16 Digit 5x7 Segment VFD Controller/Driver

DESCRIPTION

The M66004SP/FP is a controller/driver for 16 digit, 5x7 segment vacuum fluorescent displays (VFD). The M66004SP/FP is made using CMOS process, and includes the character generator ROM (CGROM) of 160 characters and CGRAM of 16 characters.

The MCU can control M66004SP/FP by three control lines, chip select ($\overline{CS}$), shift clock (SCK) and serial data (SDATA).

FEATURES

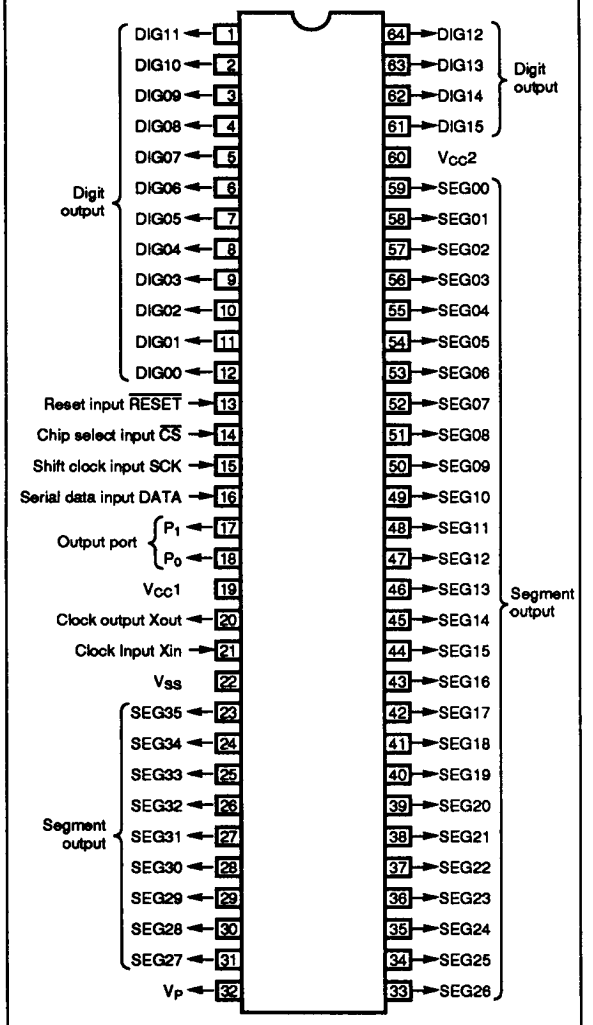
- Built-in character generator ROM (CGROM) (160 characters of 5x7 font)
- Built-in character generator RAM (CGRAM) (16 characters of 5x7 font)
- Valuable display length (9 to 16 digits)
- 2 steps of scan cycle
- 8 steps of dimmer control
- Cursor display (SEG35 output)
- Serial bus communication with MCU ($\overline{CS}$, SCK, SDATA)
- 1 byte command (*)
- Static output port (2 bits)
- Power supply V_{CC} = 5V ± 10%
- Pull down voltage $V_P = V_{CC}$ - 40V (typ)
  V_{CC} - 45V (peak)

(*): Execpt CGRAM write command

APPLICATION

Control and drive of VFD for AV, POS system

PIN CONFIGURATION (TOP VIEW)



OUTLINE 64P4B
64P2G

FUNCTION

The M6604SP/FP is a 16 digit, 5x7 segment vacuum fluorescent display (VFD) controller/driver.

The M66004SP/FP includes a CGROM of 160 characters (5x7 font) and a CGRAM of 16 characters. (Custom mask of CGROM can be available)

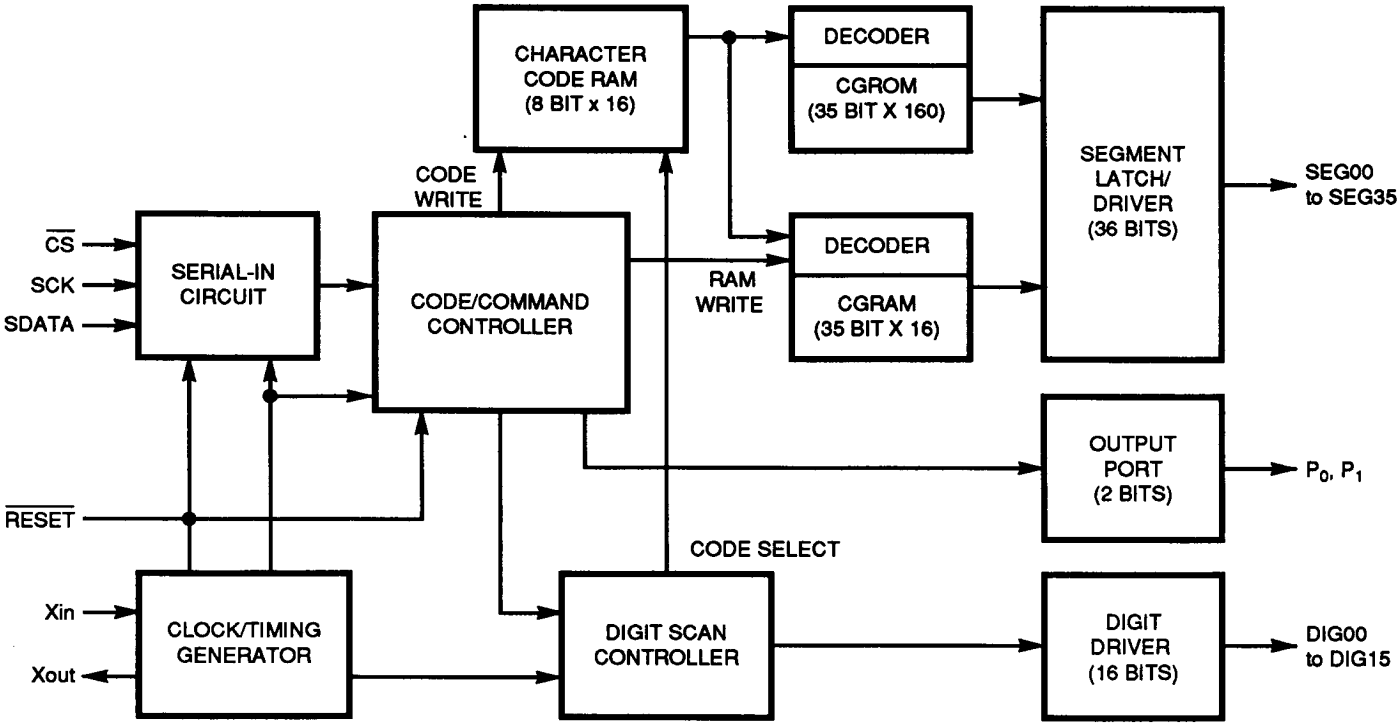
The M66004SP/FP receives serial data of 8-bit from MCU as a command or as a character code data.

SEG00 to SEG35 output drives the anode of VFD and DIG00 to DIG15 output drives the grid, and SEG35 output drives the anode for cursor.

Two static ports P0 and P1 are useful to drive LEDs or to control another peripheral ICs.

ASSP

BLOCK DIAGRAM



SUMMARY

The SERIAL-IN circuit receives the 8-bit data from MCU. After receiving a data, it generates internal latch pulse and closes the serial input gate.

If the data was a command data, the CODE/COMMAND CONTROLLER sets or resets the display control registers. And if the data is character code data, it writes the code to CHARACTER CODE RAM.

The DIGIT SCAN CONTROLLER generates the digit scan pulse to drive digit output drivers, and at the same time, a character code of 8-bit is selected from the CHARACTER CODE RAM and is sent to a decoder of CGROM or CGRAM. Then character font data of 35-bit is generated. This font data is latched and appears at the segment drivers.

PIN DESCRIPTION

Pin	Name	Function
$\overline{RESET}$	Reset input	M66004 is initialized at low-level
$\overline{CS}$	Chip select input	Communication with MCU is enabled at low-level
SCK	Shift clock input	When the input signal goes from low to high level, the serial data is stored in the shift register.
SDATA	Serial data input	This is a serial input terminal to receive a character code data or a command data (MSB first)
Xin/ Xout	Clock input/ Clock output	I/O to the built-in CR oscillator circuit. When using external clock, connect the clock source to Xin and leave Xout open.
DIG00 to DIG15	Digit output	P-ch open drain outputs with pull down resisters. Connect these outputs to GRID #1 to GRID #16 of VFD
SEG00 to SEG35	Segment output	P-ch open drain output with pull down resister. Connect thers outputs to ANODE #1 to ANODE #35 and SEG35 to an ANODE for CURSOR of VFD.
P_0, P_1	Static output port	The state of this port is controlled by a command.
$V_{CC}1$		Positive power supply for logic block. (+5V)
$V_{CC}2$		Positive power supply for DIGIT and SEGMENT output. (+5V)
V_{SS}		Ground terminal. (0V)
V_P		Negative power supply. (-35V)

SEGMENT OUTPUT PIN CONNECTION TO VFD

The connection between the SEG00 to SEG35 outputs and the anodes of VFD is as follows.

00	01	02	03	04
05	06	07	08	09
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24
25	26	27	28	29
30	31	32	33	34
35				

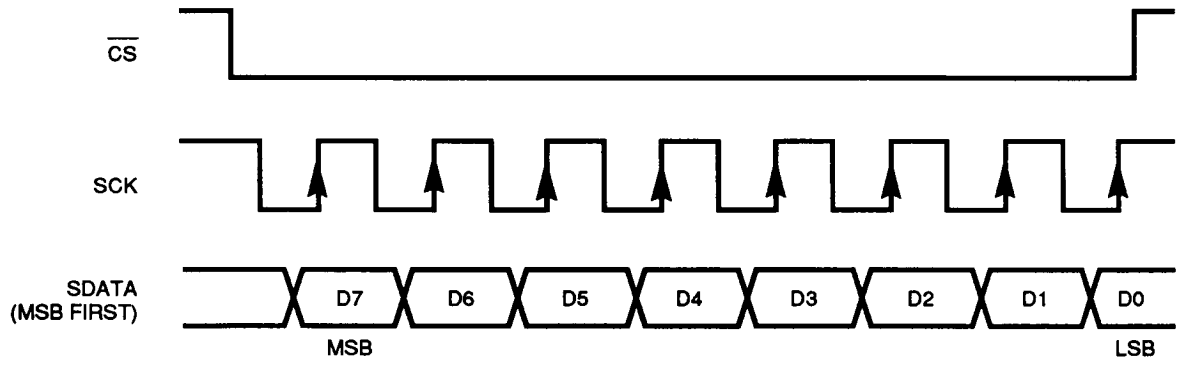
(Front view of VFD

TRANSMISSION FORMAT

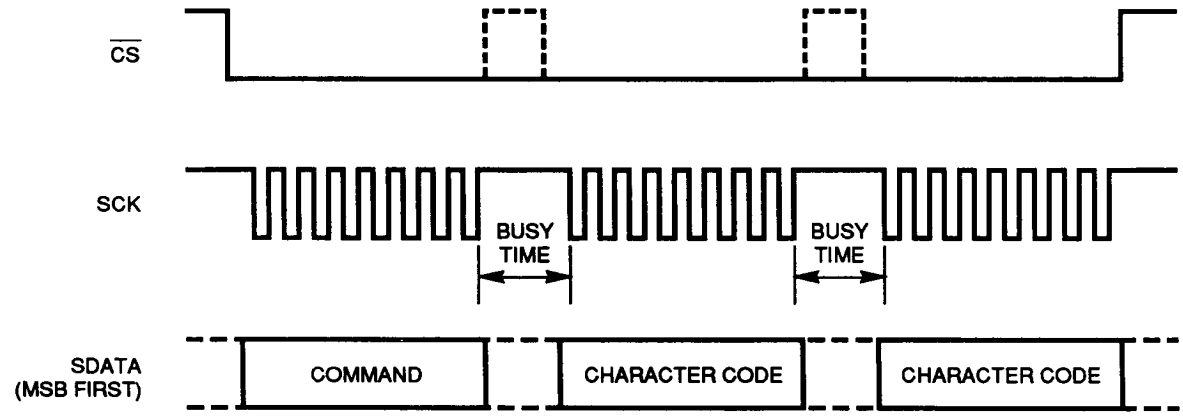
A low level of chip select ($\overline{CS}$) enables M66004 to receive serial clock and serial data from the MCU.

When the shift clock (SCK) goes from low to high level, Serial data (SDATA) is stored in the shift register.

BASIC TIMING



AN EXAMPLE OF CONTINUOUS TIMING



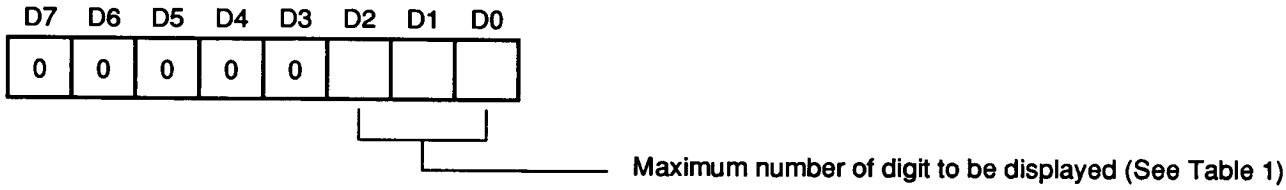
COMMAND DESCRIPTION

Function	Command Data								Contents
	D7	D6	D5	D4	D3	D2	D1	D0	
Set display length	0	0	0	0	0	*	*	*	Set the maximum number of digit to be displayed. (9 to 16 digits)
Set dimmer value	0	0	0	0	1	*	*	*	Adjust the brightness. (8 steps)
Set digit scan time	1	1	1	1	0	1	1	*	Either 128/fxin or 256/fxin is available.
Set digit pointer	1	1	1	0	*	*	*	*	This command is used to select a digit to display a character which is received as a character code data.
Automatic increment mode ON/OFF of digit pointer	1	1	1	1	0	1	0	*	When "ON", the digit pointer is advanced automatically after receiving a character code data. When "OFF", the digit pointer is fixed.
Cursor ON	0	0	0	1	*	*	*	*	Set SEG35 output "ON"
Cursor OFF	1	0	0	0	*	*	*	*	Set SEG35 output "OFF"
Display all ON/OFF	1	1	1	1	0	0	*	*	All segment outputs can be set "ON" or "OFF" at a time.
Storing data in CGRAM	1	1	1	1	1	1	X	X	This command is a declaration to define a user font to CGRAM.
Port set/reset	1	1	1	1	1	0	*	*	Set or reset of the static port P0 or P1

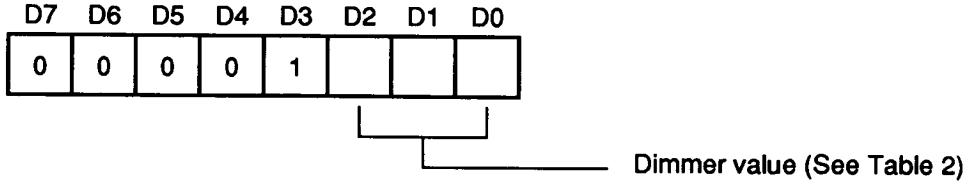
X: Don't care
*: Selection bits
"0": Low-level
"1": High-level

COMMAND FORMAT

1. Set display length



2. Set dimmer value



3. Set digit scan time

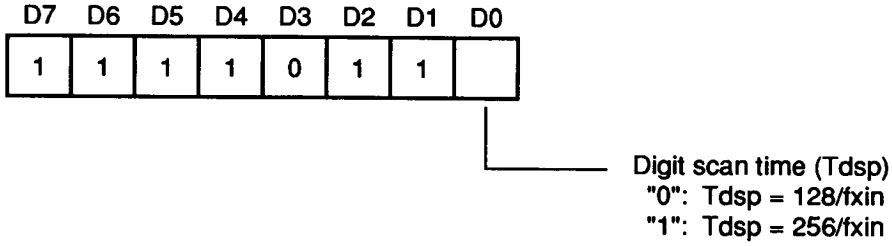


Table 1 Maximum number of digit

D2	D1	D0	Maximum Number of Digit
0	0	0	9
0	0	1	10
0	1	0	11
0	1	1	12
1	0	0	13
1	0	1	14
1	1	0	15
1	1	1	16

Table 2 Dimmer value

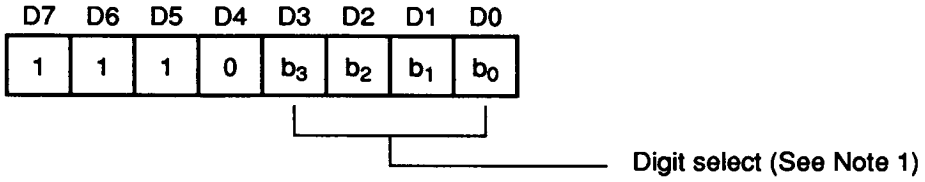
D2	D1	D0	Dimmer Value (Tdig/Tdsp)
0	0	0	1/16
0	0	1	2/16
0	1	0	4/16
0	1	1	6/16
1	0	0	8/16
1	0	1	10/16
1	1	0	12/16
1	1	1	14/16

Tdig: Digit "ON" time
Tdsp: Digit scan time

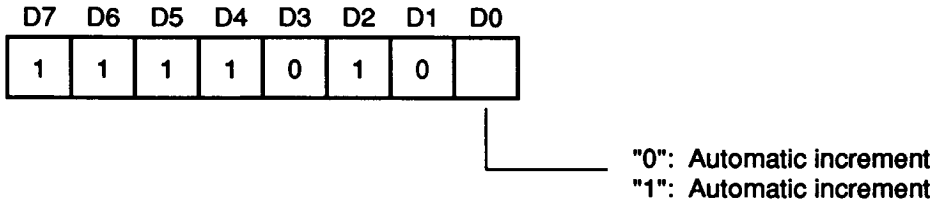
COMMAND FORMAT (continued)

4. Set digit pointer/Auto increment mode ON/OFF

(1) Set digit pointer



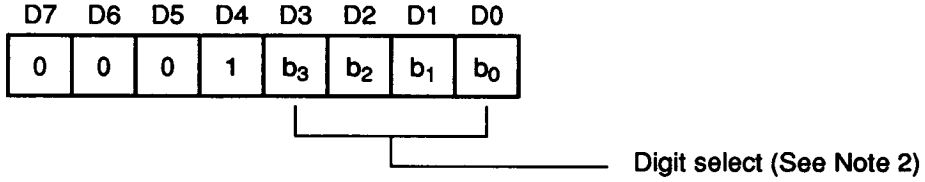
(2) Automatic increment mode ON/OFF



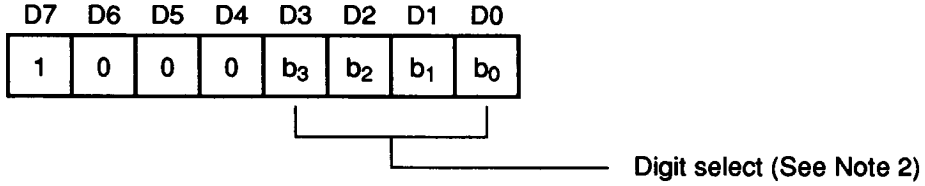
(Note1): The position N, which the digit pointer locates, are given by, $N = b_3 \cdot 2^3 + b_2 \cdot 2^2 + b_1 \cdot 2^1 + b_0 \cdot 2^0 + 1$ (N: decimal number of digit from 1 to 16) For Example when (D3, D2, D1, D0) = (0,1,0,0), the digit pointer is set at DIG#5

5. Cursor ON/OFF (SEG35 output ON/OFF)

(1) Cursor "ON"



(1) Cursor "OFF"



(Note2): The digit number N is also expressed as Note 1.

6. Display all ON/OFF

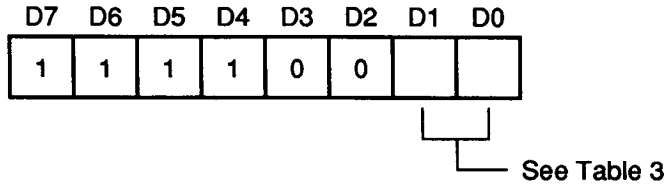


Table 3 Display mode selection

D2	D1	Function
X	0	All digits, all segments "OFF"
0	1	Normal display mode
1	1	All digits, all segments "ON"

X: Don't care

COMMAND FORMAT (continued)

7. Storing data in CGRAM

The M66004 includes CGRAM of 16 characters. It takes 3 steps to define a user font to CGRAM.

1. The declaration to define CGRAM. (1 byte command).
2. The selection of a RAM character code number. (1 byte command)
3. The data set of the font. (5 bytes command) Therefore, to define user font to CGRAM, continuous commands of 7 bytes are needed. The RAM character codes of RAM1 to RAM16 are assigned to 90_{16} to $9F_{16}$.

(1) The Declaration

	D7	D6	D5	D4	D3	D2	D1	D0
1st byte	1	1	1	1	1	1	X	X

X: Don't care

(2) RAM character code select

	D7	D6	D5	D4	D3	D2	D1	D0
2nd byte	X	X	X	X				

X: Don't care

Lower 4-bit of RAM code to be defined.

(3) Font data send

	D7	D6	D5	D4	D3	D2	D1	D0
3rd byte	00	05	10	15	20	25	30	X
4th byte	01	06	11	16	21	26	31	X
5th byte	02	07	12	17	22	27	32	X
6th byte	03	08	13	18	23	28	33	X
7th byte	04	09	14	19	24	29	34	X

X: Don't care

Data bit "0": Segment 'OFF'
"1": Segment 'ON'

The numbers 00 to 34 correspond to the segment number of VFD

00	01	02	03	04
05	06	07	08	09
10	11	12	13	14
15	16	17	18	19
20	21	22	23	24
25	26	27	28	29
30	31	32	33	34

(Front view of VFD)

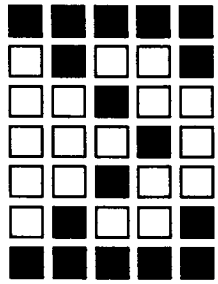
(Example) This is an example to define a font 'Σ' in RAM1.

Sequence	Serial Data (Note 3)	Remarks
1	FC_{16}	Declaration to define CGRAM
2	00_{16}	Select RAM1
3	82_{16}	Data (1,0,0,0,0,0,1,0) send
4	$C6_{16}$	Data (1,1,0,0,0,1,1,0) send
5	AA_{16}	Data (1,0,1,0,1,0,1,0) send
6	92_{16}	Data (1,0,0,1,0,0,1,0) send
7	$C6_{16}$	Data (1,1,0,0,0,1,1,0) send

Note 3: The bits of don't care are assumed as "0"

D7	1	1	1	1	1
D6	0	1	0	0	1
D5	0	0	1	0	0
D4	0	0	0	1	0
D3	0	0	1	0	0
D2	0	1	0	0	1
D1	1	1	1	1	1
D0	0	0	0	0	0

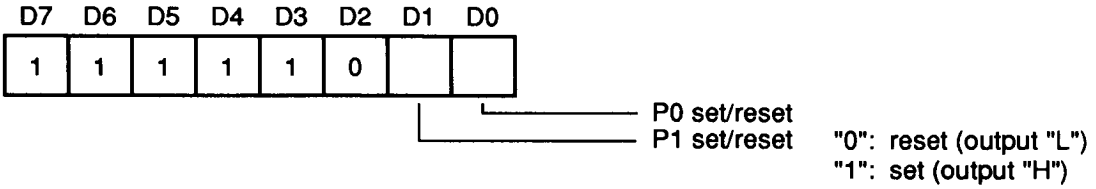
(Bit data)



(Display font)

COMMAND FORMAT (continued)

8. Port set/reset



CHARACTER DISPLAY OPERATION

The function of M66004 to display characters on VFD is divided into two modes, that is, the function in automatic increment 'ON' mode and the function in automatic increment 'OFF' mode.

In automatic increment 'ON' mode, the digit pointer, which indicates the digit to display a chaacter from MCU, is advanced every time after displaying the character. After displaying on the uppermost digit, the pointer returns to lowest digit. Therefore in this mode, the command of set digit pointer is effective only to the first character code which is received from MCU.

In automatic increment 'OFF', the digit pointer is fixed. Therefore, the received character is displayed on the same digit just before the pointer located or the digit which is set by the command of set digit pointer.

Sequence	Serial Data	Font View of VFD (1 2 3 4 5 6 7 8 9 10 11)	Remarks
1	$F4_{16}$		Set automatic increment 'ON'
2	$E1_{16}$		Set digit pointer to GRID #2
3	$4D_{16}$	M	Code of 'M'
4	36_{16}	M 6	'6'
5	36_{16}	M 6 6	'6'
6	30_{16}	M 6 6 0	'0'
7	30_{16}	M 6 6 0 0	'0'
8	34_{16}	M 6 6 0 0 4	'4'
9	53_{16}	M 6 6 0 0 4 S	'S'
10	50_{16}	M 6 6 0 0 4 S P	'P'
11	$F4_{16}$	M 6 6 0 0 4 S P	Set automatic increment 'OFF'
12	$E7_{16}$	M 6 6 0 0 4 S P	Set digit pointer to GRID #8
13	46_{16}	M 6 6 0 0 4 F P	Code of 'F'
14	53_{16}	M 6 6 0 0 4 S P	'S'
15	46_{16}	M 6 6 0 0 4 F P	'F'

DISPLAY ALL ON/OFF FUNCTION

All digit and segment outputs turn 'ON' or 'OFF' at a time by the command of display all ON/OFF command. The data of CHARACTER CODE RAM and CGRAM is not changed even in the state of display all 'ON' or all 'OFF' and any command and character code data from MCU is effective.

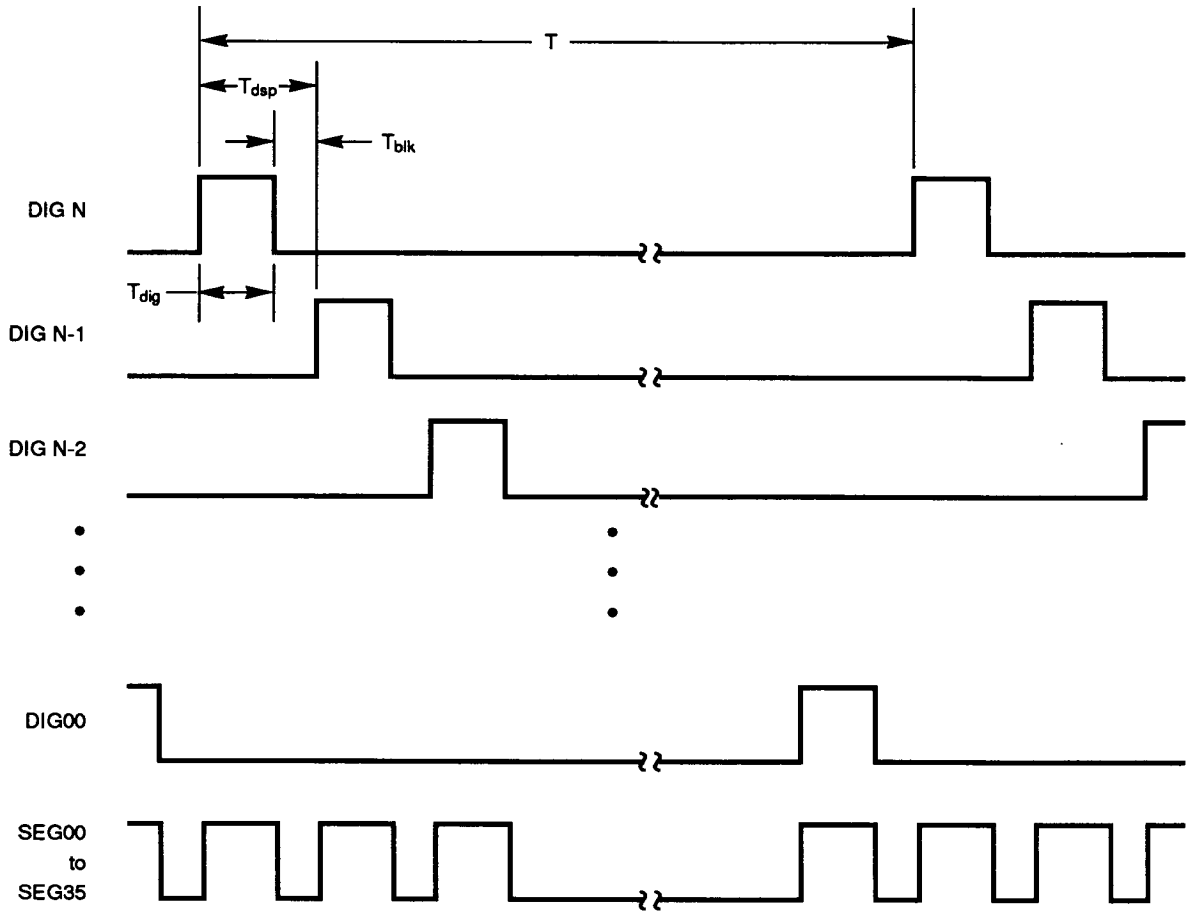
INITIALIZATION

A low level signal on RESET terminal intializes M66004. SERIAL-IN CIRCUIT is cleared and the display all 'ON/OFF' mode is in 'OFF' state. Other status and the data in RAM are kept in the previous states.

SCAN TIMING DESCRIPTION

The digit is scanned from upper figure to lower figure. And the Frame cycle time (T) is defined as T = N X Tdsp. (N and Tdsp are the value which are set by the command of Set display length and Set digit scan time) And the dimmer value is defined as Tdig/Tdsp.

(EXAMPLE)
When fxin = 500kHz and N = 16, Tdsp and T will be Tdsp = 256us, T = 4.1ms (244Hz) or Tdsp = 512us, T = 8.2ms (122Hz)



N: Maximum figure of digit

T; Frame cycle time
Tdsp: Digit scan time
Tdig: Digit 'ON' time
Tblk: Blank time

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Conditions	Ratings	Units
V_{CC}	Supply voltage			–0.3 ~ +7	V
Vp	Pull-down voltage		(Note 4)	V_{CC}–45 ~ V_{CC}+0.3	V
V_I	Input voltage			–0.3 ~ V_{CC}+0.3	V
V_O	Output voltage			–0.3 ~ V_{CC}+0.3	V
Pd	Power dissipation	SP	Ta = 25°C (Note 5)	1.6	W
		FP	Actually mounted. Ta = 25° (Note 6)	1.4	
Tstg	Storage temperature range			–65 ~ +150	°C

Note 4: Cycle time > 450us, pulse width < 30us, load capacitance < 200pF.
Note 5: Derating of 12.8mW/°C should be made at Ta > 25°C.
Note 6: Derating of 11.2mW/°C should be made at Ta > 25°C.

RECOMMENDED OPERATING CONDITIONS (Ta = –10 ~ +70°C, unless otherwise noted)

Symbol	Parameter	Conditions	Limits			Units
			Min	Typ	Max	
V_{CC}	Supply voltage		4.5	5	5.5	V
Vp	Pull-down voltage		V_{CC} - 40		V_{CC}	V
V_{SS}	Ground			0		V
V_I	Input voltage		0		V_{CC}	
Topr	Operating temperature range		–40		+40	°C

ELECTRICAL CHARACTERISTICS (Ta = −10 ~ +70°C, V_{CC} = 5V ± 10%, unless otherwise noted)

Symbol	Parameter		Conditions	Limits			Units
				Min	Typ*	Max	
V_{IH}	High-level input voltage	SDATA		0.7 V_{CC}			V
V_{IL}	Low-level input voltage					0.3 V_{CC}	V
V_{T+}	Positive-going threshold voltage	RESET CS, SCK, Xin		0.35 V_{CC}	2.8	0.7 V_{CC}	V
V_{T-}	Negative-going threshold voltage			0.2 V_{CC}	2.0	0.55 V_{CC}	V
I_{IH}	High-level input current		V_I =V_{CC}			1	uA
I_{IL}	Low-level input current		V_I =0V			−1	uA
V_{OH}	High output voltage	DIG	I_{OH} = 20mA	V_{CC} −2			V
		SEG	I_{OH} = −5mA	V_{CC} −2			V
		P_0, P_1	I_{OH} = −2mA	V_{CC} −0.8			V
V_{OL}	High level output voltage	P_0, P_1	I_{OL} = 2mA			0.55	V
I_O	Output pull-down current	DIG, SEG	Vp =V_{CC} −40V, V_O = V_{CC}	250	500	750	uA
I_{CC}	Positive power supply current (Note 7)	$V_{CC}1$, $V_{CC}2$	V_1 = 0V, output pin open			100	uA
			Output pin open, output "H", clock halt			40	mA
Ip	Negative power supply current	Vp	Output pin open, output "H", clock halt			−40	mA

Note 7: I_{CC} is the total current on $V_{CC}1$ and $V_{CC}2$.
*: Typical values are at Ta = 25°C, V_{CC} = 5V.

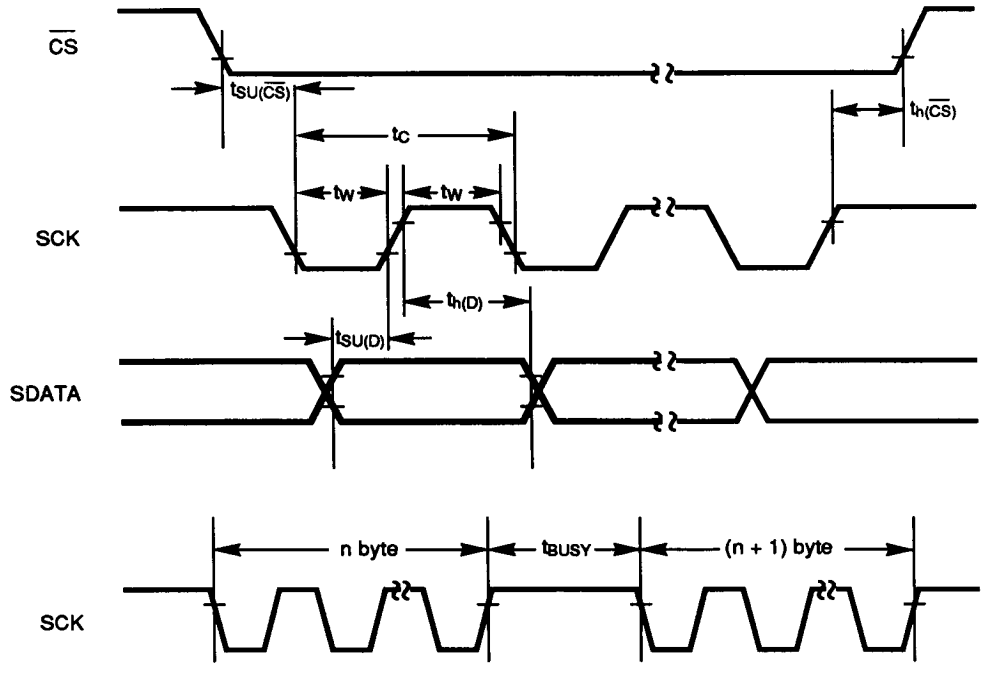
TIMING REQUIREMENTS (Ta = −10 ~ +70°C, V_{CC} = 5V ± 10%, unless otherwise noted)

Symbol	Parameter		Conditions	Limits			Units
				Min	Typ	Max	
t_C	Clock cycle time	SCK		500			ns
		Xin		1000			ns
t_W	Clock pulse width	SCK		230			ns
		Xin		460			ns
$t_{SU(D)}$	Data setup time			130			ns
$t_{h(D)}$	Data hold time			100			ns
$t_{SU(\overline{CS})}$	Chip select setup time			0			ns
$t_{h(\overline{CS})}$	Chip select hold time			130			ns
t_{BUSY}	Busy time			$t_{C(Xin)}$		6 $t_{C(Xin)}$	ns

OSCILLATION CHARACTERISTICS (Ta = −10 ~ +70°C, V_{CC} = 5V ± 10%, unless otherwise noted)

Symbol	Parameter	Conditions	Limits			Units
			Min	Typ	Max	
fosc	Oscillation frequency	C = 100pF, R = 27 kΩ		500		kHz

TIMING DIAGRAM

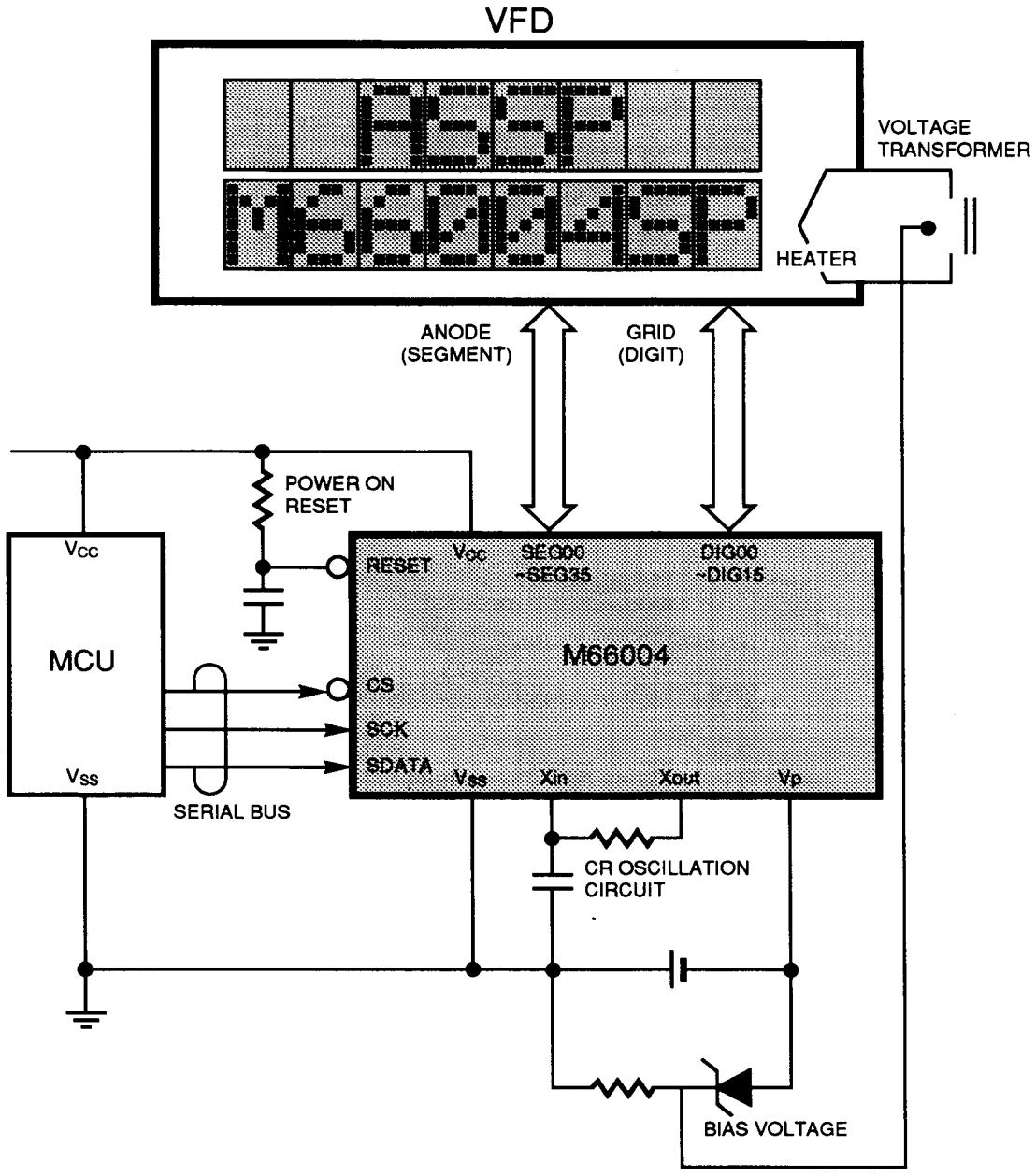


Reference Level: 0.3 V_{CC} and 0.7 V_{CC}

CHARACTER CODE

Upper / Lower	0000 (0_{16})	0001 (1_{16})	0010 (2_{16})	0011 (3_{16})	0100 (4_{16})	0101 (5_{16})	0110 (6_{16})	0111 (7_{16})	1000 (8_{16})	1001 (9_{16})	1010 (A_{16})	1011 (B_{16})	1100 (C_{16})	1101 (D_{16})	1110 (E_{16})	1111 (F_{16})
0000 (0_{16})			SPACE							RAM1	SPACE					
0001 (1_{16})										RAM2						
0010 (2_{16})										RAM3						
0011 (3_{16})										RAM4						
0100 (4_{16})										RAM5						
0101 (5_{16})										RAM6						
0110 (6_{16})										RAM7						
0111 (7_{16})										RAM8						
1000 (8_{16})										RAM9						
1001 (9_{16})										RAM10						
1010 (A_{16})										RAM11						
1011 (B_{16})										RAM12						
1100 (C_{16})										RAM13						
1101 (D_{16})										RAM14						
1110 (E_{16})										RAM15						
1111 (F_{16})										RAM16						

APPLICATION EXAMPLE



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