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April 1st, 2010
Renesas Electronics Corporation

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RENESAS

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DATA SHEET

MOS INTEGRATED CIRCUIT

μPD160088

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

DESCRIPTION

The μPD160088 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 16,700,000 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 2.7 V, this driver is applicable to UXGA-standard (1600 x 1200), SXGA-standard (1280 x 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
- 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
- High-speed data transfer : f_{CLK} = 85 MHz MAX. (Internal data transfer speed when operating at V_{DD1} = 2.7 V)
- Output dynamic range : V_{SS2} + 0.1 V to V_{DD2} – 0.1 V
- Apply for dot-line inversion, n-line inversion and column line inversion
- Output voltage polarity inversion function (POL)
- Input data inversion function (INV)
- Controllable charge sharing function (MODE)

Remark RSDS™ is a trademark of National Semiconductor Corporation.

ORDERING INFORMATION

Part Number	Package
μPD160088N-xxx	TCP (TAB package)
μPD160088NL-xxx	COF (COF package)

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

Document S16771EJ1V0DS00 (1st edition)
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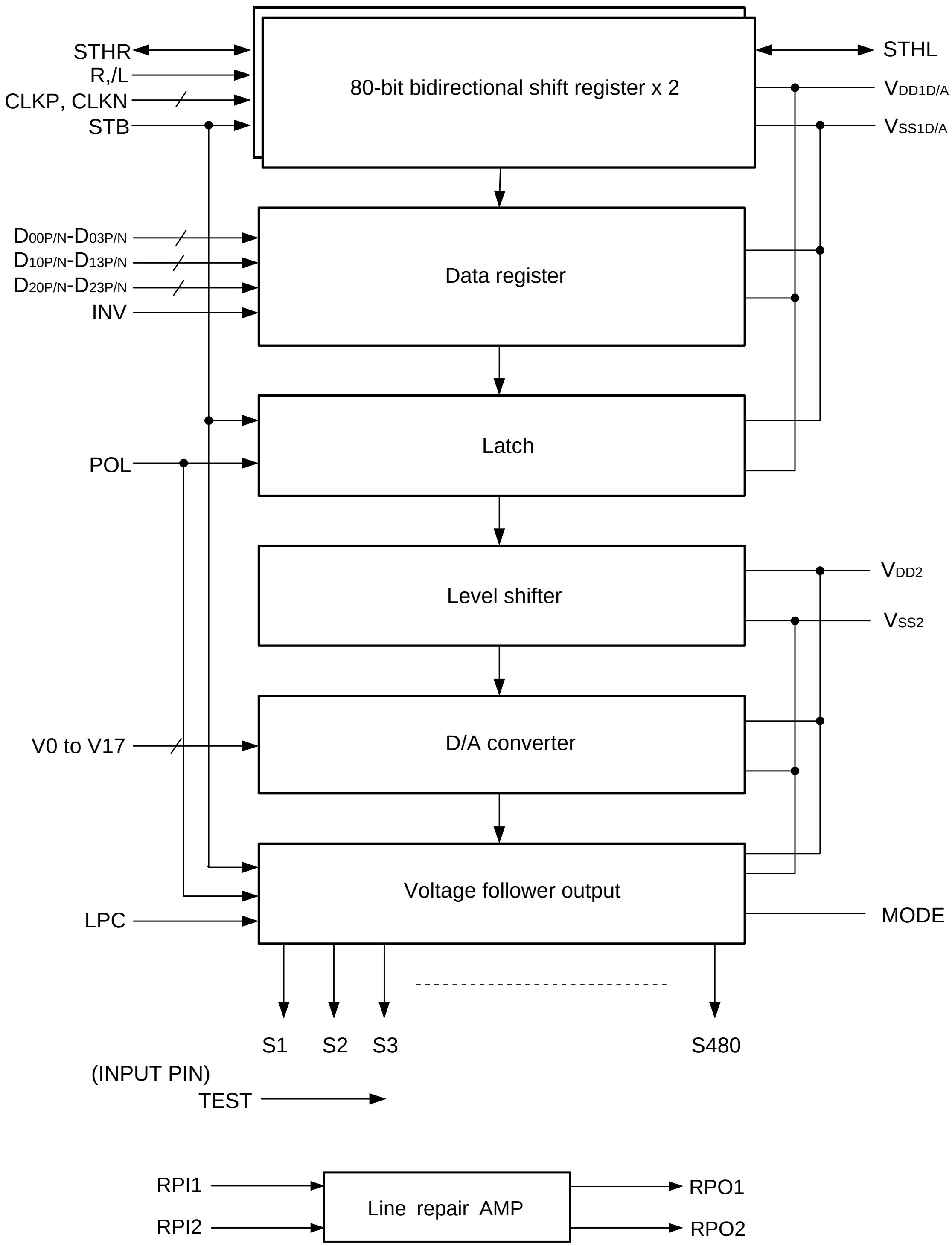
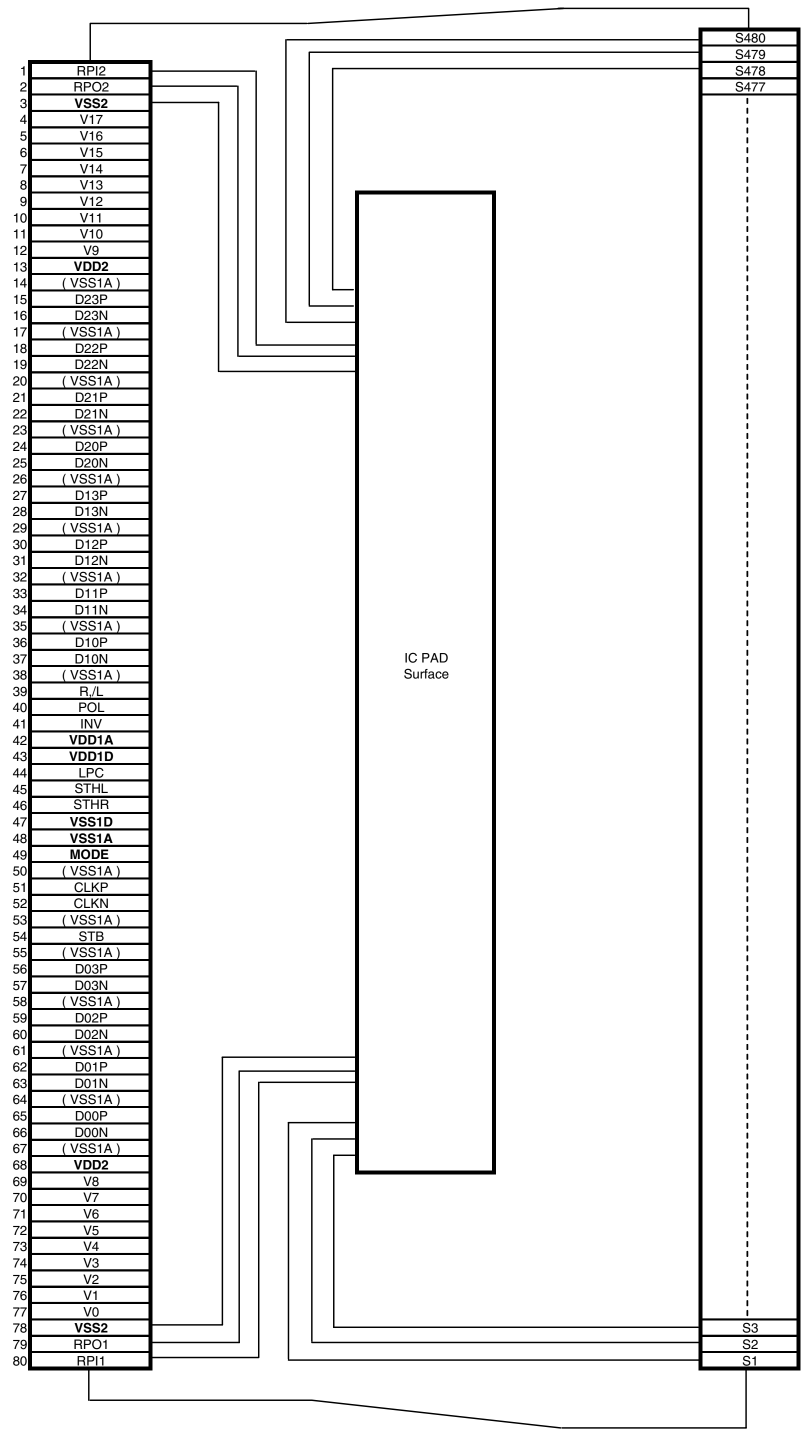
1. BLOCK DIAGRAM



Remark /xxx indicates active low signal.

2. PIN CONFIGURATION (μ PD160088N-×××: TCP, μ PD160088NL-×××: COF)



Remark This figure does not specify the TCP and COF package.

(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 pulse	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 charge sharing function are controlled by MODE. Please refer to **9. RELATIONSHIP BETWEEN MODE, STB, POL AND OUTPUTWAVEFORM** 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. Refer to **6. DATA INVERSION.**
LPC (CMOS)	Low Power Control	–	LPC = L or Open : Normal mode (default) LPC = H : Low power mode (30% lower than normal mode) This pin is pulled down to the V_{SS1D} inside the IC.
MODE (CMOS)	Charge Sharing Control	–	This pin control the Charge Sharing Function. MODE = H or Open : Disable MODE = L : Enable But Charge Sharing function works only when POL signal is changed from previous line. This pin is pulled up to V_{DD1D} inside the IC.
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 a Hi-Z period. RPI1 (RPI2) → impedance changed → RPO1 (RPO2)
RPO1, RPO2	Line-repair AMP.	Output	

Remark Hi-Z: High impedance

(2/2)

Pin Symbol	Pin Name	I/O	Description
TEST (CMOS)	Test	–	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. $V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 \geq 0.5\ V_{DD2}$ $0.5\ V_{DD2} \geq V_9 > V_{10} > V_{11} > V_{12} > V_{13} > V_{14} > V_{15} > V_{16} > V_{17} \geq V_{SS2} + 0.1\ V$
$V_{DD1D/A}$	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 $V_{DD1D/A}$, 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 $V_{DD1D/A}$ –$V_{SS1D/A}$ 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

This product 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 (r_0 to r_{255}) 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. 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} and V_{SS2}, common electrode potential V_{COM}, and γ- corrected voltages V_0-V_{17} and the input data. Be sure to maintain the voltage relationships of

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

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

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

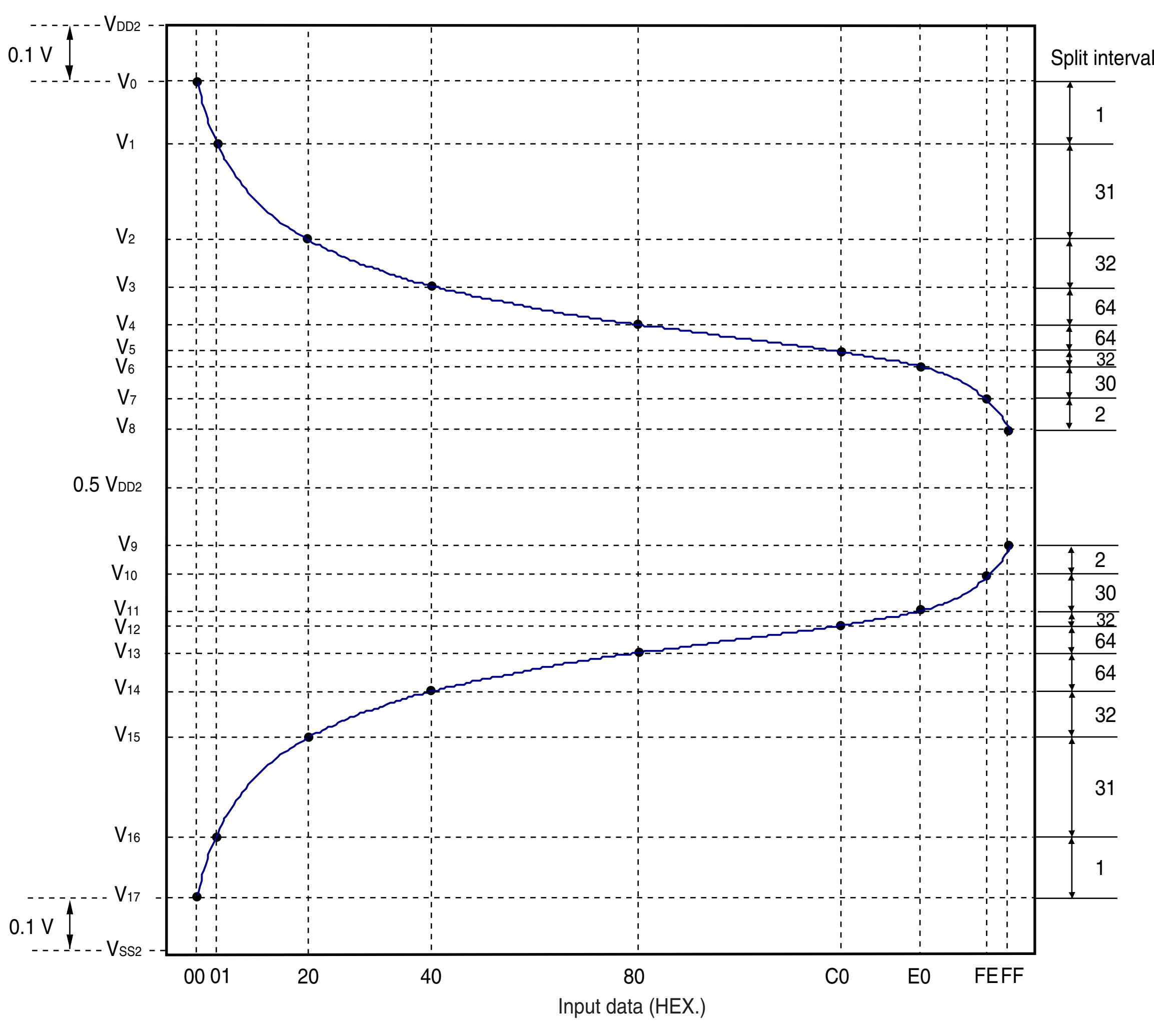
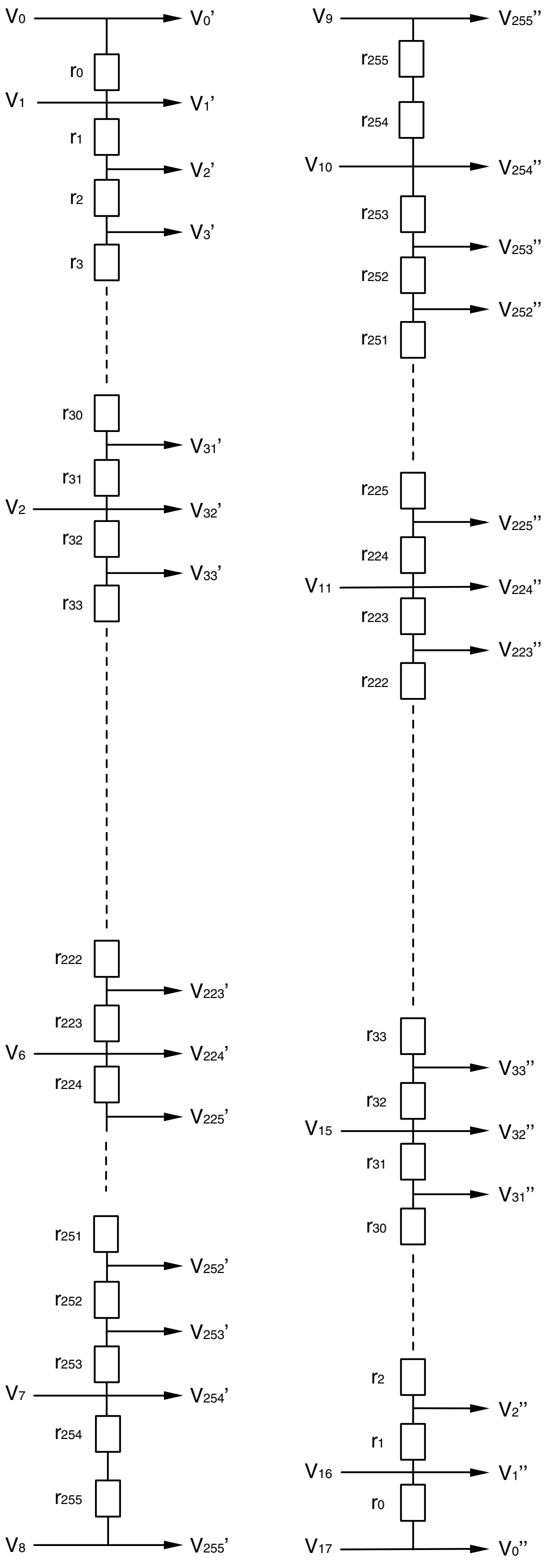


Figure 4–2. γ-corrected Voltages and Ladder Resistors Ratio



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

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

(Output Voltage 1) $V_{DD2} - 0.1\ V \geq V_0 > V_1 > V_2 > V_3 > V_4 > V_5 > V_6 > V_7 > V_8 \geq 0.5\ V_{DD2}$

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 (DxxP) and Output Voltage (INV = L) (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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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 / 2030	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} 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}	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}

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

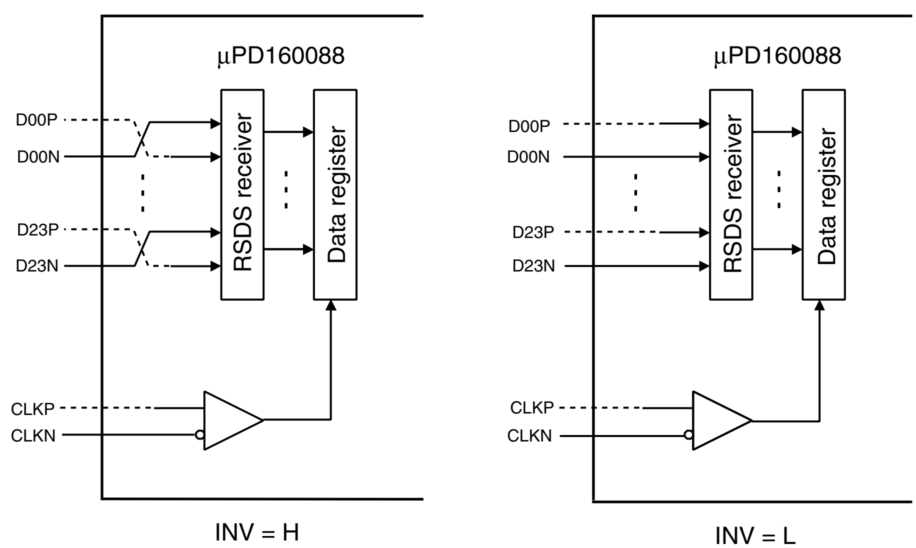
Output	S_1	S_2	S_3	S_4	···	S_{479}	S_{480}
Data	D_{00P} to D_{03P}, D_{00N} to D_{03N}	D_{10P} to D_{13P}, D_{10N} to D_{13N}	D_{20P} to D_{23P}, D_{20N} to D_{23N}	D_{00P} to D_{03P}, D_{00N} to D_{03N}	···	D_{10P} to D_{13P}, D_{10N} to D_{13N}	D_{20P} to D_{23P}, D_{20N} to D_{23N}

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

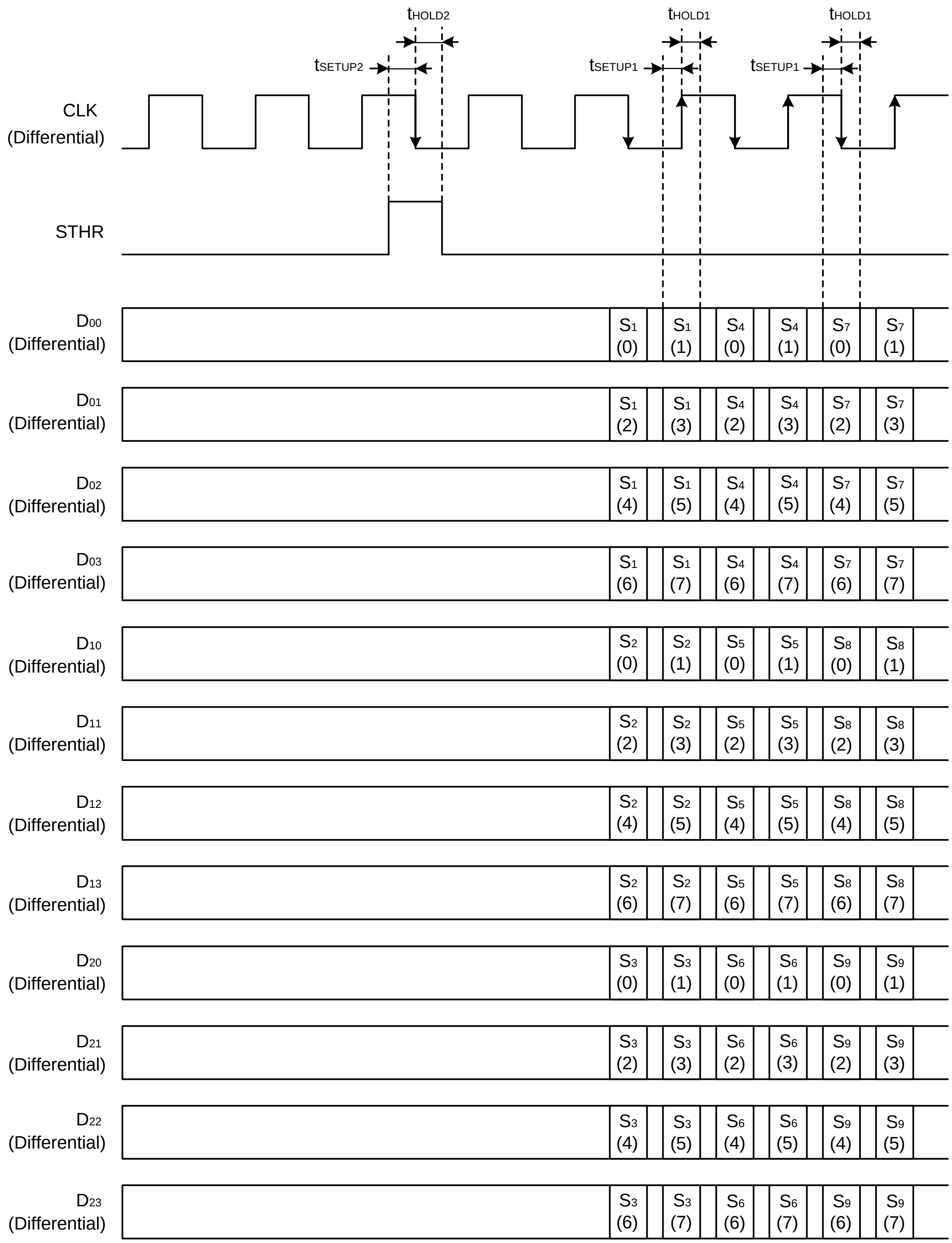
Note S_{2n-1} (Odd output), S_{2n} (Even output)

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

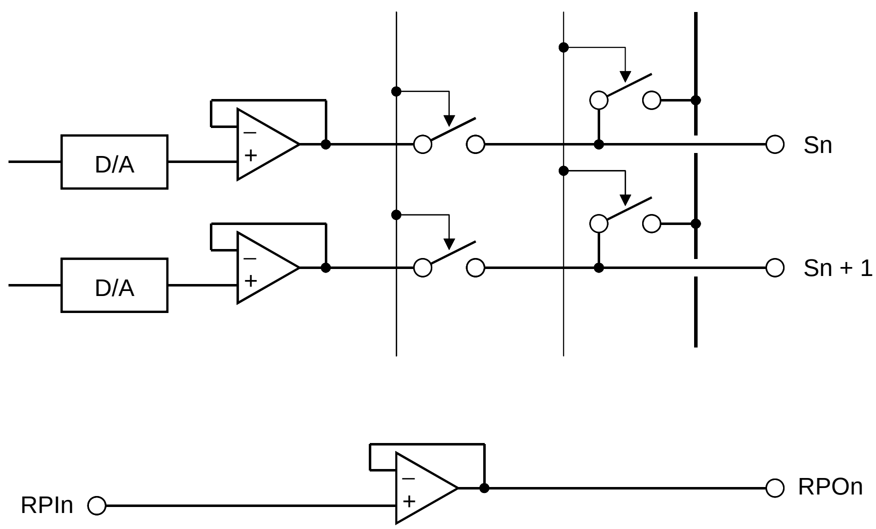
8. OUTPUT AMPLIFIER

This driver IC has two additional amplifiers called "Repair AMP" in both side of the IC for driving the repaired line. And these amplifiers have more driving ability than normal amplifier for S_1 to S_{480}. So it is recommended to evaluate its characteristic before the production if using.

<Feature of Repair AMP>

(1) The pull-up and pull-down resistor is not prepared in input pin for the characteristic.
(2) The driving ability is higher than the normal amplifier.
(3) "Hi-Z" and "Output Reset" function doesn't work.

<Block Diagram>



9. RELATIONSHIP BETWEEN MODE, STB, POL AND OUTPUT WAVEFORM

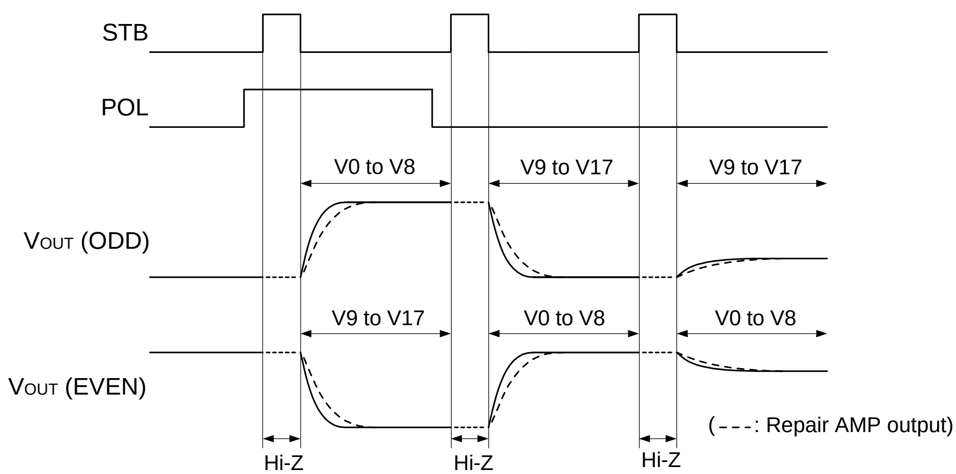
This driver IC has a "Charge Sharing" function that can be controlled by MODE pin. Refer to the following description of the detail function and decide to use this function after considering the suitable driving method.

MODE	Charge Sharing	Description of Charge Sharing
H or Open	Disable	"Charge Sharing" doesn't work.
L	Enable	"Charge Sharing" works during STB = H period only when the polarity is changed by switching POL signal. When POL signal is not switching, this function doesn't work.

< MODE = H or Open >

All outputs always become Hi-Z condition during STB = H in this mode. And "Charge Sharing" function doesn't work and all output always start at the falling edge of STB (Refer to **Figure 9–1**.).

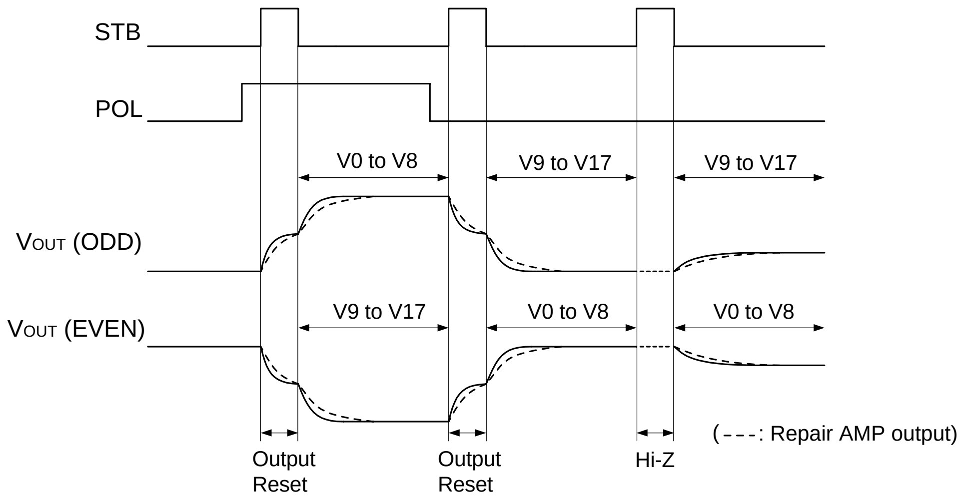
Figure 9–1. MODE = H or Open



<MODE = L>

"Charge Sharing" function works during STB = H in this mode. So all outputs are started at the falling edge of STB. But "Charge Sharing" function works only when POL signal is changed. So All output become Hi-Z condition during STB = H without any change of POL signal (Refer to **Figure 9–2**).

Figure 9–2. MODE = L



10. ELECTRICAL SPECIFICATIONS

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

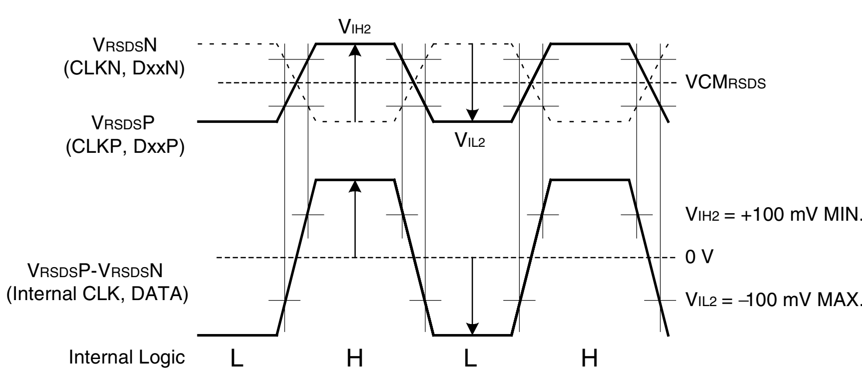
Parameter	Symbol	Ratings	Unit
Logic Part Supply Voltage	$V_{DD1D/A}$	–0.5 to +4.0	V
Driver Part Supply Voltage	V_{DD2}	–0.3 to +14.0	V
Logic Part Input Voltage	V_{I1}	–0.5 to V_{DD1} + 0.5	V
Driver Part Input Voltage	V_{I2}	–0.3 to V_{DD2} + 0.3	V
Logic Part Output Voltage	V_{O1}	–0.5 to V_{DD1} + 0.5	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, $V_{SS1D/A}$ = V_{SS2} = 0 V)

Parameter	Symbol	Conditions		MIN.	TYP.	MAX.	Unit
Logic Part Supply Voltage	$V_{DD1D/A}$			2.7	3.3	3.6	V
Driver Part Supply Voltage	V_{DD2}			10.5	12.0	13.5	V
High-Level Input Voltage1	V_{IH1}			0.7 V_{DD1}		V_{DD1}	V
Low-Level Input Voltage1	V_{IL1}			0		0.3 V_{DD1}	V
High-Level Input Voltage2 (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 Voltage2 (Differential : V_{RSDS}P–V_{RSDS}N)	V_{IL2}				–200	–100	mV
Common mode Input Voltage	V_{CM}		V_{DIFF} = 200 mV_{p-p}[Note]	0.5	1.2	1.4	V
Driver Part Output Voltage	V_O	S1 to S480, RPO1, RPO2		0.1		V_{DD2} – 0.1	V
γ- Corrected Voltage	V_n	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_{CM} = 1.2 V, V_{DIFF} = 200 mV_{p-p}				85	MHz

Note



Remark V_{CM} = (VCLKP + VCLKN) /2 or = (VDxxP + VDxxN) /2 (x = 0, 1, 2)
V_{DIFF} = (VCLKP – VCLKN) or = (VDxxP – VDxxN) (x = 0, 1, 2)

Electrical Characteristics (T_A = –10 to +75°C, V_{DD1} = 2.7 to 3.6 V, 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 MODE, LPC, TEST	80	200	500	kΩ
Driver Output Current	I_{VOH}	S_1 to S_{480}, RPO1, RPO2 V_{DD2} = 12.0 V; V_X = 11 V, V_{OUT} = 10.5 V Note1			–70	μA
	I_{VOL}	S_1 to S_{480}, RPO1, RPO2 V_{DD2} = 12.0 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 Consumption1	I_{DD11}	V_{DD1} Note2, 3, 4		3.0 Note2	6.0 Note3	mA
Logic Part Dynamic Current Consumption2	I_{DD12}	V_{DD1} Note2, 3, 4		3.0 Note4	6.0 Note5	mA
Driver Part Dynamic Current Consumption	I_{DD2}	V_{DD2} , with no load, RPI1 and RPI2 (IN) are not floating		13 Note6	25 Note7	mA

Notes 1. V_X refers to the voltage applied to analog output pins S_1 to S_{480}.
V_{OUT} refers to the output voltage of analog output pins S_1 to S_{480}.

2. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = 55H or AAH, T_A = 25°C, V_{DD1} = 3.0 V

3. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = 55H or AAH, V_{DD1} = 3.6 V

4. f_{CLKP}, f_{CLKN} = 54.0 MHz, f_{STB} = 64.9 kHz, test pattern = 55H or AAH, T_A = 25°C, V_{DD1} = 3.0 V

5. f_{CLKP}, f_{CLKN} = 54.0 MHz, f_{STB} = 64.9 kHz, test pattern = 55H or AAH, V_{DD1} = 3.6 V

6. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = 00H, T_A = 25°C, V_{DD2} = 12.0 V

7. f_{CLKP}, f_{CLKN} = 67.5 MHz, f_{STB} = 80.0 kHz, test pattern = 00H, V_{DD2} = 13.5 V

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

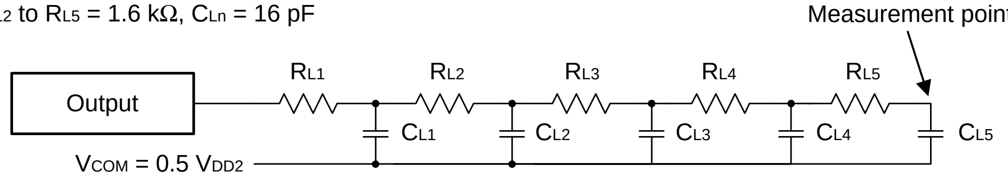
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Start Pulse Delay Time	t_{PLH1}	C_L = 15 pF		6	10	ns
Driver Output Delay Time 1	t_{PLH2} Note1	V_{DD2} = 12.0 V		2.5	5.0	μs
	t_{PLH3} Note2	S_1 to S_{480}		4.0	8.0	μs
	t_{PHL2} Note1	R_L = 9 kΩ, C_L = 80 pF		2.5	5.0	μs
	t_{PHL3} Note2			4.0	8.0	μs
Driver Output Delay Time 2	t_{PLH4} Note1	V_{DD2} = 12.0 V		2.0	5.0	μs
	t_{PLH5} Note2	RPO1, RPO2		4.0	8.0	μs
	t_{PHL4} Note1	R_L = 9 kΩ, C_L = 80 pF + 150 pF		2.0	5.0	μs
	t_{PHL5} Note2			4.0	8.0	μs
Input Capacitance	C_{I1}	Logic input besides STHR (STHL), T_A = 25°C		4	10	pF
	C_{I2}	STHR (STHL), T_A = 25°C		4	15	pF

Notes 1. The value is specified when the drive voltage value reaches the target output voltage level of 10 or 90%.

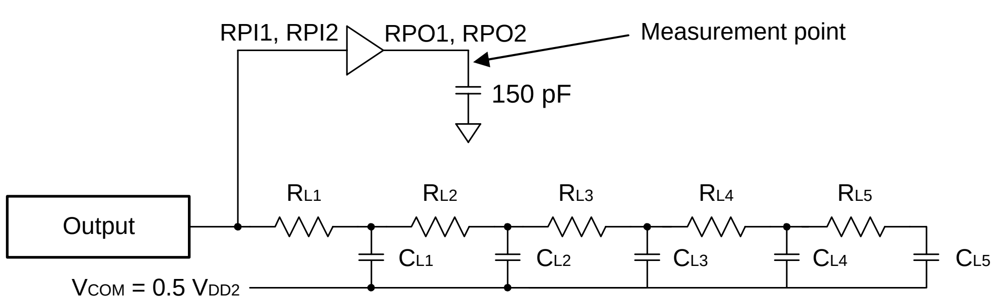
2. The value is specified when the drive voltage value reaches the target output voltage level of 8-bit accuracy.

<Test condition>

R_{L1} = 2.6 kΩ, R_{L2} to R_{L5} = 1.6 kΩ, C_{Ln} = 16 pF



R_{L1} = 2.6 kΩ, R_{L2} to R_{L5} = 1.6 kΩ, C_{Ln} = 16 pF



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

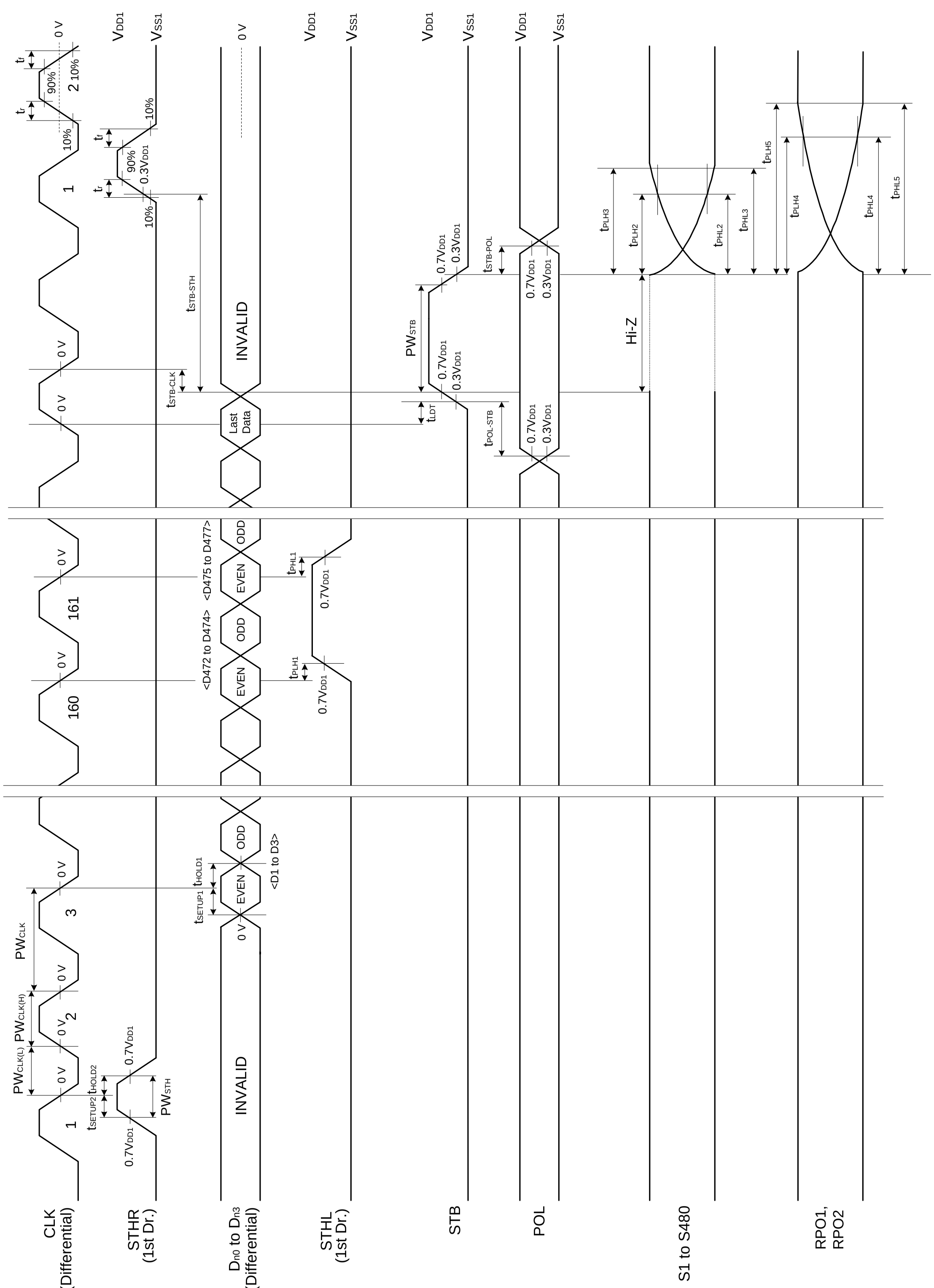
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Period	PW_{CLK}		11.8			ns
Clock Pulse High Period	$PW_{CLK(H)}$		4			ns
Clock Pulse Low Period	$PW_{CLK(L)}$		4			ns
Data Setup Time	t_{SETUP1}		2			ns
Data Hold Time	t_{HOLD1}		0			ns
Start Pulse Setup Time	t_{SETUP2}		1			ns
Start Pulse Hold Time	t_{HOLD2}		2			ns
Start Pulse High Level Width	PW_{STH}		1		2	CLKP
STB Pulse High Level Width	PW_{STB}		1			μs
Last Data Timing	t_{LDT}		1			CLKP
STB-CLK Time	$t_{STB-CLK}$	STB ↑ → CLKP-N↓	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 and t_f are defined 10 to 90% of each signal amplitude.

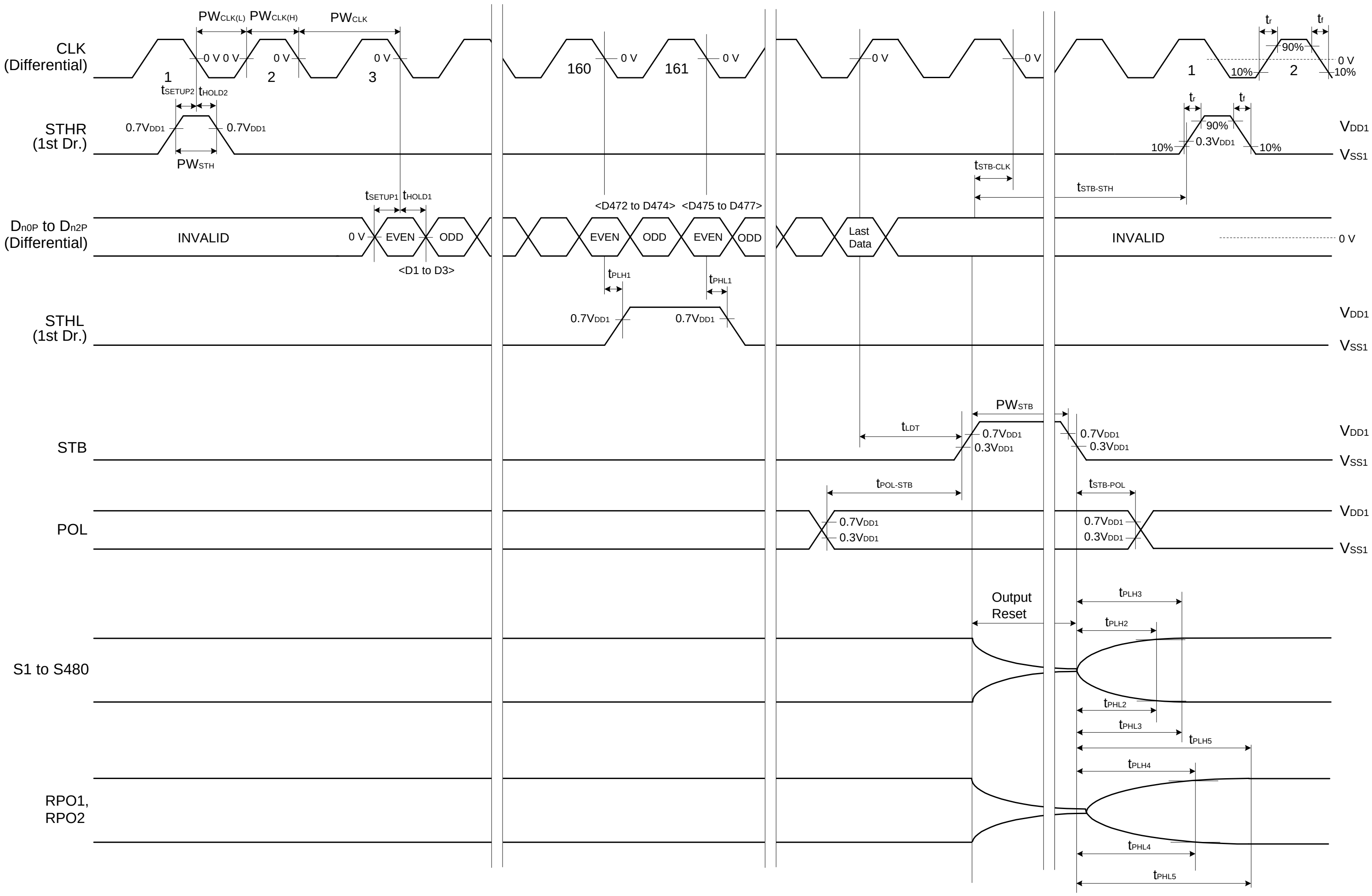
Switching Characteristics Waveform (R,/L = H)

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).

<MODE = H or Open>



<MODE = L>


CLK
(Differential)
STHR
(1st Dr.)
Dn0P to Dn2P
(Differential)
STHL
(1st Dr.)
STB
POL
S1 to S480
RPO1,
RPO2
PWCLK(L) PWCLK(H) PWCLK
tSETUP2 tHOLD2
PWSTH
tSETUP1 tHOLD1
INVALID
EVEN
ODD
<D1 to D3>
<D472 to D474> <D475 to D477>
Last
Data
tPLH1
tPHL1
160
161
tSTB-CLK
tSTB-STH
tLDT
PWSTB
tPOL-STB
tSTB-POL
Output
Reset
tPLH3
tPLH2
tPHL2
tPHL3
tPLH5
tPLH4
tPHL4
tPHL5
0.7VDD1
0.3VDD1
VDD1
VSS1
0 V
90%
10%

11. RECOMMENDED MOUNTING CONDITIONS

The following conditions must be met for mounting conditions of the μPD160088.
For more details, refer to the
[Semiconductor Device Mounting 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.

μPD160088N-xxx: TCP (TAB Package)

Mounting Condition	Mounting Method	Condition
Thermocompression	Soldering	Heating tool 300 to 350°C, heating for 2 to 3 seconds : 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 VOLTAGE APPLICATION WAVEFORM AT INPUT PIN

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (MAX) and V_{IH} (MIN) due to noise, etc., the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (MAX) and V_{IH} (MIN).

② HANDLING OF UNUSED INPUT PINS

Unconnected CMOS device inputs can be cause of malfunction. If an input pin is unconnected, it is possible that an internal input level may be generated due to noise, etc., causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND via a resistor if there is a possibility that it will be an output pin. All handling related to unused pins must be judged separately for each device and according to related specifications governing the device.

③ PRECAUTION AGAINST ESD

A 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 when it has occurred. Environmental control must be adequate. When it is dry, a humidifier should be used. It is recommended to avoid using insulators that easily build up 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 benches and floors should be grounded. The operator should be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with mounted semiconductor devices.

④ STATUS BEFORE INITIALIZATION

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

Reference Documents

NEC Semiconductor Device Reliability/Quality Control System (C10983E)

Quality Grades On NEC Semiconductor Devices (C11531E)