'	V12+(V11-V12) X 750 / 810
1FH	V31'	V16+(V15-V16) X 6480 / 6570	5FH	V95'	V14+(V13-V14) X 1120 / 2010	9FH	V159'	V13+(V12-V13) X 620 / 1280	DFH	V223'	V12+(V11-V12) X 780 / 810
20H	V32'	V15	60H	V96'	V14+(V13-V14) X 1150 2010	A0H	V160'	V13+(V12-V13) X 640 1280	E0H	V224'	V11
21H	V33'	V15+(V14-V15) X 90 / 2080	61H	V97'	V14+(V13-V14) X 1180 / 2010	A1H	V161'	V13+(V12-V13) X 660 / 1280	E1H	V225'	V11+(V10-V11) X 30 / 2940
22H	V34'	V15+(V14-V15) X 180 / 2080	62H	V98'	V14+(V13-V14) X 1210 / 2010	A2H	V162'	V13+(V12-V13) X 680 / 1280	E2H	V226'	V11+(V10-V11) X 70 / 2940
23H	V35'	V15+(V14-V15) X 260 / 2080	63H	V99'	V14+(V13-V14) X 1240 / 2010	A3H	V163'	V13+(V12-V13) X 700 / 1280	E3H	V227'	V11+(V10-V11) X 110 / 2940
24H	V36'	V15+(V14-V15) X 340 / 2080	64H	V100'	V14+(V13-V14) X 1270 / 2010	A4H	V164'	V13+(V12-V13) X 720 / 1280	E4H	V228'	V11+(V10-V11) X 150 / 2940
25H	V37'	V15+(V14-V15) X 420 / 2080	65H	V101"	V14+(V13-V14) X 1300 / 2010	A5H	V165'	V13+(V12-V13) X 740 / 1280	E5H	V229'	V11+(V10-V11) X 190 / 2940
26H	V38'	V15+(V14-V15) X 500 / 2080	66H	V102'	V14+(V13-V14) X 1330 / 2010	A6H	V166'	V13+(V12-V13) X 760 / 1280	E6H	V230'	V11+(V10-V11) X 230 / 2940
27H	V39'	V15+(V14-V15) X 575 / 2080	67H	V103'	V14+(V13-V14) X 1360 / 2010	A7H	V167'	V13+(V12-V13) X 780 / 1280	E7H	V231'	V11+(V10-V11) X 280 / 2940
28H	V40'	V15+(V14-V15) X 650 / 2080	68H	V104'	V14+(V13-V14) X 1390 / 2010	A8H	V168'	V13+(V12-V13) X 800 / 1280	E8H	V232'	V11+(V10-V11) X 330 / 2940
29H	V41'	V15+(V14-V15) X 720 / 2080	69H	V105'	V14+(V13-V14) X 1420 / 2010	A9H	V169'	V13+(V12-V13) X 820 / 1280	E9H	V233'	V11+(V10-V11) X 380 / 2940
2AH	V42'	V15+(V14-V15) X 790 / 2080	6AH	V106'	V14+(V13-V14) X 1450 / 2010	AAH	V170'	V13+(V12-V13) X 840 / 1280	EAH	V234'	V11+(V10-V11) X 440 / 2940
2BH	V43'	V15+(V14-V15) X 860 / 2080	6BH	V107'	V14+(V13-V14) X 1480 / 2010	ABH	V171'	V13+(V12-V13) X 860 / 1280	EBH	V235'	V11+(V10-V11) X 500 / 2940
2CH	V44'	V15+(V14-V15) X 930 / 2080	6CH	V108'	V14+(V13-V14) X 1510 / 2010	ACH	V172'	V13+(V12-V13) X 880 / 1280	ECH	V236'	V11+(V10-V11) X 560 / 2940
2DH	V45'	V15+(V14-V15) X 995 / 2080	6DH	V109'	V14+(V13-V14) X 1540 / 2010	ADH	V173'	V13+(V12-V13) X 900 / 1280	EDH	V237'	V11+(V10-V11) X 630 / 2940
2EH	V46'	V15+(V14-V15) X 1060 / 2080	6EH	V110'	V14+(V13-V14) X 1570 / 2010	AEH	V174'	V13+(V12-V13) X 920 / 1280	EEH	V238'	V11+(V10-V11) X 700 / 2940
2FH	V47'	V15+(V14-V15) X 1120 / 2080	6FH	V111'	V14+(V13-V14) X 1595 / 2010	AFH	V175'	V13+(V12-V13) X 940 / 1280	EFH	V239'	V11+(V10-V11) X 780 / 2940
30H	V48'	V15+(V14-V15) X 1180 / 2080	70H	V112'	V14+(V13-V14) X 1620 / 2010	B0H	V176'	V13+(V12-V13) X 960 / 1280	F0H	V240'	V11+(V10-V11) X 860 / 2940
31H	V49'	V15+(V14-V15) X 1240 / 2080	71H	V113'	V14+(V13-V14) X 1645 / 2010	B1H	V177'	V13+(V12-V13) X 980 / 1280	F1H	V241'	V11+(V10-V11) X 950 / 2940
32H	V50'	V15+(V14-V15) X 1300 / 2080	72H	V114'	V14+(V13-V14) X 1670 / 2010	B2H	V178'	V13+(V12-V13) X 1000 / 1280	F2H	V242'	V11+(V10-V11) X 1050 / 2940
33H	V51'	V15+(V14-V15) X 1360 / 2080	73H	V115'	V14+(V13-V14) X 1695 / 2010	B3H	V179'	V13+(V12-V13) X 1020 / 1280	F3H	V243'	V11+(V10-V11) X 1150 / 2940
34H	V52'	V15+(V14-V15) X 1420 / 2080	74H	V116'	V14+(V13-V14) X 1720 / 2010	B4H	V180'	V13+(V12-V13) X 1040 / 1280	F4H	V244'	V11+(V10-V11) X 1260 / 2940
35H	V53'	V15+(V14-V15) X 1475 / 2080	75H	V117'	V14+(V13-V14) X 1745 / 2010	B5H	V181'	V13+(V12-V13) X 1060 / 1280	F5H	V245'	V11+(V10-V11) X 1380 / 2940
36H	V54'	V15+(V14-V15) X 1530 / 2080	76H	V118'	V14+(V13-V14) X 1770 / 2010	B6H	V182'	V13+(V12-V13) X 1080 / 1280	F6H	V246'	V11+(V10-V11) X 1510 / 2940
37H	V55'	V15+(V14-V15) X 1585 / 2080	77H	V119'	V14+(V13-V14) X 1795 / 2010	B7H	V183'	V13+(V12-V13) X 1100 / 1280	F7H	V247'	V11+(V10-V11) X 1650 / 2940
38H	V56'	V15+(V14-V15) X 1640 / 2080	78H	V120'	V14+(V13-V14) X 1820 / 2010	B8H	V184'	V13+(V12-V13) X 1120 / 1280	F8H	V248'	V11+(V10-V11) X 1800 / 2940
39H	V57'	V15+(V14-V15) X 1690 / 2080	79H	V121'	V14+(V13-V14) X 1845 / 2010	B9H	V185'	V13+(V12-V13) X 1140 / 1280	F9H	V249'	V11+(V10-V11) X 1960 / 2940
3AH	V58'	V15+(V14-V15) X 1740 / 2080	7AH	V122'	V14+(V13-V14) X 1870 / 2010	BAH	V186'	V13+(V12-V13) X 1160 / 1280	FAH	V250'	V11+(V10-V11) X 2130 / 2940
3BH	V59'	V15+(V14-V15) X 1790 / 2080	7BH	V123'	V14+(V13-V14) X 1895 / 2010	BBH	V187'	V13+(V12-V13) X 1180 / 1280	FBH	V251'	V11+(V10-V11) X 2310 / 2940
3CH	V60'	V15+(V14-V15) X 1840 / 2080	7CH	V124'	V14+(V13-V14) X 1920 / 2010	BCH	V188'	V13+(V12-V13) X 1200 / 1280	FCH	V252'	V11+(V10-V11) X 2500 / 2940
3DH	V61'	V15+(V14-V15) X 1890 / 2080	7DH	V125'	V14+(V13-V14) X 1945 / 2010	BDH	V189'	V13+(V12-V13) X 1220 / 1280	FDH	V253'	V11+(V10-V11) X 2710 / 2940
3EH	V62'	V15+(V14-V15) X 1940 / 2080	7EH	V126'	V14+(V13-V14) X 1970 / 2010	BEH	V190'	V13+(V12-V13) X 1240 / 1280	FEH	V254'	V10
3FH	V63'	V15+(V14-V15) X 1985 / 2080	7FH	V127'	V14+(V13-V14) X 1990 / 2010	BFH	V191'	V13+(V12-V13) X 1260 / 1280	FFH	V255'	V9

5. RELATIONSHIP BETWEEN INPUT DATA AND OUTPUT PIN

Data format: 8 bits × 1 RGB (3 dots)

Input width: 12 bits x double edge (1-pixel data)

(1) R,/L = H (Right shift)

Output	S_1	S_2	S_3	S_4	…	S_{479}	S_{480}
Data	D_{00P}-D_{03P}, D_{00N}-D_{03N}	D_{10P}-D_{13P}, D_{10N}-D_{13N}	D_{20P}-D_{23P}, D_{20N}-D_{23N}	D_{00P}-D_{03P}, D_{00N}-D_{03N}	…	D_{10P}-D_{13P}, D_{10N}-D_{13N}	D_{20P}-D_{23P}, D_{20N}-D_{23N}

(2) R,/L = L (Left shift)

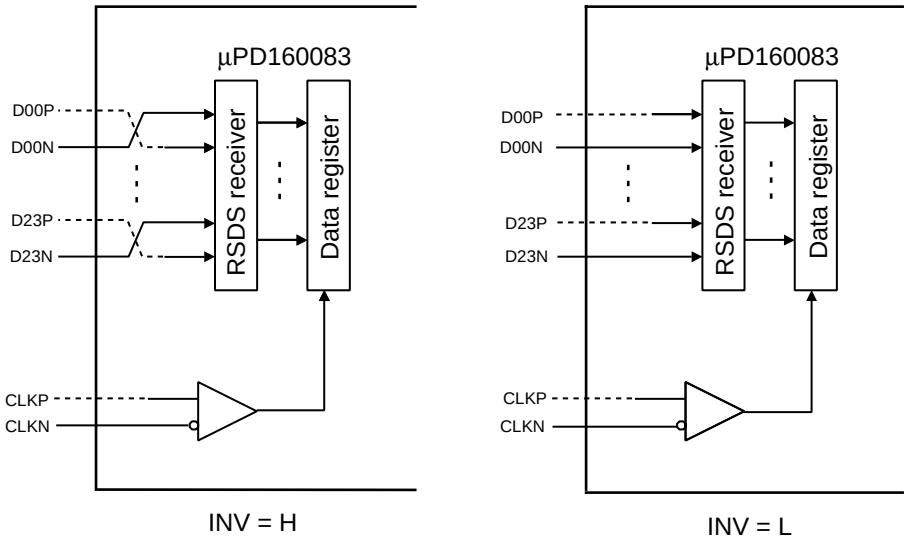
Output	S_1	S_2	S_3	S_4	…	S_{479}	S_{480}
Data	D_{00P}-D_{03P}, D_{00N}-D_{03N}	D_{10P}-D_{13P}, D_{10N}-D_{13N}	D_{20P}-D_{23P}, D_{20N}-D_{23N}	D_{00P}-D_{03P}, D_{00N}-D_{03N}	…	D_{10P}-D_{13P}, D_{10N}-D_{13N}	D_{20P}-D_{23P}, D_{20N}-D_{23N}

POL	S_{2n-1}[Note]	S_{2n}[Note]
H	V_0-V_8	V_9-V_{17}
L	V_9-V_{17}	V_0-V_8

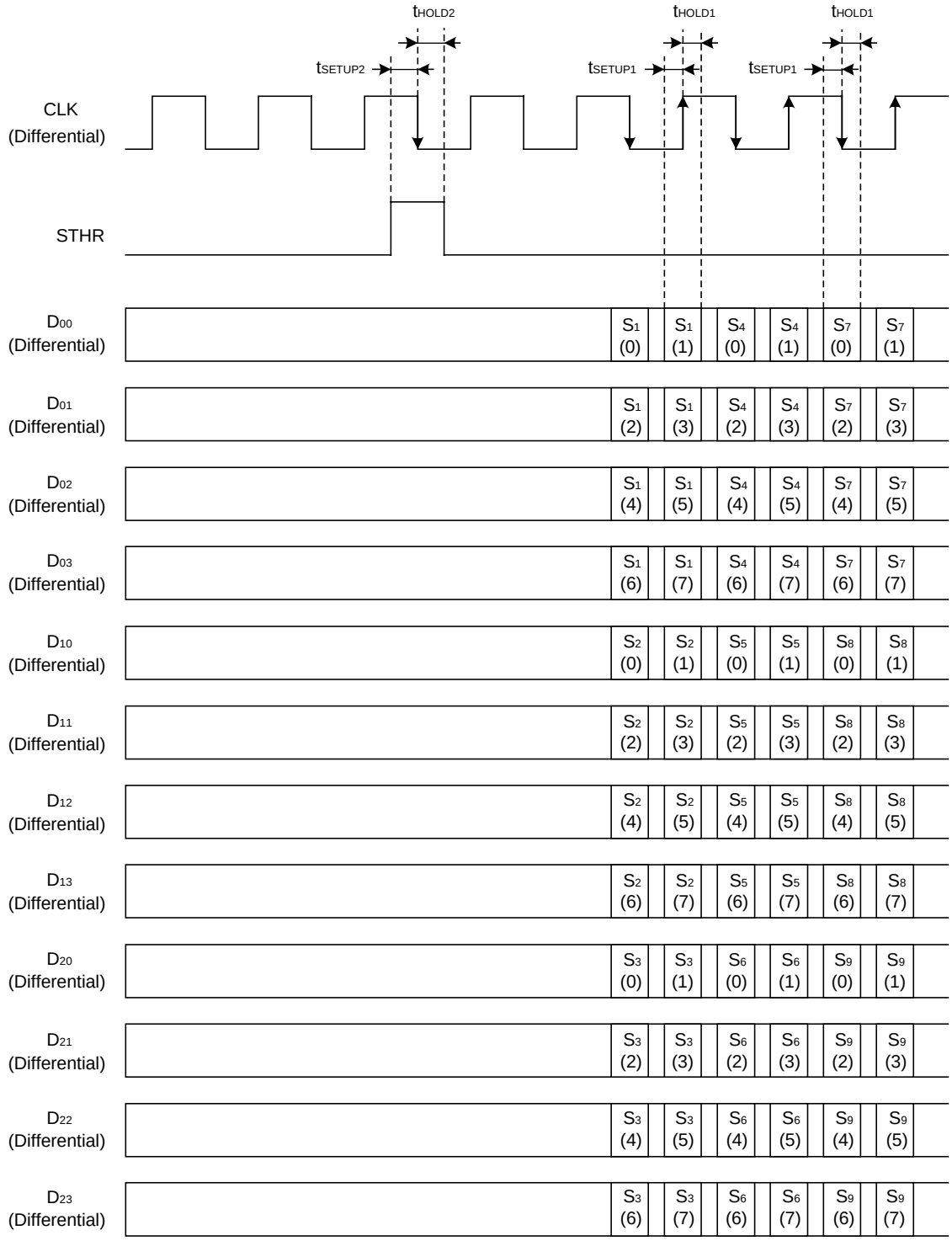
Note S_{2n-1} (Odd output), S_{2n} (Even output) , n = 1, 2, … 240

6. DATA INVERSION (INV)

INV controls the internal data inversion. When INV = H, the internal data is inverted and CLK is not inverted (See the figure as below). Using the INV pin, the RSDS data bus interface can be changed.



7. TIMING CHART AND RELATIONSHIP BETWEEN 8-BIT DATA AND DATA BUS LINE



Remark $S_{n(0)}$: LSB, $S_{n(7)}$: MSB

8. RELATIONSHIP BETWEEN MODE, STB, POL, MODE1 to MODE3 AND OUTPUT WAVEFORM

The μPD160083 has a various kind of output short function that can be controlled by MODE1 to MODE3. Please refer to the following description of each function and decide MODE1 to MODE3 after considering the suitable driving method.

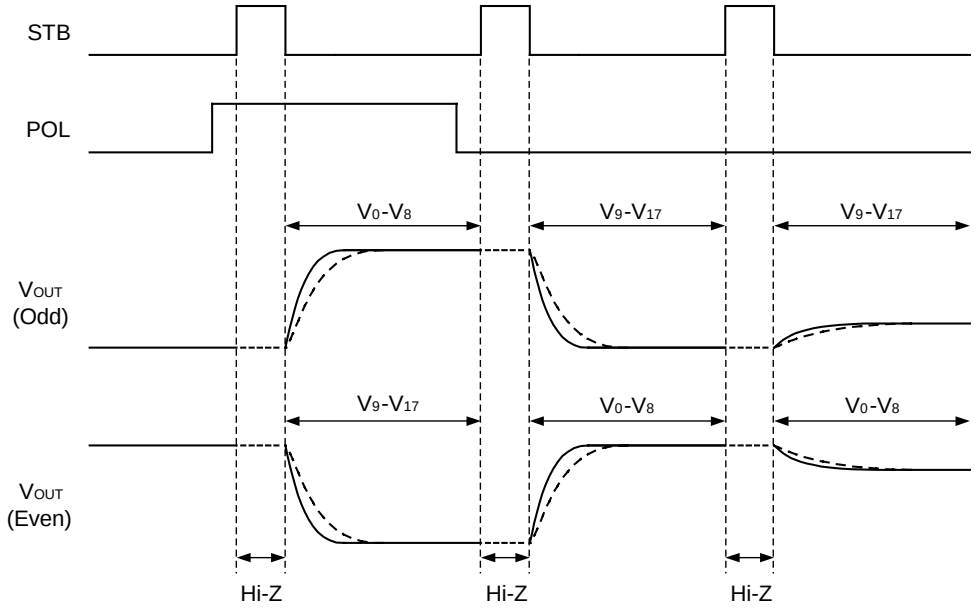
MODE1	MODE2	MODE3	Charge Sharing	Description of Output Short
H or open	X	X	Non-active	Output short doesn't work
L	H or open	X	Active	During STB = H
	L	H or open	Active	During 34 CLKs after falling edge of STB
		L	Active	During 68 CLKs after falling edge of STB

Remark X: H or L

(1) MODE1 = H or open

All outputs always become Hi-Z condition during STB = H at this mode. And output short function doesn't work and all output always start at the falling edge of STB (See figure 8–1).

Figure 8–1. MODE1 = H or open

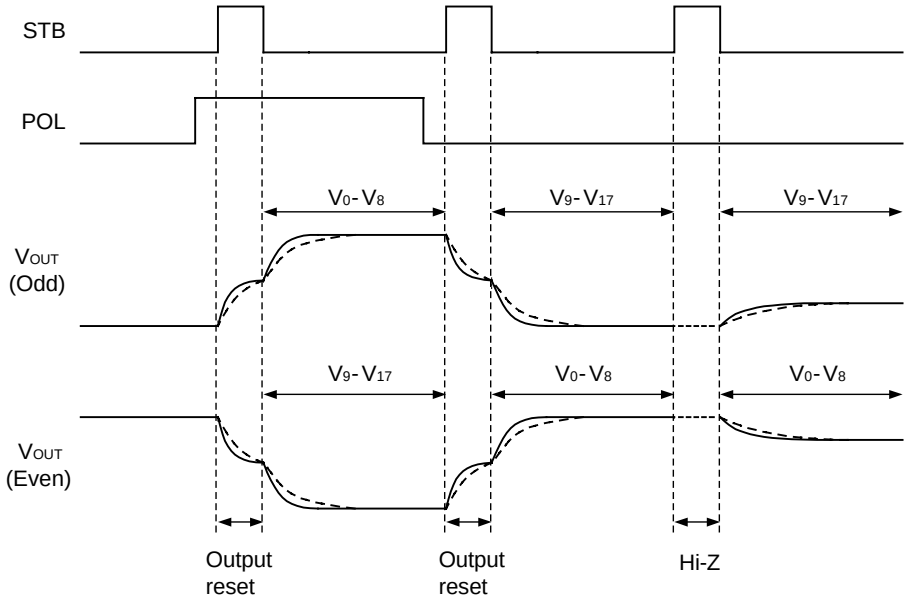


Remark – – – : Repair Amp. output

(2) MODE1 = L, MODE2 = H or open

Output short function works during STB = H at this mode. So all outputs are started at the falling edge of STB (See figure 8–2). But output short function works only when POL signal is changed. So All output become Hi-Z condition during STB = H without any change of POL signal (See figure 8–2).

Figure 8–2. MODE1 = L, MODE2 = H or open



Remark – – – : Repair Amp. output

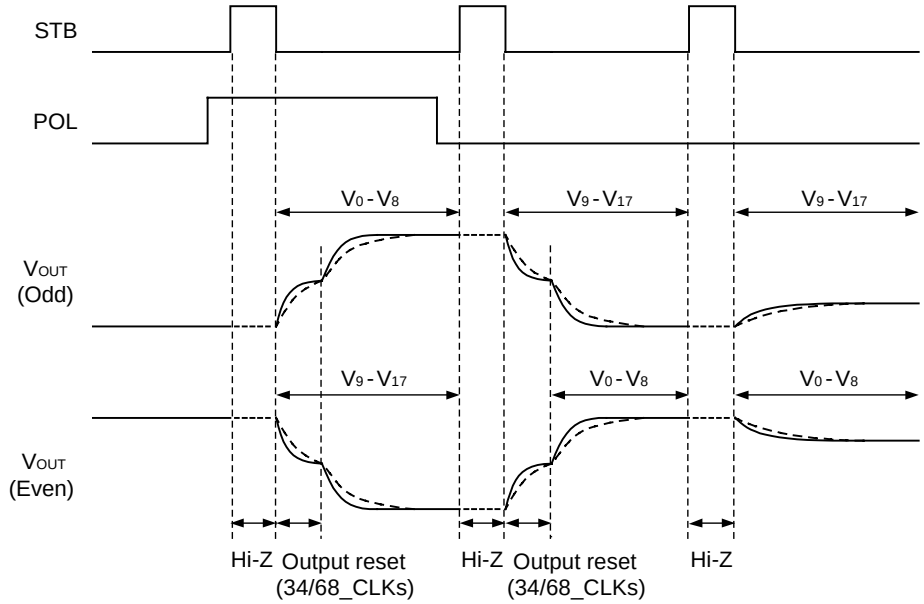
(3) MODE1 = L, MODE2 = L

All output always become Hi-Z condition during STB = H in this mode. And output short function works at the falling edge of STB during requested period by MODE3. At MODE3 = H, the driver IC counts 34 CLKs of output short period by itsself, and count 68 CLKs at MODE = L. After finishing the output short period, the gray-scale voltage to the LCD panel is started. When POL signal is not changed, the gray-scale voltage to the LCD panel is started at the falling edge of STB without any change of POL signal (See figure 8–3).

MODE3	Output Short Period
H or open	34 CLKs
L	68 CLKs

Remark MODE1 = L, MODE2 = L

Figure 8–3. MODE1 = L, MODE2 = L



Remark – – – : Repair Amp. output

9. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = +25 °C, V_{SS1D}, V_{SS1A} = V_{SS2} = 0 V)

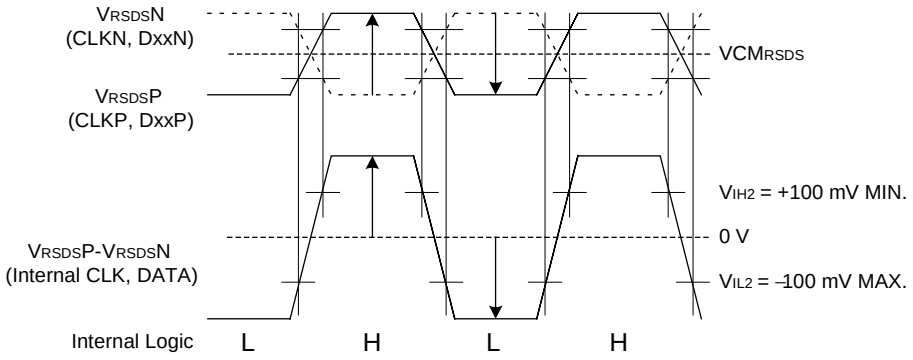
Parameter	Symbol	Ratings	Unit
Logic Part Supply Voltage	V_{DD1D}, V_{DD1A}	–0.5 to +4.0	V
Driver Part Supply Voltage	V_{DD2}	–0.5 to +14.0	V
Logic Part Input Voltage	V_{I1}	–0.5 to V_{DD1} + 0.5	V
Driver Part Input Voltage	V_{I2}	–0.3 to V_{DD2} + 0.3	V
Logic Part Output Voltage	V_{O1}	–0.5 to V_{DD1} + 0.5	V
Driver Part Output Voltage	V_{O2}	–0.5 to V_{DD2} + 0.5	V
Operating Ambient Temperature	T_A	–10 to +75	°C
Storage Temperature	T_{stg}	–55 to +125	°C

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Range (T_A = –10 to +75 °C, V_{SS1D}, V_{SS1A} = V_{SS2} = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Logic Part Supply Voltage	V_{DD1D}, V_{DD1A}			2.7	3.3	3.6	V
Driver Part Supply Voltage	V_{DD2}			10.5	12.0	13.5	V
High-Level Input Voltage 1	V_{IH1}			0.7 V_{DD1}		V_{DD1}	V
Low-Level Input Voltage 1	V_{IL1}			0		0.3 V_{DD1}	V
High-Level Input Voltage 2 (Differential :V_{RSDS}P-V_{RSDS}N)	V_{IH2}	CLK, D_{xy} (x = 0 to 2) (y = 0 to 3)	V_{CM} = 1.2 V **Note**	+100	+200		mV
Low-Level Input Voltage 2 (Differential :V_{RSDS}P-V_{RSDS}N)	V_{IL2}				–200	–100	mV
Common Mode Input Voltage	V_{CM}		V_{OFF} = 200 mV_{p-p} **Note**	0.5	1.2	1.4	V
Driver Part Output Voltage	V_O	S_1 to S_{480}, RPO1, RPO2		0.1		V_{DD2} – 0.1	V
γ-Corrected Voltage	V_{Nv}	V_0-V_8		0.5 V_{DD2}		V_{DD2} – 0.1	V
		V_9-V_{17}		0.1		0.5 V_{DD2}	V
Clock Frequency	f_{CLK}	V_{DD1} = 2.7 V				70	MHz
		V_{DD1} = 3.0 V				85	MHz

Note



Remark VCM = (VCLKP + VCLKN) /2 or = (VDxxP + VDxxN) /2 (x = 0, 1, 2)
VDIFF = (VCLKP – VCLKN) /2 or = (VDxxP – VDxxN) /2 (x = 0, 1, 2)

Electrical Characteristics (T_A = –10 to +75 °C, V_{DD1} = 2.7 to 3.6V, V_{DD2} = 10.5 to 13.5 V , V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Input Leak Current	I_{IL}				±1.0	μA
High-Level Output Voltage	V_{OH}	STHR (STHL), I_{OH} = 0 mA	V_{DD1} – 0.4		V_{DD1}	V
Low-Level Output Voltage	V_{OL}	STHR (STHL), I_{OL} = 0 mA	V_{SS1}		V_{SS1} + 0.4	V
γ-Corrected Resistance	R_γ	V_{DD2} = 12.0 V, T_A = 25°C, V_0-V_8 = V_9-V_{17} = 5.0 V	11.91	17.02	22.13	kΩ
Pull-up/pull-down Resistance	R_{PU}	V_{DD1} = 3.3 V, MODE1 to MODE3, LPC, TEST	80	200	500	kΩ
Driver Output Current	I_{VOH}	S_1 to S_{480}, RPO1, RPO2, V_{DD2} = 12 V; V_X = 11 V, V_{OUT} = 10.5 V Note1			–70	μA
	I_{VOL}	S_1 to S_{480}, RPO1, RPO2, V_{DD2} = 12 V; V_X = 1.0 V, V_{OUT} = 1.5 V Note1	70			μA
Output Voltage Deviation (DV_O)	ΔV_O	V_O = 1.5 V to V_{DD2} – 1.5 V.		±12	±20	mV
		V_O = 0.1 to 1.5 V, V_O = V_{DD2} – 1.5 V to V_{DD2} – 0.1 V		±40	±50	mV
Output Swing Voltage Difference Deviation (DV_{RMS})	ΔV_{p-p1}	V_O = 1.5 V to V_{DD2} – 1.5 V		±6	±10	mV
	ΔV_{p-p2}	V_O = 0.1 to 1.5 V, V_O = V_{DD2} – 1.5 V to V_{DD2} – 0.1 V		±30	±50	mV
Output Swing Voltage Average Deviation	AV_O	Input data: 80H		±1	±7.5	mV
Logic Part Dynamic Current Consumption 1	I_{DD11}	V_{DD1} Note1 to note3		2.5 Note2	6.0 Note3	mA
Logic Part Dynamic Current Consumption 2	I_{DD12}	V_{DD1}, Note1 to note3		2.0 Note4	6.0 Note5	mA
Driver Part Dynamic Current Consumption	I_{DD2}	V_{DD2} , with no load, RPI1, RPI2 are not floating		15.0 Note6	45.0 Note7	mA

Notes 1. V_X refers to the otuput voltage of analog output pins S_1 to S_{384}.
V_{OUT} refers to the voltage applied to analog output pins S_1 to S_{384}.

2. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = dot inversion, T_A = 25°C, V_{DD1} = 3.0 V

3. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = dot inversion, V_{DD1} = 3.6 V

4. f_{CLKP}, f_{CLKN} = 54.0 MHz, f_{STB} = 64.9 kHz, test pattern = dot inversion, T_A = 25°C, V_{DD1} = 3.0V

5. f_{CLKP}, f_{CLKN} = 54.0 MHz, f_{STB} = 64.9 kHz, test pattern = dot inversion, V_{DD1} = 3.6 V

6. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = dot inversion, T_A = 25°C, V_{DD2} = 12.0 V

7. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = dot inversion, V_{DD2} = 13.5 V

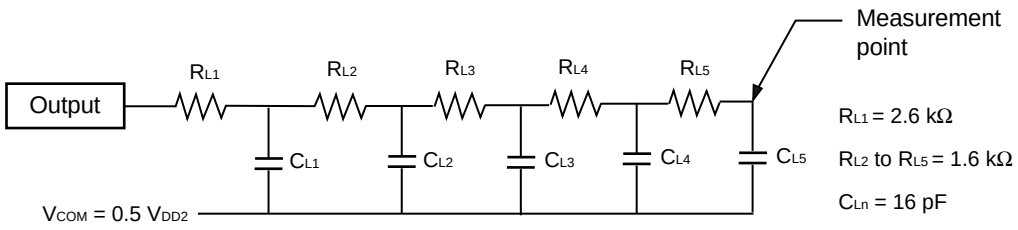
Switching Characteristics (T_A = –10 to +75 °C, V_{DD1} = 2.7 to 3.6V, V_{DD2} = 10.5 to 13.5 V, V_{SS1} = V_{SS2} = 0 V)

Parameter	Symbol	Condition		MIN.	TYP.	MAX.	Unit
Start Pulse Delay Time	t_{PLH1}	C_L = 15 pF	V_{DD1} < 3.0 V	4		12.5	ns
			V_{DD1} ≥ 3.0 V	4		10.0	ns
Driver Output Delay Time	t_{PLH2} Note1	V_{DD2} = 12.0 V, RPO1, RPO2, S_1 to S_{480}, R_L = 9 kΩ, C_L = 80 pF			4	5	μs
	t_{PLH3} Note2				5	8	μs
	t_{PHL2} Note1				4	5	μs
	t_{PHL3} Note2				5	8	μs
	t_{PLH4} Note1				4	5	μs
	t_{PLH5} Note2				5	8	μs
	t_{PHL4} Note1				4	5	μs
	t_{PHL5} Note2				5	8	μs
Input Capacitance	C_{I1}	Logic input besides STHR (STHL), T_A = 25°C				10	pF
	C_{I2}	STHR (STHL), T_A = 25°C				15	pF

Notes 1. The value is specified when the drive voltage valuw reaches the target output voltage level of ±10%.

2. The value is specified when the drive voltage valuw reaches the target output voltage level of ±0.02 V (Condition: V_O = 3.0 V ↔12.0 V).

<Test condition>



Timing Requirement (T_A = –10 to +75°C, V_{DD1} = 2.7 to 3.6V, V_{SS1} = 0 V, $t_r = t_f$ = 3.0 ns (CMOS), $t_r = t_f$ = 1.0 ns (RSDS))

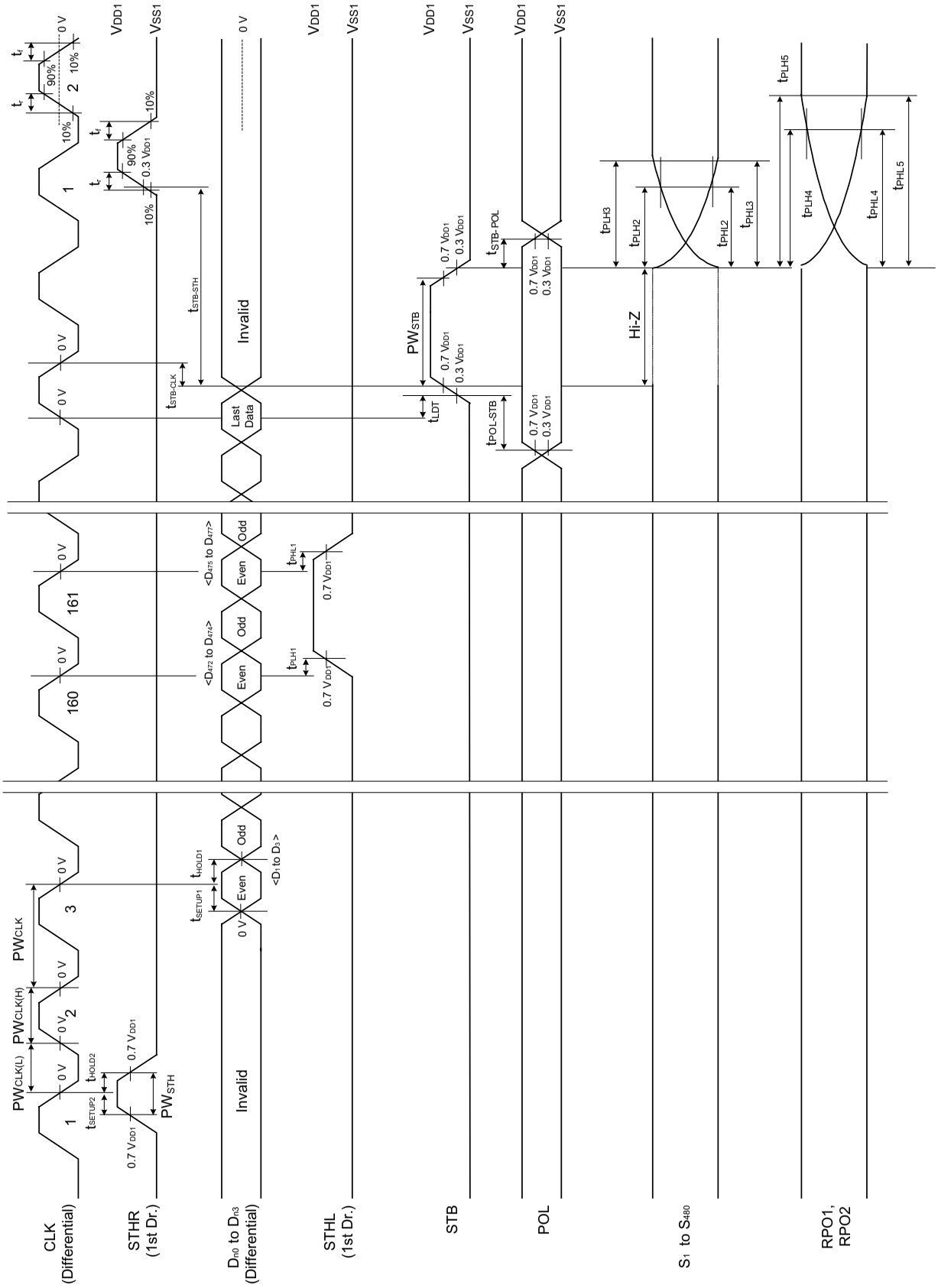
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Period	PW_{CLK}	V_{DD1} = 2.7 V	14.3			ns
		V_{DD1} = 3.0 V	11.8			ns
Clock Pulse High Period	$PW_{CLK(H)}$		5			ns
Clock Pulse Low Period	$PW_{CLK(L)}$		5			ns
Data Setup Time	t_{SETUP1}	V_{DD1} = 2.7 V	3			ns
		V_{DD1} = 3.0 V	2			ns
Data Hold Time	t_{HOLD1}	V_{DD1} = 2.7 V	1			ns
		V_{DD1} = 3.0 V	0			ns
Start Pulse Setup Time	t_{SETUP2}		1			ns
Start Pulse Hold Time	t_{HOLD2}		3			ns
Start Pulse “H” Width	PW_{STH}		1		2	CLKP
STB Pulse “H” Width	PW_{STB}		1			us
Last Data Timing	t_{LDT}		1			CLKP
STB-CLK Time	$t_{STB-CLK}$	STB ↑ → CLKP, CLKN ↓	3			ns
Time Between STB and Start Pulse	$t_{STB-STH}$	STB ↑ → STHR (STHL) ↑	5			CLKP
POL-STB Time	$t_{POL-STB}$	POL ↑ or ↓ → STB ↑	14			ns
STB-POL Time	$t_{STB-POL}$	STB ↓ → POL ↓ or ↑	10			ns

Remark t_r, t_f are defined 10 to 90% of each signal amplitude.

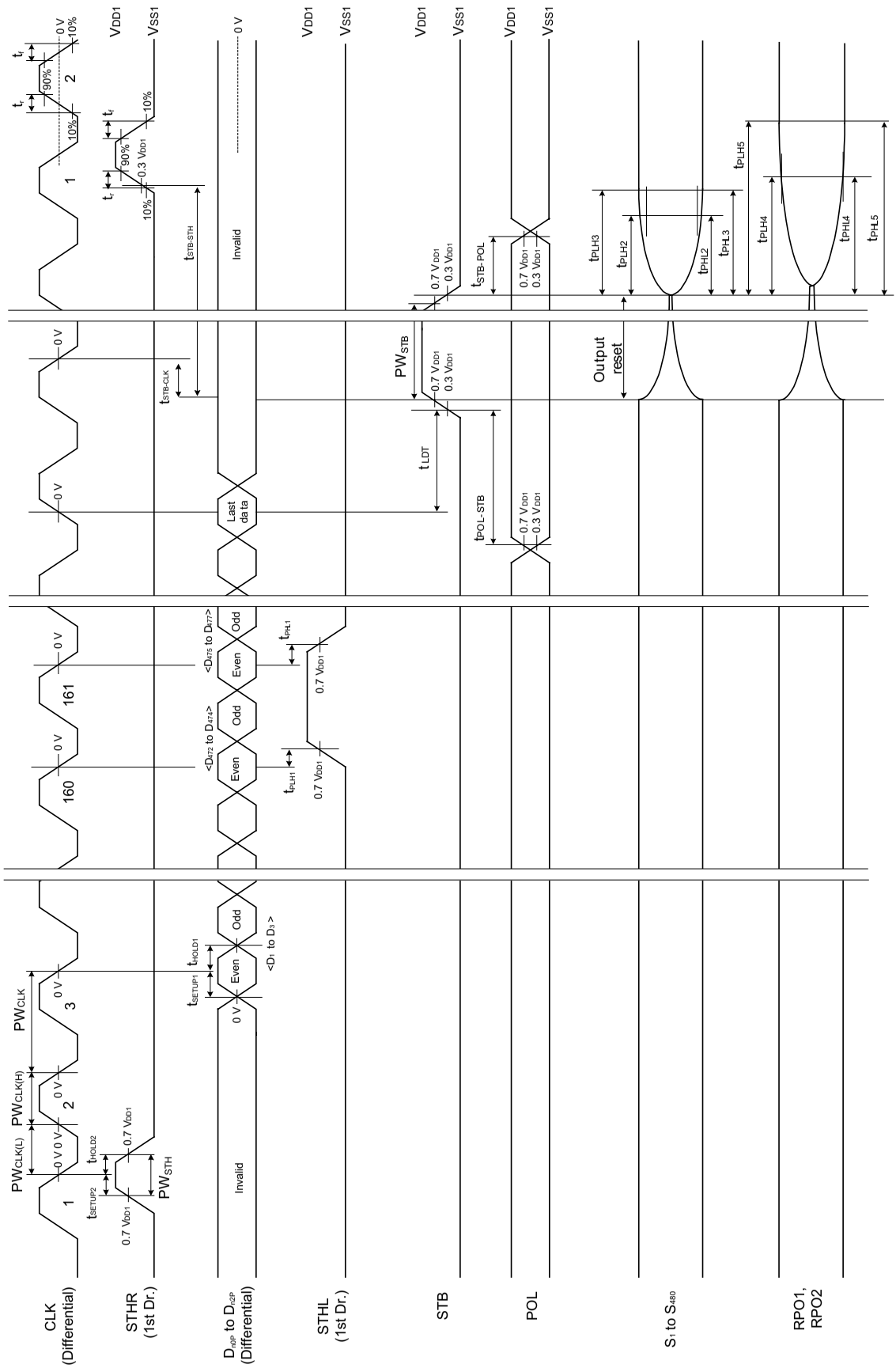
Switching Characteristics Waveform (R,/L = H)

Unless otherwise specified, the input level is defined to be V_{IH} = 0.7 V_{DD1}, V_{IL} = 0.3 V_{DD1} at CMOS signal and 0 V at differential signal (RSDS).

<MODE1 = H>



<MODE1 = L, MODE2 = H>



10. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μPD160010.

For more details, refer to the

[Semiconductor Device Mount Manual] (http://www.necel.com/pkg/en/mount/index.html)

Please consult with our sales offices in case other mounting process is used, or in case the mounting is done under different conditions.

μPD160083N-xxx: TCP (TAB Package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C, heating for 2 to 3 sec, pressure 100g (per solder).
	ACF (Adhesive Conductive Film)	Temporary bonding 70 to 100°C, pressure 3 to 8 kg/cm^2, time 3 to 5 sec. Real bonding 165 to 180°C pressure 25 to 45 kg/cm^2, time 30 to 40 sec. (When using the anisotropy conductive film SUMIZAC1003 of Sumitomo Bakelite, Ltd.)

Caution To find out the detailed conditions for mounting the ACF part, please contact the ACF manufacturing company. Be sure to avoid using two or more mounting methods at a time.

NOTES FOR CMOS DEVICES

① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.