

ML9213

56-Bit Duplex/Triplex (1/2 duty/1/3 duty) VFD Controller/Driver with Anode Digital Dimming

GENERAL DESCRIPTION

The ML9213 is a full CMOS controller/driver for Duplex or Triplex (1/2 duty or 1/3 duty) vacuum fluorescent display tube. It consists of a 56-segment driver multiplexed to drive up to 168 segments, and 10-bit digital dimming circuit.

ML9213 features a selection of a master mode and a slave mode, and therefore it can be used to expand segments for the VFD driver with keyscan and A/D converter function.

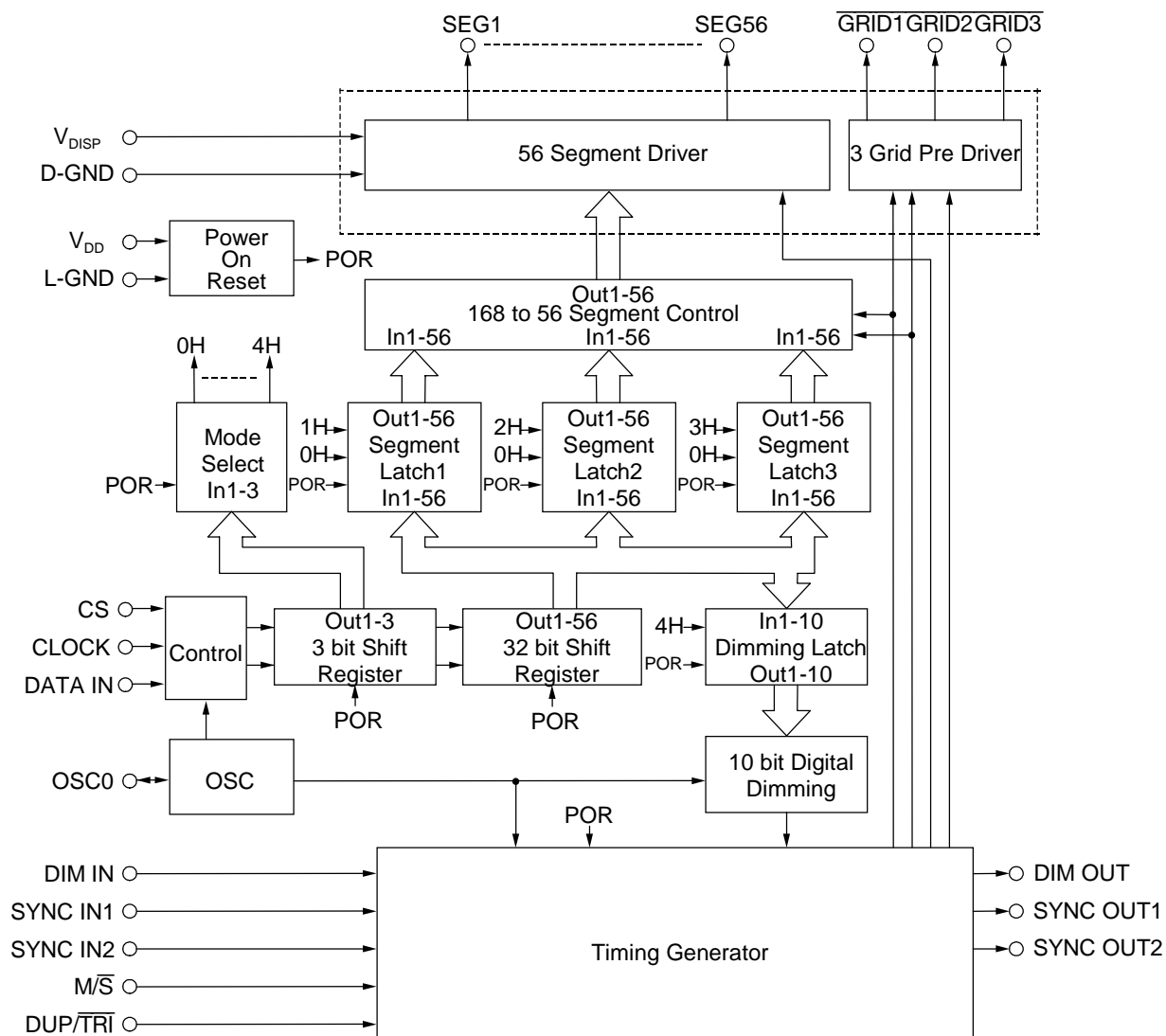
ML9213 provides an interface with a microcontroller only by three signal lines: DATA IN, CLOCK and CS.

FEATURES

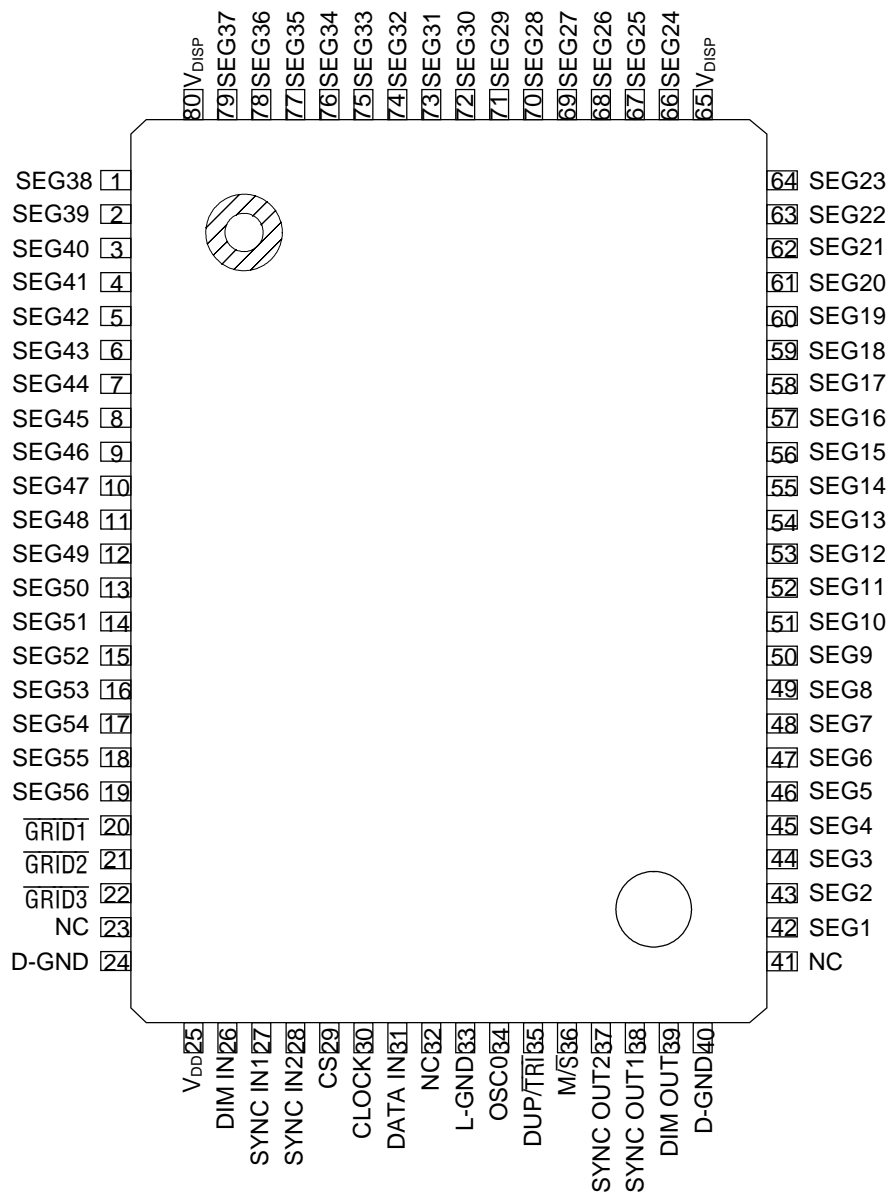
- Logic supply voltage (V_{DD}) : 5.0 V \pm 10%
- Driver supply voltage (V_{DISP}) : 8.0 to 18.0 V
- Duplex/Triplex (1/2 duty / 1/3 duty) selectable
 $DUP/\overline{TRI} = 1/2$ duty selectable at “H” level
 $DUP/\overline{TRI} = 1/3$ duty selectable at “L” level
- Number of display segments
 112 segments max. (during 1/2 duty mode)
 168 segments max. (during 1/3 duty mode)
- Master/Slave selectable
 $M/\overline{S} = \text{“H” level}$: Master mode
 $M/\overline{S} = \text{“L” level}$: Slave mode
- Interface with a microcontroller
 Three lines: CS, CLOCK, and DATA IN
- 56-segment driver outputs : $I_{OH} = -5.0$ mA at $V_{OH} = V_{DISP} - 0.8$ V (SEG1 to 37)
 (can be directly connected to VFD tube : $I_{OH} = -10.0$ mA at $V_{OH} = V_{DISP} - 0.8$ V (SEG38 to 56)
 and requires no external resistors) : $I_{OL} = 500$ μ A at $V_{OL} = 2.0$ V (SEG1 to 56)
- 3-grid pre-driver outputs : $I_{OH} = -5.0$ mA at $V_{OH} = V_{DISP} - 0.8$ V
 (requires external drivers) : $I_{OL} = 10.0$ mA at $V_{OL} = 2.0$ V
- Logic outputs : $I_{OH} = -200$ μ A at $V_{OH} = V_{DD} - 0.8$ V
 $I_{OL} = 200$ μ A at $V_{OL} = 0.8$ V
- Built-in anode digital dimming circuit (10-bit resolution)
- Built-in oscillation circuit (external resistor and capacitor)
- Built-in Power-On-Reset circuit
- Package options:

80-pin plastic QFP (QFP80-P-1420-0.80-BK)	Product name: ML9213GA
80-pin plastic QFP (QFP80-P-1414-0.65-K)	Product name: ML9213GP

BLOCK DIAGRAM

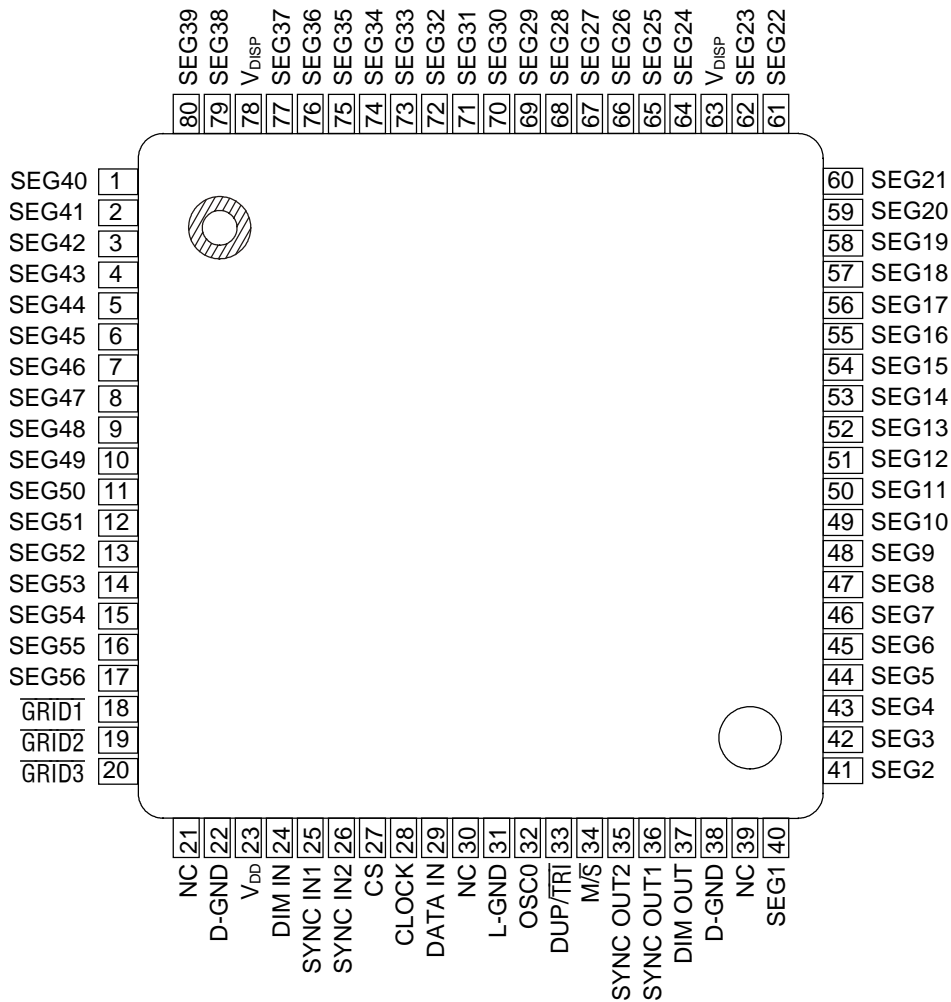


PIN CONFIGURATION (TOP VIEW)



NC: No connection

ML9213GA
80-Pin Plastic QFP
(QFP80-P-1420-0.80-BK)



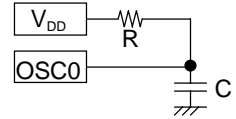
NC: No connection

ML9213GP
80-Pin Plastic QFP
(QFP80-P-1414-0.65-K)

PIN DESCRIPTIONS

Symbol	Pin		Type	Description
	ML9213GA	ML9213GP		
V_{DISP}	65, 80	63, 78	—	Power supply pins for VFD driver circuit. These should be connected externally.
V_{DD}	25	23	—	Power supply pin for logic drive.
D-GND	24, 40	22, 38	—	D-GND is ground pin for the VFD driver circuit. L-GND is ground pin for the logic circuit. These should be connected externally.
L-GND	33	31	—	
SEG1 to 37	42 to 64, 66 to 79	40 to 62, 64 to 77	O	Segment (anode) signal output pins for a VFD tube. These pins can be directly connected to the VFD tube. External circuit is not required. $I_{\text{OH}} \leq -5 \text{ mA}$
SEG38 to 56	1 to 19	79, 80, 1 to 17	O	Segment (anode) signal output pins for a VFD tube. These pins can be directly connected to the VFD tube. External circuit is not required. $I_{\text{OH}} \leq -10 \text{ mA}$
$\overline{\text{GRID1}}$	20	18	O	Inverted Grid signal output pins. Since these pins are connected to the pre-driver, an external circuit is required. $I_{\text{OL}} \leq 10 \text{ mA}$
$\overline{\text{GRID2}}$	21	19		
$\overline{\text{GRID3}}$	22	20		
CS	29	27	I	Chip select input pin. Data is not transferred when CS is set to a Low level.
CLOCK	30	28	I	Shift clock input pin. Serial data shifts at the rising edge of the CLOCK.
DATA IN	31	29	I	Serial data input pin (positive logic). Data is input to the shift register at the rising edge of the CLOCK signal.
DUP/ $\overline{\text{TRI}}$	35	33	I	Duplex/Triplex operation select input pin. Duplex (1/2 duty) operation is selected when this pin is set to V_{DD} . Triplex (1/3 duty) operation is selected when this pin is set to L-GND.
$\text{M}/\overline{\text{S}}$	36	34	I	Master/Slave mode select input pin. Master mode is selected when this pin is set to V_{DD} . Slave mode is selected when this pin is set to L-GND.
DIM IN	26	24	I	Dimming pulse input. When the slave mode is selected, connect this pin to the master side DIM OUT pin. The pulse width of all the segment outputs is controlled by an input pulse width of DIM IN. When the master mode is selected, input to this pin is ignored; therefore, connect this pin to V_{DD} or L-GND. The pulse width of all the segment outputs is controlled by the built-in digital dimming circuit, and the pulse width of all the grid outputs is controlled by the internal timing generator.
SYNC IN1	27	25	I	Synchronous signal input. When the slave mode is selected, connect these pins to the master side SYN COUT1 and 2 pins.
SYNC IN2	28	26		When the master mode is selected, input to these pins is ignored; therefore, connect these pins to V_{DD} or L-GND.
DIM OUT	39	37	O	Dimming pulse output. Connect this pin to the slave side DIM IN pin.

Symbol	Pin		Type	Description
	ML9213GA	ML9213GP		
SYNC OUT1	38	36	O	Synchronous signal output. Connect these pins to the slave side SYNC IN1 and 2 pins.
SYNC OUT2	37	35		
OSC0	34	32	I/O	RC oscillator connecting pins. Oscillation frequency depends on display tubes to be used. For details, refer to ELECTRICAL CHARACTERISTICS.



ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Condition		Rating	Unit
Driver Supply Voltage	V_{DISP}	—		−0.3 to +20	V
Logic Supply Voltage	V_{DD}	—		−0.3 to +6.5	V
Input Voltage	V_{IN}	—		−0.3 to $V_{DD}+0.3$	V
Power Dissipation	P_D	$T_a \geq 25^\circ\text{C}$	QFP80-P-1420-0.80-BK	342	mW
			QFP80-P-1414-0.65-K	343	
Storage Temperature	T_{STG}	—		−55 to +150	$^\circ\text{C}$
Output Current	I_{O1}	SEG1 to 37		−10.0 to +2.0	mA
	I_{O2}	SEG38 to 56		−20.0 to +2.0	mA
	I_{O3}	GRID1 to 3		−10.0 to +20.0	mA
	I_{O4}	DIM OUT, SYNC OUT1, SYNC OUT2		−2.0 to +2.0	mA

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Condition		Min.	Typ.	Max.	Unit
Driver Supply Voltage	V _{DISP}	—		8.0	13.0	18.0	V
Logic Supply Voltage	V _{DD}	—		4.5	5.0	5.5	V
High Level Input Voltage	V _{IH}	All inputs except OSC0		0.8V _{DD}	—	—	V
Low Level Input Voltage	V _{IL}	All inputs except OSC0		—	—	0.2V _{DD}	V
Clock Frequency	f _C	—		—	—	2.0	MHz
Oscillation Frequency	f _{OSC}	R = 10 kΩ ± 5%, C = 27 pF ± 5%		2.2	3.3	4.4	MHz
Frame Frequency	f _{FR}	R = 10 kΩ ± 5%, C = 27 pF ± 5%	1/3 Duty	179	269	358	Hz
			1/2 Duty	268	403	538	Hz
Operating Temperature	T _{OP}	—		−40	—	+105	°C

ELECTRICAL CHARACTERISTICS

DC Characteristics

$T_a = -40$ to $+105^\circ\text{C}$, $V_{\text{DISP}} = 8.0$ to 18.0 V, $V_{\text{DD}} = 4.5$ to 5.5 V

Parameter	Symbol	Applied pin	Condition		Min.	Max.	Unit
High Level Input Voltage	V _{IH}	*1)	—		0.8V _{DD}	—	V
Low Level Input Voltage	V _{IL}	*1)	—		—	0.2V _{DD}	V
High Level Input Current	I _{IH}	*1)	V _{IH} = V _{DD}		−1.0	+1.0	μA
Low Level Input Current	I _{IL}	*1)	V _{IL} = GND		−1.0	+1.0	μA
High Level Output Voltage	V _{OH1}	SEG1-37	V _{DISP} = 9.5 V	I _{OH1} = −5 mA	V _{DISP} −0.8	—	V
	V _{OH2}	SEG38-56		I _{OH2} = −10 mA	V _{DISP} −0.8	—	V
	V _{OH3}	GRID1-3		I _{OH3} = −5 mA	V _{DISP} −0.8	—	V
	V _{OH4}	*2)	V _{DD} = 4.5V	I _{OH4} = −200 μA	V _{DD} −0.8	—	V
Low Level Output Voltage	V _{OL1}	SEG1-37	V _{DISP} = 9.5 V	I _{OL1} = 500 μA	—	2.0	V
	V _{OL2}	SEG38-56		I _{OL2} = 500 μA	—	2.0	V
	V _{OL3}	GRID1-3		I _{OL3} = 10 mA	—	2.0	V
	V _{OL4}	*2)	V _{DD} = 4.5 V	I _{OL4} = 200 μA	—	0.8	V
Supply Current	I _{DISP}	V _{DISP}	R=10 kΩ ±5%,C=27 pF ±5%,		—	100	μA
	I _{DD}	V _{DD}	no load		—	5.0	mA

*1) CS, CLOCK, DATA IN, DIM IN, SYNC IN1, SYNC IN2, M/ \bar{S} , DUP/ $\bar{\text{TRI}}$

*2) DIM OUT, SYNC OUT1, SYNC OUT2

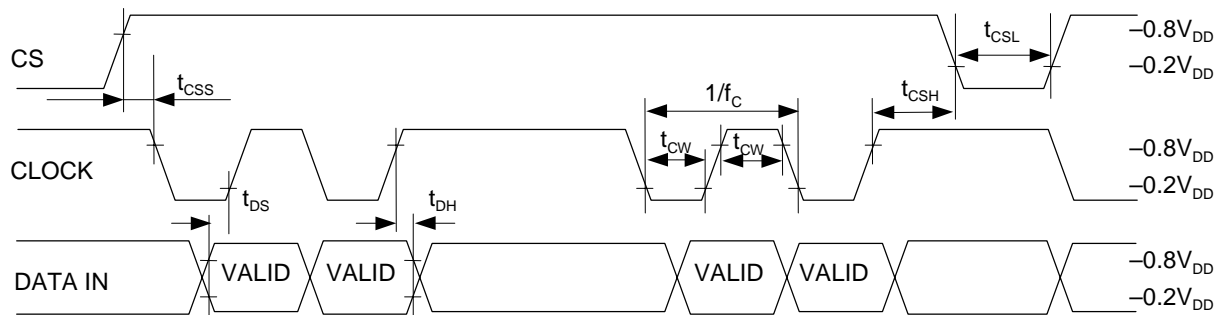
AC Characteristics

$T_a = -40$ to $+105^\circ\text{C}$, $V_{\text{DISP}} = 8.0$ to 18.0 V, $V_{\text{DD}} = 4.5$ to 5.5 V

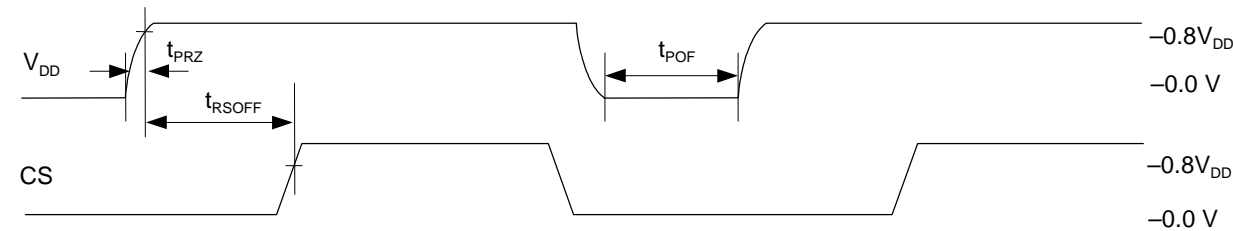
Parameter	Symbol	Condition		Min.	Max.	Unit
Clock Frequency	f _C	—		—	2.0	MHz
Clock Pulse Width	t _{CW}	—		200	—	ns
Data Setup Time	t _{DS}	—		200	—	ns
Data Hold Time	t _{DH}	—		200	—	ns
CS Off Time	t _{CSL}	—		20	—	μs
CS Setup Time (CS–Clock)	t _{CSS}	—		200	—	ns
CS Hold Time (Clock–CS)	t _{CSH}	—		200	—	ns
CS Wait Time	t _{RSOFF}	—		400	—	μs
Output Slew Rate Time	t _R	C _L = 100 pF	t _R = 20% to 80%	—	2.0	μs
	t _F		t _F = 80% to 20%	—	2.0	μs
V _{DD} Rise Time	t _{PRZ}	Mounted in a unit		—	100	μs
V _{DD} Off Time	t _{POF}	Mounted in a unit, V _{DD} = 0.0 V		5.0	—	ms

TIIMING DIAGRAM

• Data Input Timing



• Reset Timing



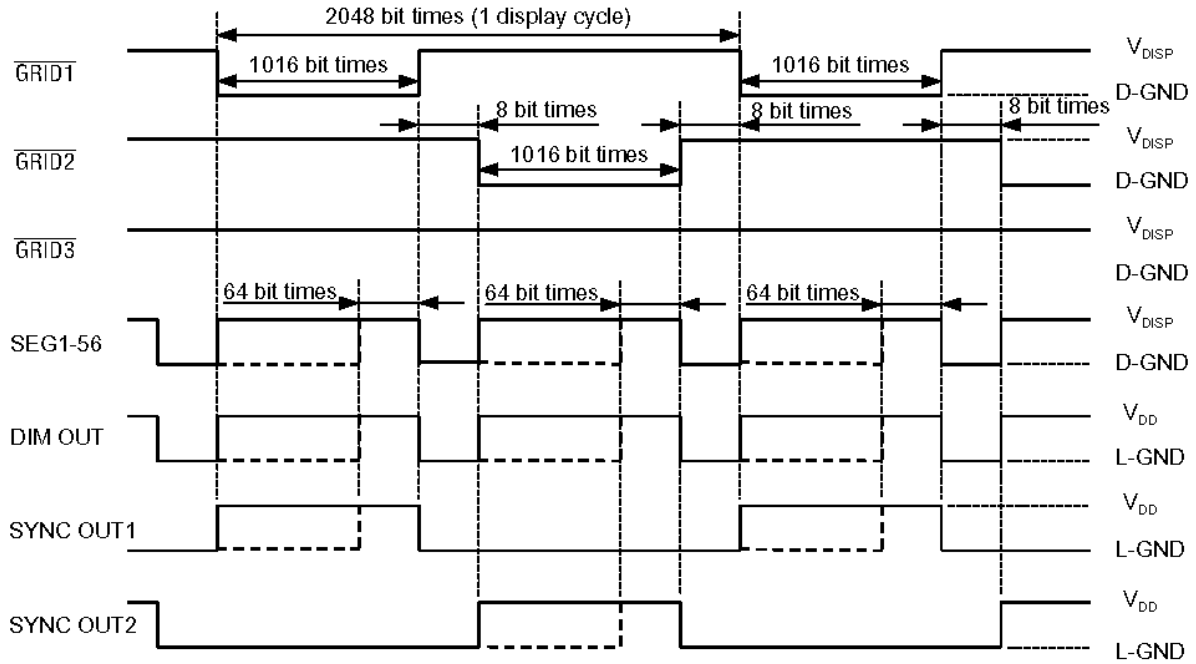
• Driver Output Timing



• **Output Timing (Duplex Operation)** *1 bit time = $4/f_{OSC}$

Solid line: Indicates that the anode dimming data is 1016/1024 in the master mode.

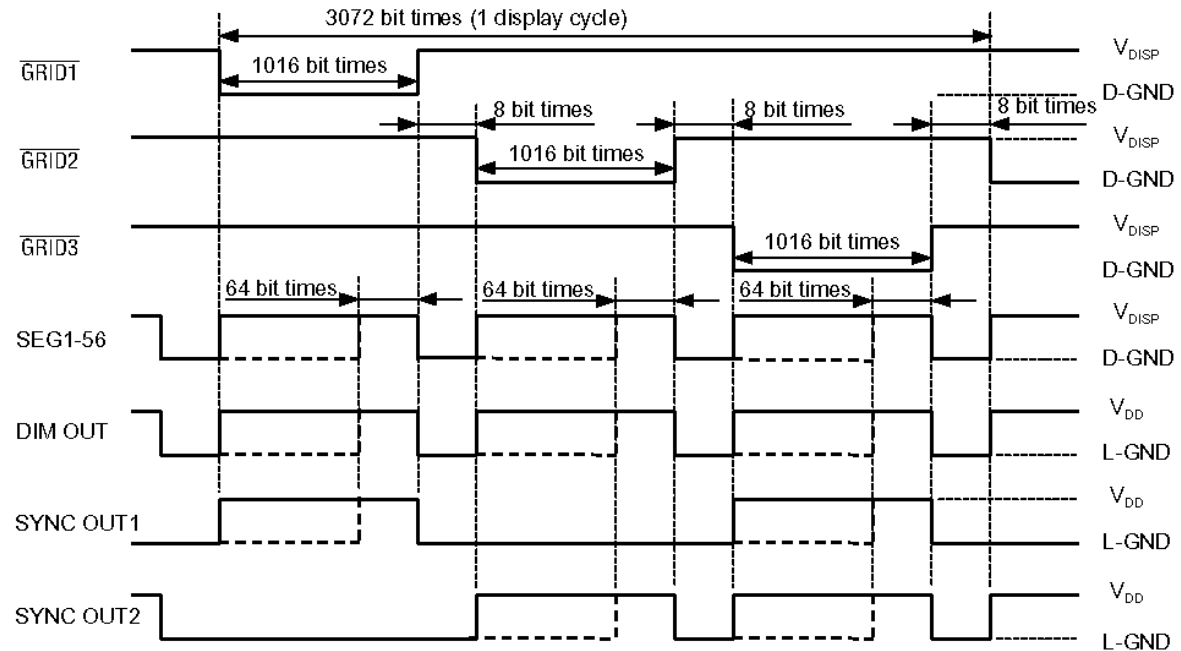
Chain line: Indicates that the anode dimming data is 64/1024 in the master mode.



• **Output Timing (Triplex Operation)** *1 bit time = $4/f_{OSC}$

Solid line: Indicates that the anode dimming data is 1016/1024 in the master mode.

Chain line: Indicates that the anode dimming data is 64/1024 in the master mode.



FUNCTIONAL DESCRIPTION

Power-on Reset

When power is turned on, the ML9213 is initialized by the internal power-on reset circuit. The status of the internal circuit after initialization is as follows:

- The contents of the shift registers and latches are set to “0”.
- The anode dimming duty cycle is set to “0”.
- All segment outputs (SEG1 to 56) are set to Low level.
- The $\overline{\text{GRID1}}$ output is set to Low level.
- The $\overline{\text{GRID2}}$ and $\overline{\text{GRID3}}$ outputs are set to High level.

Data Transfer Method

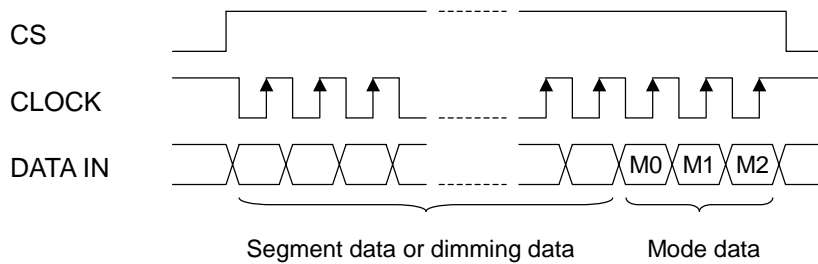
Data can be transferred between the rising edge and the next falling edge of chip select input.

The mode data, segment data and anode dimming data are written by a serial transfer method. The serial data is input to the shift register at the rising edge of a shift clock pulse.

The mode data (M0 to M2) must be transferred after the segment data and anode dimming data succeedingly.

When the chip select input falls, an internal LOAD signal is automatically generated and data is loaded to the latches.

Set the shift clock to a High level except during data transfer.



Function Mode

Function mode is selected by the mode data (M0 to M2). The relation between function mode and mode data is as follows:

FUNCTION MODE	OPERATING MODE	MODE DATA		
		M0	M1	M2
0	Segment Data for $\overline{\text{GRID1-3}}$ Input	0	0	0
1	Segment Data for $\overline{\text{GRID1}}$ Input	1	0	0
2	Segment Data for $\overline{\text{GRID2}}$ Input	0	1	0
3	Segment Data for $\overline{\text{GRID3}}$ Input	1	1	0
4	Digital Dimming Data Input	0	0	1

Segment Data Input [Function Mode: 0 to 3]

- ML9213 receives the segment data when function mode 0 to 3 are selected.
- The same segment data is transferred to the 3 segment data latches corresponding to $\overline{\text{GRID1}}$ to $\overline{3}$ at the same time when the function mode 0 is selected.
- The segment data is transferred to only one segment data latch corresponding to the specified GRID when the function mode is 1, 2 or 3 is selected.
- Segment output (SEG1 to 56) becomes High level (lighting) when the segment data (S1 to S56) is set to "1".

[Data Format]

Input Data : 59 bits

Segment Data: 56 bits

Mode Data : 3 bits

Bit	1	2	3	4	53	54	55	56	57	58	59
Input Data	S1	S2	S3	S4	S53	S54	S55	S56	M0	M1	M2
	← Segment Data (56 bits) →									← Mode Data (3 bits) →		

[Bit correspondence between segment output and segment data]

Segment output	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Segment data	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
Segment output	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Segment data	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30	S31	S32
Segment output	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Segment data	S33	S34	S35	S36	S37	S38	S39	S40	S41	S42	S43	S44	S45	S46	S47	S48
Segment output	49	50	51	52	53	54	55	56	---	---	---	---	---	---	---	---
Segment data	S49	S50	S51	S52	S53	S54	S55	S56	---	---	---	---	---	---	---	---

Anode Dimming Data Input [Function Mode: 4]

- ML9213 receives the anode dimming data when function mode 4 is selected.
- The output duty changes in the range of 0/1024 (0%) to 1016/1024 (99.2%) for each grid.
- The 10-bit anode dimming data is input from LSB.

[Data Format]

Input Data : 13 bits
 Anode Dimming Data : 10 bits
 Mode Data : 3 bits

Bit	1	2	3	4	5	6	7	8	9	10	11	12	13
Input Data	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	M0	M1	M2
	<div>LSB<div><div></div><div>Digital Dimming Data (10bits)</div><div></div></div>MSB</div>												
											Mode Data (3bits)		
(LSB)Dimming Data(MSB)											Duty Cycle		
D1	D2	D3	D4	D5	D6	D7	D8	D9	D10				
0	0	0	0	0	0	0	0	0	0	0	0/1024		
1	0	0	0	0	0	0	0	0	0	0	1/1024		
1	1	1	0	1	1	1	1	1	1	1	1015/1024		
0	0	0	1	1	1	1	1	1	1	1	1016/1024		
1	0	0	1	1	1	1	1	1	1	1	1016/1024		
1	1	1	1	1	1	1	1	1	1	1	1016/1024		

Master Mode

Master Mode is selected when $\overline{M/S}$ pin is set at High level. The master mode operation is as follows:

- Input to DIM IN, SYNC IN1 and SYNC IN2 is ignored, and these pins should be connected to L-GND or V_{DD} .
- The pulse width of SEG1 to SEG56 is controlled by the internal digital dimming circuit.
- The segment data corresponding to $\overline{GRID1}$ to $\overline{3}$ is selected by the internal timing generator.

Slave Mode

Slave Mode is selected when M/\overline{S} pin is set at Low level. The slave mode operation is as follows:

- Output from internal anode dimming circuit is ignored. Connect the DIM IN, SYNC IN1 and SYNC IN2 pins to the master side DIM OUT, SYNC OUT1 and SYNC OUT2 pins respectively.
- The pulse width of SEG1 to 56 is controlled by the pulse width of DIM IN signal.
- The segment data corresponding to $\overline{GRID1}$ to $\overline{3}$ is selected by combinations of the SYNC IN1 and SYNC IN2 signals.
- The output levels of $\overline{GRID1}$ to $\overline{3}$ are set at High level. The output levels of DIM OUT, SYNC OUT1 and SYNC OUT2 are set at Low level.

[Correspondence between SYNC IN1, 2 and $\overline{GRID1}$ to $\overline{3}$]

SYNC IN 1	SYNC IN 2	Segment Latch	GRID
0	0	No	No
1	0	Latch1	$\overline{GRID1}$
0	1	Latch2	$\overline{GRID2}$
1	1	Latch3	$\overline{GRID3}$

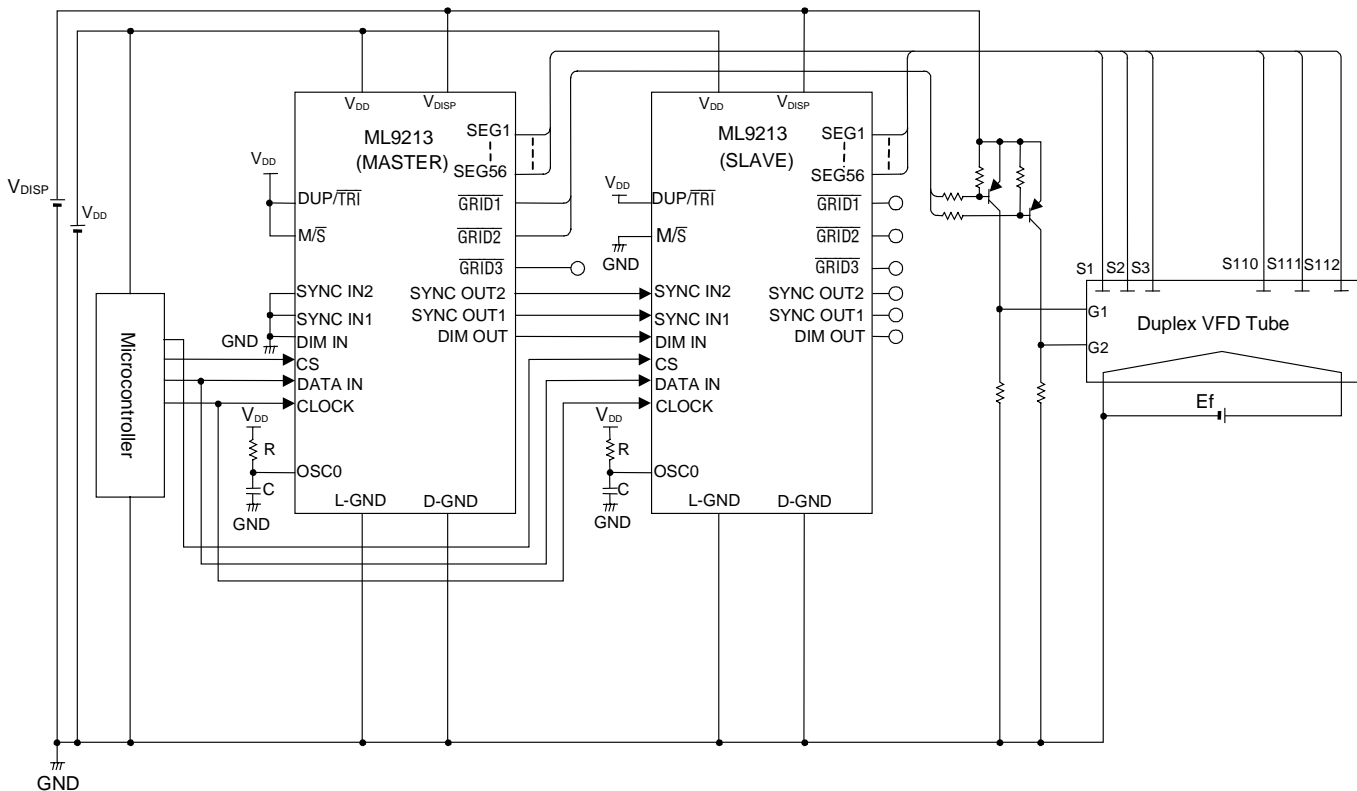
[Correspondence between DIM IN and SEG1 to 56]

DIM IN	SEG1 to 56
0	Low
1	High

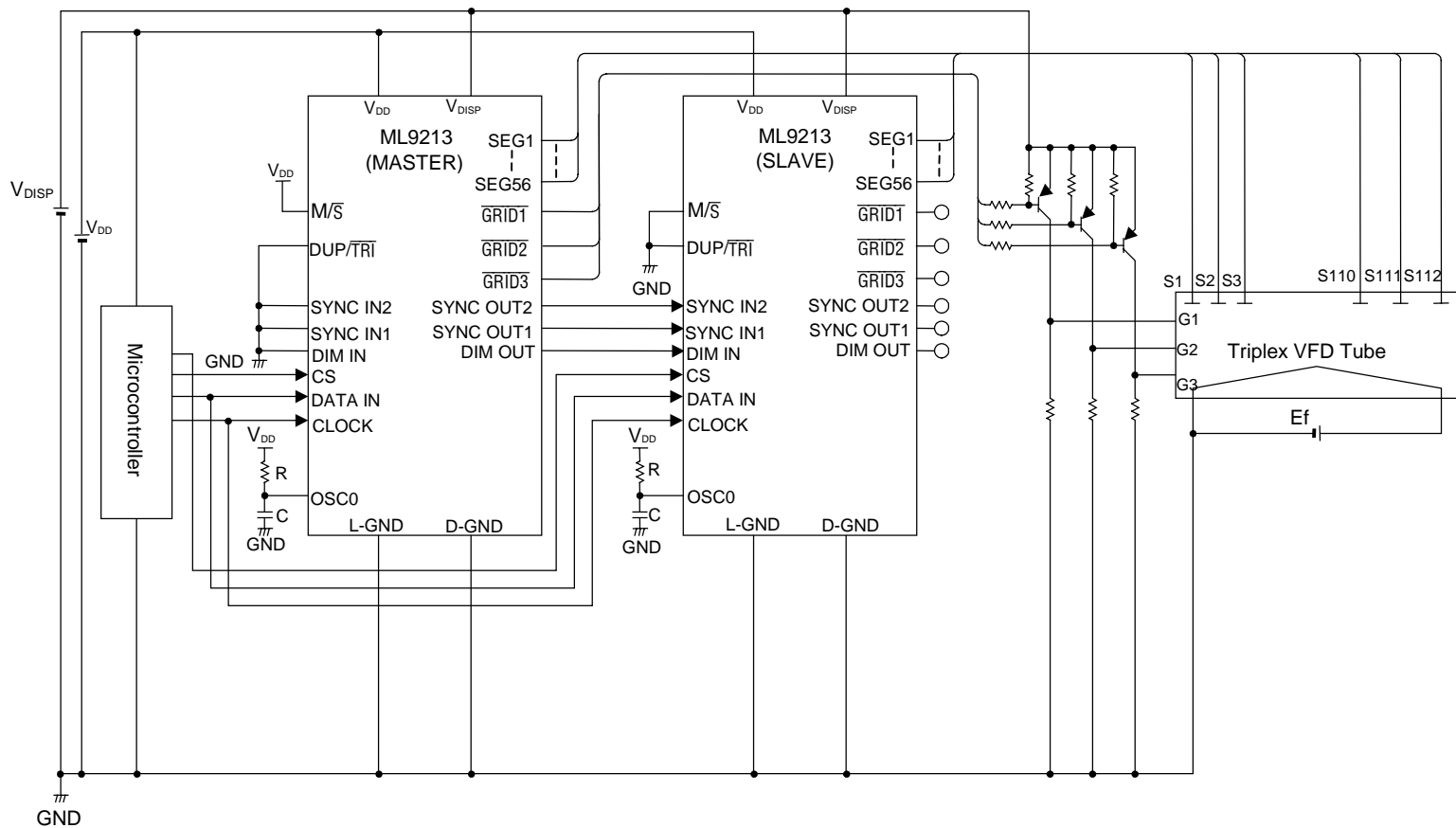
Note: Low: Lights OFF
High: Lights ON

APPLICATION CIRCUITS

1. Circuit for the duplex VFD tube (2-Grid × 112-Anode)

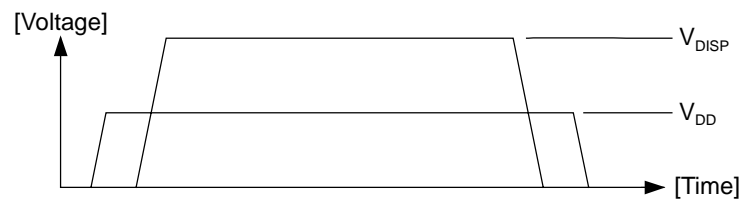


2. Circuit for the triplex VFD tube (3-Grid x 112-Anode)

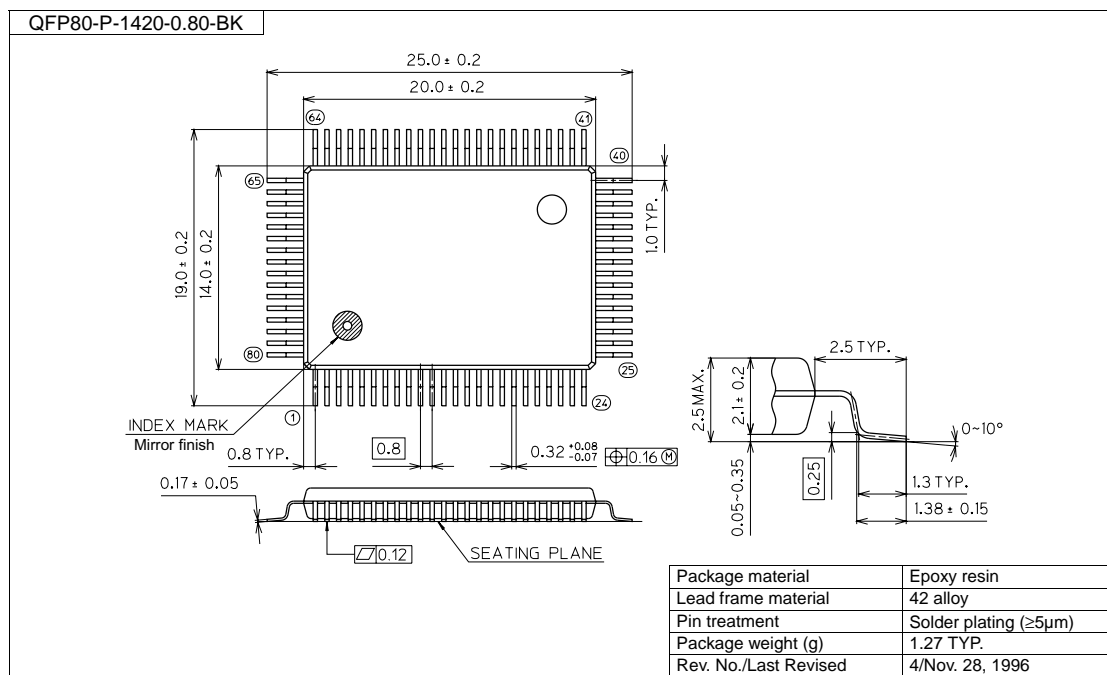


NOTES ON TURNING POWER ON/OFF

- Connect L-GND and D-GND externally to be an equal potential voltage.
- To avoid wrong operations, turn on the driver power supply after turning on the logic power supply. Conversely, turn off the logic power supply after turning off the driver power supply.

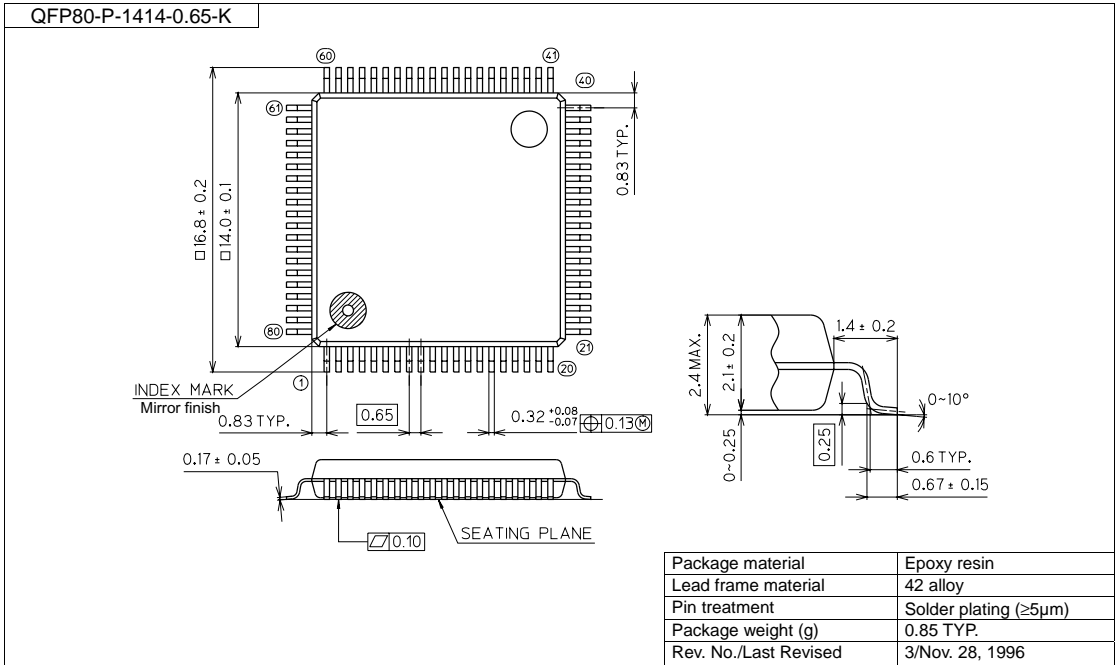


(Unit: mm)



Therefore, before you perform reflow mounting, contact responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

(Unit: mm)



Notes for Mounting the Surface Mount Type Package

The surface mount type packages are very susceptible to heat in reflow mounting and humidity absorbed in storage. Therefore, before you perform reflow mounting, contact responsible sales person for the product name, package name, pin number, package code and desired mounting conditions (reflow method, temperature and times).

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