

Microprocessor Compatible Monitor Controller

FEATURES

- Synchronous signal processing for use in green monitor applications.
- Easy command interface for external microprocessor controls.
- D/A converters up to 12V output.
- Built-in self-test pattern generator.
- On-chip clock oscillator allows external TTL level clock signal input.

GENERAL DESCRIPTION

MTV003 is intended for use in digital-controlled, power-conscious (Green) monitor applications. It integrates 4 major function blocks traditionally implemented in discrete parts and provides an easy interface for microprocessor controls. The functional blocks included in MTV003 are: SYNC processing, D/A converters, self-test pattern generator and command interface.

BLOCK DIAGRAM

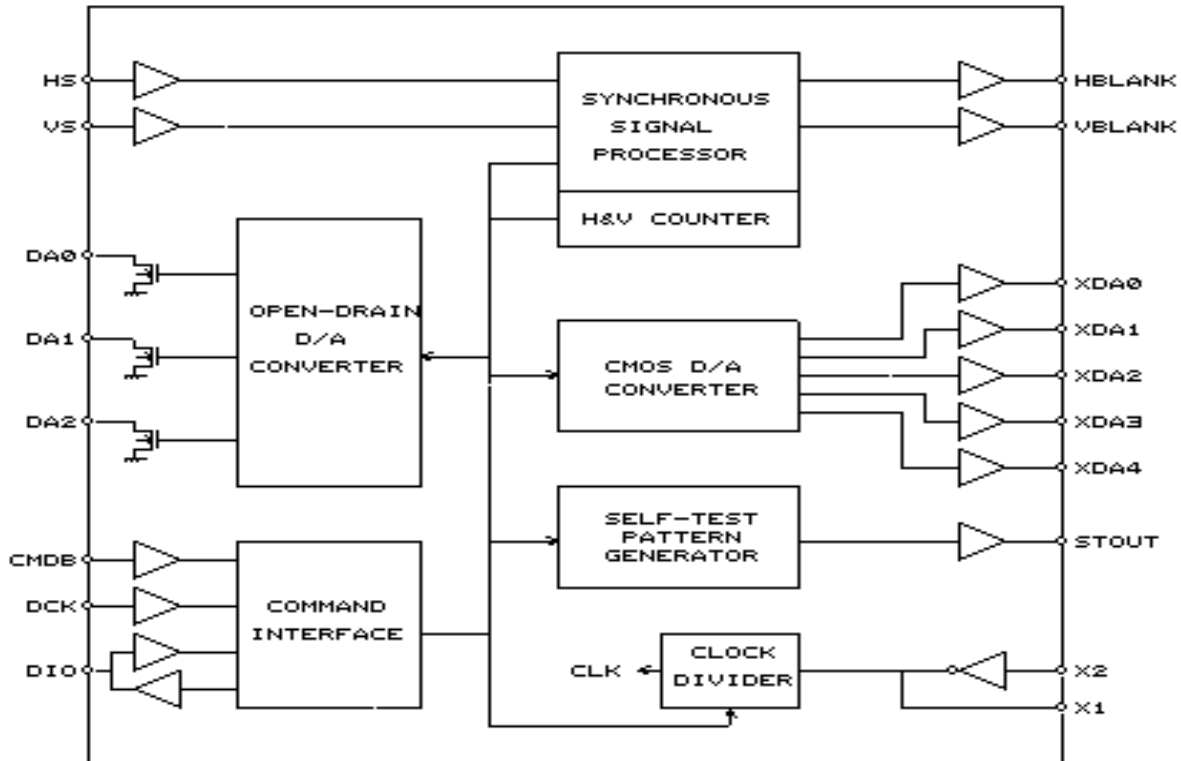
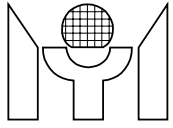


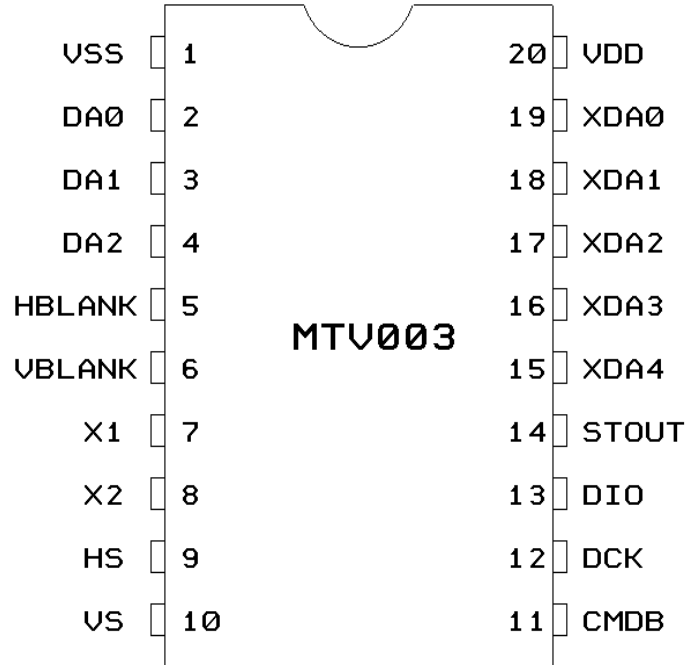
Figure 1. Block Diagram

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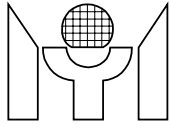
1.0 CONNECTION DIAGRAM

(20 PIN PDIP 300 MIL PACKAGE)



2.0 PIN DESCRIPTIONS

Name	I/O	Pin#	Function
VSS		1	Ground (0 V).
DA0	O	2	Open-Drain PWM (Pulse Width Modulation) D/A Converter 0. The output pulse width is programmable by writing data to Reg10 with 8-bit resolution to control the pulse width duration from 0 to 255/256. The output frequency is 31.25KHz (or15.625KHz). In applications, the external pull-up resistor can be connected to 12V for the desired full-scale output.
DA1	O	3	Open-Drain PWM D/A Converter 1. See DA0. The output pulse width is programmable by Reg11 .
DA2	O	4	Open-Drain PWM D/A Converter 2. See DA0. The output pulse width is programmable by Reg12 .
HBLANK	O	5	Horizontal Blank. The pulse width and the delay of HBLANK vs.HS input leading edges are programmable by Reg7 and Reg6 , respectively.
VBLANK	O	6	Vertical Blank. The output pulse width is programmable by Reg9 .
X1	I/O	7	Crystal 1. Used to interface to the oscillator. An 8MHz(or 4MHz) crystal must be connected between this pin and pin X2. An appropriate capacitor to Ground, whose value depends on the specified C_L of the crystal, must be connected. This pin can also be used as a direct input when the external oscillator is used.



Name	I/O	Pin#	Function
X2	O	8	Crystal 2. See X1. An appropriate capacitor to Ground, whose value depends on the specified C_L of the crystal, must be connected. For the external clock source, this pin must be tied to Ground.
HS	I	9	Horizontal Sync. Horizontal synchronous signal input. The input level is TTL compatible with internal 0.2V hysteresis. An internal 50K Ohm pull-up resistor is connected to this pin.
VS	I	10	Vertical Sync. Vertical synchronous signal input. The input level is TTL compatible with internal 0.2V hysteresis. An internal 50K Ohm pull-up resistor is connected to this pin.
CMDB	I	11	Command Interface Enabler. A low active pin which must be forced to low in excess of 16 cycles of DCK for 1 successful access of command interface. It has an internal 50K Ohm pull-up resistor.
DCK	I	12	Command Interface Clock. This pin is used as the timing base for command interface. The address or data portion for the serial in (out) of DIO is recognized by counting the number of DCKs. It has an internal 50K Ohm pull-up resistor.
DIO	I/O	13	Command Interface Data. This pin is a bidirectional pin. A microprocessor can access any internal command registers through the protocol of the address portion followed by the succeeding data portion. It must complete 16 full DCK cycles for a valid access.
STOUT	O	14	Self-Test Video Output. (for self-test mode) This pin is the video output pin of the self-test pattern generator. The generator enabler, pattern modes, output band selection and output enabler are programmed by Reg16 .
XDA4	O	15	CMOS PWM D/A Converter 4. See DA0. The output pulse width can be programmed by Reg30 . It is a CMOS type output.
XDA3	O	16	CMOS PWM D/A Converter 3. See DA0. The output pulse width can be programmed by Reg29 . It is a CMOS type output.
XDA2	O	17	CMOS PWM D/A Converter 2. See DA0. The output pulse width can be programmed by Reg28 . It is a CMOS type output.
XDA1	O	18	CMOS PWM D/A Converter 1. See DA0. The output pulse width can be programmed by Reg27 . It is a CMOS type output.
XDA0	O	19	CMOS PWM D/A Converter 0. See DA0. The output pulse width can be programmed by Reg26 . It is a CMOS type output.
VDD		20	Positive Power Supply. +5 volts. 2 decoupling capacitors, 0.1 uF and 100 uF, must be connected to VDD and Ground as close to the device as possible.

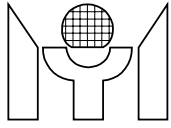
3.0 FUNCTIONAL DESCRIPTION

3.1 Crystal Oscillator and Clock Generator

The crystal oscillator shall be connected to an 8MHz(or 4MHz) crystal. X1, as shown in Fig.1, can be used as an input source for the external clock or an output clock source to drive the external MCU. All timing specifications are based on the frequency of X1 (or X1 divided by 2).

3.2 PWM D/A Converter

There are 2 types of D/A converters with 8-bit resolution: open-drain type (DA0 to DA2) and CMOS type (XDA0 to XDA4). The sampling frequency is 31.25KHz or 15.625KHz, depending on the use of the crystal. The maximum external voltage applied is 12V for the open-drain type, and the output pulse width is programmable



for each converter by setting the corresponding register.

3.3 SYNC Processor

The sync processor contains the following functions: polarity detection, presence detection, H-Freq counter, V-Freq counter and sync signal separation for input SYNC sources (HS and VS). It can be programmed to change the detected polarity status and output polarity of SYNC pins (HBLANK and VBLANK) by using the command interface. The timing diagrams of sync processing are shown as Fig. 2 in section 8.0. The internal SYNC signals (Hsync and Vsync) are extracted from different bits sources according to the following modes of operation.

	Mode	VS	HS	Comment
1	Separate(H+V)	present	present	HS = H or H/V sync
2	Composite(H/V)	not present	present	HS= H/V sync
3	Suspend	present	not present	-
4	Off	not present	not present	-

3.4 H-Freq Table

After the "start H-Freq count" command is issued over 10 ms (for 15.7KHz) and HCFF(H-Freq Count Finished Flag) is set **High**, the H-Freq output (HF9 - HF0) is valid. The output value of H-Freq is calculated using the following formula:

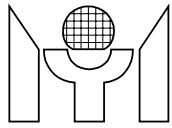
$$\text{output value} = [(1/f_{\text{Hfreq}}(\text{KHz})) \times 64 \times 4000] / 16$$

	H-Freq(KHz)	Output value hexadecimal	11 bits decimal	Tolerance (%)
1	15.7	3FB	1019	0.0981354
2	18.7	357	855	0.1169591
3	21.8	2DD	733	0.1364256
4	30	215	533	0.1876172
5	31.5	1FB	507	0.1972386
6	33.5	1DD	477	0.2096436
7	35.5	1C2	450	0.2222222
8	36.8	1B2	434	0.2304147
9	38	1A5	421	0.2375297
10	40	190	400	0.2500000
11	48	14D	333	0.3003003
12	50	140	320	0.3125000
13	57	118	280	0.3571428
14	60	10A	266	0.3759398
15	64	0FA	250	0.4000000
16	100	0A0	160	0.6250000

3.5 V-Freq Table

After the "start V-Freq count" command is issued over 120 ms (for 50HZ) and VCFF (V-Freq Count Finish Flag) is set **High**, the V-Freq output (VF8 - VF0) is valid. The output value of V-Freq is calculated according to the following formula:

$$\text{output value} = [(4/f_{\text{Vfreq}}(\text{Hz})) \times 4000000] / (64 \times 16)$$



	V-Freq(Hz)	Output value hexadecimal 9 bits decimal		Tolerance (%)
1	20	30D	781	0.12804
2	56.25	115	277	0.36101
3	59.94	104	260	0.38461
4	60	104	260	0.38461
5	60.32	103	259	0.38610
6	60.53	102	258	0.38759
7	66.67	0EA	234	0.42735
8	70.069	0DE	222	0.45045
9	70.08	0DE	222	0.45045
10	72	0D9	217	0.46082
11	72.378	0D7	215	0.46511
12	72.7	0D6	214	0.46728
13	87	0B3	179	0.55865

3.6 Command Interface

The command interface contains 3 pins. Each transfer of command is comprised of 16 DCK clock periods. The first 8 DCK clocks are for the address and direction of DIO, and the succeeding 8 DCK clocks are for the data. Each transfer is initiated by setting CMDDB **Low**. The CMDDB pin must be pulled **High** after data transfer is completed.

- Command Format

- B0 - 4 (*ADD4 - 0*) : Address of the registers.
- B5 (*W/RB*) : Transfer direction, 1=write, 0=read.
- B6 - 7 : Reserved.
- B8 - 15 (*DA0 - 7*) : Data input when *W/RB*=1.
- (*DA7 - 0*) : Data output when *W/RB*=0.

- Register Allocation

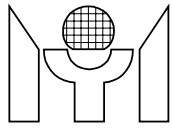
a. Read Transfer

Reg #	Address Portion		Data Portion							
	<i>ADD4-0</i>	<i>W/RB</i>	<i>DA7 - 0</i>							
	B0 - 4	B5	B8	B9	B10	B11	B12	B13	B14	B15
Reg0	00000	0	H _{pol}	V _{pol}	HS _{pre}	VS _{pre}	HV _{pre}	H _{sl}	V _{sl}	x
Reg1	00001	0	x	x	x	x	HCFF	HF10	HF9	HF8
Reg2	00010	0	HF7	HF6	HF5	HF4	HF3	HF2	HF1	HF0
Reg3	00011	0	x	x	x	x	x	x	VCFF	VF8
Reg4	00100	0	VF7	VF6	VF5	VF4	VF3	VF2	VF1	VF0

Table 4

b. Write Transfer

Reg #	Address Portion		Data Portion							
	<i>ADD4-0</i>	<i>W/RB</i>	<i>DA0 - 7</i>							
	B0 - 4	B5	B8	B9	B10	B11	B12	B13	B14	B15
Reg0	00000	1	x	x	x	x	x	x	x	x
Reg1	00001	1	V _{pf0}	V _{pf1}	H _{pf0}	H _{pf1}	VB _{pl}	HB _{pl}	HV _{cvs}	x
Reg2	00010	1	x	x	x	x	x	x	x	x
Reg3	00011	1	CLK4M	TEST	x	x	x	x	x	x



Reg4	00100	1	Reserved							
Reg5	00101	1	Reserved							
Reg6	00110	1	HBD0	HBD1	HBD2	HBD3	HBD4	HBD5	HBD6	HBD7
Reg7	00111	1	HBW0	HBW1	HBW2	HBW3	HBW4	HBW5	HBW6	HBW7
Reg8	01000	1	Reserved							
Reg9	01001	1	VBW0	VBW1	VBW2	VBW3	VBW4	VBW5	x	VBW7
Reg10	01010	1	DA0 _{b0}	DA0 _{b1}	DA0 _{b2}	DA0 _{b3}	DA0 _{b4}	DA0 _{b5}	DA0 _{b6}	DA0 _{b7}
Reg11	01011	1	DA1 _{b0}	DA1 _{b1}	DA1 _{b2}	DA1 _{b3}	DA1 _{b4}	DA1 _{b5}	DA1 _{b6}	DA1 _{b7}
Reg12	01100	1	DA2 _{b0}	DA2 _{b1}	DA2 _{b2}	DA2 _{b3}	DA2 _{b4}	DA2 _{b5}	DA2 _{b6}	DA2 _{b7}
Reg13	01101	1	Reserved							
Reg14	01110	1	Reserved							
Reg15	01111	1	Reserved							
Reg16	10000	1	STF	RT0	RT1	ST _{bsh}	Selft	x	x	x
Reg17	10001	1	x	x	x	x	x	x	x	x
Reg18 Reg25	10010 11001		Reserved							
Reg26	11010	1	XA0 _{b0}	XA0 _{b1}	XA0 _{b2}	XA0 _{b3}	XA0 _{b4}	XA0 _{b5}	XA0 _{b6}	XA0 _{b7}
Reg27	11011	1	XA1 _{b0}	XA1 _{b1}	XA1 _{b2}	XA1 _{b3}	XA1 _{b4}	XA1 _{b5}	XA1 _{b6}	XA1 _{b7}
Reg28	11100	1	XA2 _{b0}	XA2 _{b1}	XA2 _{b2}	XA2 _{b3}	XA2 _{b4}	XA2 _{b5}	XA2 _{b6}	XA2 _{b7}
Reg29	11101	1	XA3 _{b0}	XA3 _{b1}	XA3 _{b2}	XA3 _{b3}	XA3 _{b4}	XA3 _{b5}	XA3 _{b6}	XA3 _{b7}
Reg30	11110	1	XA4 _{b0}	XA4 _{b1}	XA4 _{b2}	XA4 _{b3}	XA4 _{b4}	XA4 _{b5}	XA4 _{b5}	XA4 _{b7}
Reg31	11111	1	Reserved							

* The above x may represent any data.

- Command Descriptions

Reg0 (write) : Begins the H-Freq count. To read the value in the H-Freq registers, the write command (**Reg0**) needs to be issued first.

Reg0 (read) : The status of polarity, presence and static level for HS and VS.

1. Hpol, Vpol = 1 -> positive, = 0 -> negative.
2. HSpre, VSpre, HVpre = 1 -> present, = 0 -> not present.
3. Hsl, Vsl = 1 -> high, = 0 -> low.

* HVpre represents the status of the composite (H/V) presence in HS. Hsl or Vsl is valid only when HSpre or VSpre is not present.

Reg1 (read) : Hfreq Count Finish flags, Hfreq high bit.

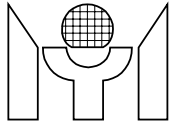
1. HCFF = 1 -> valid, = 0 -> not valid.
2. HF10 - HF8 = 3 high bit of Hfreq.

Reg1 (write) : Selects the source of VBLANK and controls the polarity status of Hpol, Vpol and SYNC output polarity.

1. HVcvs = 1 -> VBLANK is extracted from HS.
= 0 -> VBLANK is extracted from VS.
2. HBpl = 1 -> negative HBLANK output, = 0 -> positive HBLANK output.
3. VBpl = 1 -> negative VBLANK output, = 0 -> positive VBLANK output.

* After power-on, HBpl and VBpl shall be initialized to 0.

4. Hpf1, Hpf0 = 0,0 or 1,1 -> Hpol = x, by auto detection.
= 0,1 -> force Hpol = 1.
= 1,0 -> force Hpol = 0.
5. Vpf1, Vpf0 = 0,0 or 1,1 -> Vpol = x, by auto detection.



= 0,1 -> force Vpol = 1.
= 1,0 -> force Vpol = 0.

Reg 2 (read) : H-Freq low byte.

Reg 2 (write) : Begins V-Freq count. To read the value in V-Freq registers, the write command (**Reg2**) must be issued first.

Reg3 (read) : V-Freq Count Finish flag, V-Freq high bit.
1. VCFF = 1 -> valid, = 0 -> not valid.
2. VF8 = the high bit of V-Freq.

Reg3 (write) : Controls test and clock modes.
1. TEST = 0 -> Normal mode.
= 1 -> **Test mode, not allowed in applications.**
2. CLK4M = 0 -> CLK = X1 divided by 2 (for 8MHz crystal power-on [default]).
= 1 -> CLK = X1 (for 4MHz crystal power-on [default]).

Reg4 (read) : V-Freq low byte.

Reg4 (write) : Reserved.

Reg5 (write) : Reserved.

Reg6 (write) : Controls the delay of HBLANK output (7 bits).
(HBD7 - 0)
= 10000000 -> Directly bypasses Hsync to output.
= 01000000 -> Min. propagation delay (approximately 300ns).
= 00000000 -> T + 500ns.
= 00000001 -> 2T + 500ns.
= 00111111 -> 64T + 500ns.

Reg7 (write) : Controls the width of HBLANK output (7 bits).
(HBW7 - 0)
= 10000000 -> Directly bypasses Hsync to output.
= 01000000 -> Min. width (approximately 300ns).
= 00000000 -> T + 500ns.
= 00000001 -> 2T + 500ns.
= 00111111 -> 64T + 500ns.

Reg8 (write) : Reserved.

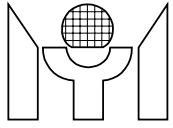
Reg9 (write) : Controls the width of Vblank output (7 bits).
(VBW7 - 0)
= 1-000000 -> Directly bypasses Vsync to output.
= 0-000000 -> Min. width (approximately 8us).
= 0-000001 -> 16 + 8(us).
= 0-111111 -> 16 * 63 + 8(us) = 1.016ms.

Reg10 (write) : Output pulse width control for DA0.

Reg11 (write) : Output pulse width control for DA1.

Reg12 (write) : Output pulse width control for DA2.

Reg13 (write) : Reserved.



Reg14 (write) : Reserved.

Reg15 (write) : Reserved.

Reg16 (write) : Controls i) enabler, ii) band selection, iii) 4 pattern modes and iv) output enabler for the self-test pattern generator.

- | | | |
|-------------|-------|--|
| 1. Selft | = 1 | -> Enables generator. |
| | = 0 | -> Disables generator. |
| 2. STbsh | = 1 | -> 63.5KHz (horizontal) output selected. |
| | = 0 | -> 31.75 KHz (horizontal) output selected. |
| 3. RT1, RT0 | = 0,0 | -> Positive cross-hatch pattern output. |
| | = 0,1 | -> Negative cross-hatch pattern output. |
| | = 1,0 | -> Full white pattern output. |
| | = 1,1 | -> Full black pattern output. |
| 4. STF= 1 | | -> Enables STOUT output. |
| | = 0 | -> Disables STOUT output. |

Reg17 (write) : Reinitializes all internal registers.

Reg26 (write) : Output pulse width control for XDA0.

Reg27 (write) : Output pulse width control for XDA1.

Reg28 (write) : Output pulse width control for XDA2.

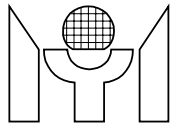
Reg29 (write) : Output pulse width control for XDA3.

Reg30 (write) : Output pulse width control for XDA4.

Reg31 (write) : Reserved.

*1. The above T = 250ns.

- All D/A converters are centered with a value of **DA7 - 0** = 10000000, and other registers are initialized with **low** after power-on or a **Reg17** write.
- The duration of power-on initialization is 200ms and **Reg17** write reinitiation is 2.5ms. No register access is allowed during initialization.



4.0 ABSOLUTE MAXIMUM RATINGS

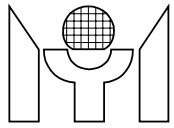
DC Supply Voltage (VDD)	-0.3 to 7 V
Voltage with respect to Ground:	
All pins except VDD and DA0 to DA2	-0.3 to VDD+ 0.3 V
DA0 to DA2	-0.3 to +13.2 V
Storage Temperature	-65 to +150 °C
Ambient Operating Temperature	0 to +70 °C

5.0 OPERATING CONDITIONS

DC Supply Voltage (VDD)	+4.75 V to +5.25 V
External D/A Power Supply	+5 V to 12 V
Operating Temperature	0 to +70 °C

6.0 ELECTRICAL CHARACTERISTICS (Under Operating Conditions)

Symbol	Parameter	Conditions (Notes)	Min.	Max.	Unit
V _{IH}	Input High Voltage	- (for all input pins)	2.4	VDD+ 0.3	V
V _{IL}	Input Low Voltage	- (for all input pins)	VSS-0.3	0.8	V
V _{OH}	Output High Voltage	I _{OH} = -500 uA (for pins of HBLANK, VBLANK, DIO, Bout, STOUT, XDA4-0)	3.0	-	V
V _{OL}	Output Low Voltage	I _{OL} = 4 mA (see V _{OH})	-	0.5	V
V _{DAOL}	Open-Drain D/A Output Low Voltage	I _{DAOL} = 3 mA (for pins of DA2-0)	-	0.35	V
V _{DAOH}	Open-Drain D/A Output High Voltage	- (for pins of DA2-0, pulled up by external 5 to 12V power supply)	5	12	V
I _{CC}	Maximum Quiescent Supply Current	V _{in} = VDD, I _{out} = 0 uA. (all input pins connected to VDD, all output pins without connection)	-	20	mA



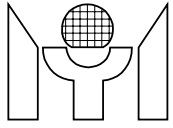
7.0 SWITCHING CHARACTERISTICS (Under Operating Conditions and X1=8MHz)

Symbol	Parameter	Min.	Typ.	Max.	Unit
f _{DAO}	D/A Converter Output Frequency	-	31.25	-	KHz
f _{XTAL}	Crystal Frequency	-	8	-	MHz
f _{HS}	HS Input Frequency	15	-	100	KHz
f _{VS}	VS Input Frequency	20	-	100	Hz
t _{HIPW}	HS Input Pulse Width	0.5	-	6.5	us
t _{VIPW}	VS Input Pulse Width	25	-	2000	us
t _{HHBD}	HSYNC (Rise) to HBLANK Output Delay (programmed by Reg6)	300	(N+1)xT+500	64xT+850	ns
	HSYNC (Rise) to HBLANK Output Delay (bypass HSYNC to HBLANK Output directly)	-	-	50	ns
t _{HBW}	HBLANK Output Width (programmed by Reg7)	300	(N+1)xT+500	64xT+850	ns
	HBLANK Output Width (bypass HSYNC to HBLANK Output directly)	0.5	-	7	us
t _{HBJ}	HSYNC to HBLANK Output Jitter	-	-	(+/-) 25	ns
t _{VBW}	VBLANK Output Width (programmed by Reg9)	16	(Nx16)+8	1016	us
	VBLANK Output Width (bypass VSVNC to VBLANK Output directly)	25	-	2000	us
t _{HVBD}	HSYNC to VBLANK Output Delay (H/V mode)	-	1 H-line	-	-
t _{VVBD}	VS to VBLANK Output Delay (H+V mode)	-	-	50	ns
t _{VVBJ}	VSYNC to VBLANK Output Jitter(H+V mode)	-	-	(+/-) 25	ns
t _{HVBJ}	HSYNC to VBLANK Output Jitter (H/V mode)	-	-	(+/-) 25	ns
t _{CDSU}	CMDB to DCK Setup Time	200	-	-	ns
t _{CDH}	CMDB to DCK Hold Time	100	-	-	ns
t _{DDSU}	DIO to DCK Setup Time (write)	200	-	-	ns
t _{DDH}	DIO to DCK Hold Time(write)	100	-	-	ns
t _{DCKH}	DCK High Time	200	-	-	ns
t _{DCKL}	DCK Low Time	200	-	-	ns
T _{DDD}	DCK to DIO Delay Time(read)	100	-	-	ns

* 1. The above HSYNC is extracted from HS input and VSYNC is extracted from VS, HS input.

* 2. T = 250ns (1/4MHz) is fixed regardless of whether or not an 8(or 4)MHz crystal is used.

* 3. $0 \leq N \leq 63$



8.0 TIMING DIAGRAMS

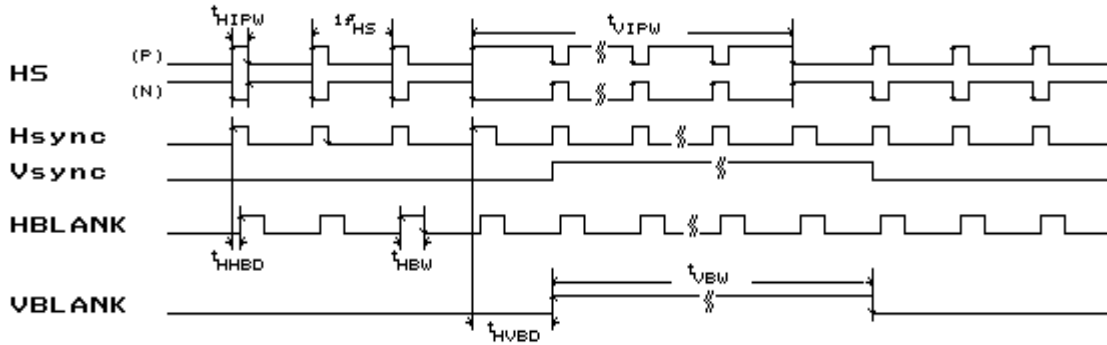


Figure 2. H/V Mode Timing

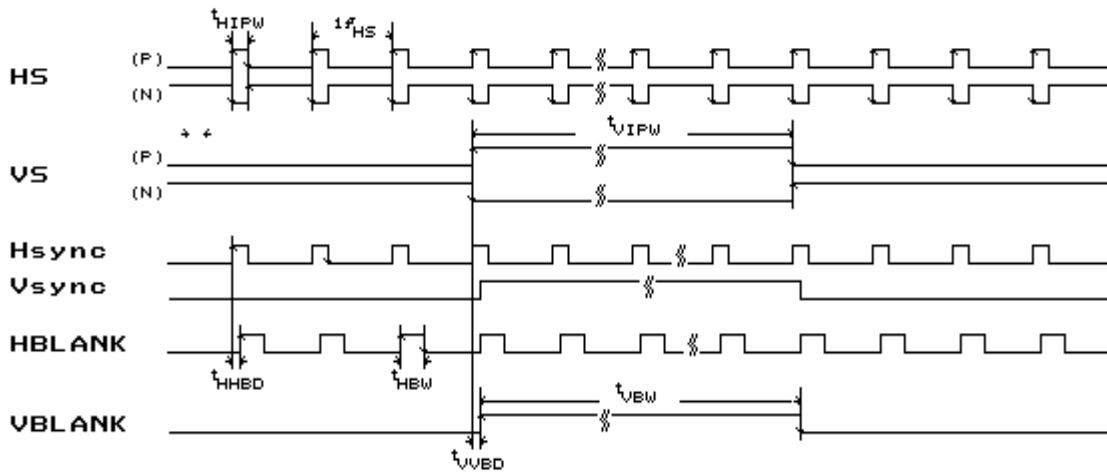


Figure 3. H+V Mode Timing

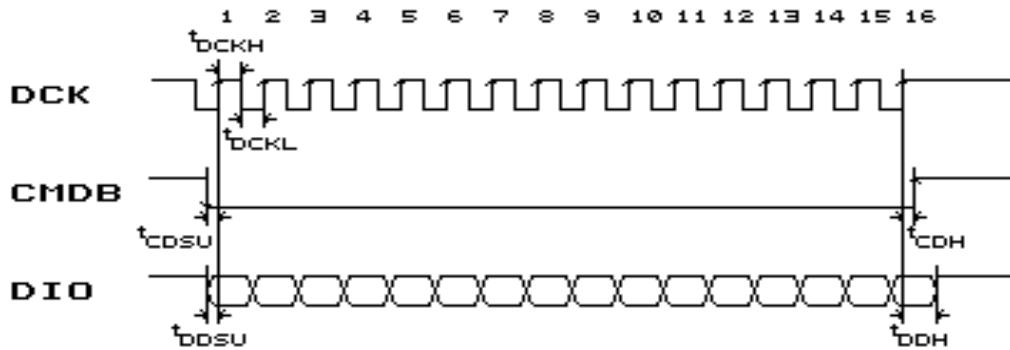


Figure 4. Command Interface Write Timing.

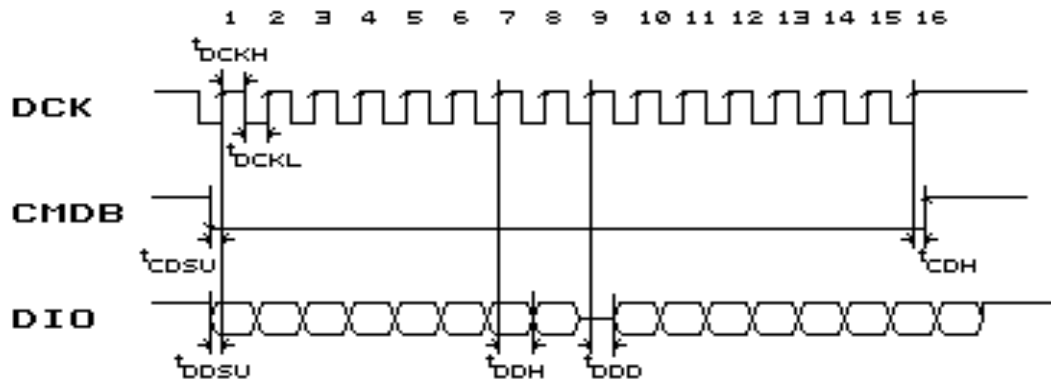
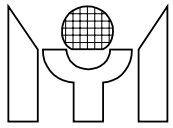


Figure 5. Command Interface Read Timing.

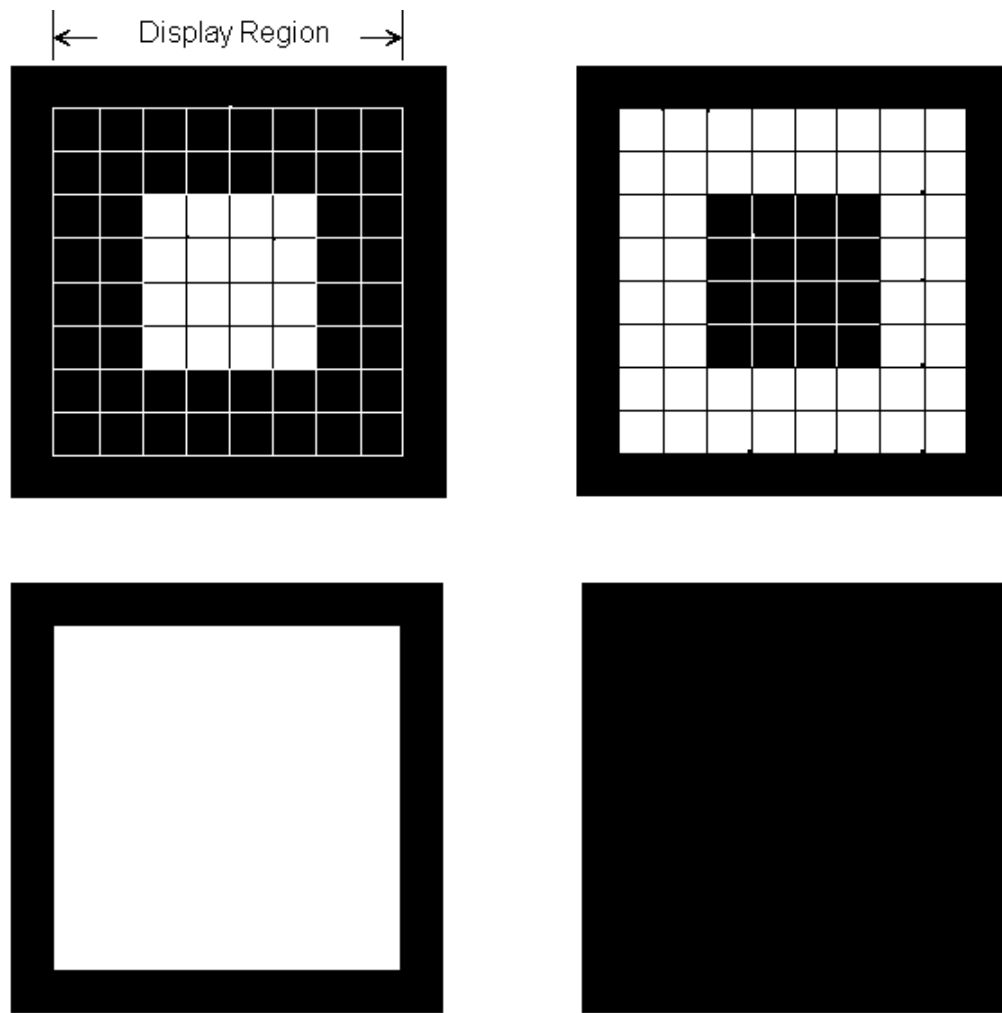
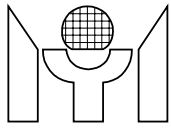
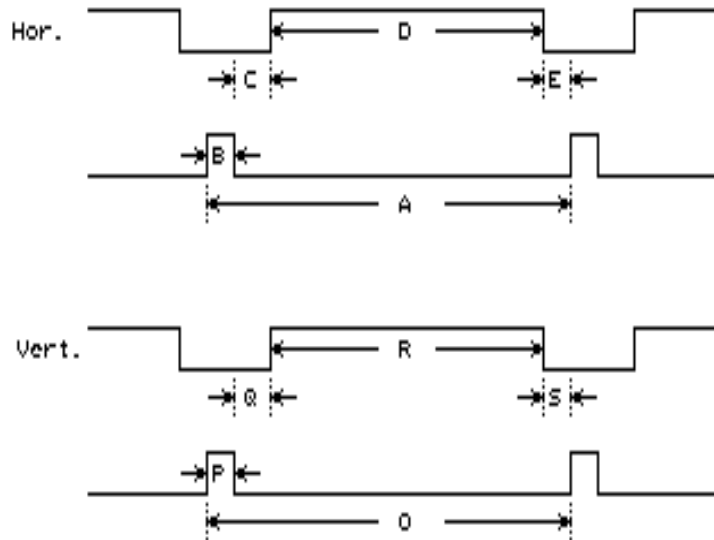


Figure 6. 4 Self-Test Patterns



MTV003 SELF TEST PATTERN TIMING.



A) 63.5KHz, 60Hz

B) 31.75KHz, 60Hz

	(Absolute time)	(H dots)	(Absolute time)	(H dots)
1. Hor. total time	us(A)=15.75	1280	us(A)=31.5	640
2. Hor. active time	us(D)=12.05	979.3	us(D)=24.05	488.6
3. Hor. F.P.	us(E)=0.2	16.25	us(E)=0.45	9
4. SYNC pulse width	us(B)=1.5	122	us(B)=3	61
5. Hor. B.P.	us(C)=2	162.54	us(C)=4	81.27
		(V lines)		(V lines)
6. Vert. total time	ms(O)=16.6635	1024	ms(O)=16.6635	480
7. Vert. active time	ms(R)=15.6555	962	ms(R)=15.6555	451
8. Vert. F.P.	ms(S)=0.063	3.87	ms(S)=0.063	1.82
9. SYNC pulse width	ms(P)=0.063	3.87	ms(P)=0.063	1.82
10. Vert. B.P.	ms(Q)=0.882	54.2	ms(Q)=0.882	25.4

* 8 x 8 blocks of cross hatch pattern in display region.

Figure 7. Self-Test Timing