



# Digitally Programmable 8 to 25 Multiplex LCD Controller & Driver

## Features

- Slim IC for chip-on-board, with gold bumps for Chip-On-Glas and Chip-On-Flex technologies
- Very simple 2-wire interface
- Digitally programmable multiplex rates: 8 x 113, 9 x 112, 16 x 105, 17 x 104, 20 x 101, 21 x 100, 24 x 97, 25 x 96
- No lost pads while row driver from 8 up to 25
- On chip: Voltage multiplier,  $V_{LCD}$  up to 7 V (3 to 6 V at 25 °C), 64  $V_{LCD}$  digitally programming steps, 4  $V_{LCD}$  temperature compensation factors, bias generation,  $V_{ON} / V_{OFF}$  generation, frame frequency, display refresh RAM
- No busy state
- High noise immunity in inputs
- No external components needed, except a  $V_{LCD}$  capacitor
- Digitally reversing row data
- Digitally reversing column data
- Inverting data function
- Blank function
- Set function
- Checker and Inverted Checker functions
- Sleep modes
- Low LCD operating current consumption
- Wide  $V_{DD}$  voltage supply range, 2 to 5 V
- Wide temperature range: -40 to + 85 °C
- Direct display of RAM data through the display data RAM

(To cascade ICs, please see Fig. 19 and contact EM-Marlin.)

## Description

The EM6124 is a low power CMOS LCD controller and driver. The 8, 16, 20 and 24 way multiplex are digitally programmable by the command byte. One additional line can be added for Icons or Inverted Video by programming 9, 17, 21 or 25 way multiplex. The display refresh is handled on chip by an internal RC oscillator via one selectable 25 x 116 RAM which holds the LCD content driven by the driver. LCD pixels (or segments) are addressed on a one to one basis with the 25 x 116 bit RAM (a set bit corresponds to an activated LCD pixel). The EM6124 has very low dynamic current consumption, typically 70  $\mu A$  at  $V_{DD} = 2 V$ ,  $V_{LCD} = 7 V$  making it particularly attractive for portable and battery powered products. The wide operating range on supply voltages and temperature offers much application flexibility. The LCD voltage, bias generation and frame frequency are generated on chip. The clock signal can be used to shift and to latch the data into the RAM.

## Applications

- Mobile phones (GSM, DECT)
- Smart cards
- Automotive displays
- Portable, battery operated products
- Balances and scales, utility meters

## Typical Operating Configuration

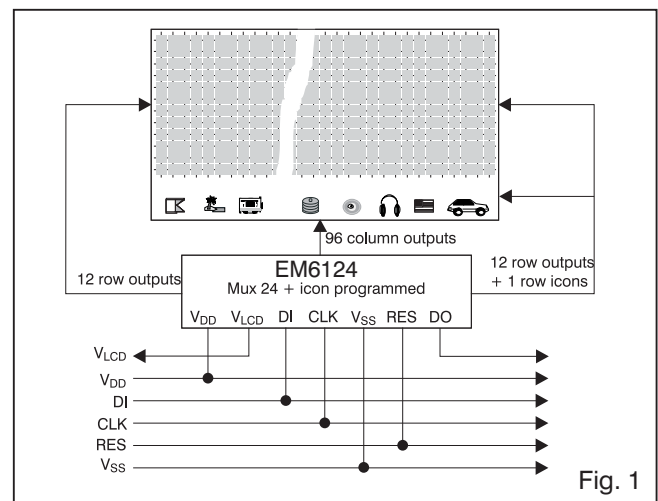
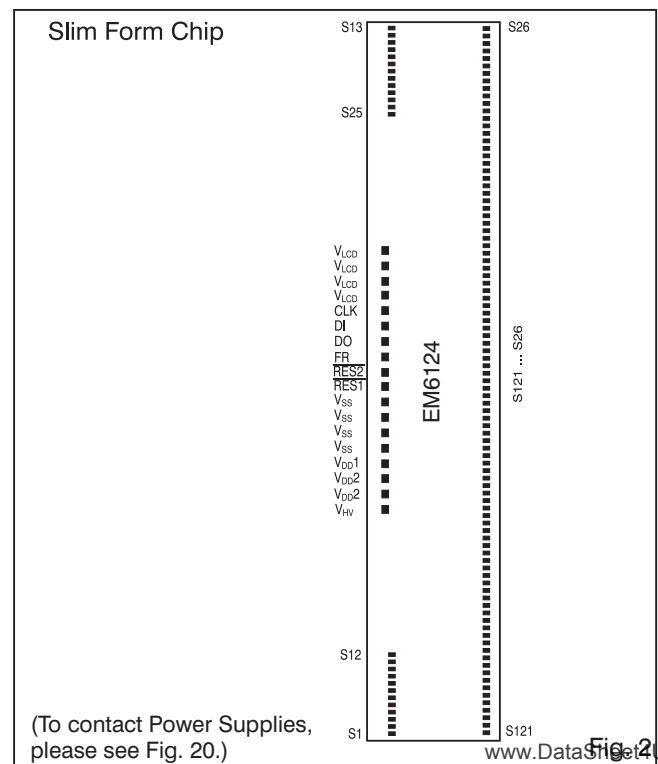


Fig. 1

## Pad Assignment



(To contact Power Supplies, please see Fig. 20.)

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## Absolute Maximum Ratings

Parameter	Symbol	Conditions
Supply voltage range	$V_{DD1,2}$	-0.3 V to 6 V
Supply high voltage range	$V_{HV}$	-0.3 V to 6 V
Internal generated $V_{LCD}$	$V_{LCD}$	7 V
Voltage at DI, DO, CLK, FR, RES	$V_{LOGIC}$	-0.3 V to $V_{DD} + 0.3$ V
Voltage at S1 to S121	$V_{DISP}$	-0.3 V to $V_{LCD} + 0.3$ V
Storage temperature range	$T_{STO}$	-65 to +150 °C
Electrostatic discharge max. to MIL-STD-883C method 3015	$V_{Smax}$	1000 V
Maximum soldering conditions	$T_{Smax}$	250 °C x 10 s

Table 1

Stresses above these listed maximum ratings may cause permanent damage to the device. Exposure beyond specified operating conditions may affect device reliability or cause malfunction.

## Handling Procedures

This device has built-in protection against high static voltages or electric fields; however, anti-static precautions must be taken as for any other CMOS component. Unless otherwise specified, proper operation can only occur when all terminal voltages are kept within the supply voltage range. Unused inputs must always be tied to a defined logic voltage level.

## Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit
Operating temperature	$T_A$	-40		+85	°C
Logic supply voltage	$V_{DD1,2}$	2	3	5.5	V
Supply high voltage	$V_{HV}$	2.5	3	5.5	V

Table 2

## Electrical Characteristics

$V_{DD1} = V_{DD2} = 3$  V,  $V_{HV} = 2.5$  to 5 V, and  $T_A = -40$  to +85 °C, unless otherwise specified

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Standby supply current	$I_{DD}$	See note <sup>1)</sup>		16	22	$\mu$ A
Standby supply current	$I_{HV}$	See note <sup>1)</sup> , $V_{LCD}$ step 30 (hexa)		65	170	$\mu$ A
Dynamic supply current	$I_{DD}$	See note <sup>2)</sup>		57	75	$\mu$ A
Standby supply current	$I_{HV}$	See note <sup>3)</sup> , $V_{LCD}$ step 00 (hexa)		35	140	$\mu$ A
Sleep mode supply current	$I_{DD}$			0.1		$\mu$ A
Sleep mode supply current	$I_{HV}$			0.1		$\mu$ A
<b>Control Signals DI, CLK, FR, RES1, RES2</b>						
Input leakage	$I_{IN}$	$V_{DD1,2}$ or $V_{SS}$	-1		1	$\mu$ A
Input capacitance	$C_{IN}$	at $T_A = 25$ °C		8		pF
Low level input voltage	$V_{IL}$		0		$0.3 V_{DD1,2}$	V
High level input voltage	$V_{IH}$		$0.7 V_{DD1,2}$		$V_{DD1,2}$	V
DC output component	$\pm$ VDC	See table 4		30	100	mV
$V_{LCD}$ (internally generated)	$V_{LCD}$	See note <sup>4)</sup>		6.15		
$V_{LCD}$	$V_{LCD}$	See note <sup>5)</sup>		3.15 - 7.09		V
	$V_{LCD}$ step			62.5		mV

Table 3

<sup>1)</sup> All outputs open, DI and CLK at  $V_{SS}$ , mux ratio = 24, checker pattern.

<sup>2)</sup> All outputs open, DI at  $V_{SS}$ ,  $f_{CLK} = 1$  MHz, mux ratio = 24, checker pattern.

<sup>3)</sup> DI and CLK at  $V_{SS}$ , checker pattern, mux ratio = 8.

<sup>4)</sup> Initialization bits 18 to 23 = 110000 and initialization bits 10, 11 = 00; laser trimming on request.

<sup>5)</sup> Initialization bits 18 to 23 = 000000/111111.

## DC Output Component

Output	Frame	Logic Data	Measured*	Guaranteed
Row Driver	n	OL	$ V_{LCD} - V_1 $	$V_1 = 0.83 \times V_{LCD} \pm 100$ mV
	n + 1	OL	$ V_4 - V_{SS} $	$V_2 = 0.66 \times V_{LCD} \pm 100$ mV
Column Driver	n	OL	$ V_{LCD} - V_2 $	$V_3 = 0.34 \times V_{LCD} \pm 100$ mV
	n + 1	OL	$ V_3 - V_{SS} $	$V_4 = 0.17 \times V_{LCD} \pm 100$ mV

$$*V_x = \frac{V_x (\text{load} = +1 \mu\text{A}) + V_x (\text{load} = -1 \mu\text{A})}{2}, \text{ mux 24 or 25 programmed, } V_{LCD} = 6 \text{ V, } T_A = 25 \text{ °C.}$$

Table 4

Test is performed for multiplex rate = 25. All multiplex rate  $\neq$  25 are guaranteed by design. If multiplex rate  $\neq$  25, test will be performed on request.



## Timing Characteristics

$V_{DD1} = V_{DD2} = 2$  to  $3$  V,  $V_{HV} = 2.5$  to  $5$  V, and  $T_A = -40$  °C to  $+85$  °C

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Clock high pulse width	$t_{CH}$		70			ns
Clock low pulse width	$t_{CL}$		110			ns
Clock period	$t_{per}$		550			ns
Reset 1 pulse width	$t_{RES1}$		10			$\mu$ s
Reset 2 pulse width	$t_{RES2}$		130			ns
Clock and FR rise time	$t_{CR}$				200	ns
Clock and FR fall time	$t_{CF}$				200	ns
Data input setup time	$t_{DS}$		20			ns
Data input hold time	$t_{DH}$		260			ns
FR (internal frame frequency)	$f_{FR}^{1)}$			75		Hz

<sup>1)</sup> EM6124 (n), FR = n times the desired LCD refresh rate where n is the EM6124 mux mode number; laser trimming on request.

Table 5a

See Fig. 17.01 and 17.02 for more details concerning the frame frequency

$V_{DD1} = V_{DD2} = 3$  to  $5$  V,  $V_{HV} = 2.5$  to  $5$  V, and  $T_A = -40$  °C to  $+85$  °C

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Clock high pulse width	$t_{CH}$		50			ns
Clock low pulse width	$t_{CL}$		55			ns
Clock period	$t_{per}$		350			ns
Reset 1 pulse width	$t_{RES1}$		10			$\mu$ s
Reset 2 pulse width	$t_{RES2}$		80			ns
Clock and FR rise time	$t_{CR}$				200	ns
Clock and FR fall time	$t_{CF}$				200	ns
Data input setup time	$t_{DS}$		20			ns
Data input hold time	$t_{DH}$		140			ns
FR (internal frame frequency)	$f_{FR}^{1)}$			75		Hz

<sup>1)</sup> EM6124 (n), FR = n times the desired LCD refresh rate where n is the EM6124 mux mode number; laser trimming on request.

Table 5b

## Timing Waveforms

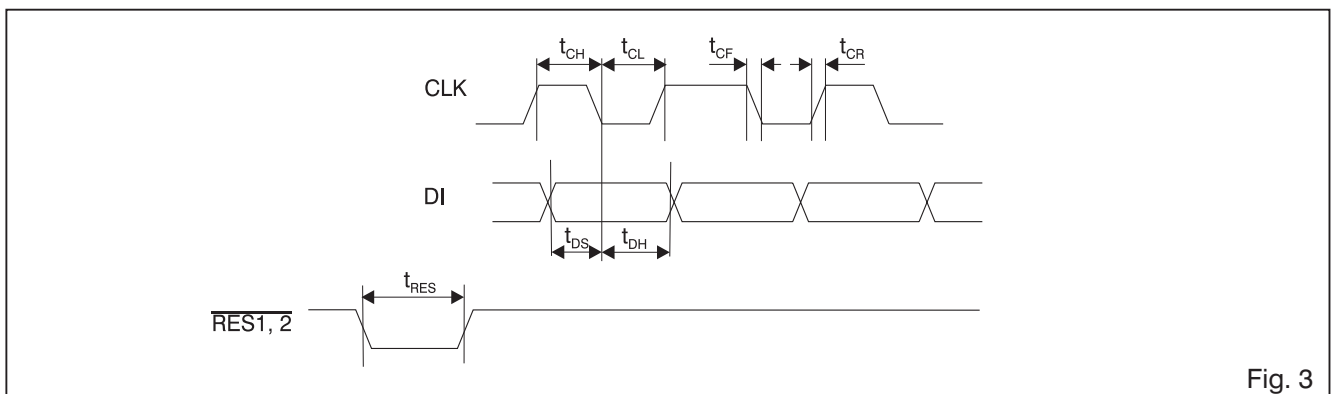


Fig. 3



## 1 Bit Interface Description

This 1 bit interface is very simple to use. There are three modes to load data into the EM6124.

### Command byte only mode

To validate this mode, 8 bits must be shifted with bit 3 to bit 7 setted to 1L. This mode is used for blank, set or sleep mode functions.

### Command byte and initialization mode

To validate this mode, 32 bits must be shifted with bit 0 and bit 1 setted to 1L. Bit 2 (sleep) can be active or inactive. Bit 3 to bit 7 (RAM address) can be in any state but it is important that they are not all simultaneously setted to 1L, otherwise the chip will be in command byte only mode.

### Command byte and display information mode

To validate this mode, 128 bits must be shifted, eight first bits are for command byte, all the other are RAM data depending of col bit mode and multiplex ratio. There are also x bits don't care in each loading depending on the programming of the chip (see Fig. 4 for more details). In each RAM's data loading, the command byte has to be introduced for the RAM address. Before loading any data into the RAM the chip has to be initialized.

### Command Byte

Command Bits 0 to 7								
0	1	2	3	4	5	6	7	
Blank	Set	Sleep	RAM address					

Table 6

**Cmdbit 0:** Blank bit forces all column outputs off.

**Cmdbit 1:** Set bit forces all column output on.

Note: If bit 0 and bit 1 are both to 1L, the chip will be in initialization mode. See remarks below.

**Cmdbit 2:** Sleep mode bit, stops the voltage booster and the internal oscillator, active bit col forces all outputs to  $V_{SS}$ .

**Cmdbits 3-7:** RAM address bits. See table 6.

If Cmdbits 3-7 are set to 1L, EM6124 is in Cmd byte only mode.

### Initialization Bits

Initialization Bits 8 to 15							
8	9	10	11	12	13	14	15
Mux Mode	Temp. Coeff.	Checker	Inv.Checker	Col	Inv.Row		
Initialization Bits 16 to 23							
16	17	18	19	20	21	22	23
M/LSB	Video	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Initialization Bits 24 to 31							
24	25	26	27	28	29	30	31
Icon	Sleep 2	Test 6	Test 5	Test 4	Test 3	Test 2	Test 1

Table 7

Mux ratio (Init. bit 8, 9)		
8	9	mux mode
0	0	8
0	1	16
1	0	20
1	1	24

Table 8

**Init.bit 8-9:** Mux mode bits. The multiplex ratio is selected by these two bits. Table 8 shows the corresponding values.

**Init.bit 10-11:**  $V_{LCD}$  temperature coefficient is selected by these two bits. Table 11 shows the corresponding values.

**Init.bit 12:** Checker bit gives the possibility to force all outputs segments in checked form (see Fig. 10 and Fig. 18.14).

**Init.bit 13:** Inverse Checker bit gives the possibility to force all outputs segments in inverse checked form (see Fig. 10 and Fig. 18.15).

**Init.bit 14:** Col bit configures the EM6124 on row and column driver or column driver only. In this mode the frame frequency must be external.

**Init.bit 15:** Row inversion, possibility to inverse the order of the row outputs (see Table 10 and Fig. 18.12).

**Init.bit 16:** M/LSB, possibility to inverse the order loading for RAM data (see Fig. 4).

**Init.bit 17:** Video bit, possibility to inverse the content of the RAM. All the 0L pass to 1L and all the 1L pass to 0L (see Fig. 18.11).

**Init.bit 18-23:**  $V_{LCD}$  64 steps programming bits. See Fig. 8. Bit 18 (step 1) for MSB and bit 23 (step 6) for LSB.

**Init.bit 24:** Icon bit adds one line more to the selected mux mode ratio for icon segments outputs.

**Init.bit 25:** Sleep 2. Set all outputs at  $V_{SS}$ .

**Init.bit 26-31:** Must be setted to 0L.

### Reset 1

**Power-up:** Must be followed by a RESET cycle. After the reset 1 pulse the LCD controller driver is set to the following status:

- All outputs at  $V_{SS}$
- Blank & Set (cmdbits 0,1) = 0L
- Sleep mode (cmdbit 2) = 0L
- RAM address (cmdbits 3 to 7) = 0L
- Multiplex ratio (init.bits 8, 9) = 0L
- Temperature coefficient (init.bits 10,11) = 0L
- Checker & Inv.Checker (init.bits 12, 13) = 0L
- Col Mode (init.bit 14) = 1L
- Inv. Row (init.bit 15) = 0L
- M/LSB (init.bit 16) = 1L
- Video (init.bit 17) = 1L
- $V_{LCD}$  step (init.bits 18 to 23) = 0L
- Icon (init.bit 24) = 0L
- Sleep 2 (init.bit 25) = 1L
- The content of the RAM remains unchanged

An initialization should take place after reset (32 bits sent).

## Pin Assignment

Name	Function
S1...S121	LCD outputs, see Fig.4
FR	AC I/O signal for LCD driver output
DI	Serial data input
DO	Serial data output
CLK	Data clock input
RES1	General reset
RES2	Reset the serial interface counter
$V_{LCD}$	Internal generated voltage output
$V_{DD1}$	Power supply for logic
$V_{DD2}$	Power supply for analogic
$V_{HV}$	Power supply for high voltage
$V_{SS}$	Supply GND

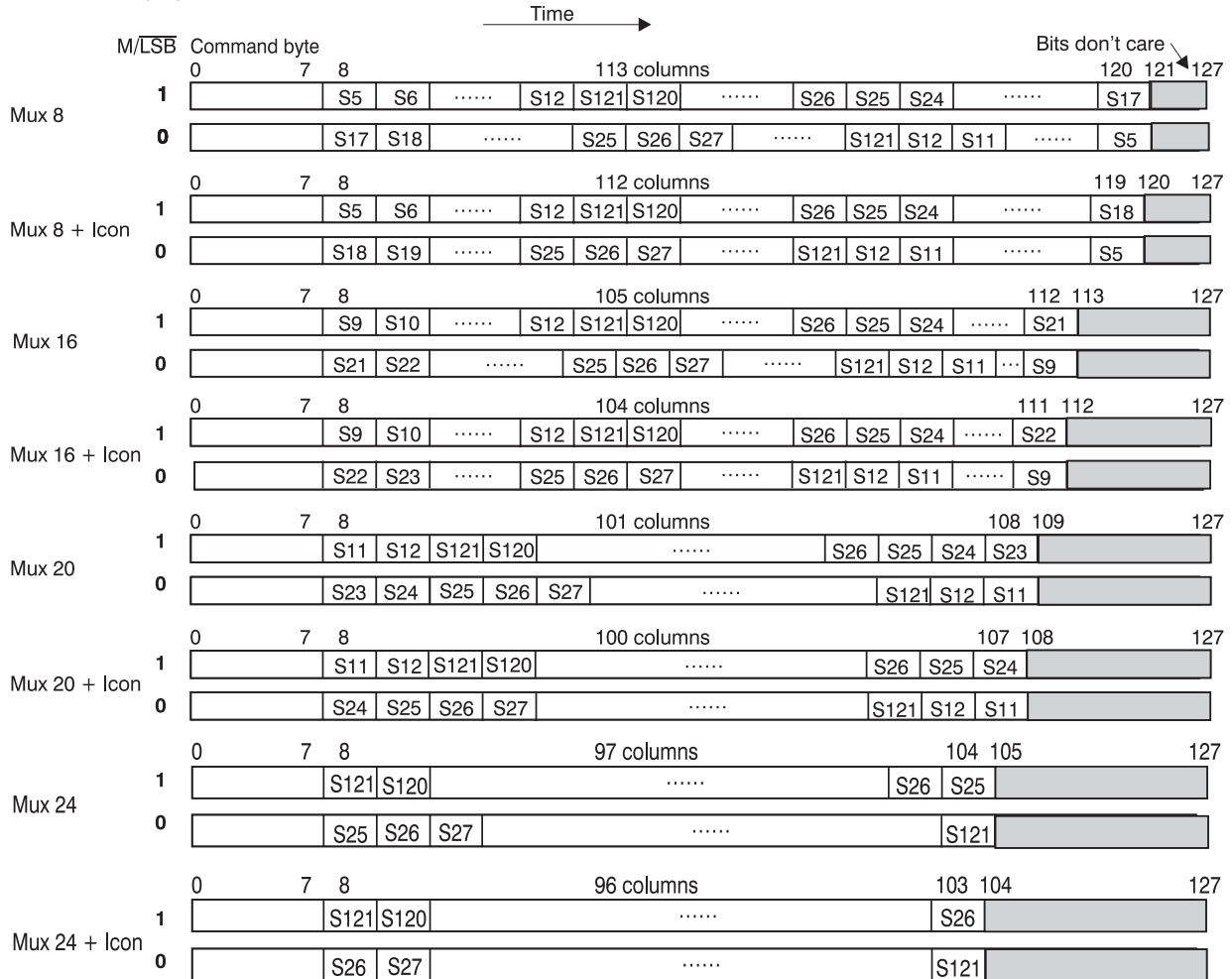
Table 9



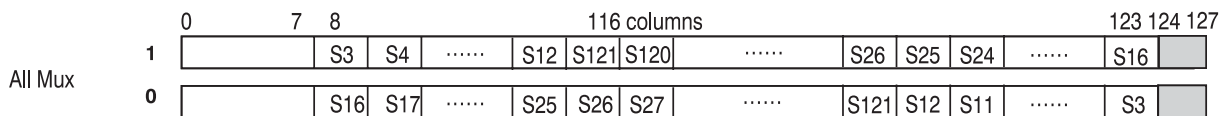
## Data Transfer Cycle

### 1. $\overline{CoI}$ inactive (1L)

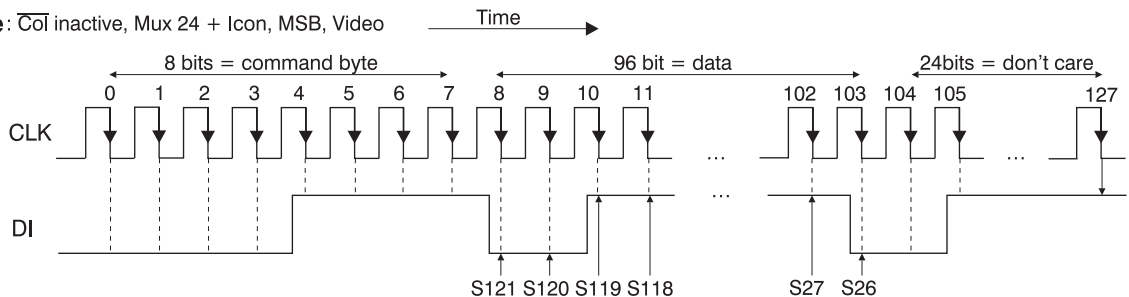
Command byte and display information mode need 128 bit load cycles.



### 2. $\overline{CoI}$ active (0L)



### 3. Example: $\overline{CoI}$ inactive, Mux 24 + Icon, MSB, Video



RAM address = 01111 = S16 (See table 10).

For row connected to pad S16, column connected to pad S119 is "ON", to pad S26 is "OFF".

Fig. 4



## Output Row Assignments

Row	RAM Address					Mux Mode																			
						Mux 8		Mux 8 + Icon		Mux 16		Mux 16 + Icon		Mux 20		Mux 20 + Icon		Mux 24		Mux 24 + Icon					
						Inv. Row		Inv. Row		Inv. Row		Inv. Row		Inv. Row		Inv. Row		Inv. Row		Inv. Row					
Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1			
1	0	0	0	0	0	S1	S16	S1	S17	S1	S20	S1	S21	S1	S22	S1	S23	S1	S24	S1	S25				
2	0	0	0	0	1	S2	S15	S2	S16	S2	S19	S2	S20	S2	S21	S2	S22	S2	S23	S2	S24				
3	0	0	0	1	0	S3	S14	S3	S15	S3	S18	S3	S19	S3	S20	S3	S21	S3	S22	S3	S23				
4	0	0	0	1	1	S4	S13	S4	S14	S4	S17	S4	S18	S4	S19	S4	S20	S4	S21	S4	S22				
5	0	0	1	0	0	S13	S4	S13	S13	S5	S16	S5	S17	S5	S18	S5	S19	S5	S20	S5	S21				
6	0	0	1	0	1	S14	S3	S14	S4	S6	S15	S6	S16	S6	S17	S6	S18	S6	S19	S6	S20				
7	0	0	1	1	0	S15	S2	S15	S3	S7	S14	S7	S15	S7	S16	S7	S17	S7	S18	S7	S19				
8	0	0	1	1	1	S16	S1	S16	S2	S8	S13	S8	S14	S8	S15	S8	S16	S8	S17	S8	S18				
9	0	1	0	0	0			S17	S1	S13	S8	S13	S13	S9	S14	S9	S15	S9	S16	S9	S17				
10	0	1	0	0	1					S14	S7	S14	S8	S10	S13	S10	S14	S10	S15	S10	S16				
11	0	1	0	1	0					S15	S6	S15	S7	S13	S10	S13	S13	S11	S14	S11	S15				
12	0	1	0	1	1					S16	S5	S16	S6	S14	S9	S14	S10	S12	S13	S12	S14				
13	0	1	1	0	0					S17	S4	S17	S5	S15	S8	S15	S9	S13	S12	S13	S13				
14	0	1	1	0	1					S18	S3	S18	S4	S16	S7	S16	S8	S14	S11	S14	S12				
15	0	1	1	1	0					S19	S2	S19	S3	S17	S6	S17	S7	S15	S10	S15	S11				
16	0	1	1	1	1					S20	S1	S20	S2	S18	S5	S18	S6	S16	S9	S16	S10				
17	1	0	0	0	0							S21	S1	S19	S4	S19	S5	S17	S8	S17	S9				
18	1	0	0	0	1									S20	S3	S20	S4	S18	S7	S18	S8				
19	1	0	0	1	0									S21	S2	S21	S3	S19	S6	S19	S7				
20	1	0	0	1	1									S22	S1	S22	S2	S20	S5	S20	S6				
21	1	0	1	0	0											S23	S1	S21	S4	S21	S5				
22	1	0	1	0	1													S22	S3	S22	S4				
23	1	0	1	1	0													S23	S2	S23	S3				
24	1	0	1	1	1													S24	S1	S24	S2				
25	1	1	0	0	0															S25	S1				

Table 10

### Command Byte Only Mode

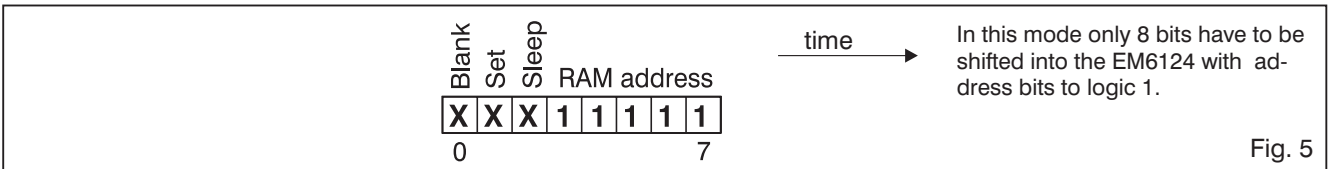


Fig. 5

### Command Byte and Initialization Mode

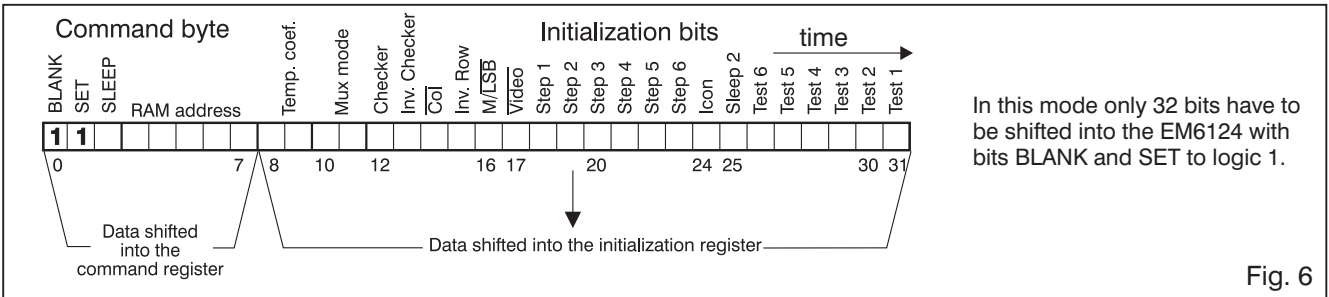


Fig. 6

### Command Byte and Display Information Mode

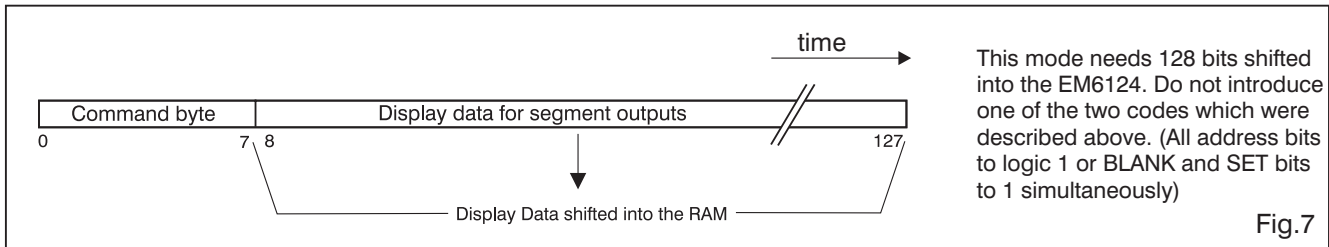
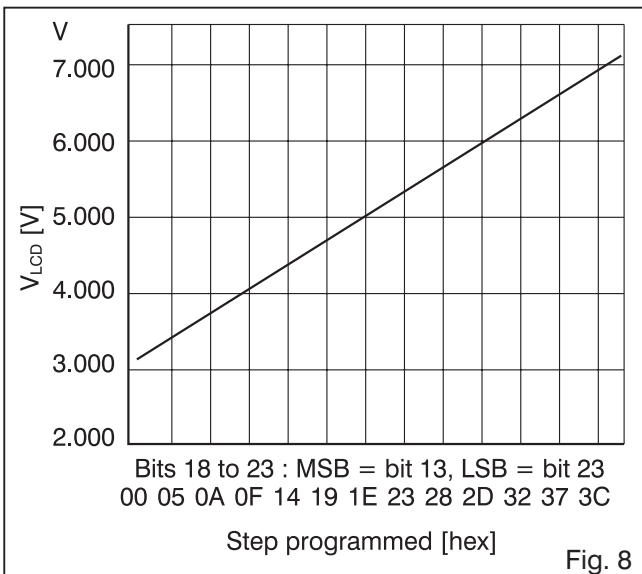


Fig. 7



## Typical $V_{LCD}$ Programming



## Temperature Control

Due to the temperature dependency of liquid crystals viscosity the LCD controlling voltage  $V_{LCD}$  must be increased for lower temperatures to maintain optimal contrast. The EM6124 is available with 4 different temperature coefficients (see Fig. 9). The coefficient is selected by 2 bits in the initialization code TC bits 10 and 11. Table 11 shows the typical values of the different temperature coefficients. They are proportional to the programmed  $V_{LCD}$ .

### Typical Values of the Temperature Coefficients

Bit 10, Bit 11	Value	Unit
0 0	$- 0.02 \times V_{LCD}$	mV/°C
0 1	$- 0.52 \times V_{LCD}$	mV/°C
1 0	$- 1.16 \times V_{LCD}$	mV/°C
1 1	$- 1.82 \times V_{LCD}$	mV/°C

Table 11

## Temperature Coefficients

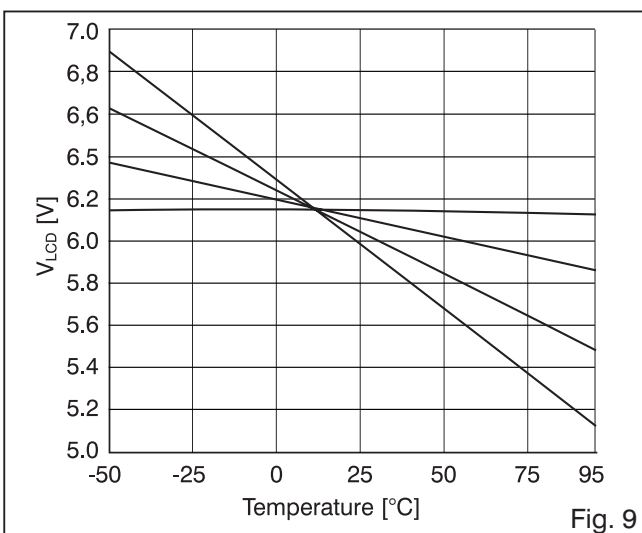


Fig. 9

## Checker and Checker Inverse

A fast check display can be easily created setting initialization bits 12 and 13 (called “Checker” and “Inv. Checker”). The display is completely checked with only 2 initialization sequences, one “Checker” and one “Inv. Checker”. For Checker, the pattern fills the display with alternately ON and OFF pixels as shown in Fig. 10. For Inv. Checker, everything is inverted (see Fig. 18.14 and 18.15).

### Pattern of Checker Mode

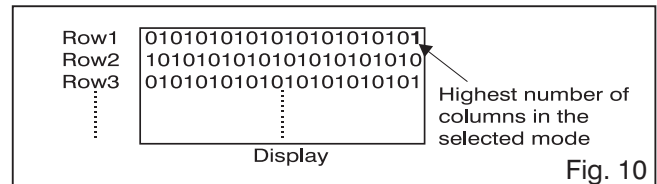
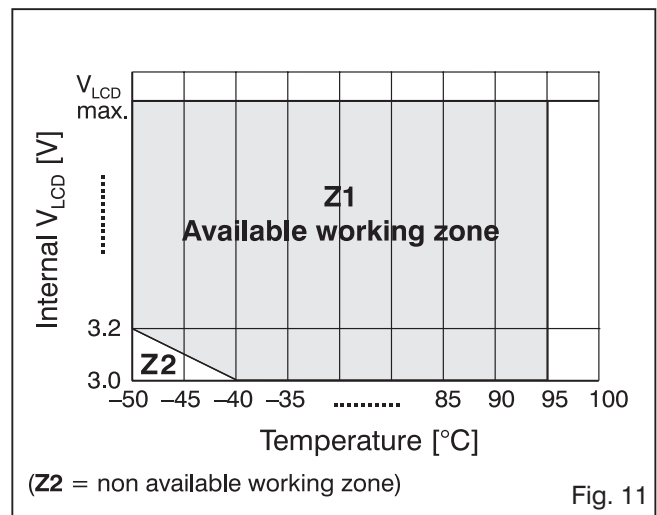


Fig. 10

## Internally Generated $V_{LCD}$ versus Temperature



(Z2 = non available working zone)

Fig. 11



## Display Functions

Bit	State	
	Logic 0	Logic 1
8 - 9: Mux Mode	See table 8	
10 - 11: Temp.Coeff.	See table 11	
12: Checker	Inactive	Chess display
13: Inv. Checker	Inactive	Inverse chess display
14: Col	Colum driver only	Row and column driver
15: Inv. Row	Increment rows (example for mux 24: row 1, 2, 3, ... , 24, 1, 2, ...)	Decrement rows (example for mux 24: row 24, 23, 22, ... , 2, 1, 24, 23, ...)
16: $\overline{M/LSB}$	Loading in LSB mode	Loading in MSB mode
17: $\overline{Video}$	Inverse content of RAM	Inactive
18 - 23: $V_{LCD}$ step	See Fig. 8	
24: Icon	Inactive	Add one line more to selected mux mode
25: Sleep	Inactive	All outputs at $V_{SS}$
26 - 31:	Must be at 0L	

Table 12





## Block Diagram

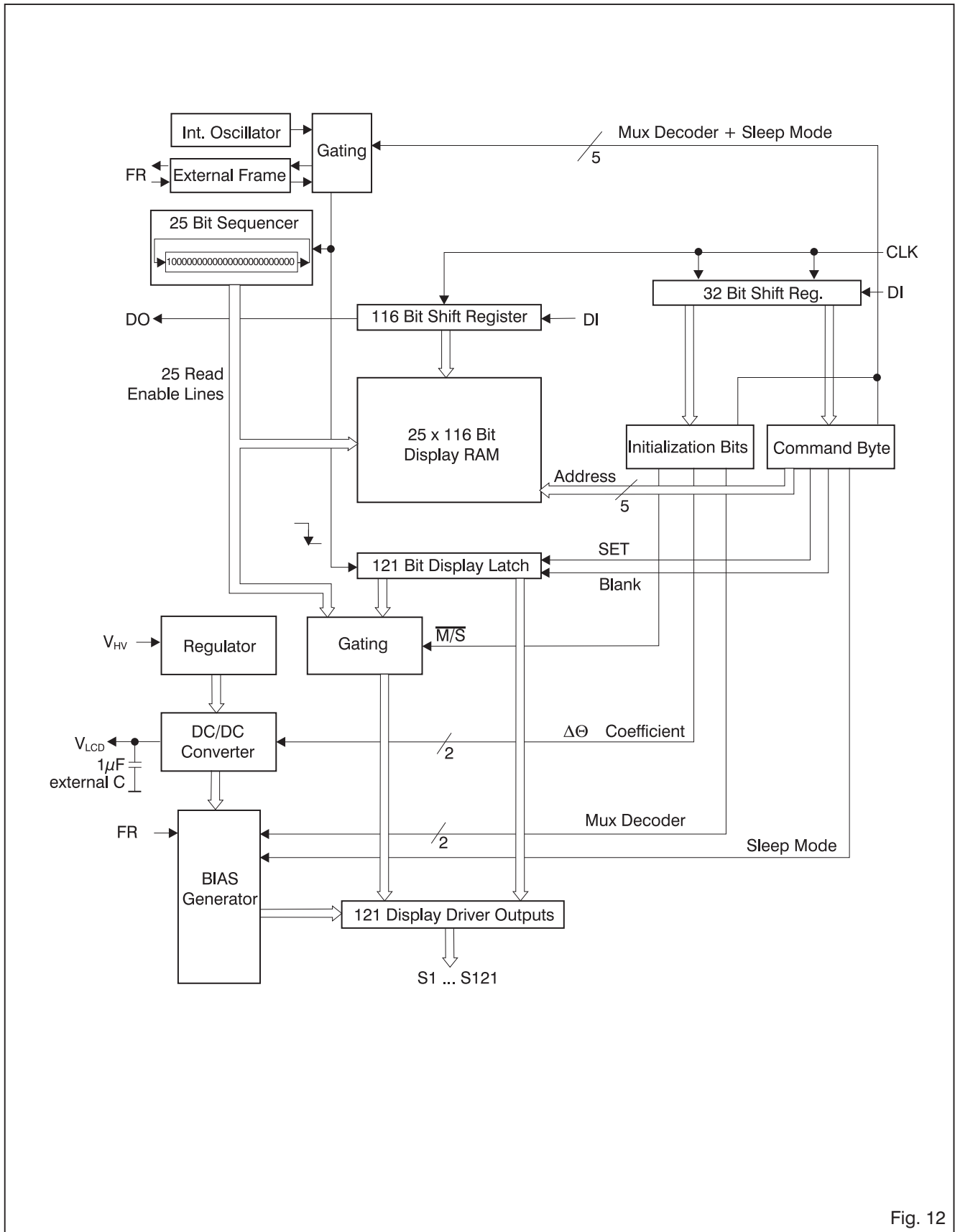


Fig. 12



## LCD Voltage Bias Levels

LCD Drive Type	LCD Bias Configuration	$\frac{V_{OP}}{V_{OFF} (rms)}$	$\frac{V_{ON} (rms)}{V_{OFF} (rms)}$
EM6124 (24) n=24 1:24 MUX	6 Levels	$\sqrt{\frac{\sqrt{n}(\sqrt{n}+1)^2}{2(\sqrt{n}-1)}} = 4.68$	$\sqrt{\frac{\sqrt{n}+1}{\sqrt{n}-1}} = 1.230$
EM6124 (20) n=20 1:20 MUX	6 Levels	$\sqrt{\frac{\sqrt{n}(\sqrt{n}+1)^2}{2(\sqrt{n}-1)}} = 4.39$	$\sqrt{\frac{\sqrt{n}+1}{\sqrt{n}-1}} = 1.255$
EM6124 (16) n=16 1:16 MUX	1/5 Bias 6 Levels	$\sqrt{\frac{\sqrt{n}(\sqrt{n}+1)^2}{2(\sqrt{n}-1)}} = 4.08$	$\sqrt{\frac{\sqrt{n}+1}{\sqrt{n}-1}} = 1.291$
EM6124 (8) n=8 1:8 MUX	1/4 Bias 5 Levels	$\frac{4}{\sqrt{1+\frac{3}{n}}} = 3.4$	$\sqrt{\frac{n-15}{n+3}} = 1.446$

Table 13

## Optimum LCD Bias Voltages

Multiplex Rate	$V_{LCD}$	V1	V2	V3	V4	$V_{SS}$
1 : 24	1	0.830	0.660	0.340	0.170	0
1 : 20	1	0.817	0.634	0.366	0.183	0
1 : 16	1	0.800	0.600	0.400	0.200	0
1 : 8	1	0.750	0.500	0.250	-	0

$V_{LCD} > V1 > V2 > V3 > V4 > V_{SS}$

The values in the above table are given in reference to  $V_{LCD}$  e.g. 0.5 means  $0.5 \times V_{LCD}$

Table 14



## Row and Column Multiplexing Waveform EM6124 (8)

$$V_{OP} = V_{LCD} - V_{SS}, V_{STATE} = V_{COL} - V_{ROW}$$

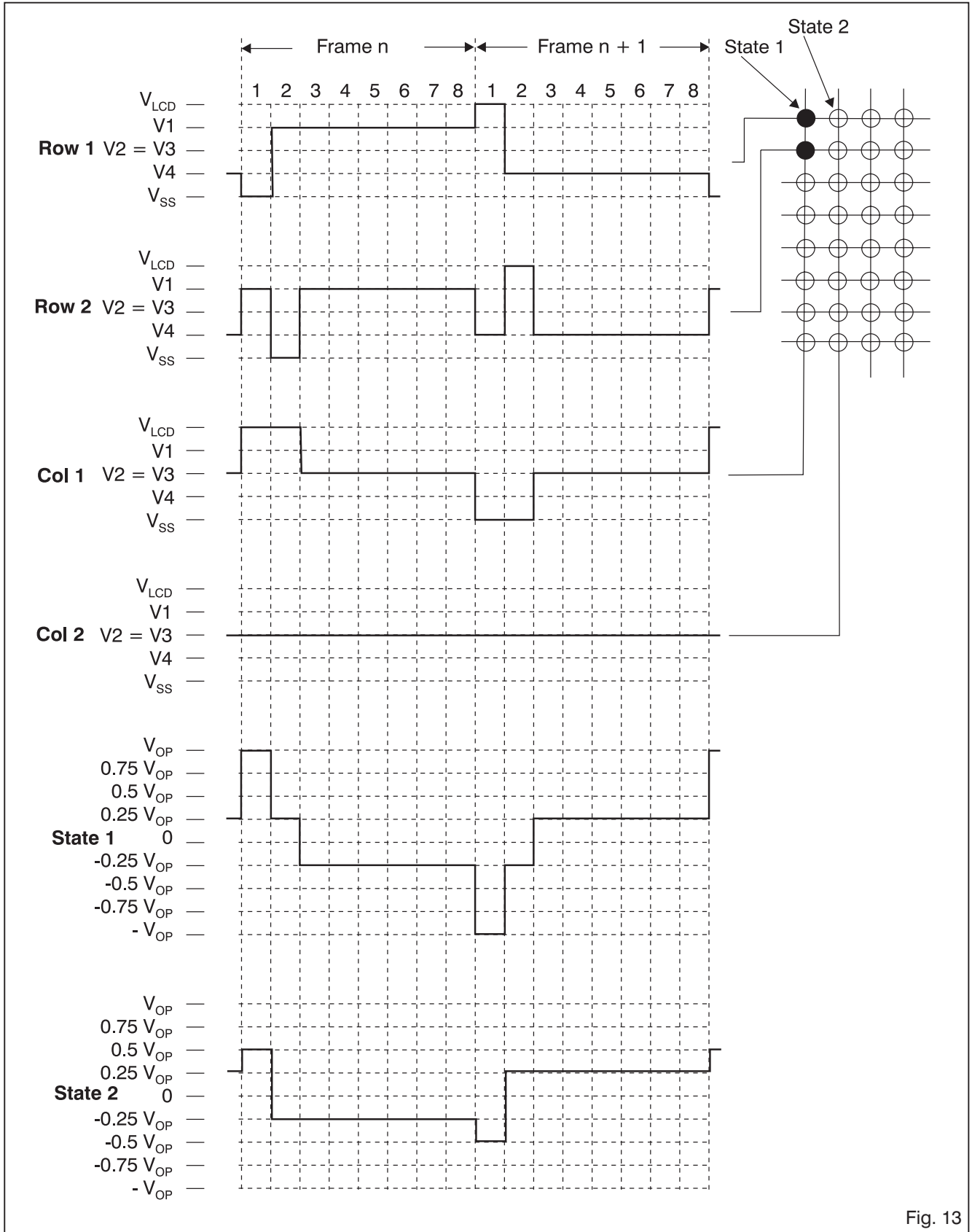


Fig. 13



## Row and Column Multiplexing Waveform EM6124 (16)

$$V_{OP} = V_{LCD} - V_{SS}, V_{STATE} = V_{COL} - V_{ROW}$$

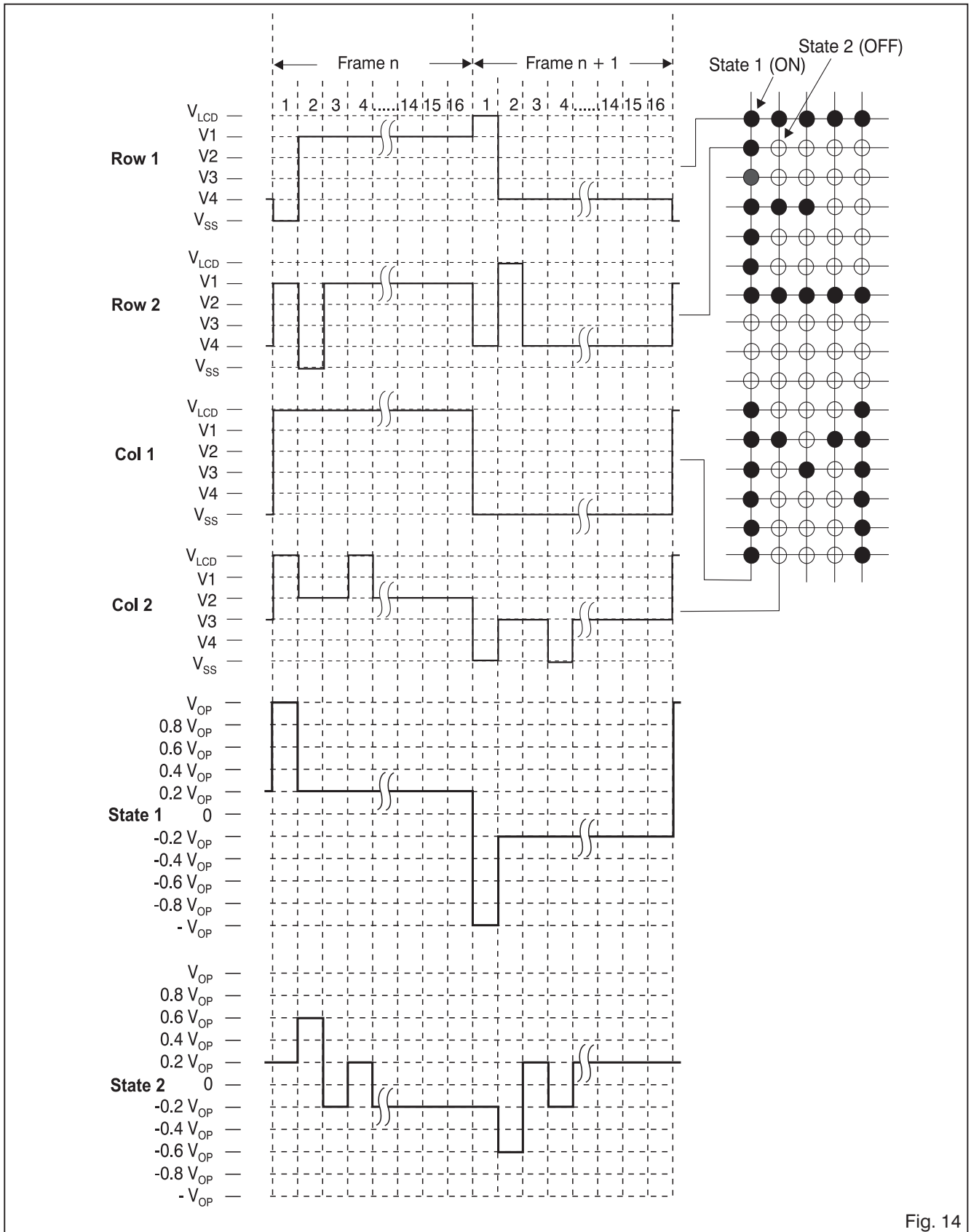


Fig. 14



## Row and Column Multiplexing Waveform EM6124 (20)

$$V_{OP} = V_{LCD} - V_{SS}, V_{STATE} = V_{COL} - V_{ROW}$$

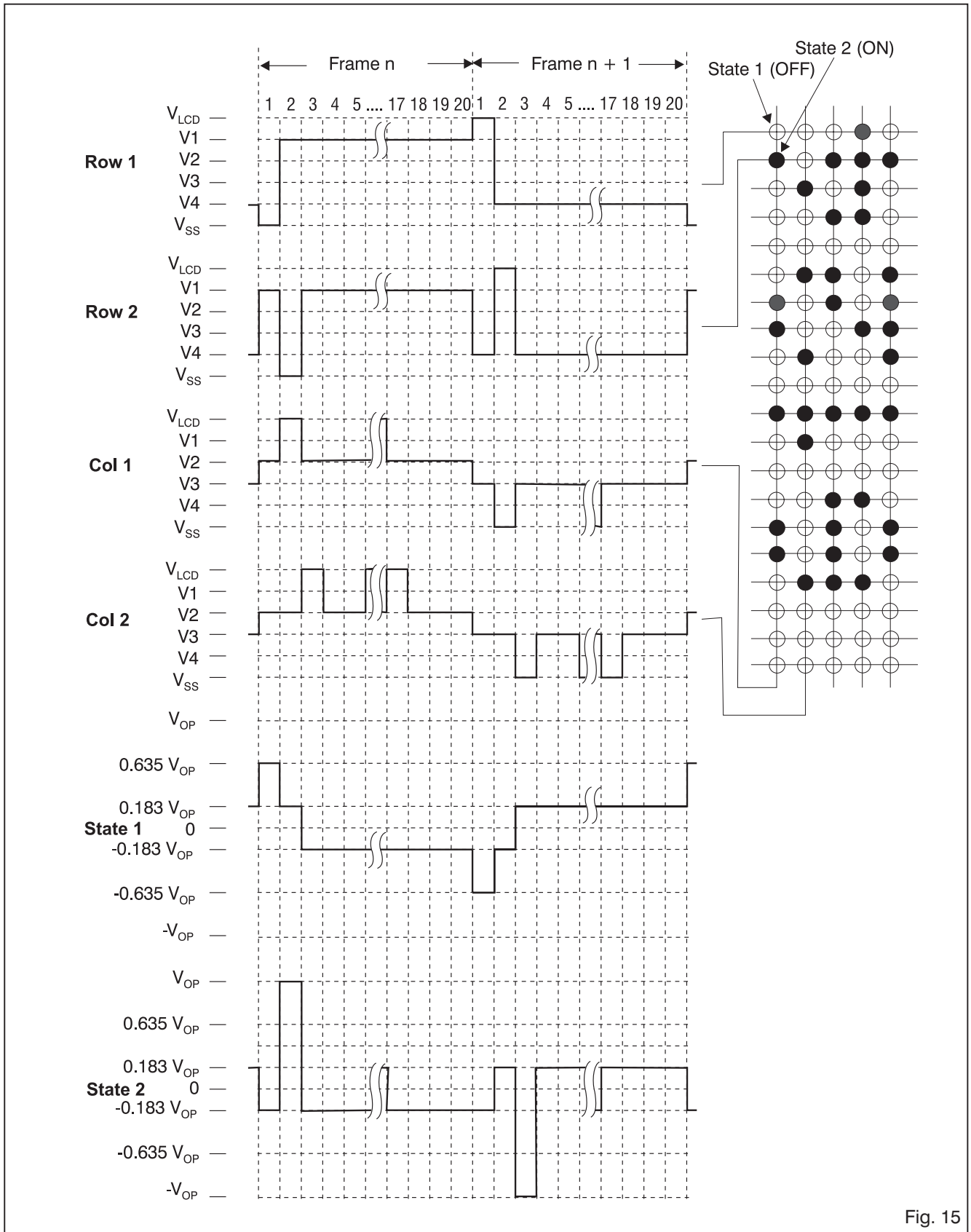


Fig. 15



## Row and Column Multiplexing Waveform EM6124 (24)

$$V_{OP} = V_{LCD} - V_{SS}, V_{STATE} = V_{COL} - V_{ROW}$$

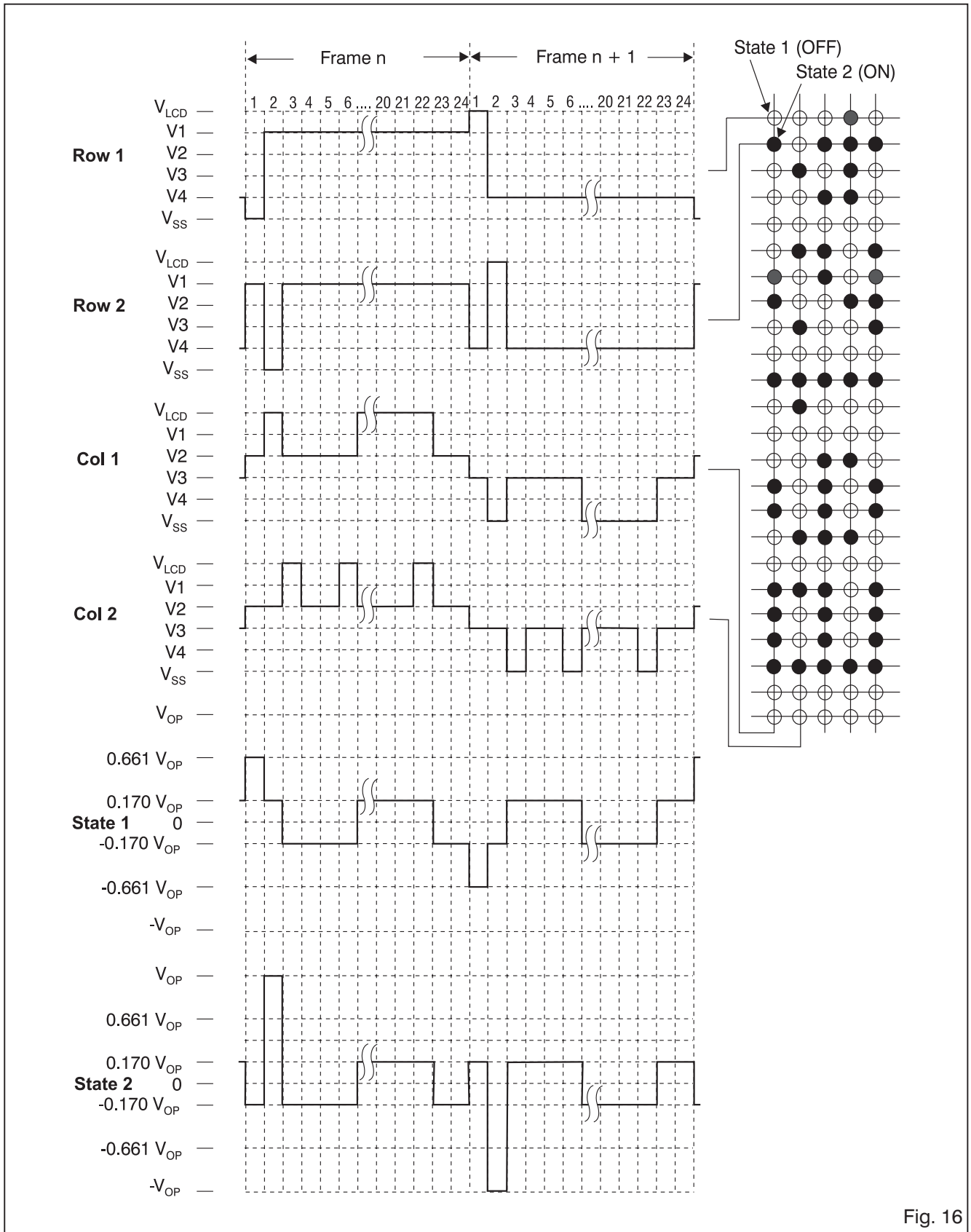


Fig. 16



## Functional Description

### Supply Voltage $V_{DD1}$ , $V_{DD2}$ , $V_{HV}$ , $V_{LCD}$ , $V_{SS}$

The voltage between  $V_{DD1}$  and  $V_{SS}$  is the supply voltage for the logic and the interface. The voltage between  $V_{DD2}$  and  $V_{SS}$  is the supply voltage for the analogic.  $V_{DD1}$  and  $V_{DD2}$  must be the same voltage and, in order to guarantee the best functioning,  $V_{DD1}$  and  $V_{DD2}$  have to be separately connected to the PCB (see Fig. 19). The voltage  $V_{LCD}$  is internally generated for the supply voltage of the LCD and is used for the generation of the internal LCD bias level. An external capacitor of  $1 \mu\text{F}$  must be connected between  $V_{LCD}$  and  $V_{SS}$ . Table 15 shows the relationship between  $V1$ ,  $V2$ ,  $V3$ ,  $V4$  for a programmed multiplex rate. Note that  $V_{LCD} > V1 > V2 > V3 > V_{SS}$  for the EM6124 8 mux programmed, and for the EM6124 16, 20, 24 mux programmed  $V_{LCD} > V1 > V2 > V3 > V4 > V_{SS}$ . The voltage between  $V_{HV}$  and  $V_{SS}$  is the supply voltage for high voltage part of the EM6124. An external  $V_{LCD}$  may also be used by connecting a power supply and programming a lower  $V_{LCD}$  voltage during initialization.

### Data Input

The data input pin, DI, is used to load serial data into the EM6124. The normal serial data word length is 128 bits. 32 and 8 bits are also available in a special mode (see 1 Bit Interface Description). The command byte is loaded first and then the segment data bits (see Fig. 4).

### $\overline{\text{RES1}}$ Input

Reset is accomplished by applying an external  $\overline{\text{RES1}}$  pulse (active low). When reset occurs within the specified time, all internal register are reset however the content of the RAM is still unchanged. The state after reset is described on page 4.

### $\overline{\text{RES2}}$ Input

Reset is accomplished by applying an external  $\overline{\text{RES2}}$  pulse (active low). When reset occurs within the specified time, the internal counter for serial interface is reset. The counter of the serial interface for data inputs is ready for a

new loading of data. This reset 2 does not change the content of the RAM neither the content of the command and the initialization bits. To avoid trouble in case of software interrupt of the MPU during data loading, this function can be used.

### Power-Up

On power up the data in the shift registers, the display RAM, the sequencer driving the 8/16/20/24 rows and the 121 bit display latches are undefined.

### CLK Input

The clock input is used to clock the DI serial data into the EM6124.

### FR Input / Output

The frame frequency is realized by an internal oscillator with a typical value of 75 Hz. The internal row frequency changes with the number of rows ( $F_{\text{row}} = 75 \times n$ , where  $n = 8, 16, 20, 24$ ). When bit 14 (Col) is inactive (active low), the frame frequency is given by the internal oscillator. This frequency can be measured on the I/O FR. When bit 14 ( $\overline{\text{Col}}$ ) is active (active low), the frame frequency is external then the frequency is given directly by the FR input to the row and column driver (see Fig. 16 and 17 for more details concerning the frame frequency).

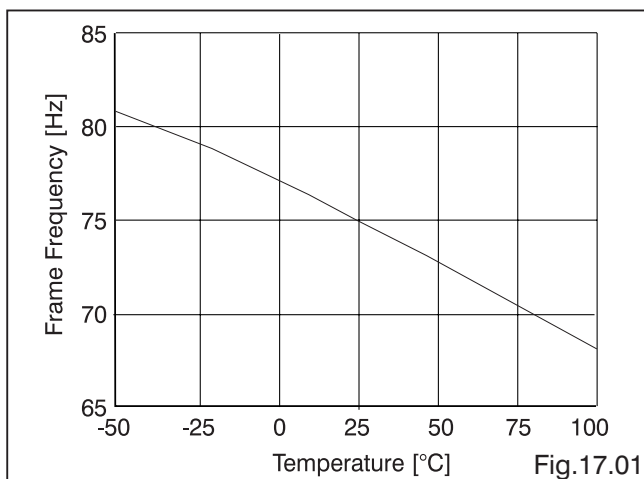
### Driver Outputs S1 to S116

There are 121 LCD driver outputs on the EM6124. The output assignments depend on the chosen mux mode ratio (init. bits 8, 9) and the Col function (init. bit 14).

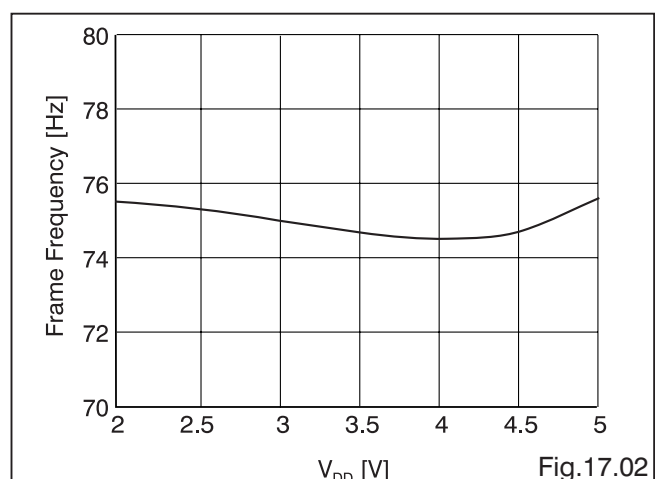
When init. bit 14 (Col) is active, all 116 outputs function as column drivers. Table "Output Row Assignments" and Fig. 4 describe exactly the correspondent data to the output of the chip. There is one to one relationship between the display RAM and the LCD driver outputs. Each pixel (segment) driven by the EM6124 on the LCD has a display RAM bit which corresponds to it. Setting the bit turns the pixel "on" and Clearing it turns "off".

For chip-on-glass better performances can be obtained by covering the backside of the chip.

### Typical Frame Frequency at $V_{DD} = 3 \text{ V}$



### Typical Frame Frequency at $T_A = 25 \text{ °C}$





## Application Example

These tables/figures show how to use the EM6124 with a given initialization. Rows "Data" show the logical value to affect pad DI for each falling edge of pad CLK. A reset cycle pad RES1 at OL is required before sending data.

Command byte	Initialization bits or display data
--------------	-------------------------------------

Bit No	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
<b>Data</b>	1	1	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	0	0
<b>Description</b>	<b>Bits 0,1=1,1</b> : initialization is programmed <b>Bit 2=0</b> : no sleep mode <b>Bits 3 to 7</b> : don't care in this case (not 11111)								<b>Bits 8,9,24 = 1,1,1</b> : mux mode 24 + icon ; 25 rows driven. <b>Bits 10,11 = 0,1</b> : temperature coefficient = $-(0.52 \cdot V_{LCD})$ mV/°C <b>Bits 12,13 = 0,0</b> : no checker or inv. checker functions <b>Bit 14 = 1</b> : row and column driver configuration <b>Bit 15 = 0</b> : row 1 of the RAM displayed on S1, row 2 on S2, ... and row 25 on S25. <b>Bit 16 = 0</b> : first data sent displayed on S26, last one on S121 <b>Bit 17 = 1</b> : 1L in the RAM corresponds to a pixel "ON" <b>Bits 18 to 23 = 1,1,0,0,0,0</b> : programmed $V_{LCD} = 3.15 + (1 \cdot 32 + 1 \cdot 16 + 0 \cdot 8 + 0 \cdot 4 + 0 \cdot 2 + 0 \cdot 1) \cdot 0.0625 = 6.150$ V <b>Bit 25 = 0</b> : no sleep 2 <b>Bits 26 to 31 = 0,0,0,0,0,0</b> : every test bits must be set to 0.																							
<b>Result</b>																																

First Initialization

Fig. 18.01

Bit No	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	.....	125	126	127		
<b>Data</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.....	0	0	0		
<b>Description</b>	<b>Bits 0,1,2= 0,0,0</b> : no set, no blank, no sleep <b>Bits 3 to 7 = 0,0,0,0,0</b> : data sent to row 1 of the RAM								<b>Bits 8 to 103 = 0,0,...., 0</b> : first row of the RAM is loaded with 0,0,...., 0 <b>Bits 104 to 127 = don't care</b>																							
<b>Result</b>																																

Write Row 1

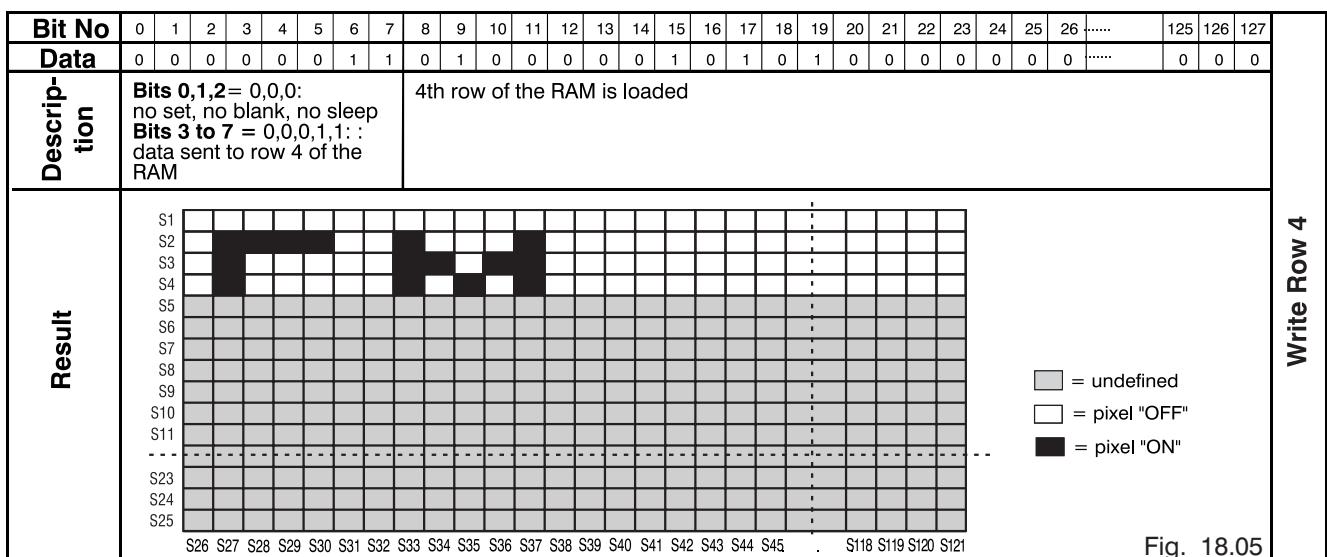
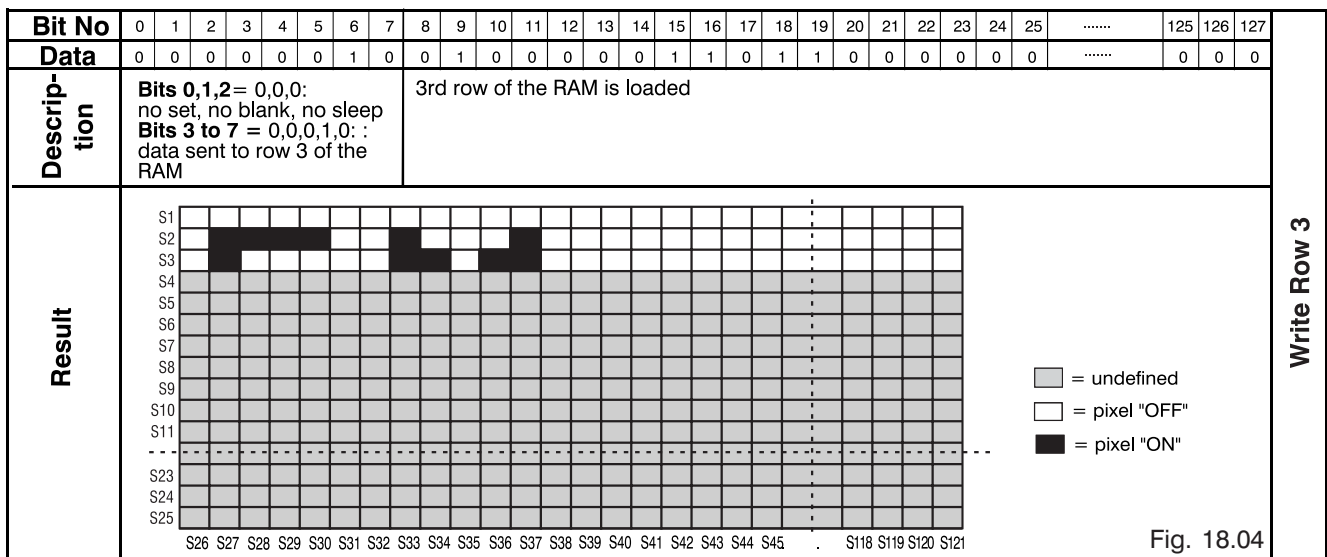
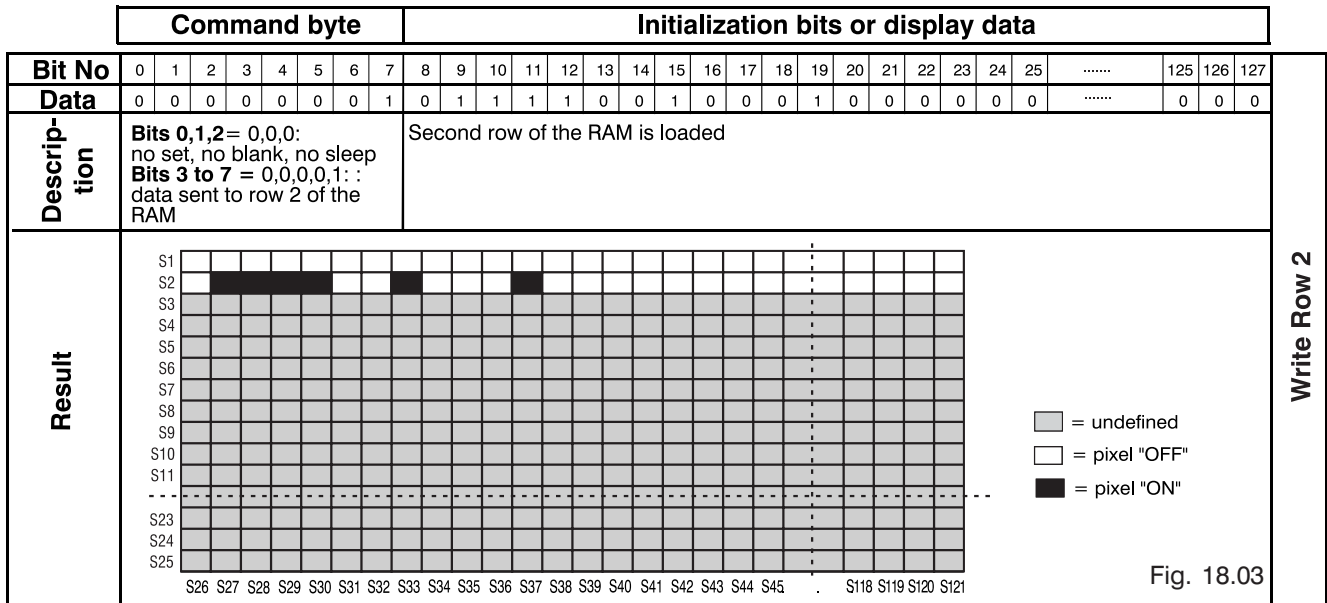
Fig. 18.02

Table 15  
(continued on next pages)



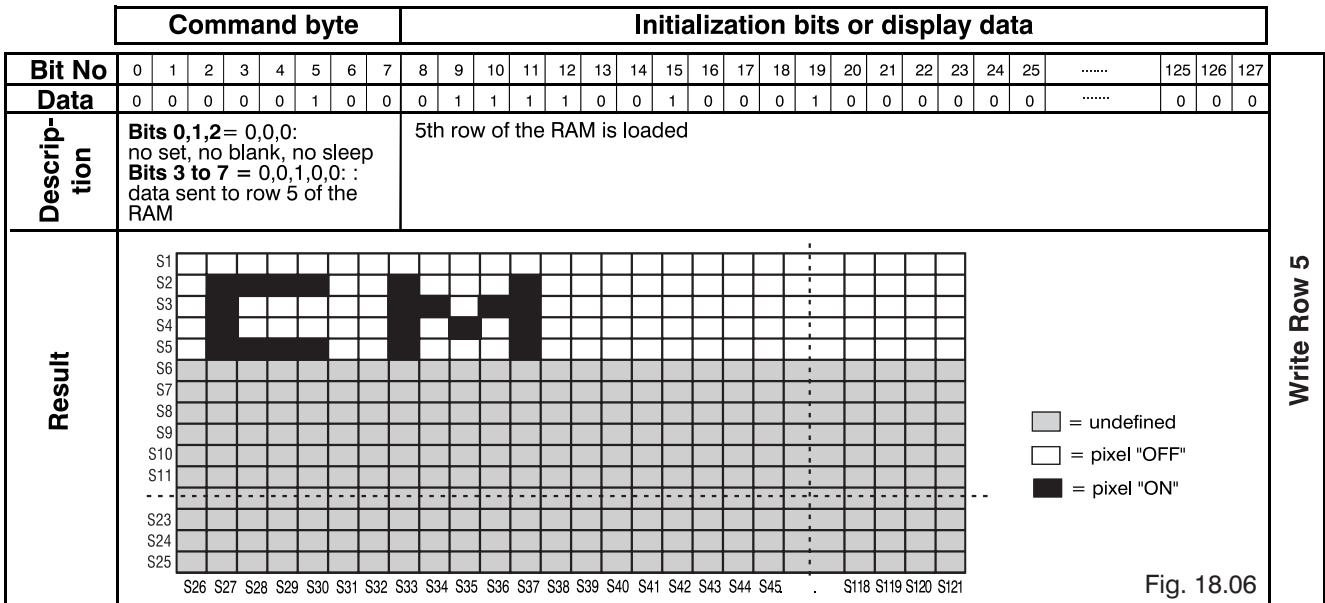


## Application example continued

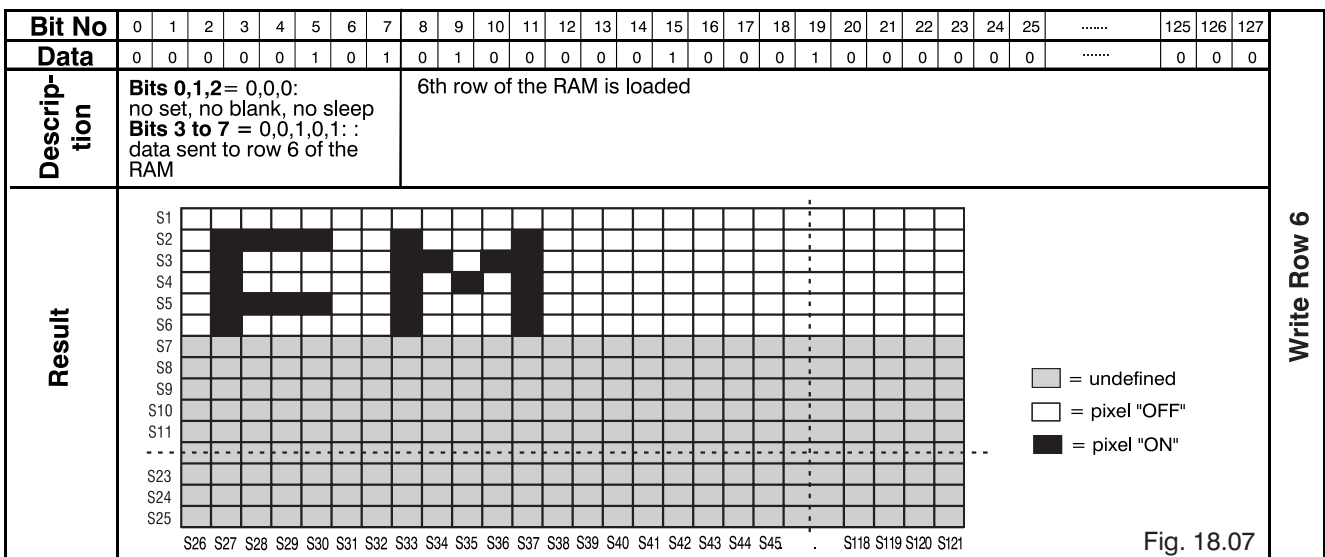




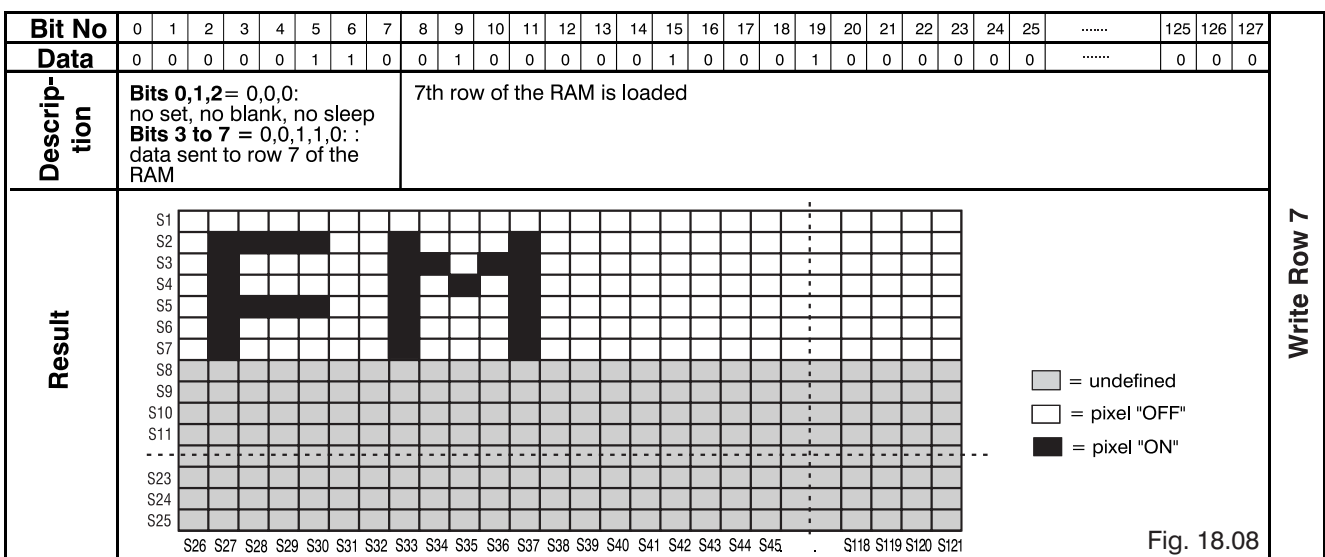
## Application example continued



Write Row 5



Write Row 6



Write Row 7

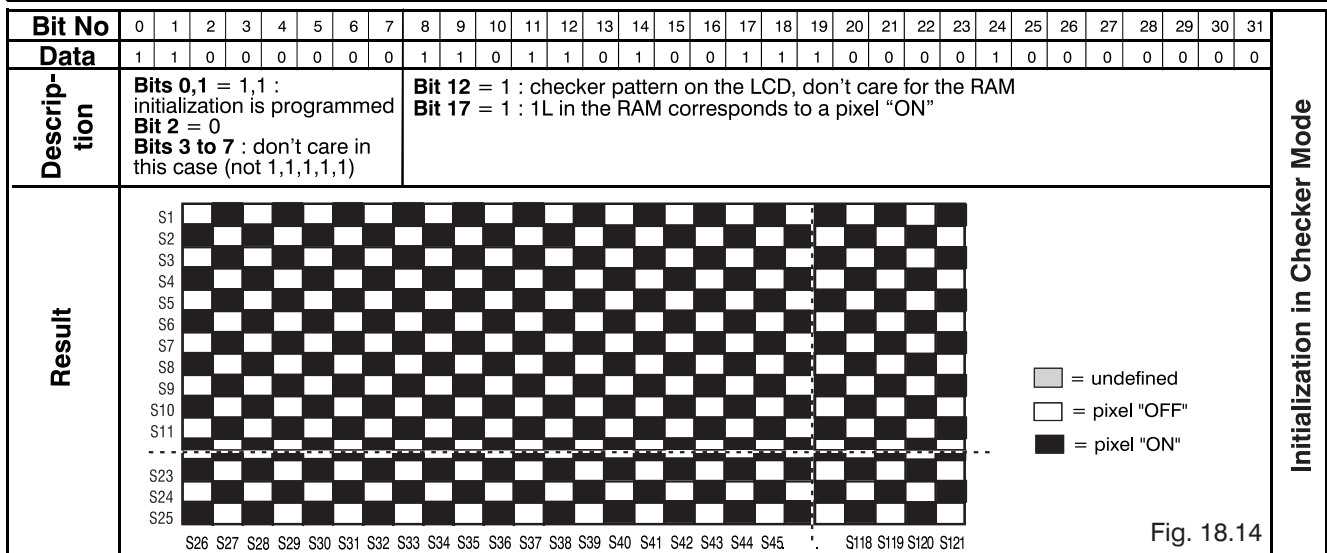
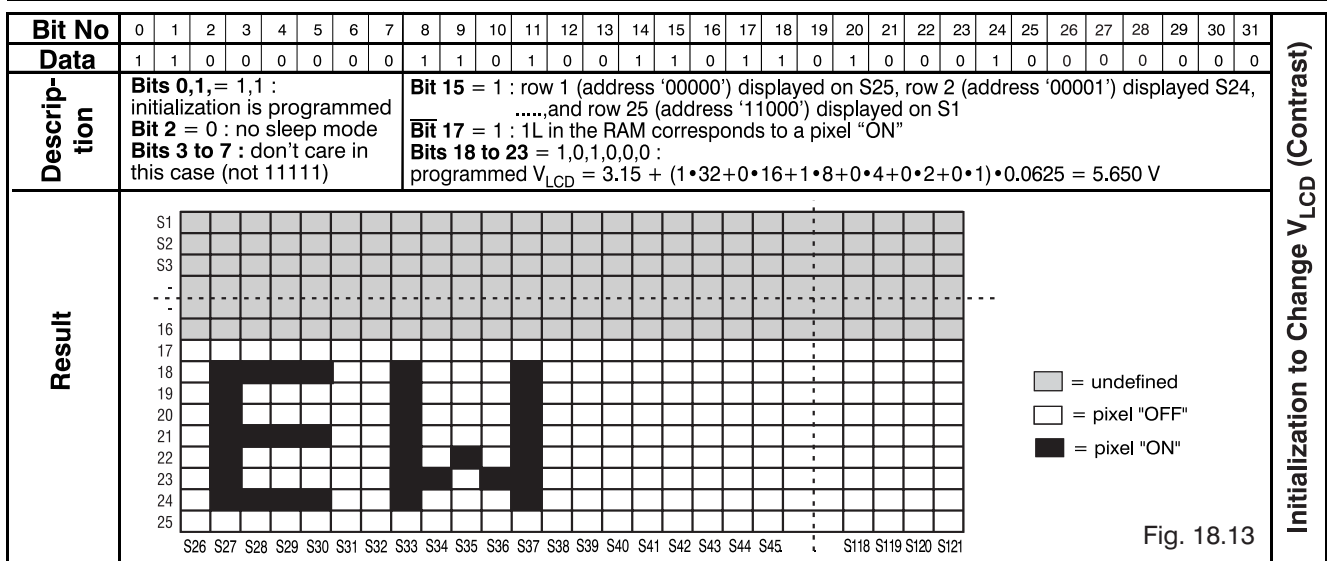
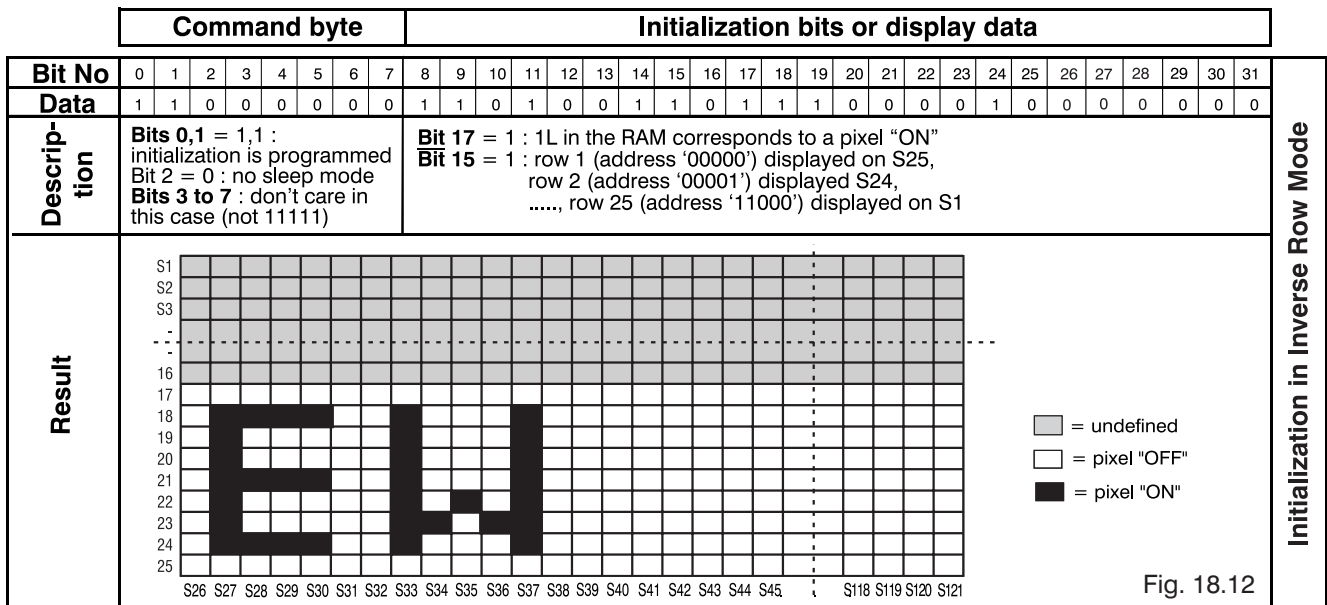


## Application example continued

		Command byte							Initialization bits or display data																											
<b>Bit No</b>	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	.....	125	126	127						
<b>Data</b>	0	0	0	0	0	1	1	1	0	1	1	1	1	0	0	1	0	0	0	1	0	0	0	0	0	0	.....	0	0	0						
<b>Description</b>	<b>Bits 0,1,2</b> = 0,0,0: no set, no blank, no sleep <b>Bits 3 to 7</b> = 0,0,1,1,1: : data sent to row 8 of the RAM							8th row of the RAM is loaded																												
<b>Result</b>																																				
		Fig.18.09																																		
<b>Bit No</b>	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	.....	125	126	127						
<b>Data</b>	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	.....	0	0	0						
<b>Description</b>	<b>Bits 0,1,2</b> = 0,0,0: no set, no blank, no sleep <b>Bits 3 to 7</b> = 0,1,0,0,0: : data sent to row 9 of the RAM							9th row of the RAM is loaded																												
<b>Result</b>																																				
		Fig.18.10																																		
<b>Bit No</b>	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
<b>Data</b>	1	1	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0				
<b>Description</b>	<b>Bits 0,1</b> = 1,1 : initialization is programmed <b>Bit 2</b> = 0 <b>Bits 3 to 7</b> : don't care in this case (not 1,1,1,1,1)							<b>Bit 17</b> = 0: 1L in the RAM corresponds to a pixel "OFF"																												
<b>Result</b>																																				
		Fig.18.11																																		

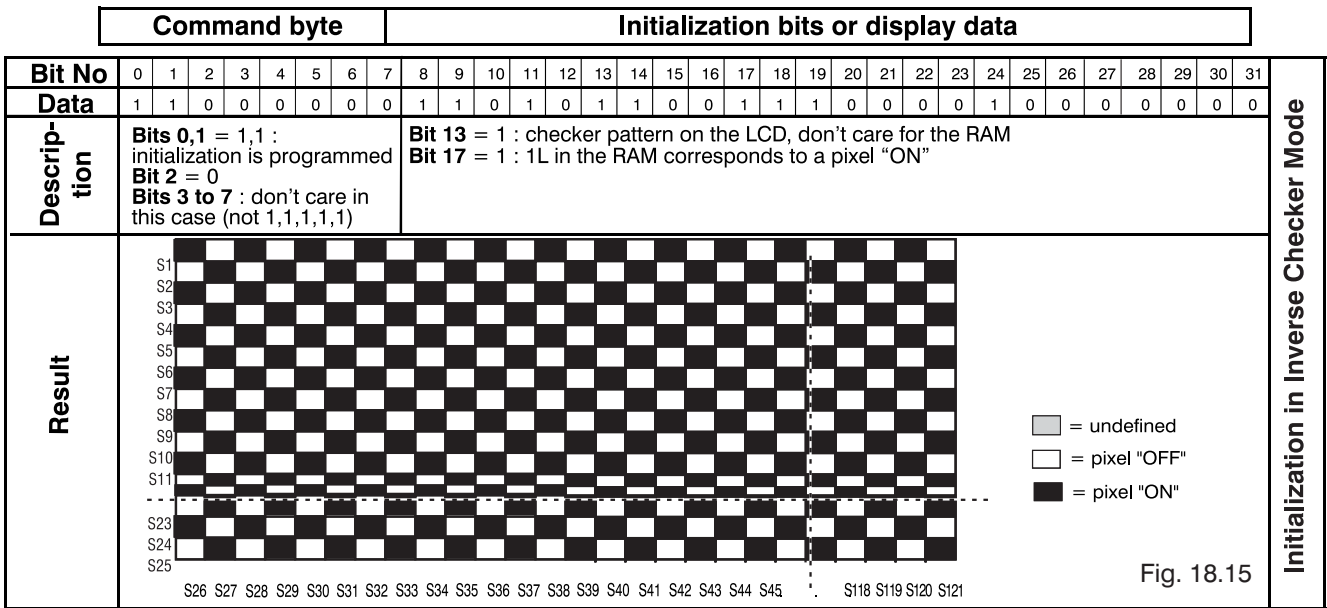


## Application example continued

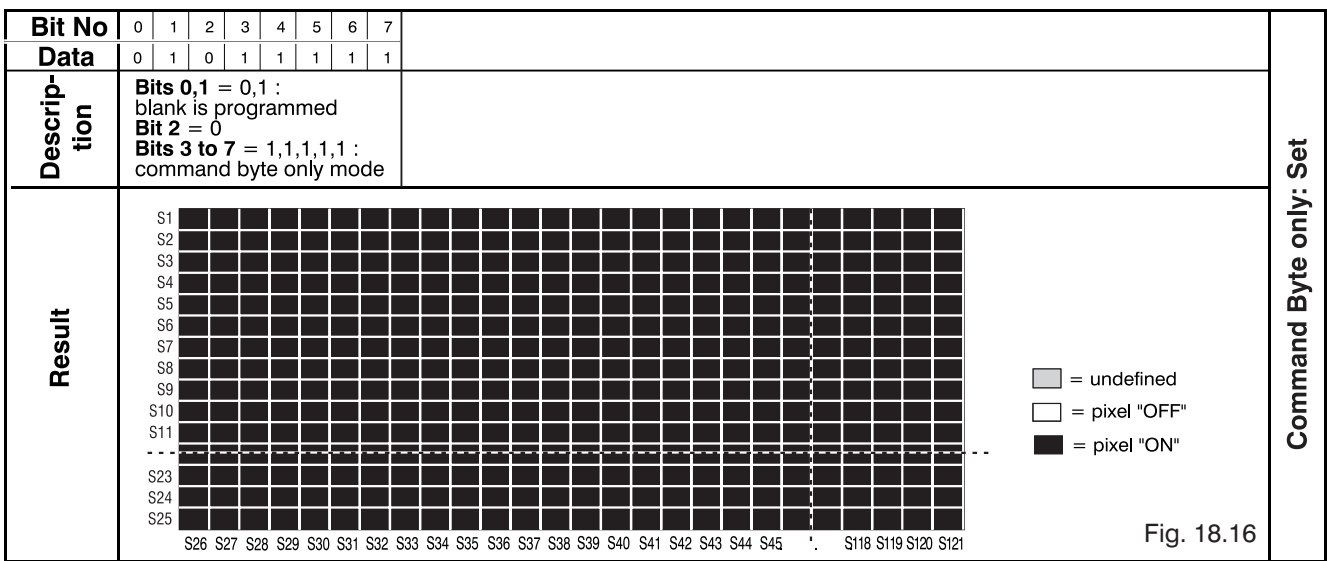




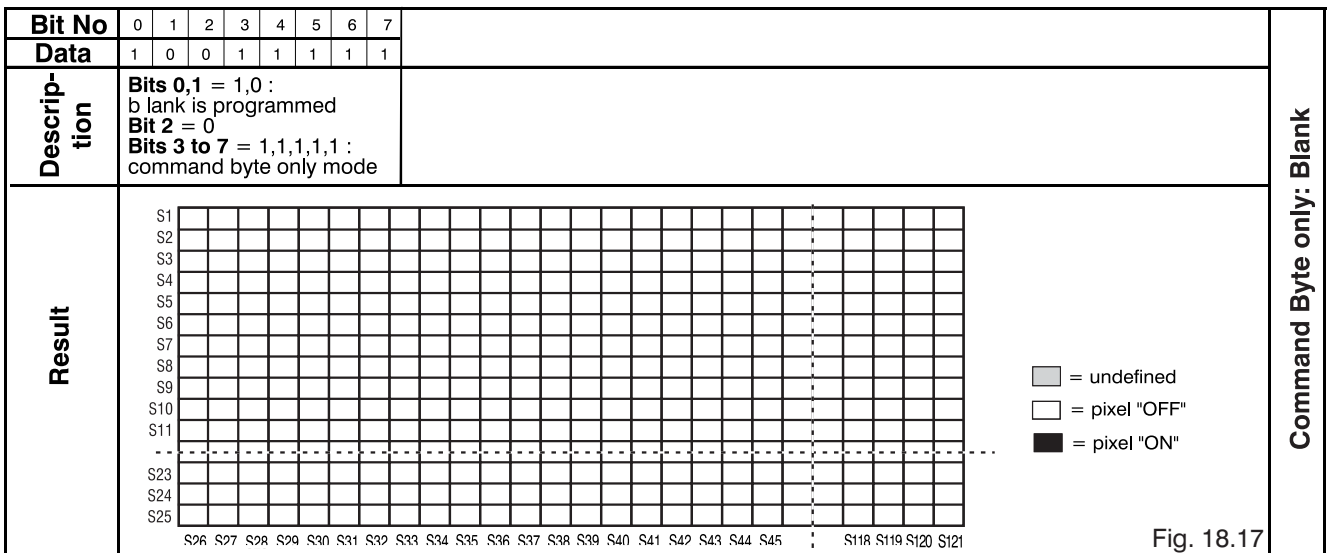
## Application example continued



Initialization in Inverse Checker Mode



Command Byte only: Set

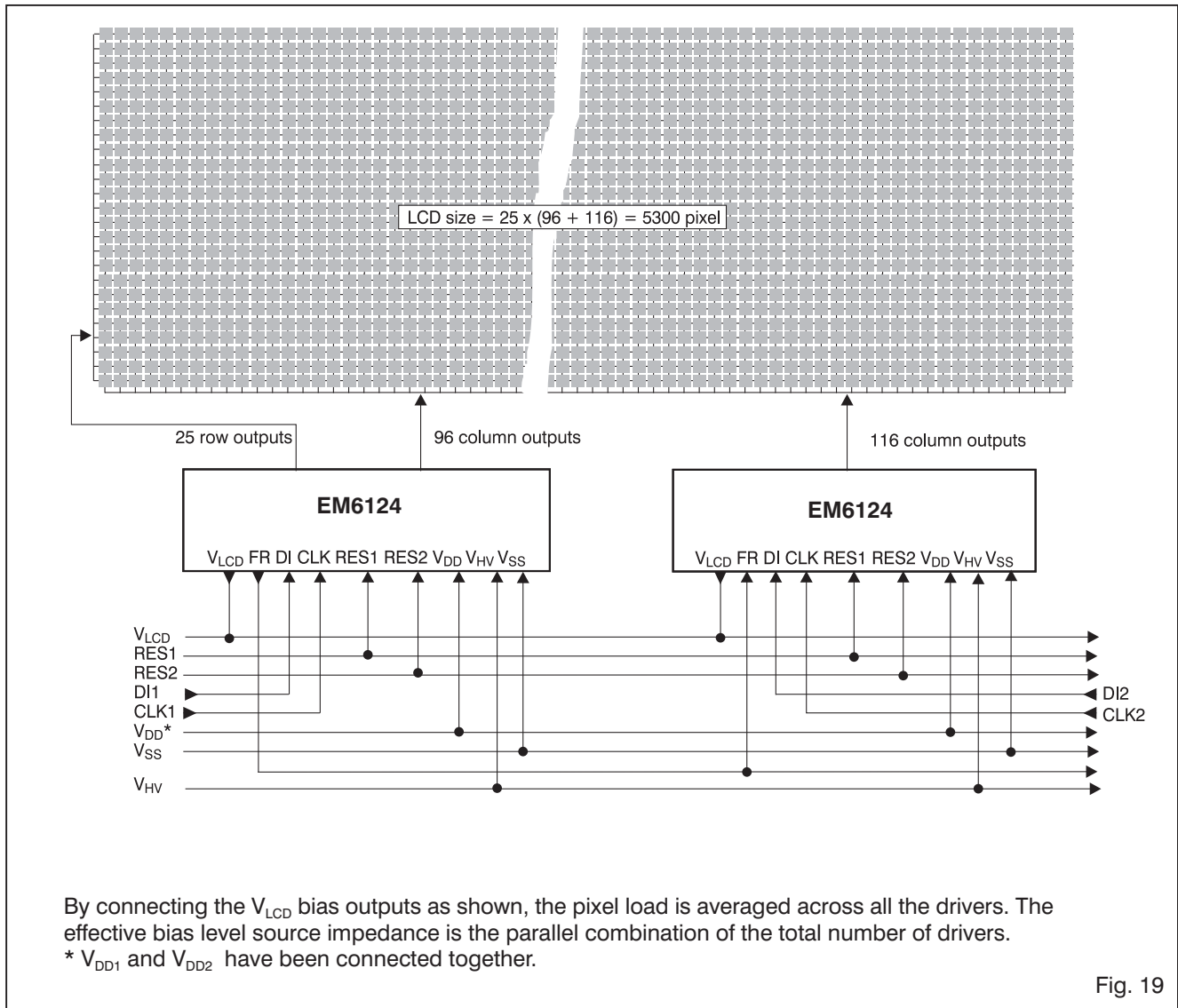


Command Byte only: Blank

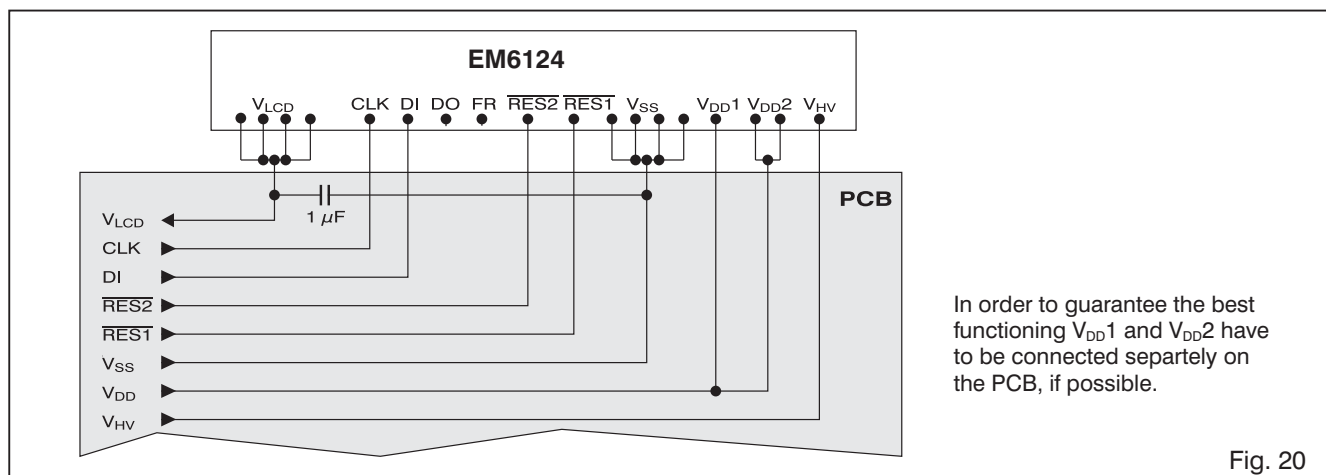


## Applications

Two EM6124 work in parallel to drive up to 50 rows x 96 columns or 25 rows x 212 columns as below



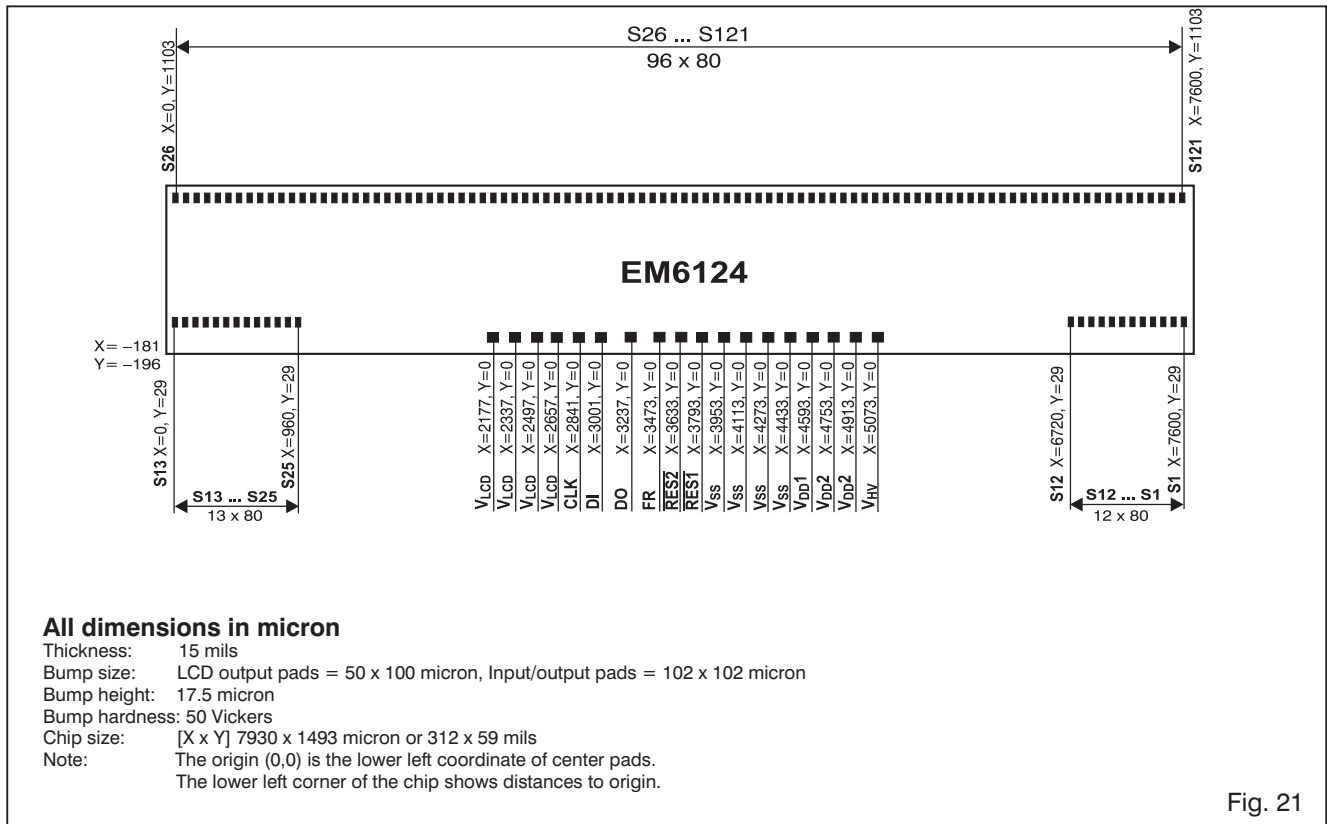
## Contacting Power Supply





# EM6124

## Dimensions of Chip Form and Bumped Die



## Ordering Information

When ordering, please specify the complete Part Number

Part Number	Die Form	Bumping
EM6124WP15E	Die in waffle pack, 15 mils thickness	With gold bumps

For other delivery form in die (with or without bumps), please contact EM Microelectronic-Marín S.A. Minimum order quantity might apply.

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