M50423FP

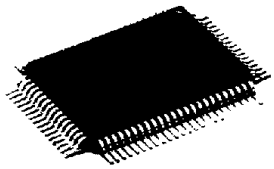
CD PLAYER DIGITAL SIGNAL PROCESSOR

DESCRIPTION

The M50423FP is a CMOS IC developed for compact disc (CD) sound reproducing applications. It has adjustment-free PLL, error correction circuitry, etc. and is used in a CD digital signal processing section. Applications include also CD-ROM and CD-G, as well as CD-DA.

FEATURES

- Adjustment free EFM-PLL circuit (built-in VCO)
- ± 8 frames jitter margin
- Easy-to-handle CLV servo commands
- Subcode parallel/serial interface
- Selection available from 2 times and 4 times over sampling
- 18/20bit output available (with 4 times oversampling)
- Dual DAC output available (with 4 times oversampling)



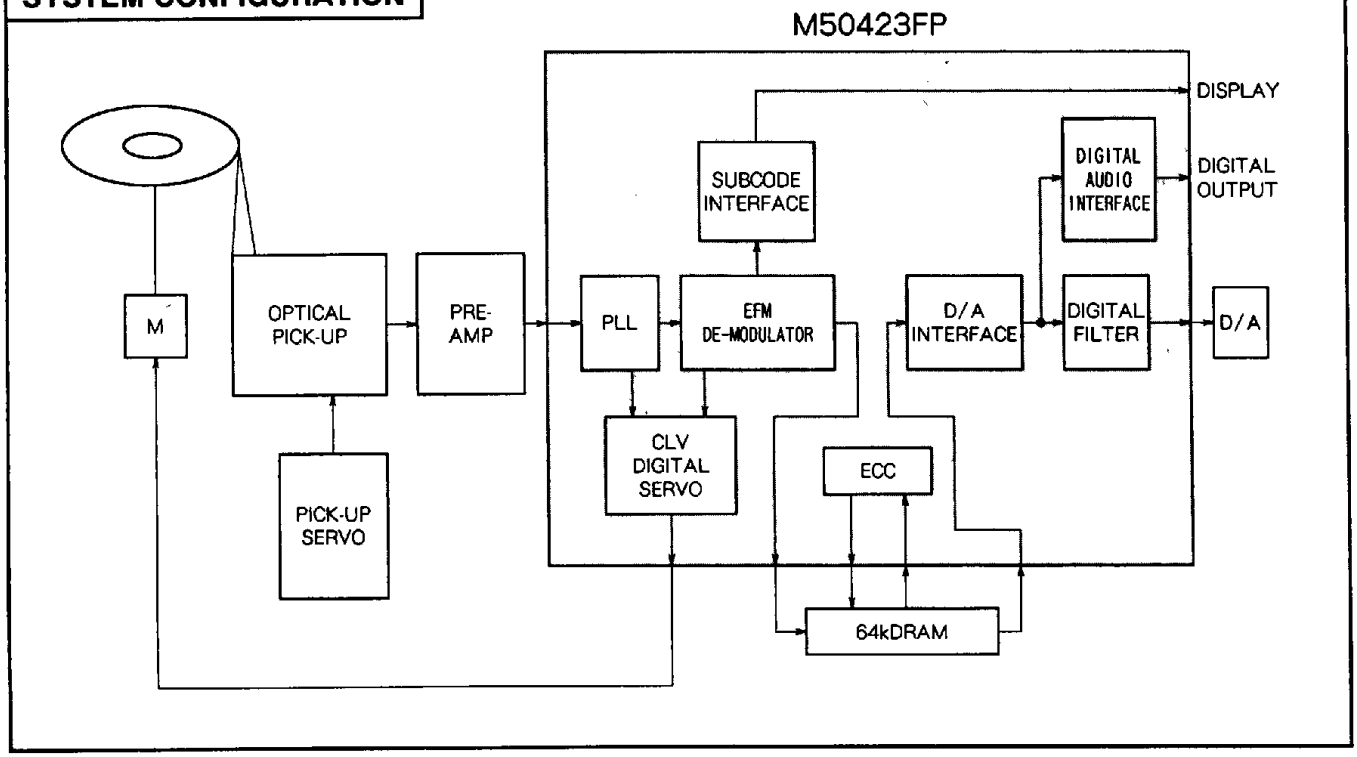
Outline 80P6-B

0.8mm pitch QFP
(20.0mm × 14.0mm × 2.15mm)

RECOMMENDED OPERATING CONDITIONS

Supply voltage range ..... V_{DD} = 4.5~5.5V
Rated supply voltage ..... V_{DD} = 5V
Rated power dissipation 90mW

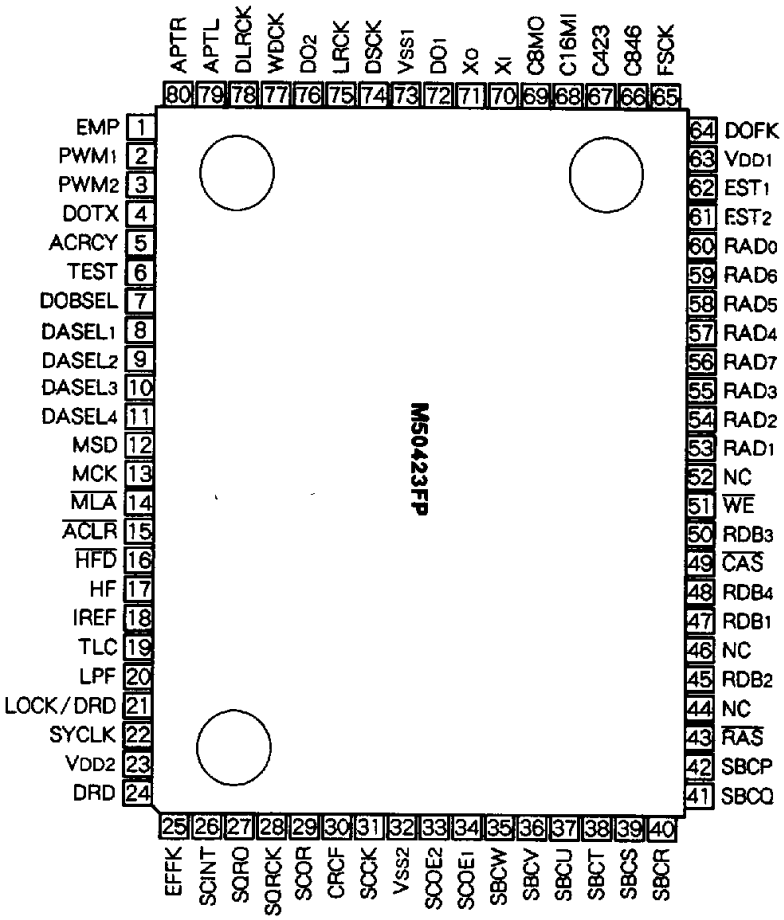
SYSTEM CONFIGURATION



M50423FP

CD PLAYER DIGITAL SIGNAL PROCESSOR

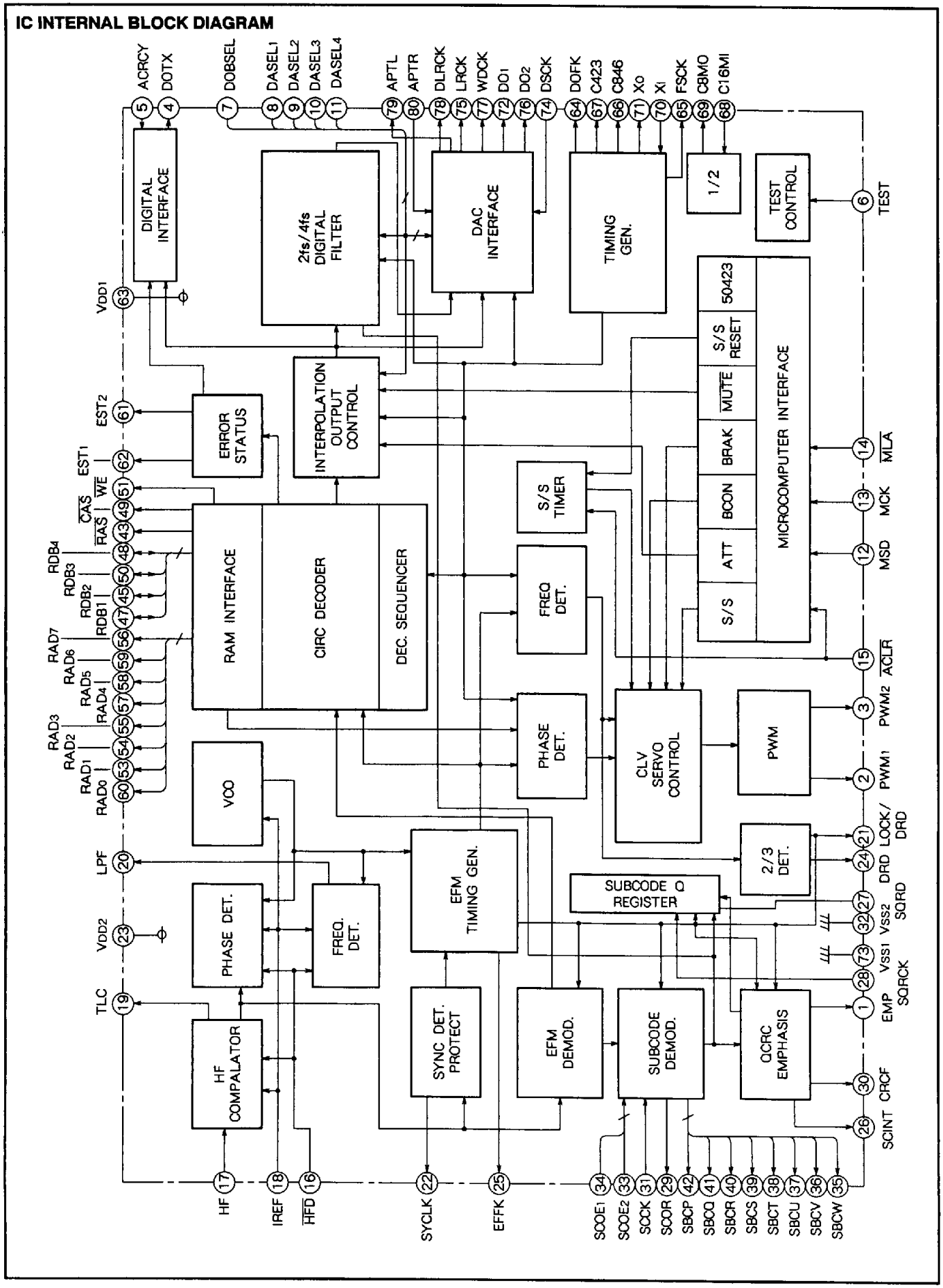
PIN CONFIGURATION



Outline 80P6-B

NC : NO CONNECTION

IC INTERNAL BLOCK DIAGRAM



M50423FP

CD PLAYER DIGITAL SIGNAL PROCESSOR

PIN DESCRIPTION

Name	I/O	Function
EMP	O	Emphasis flag output. Emphasis = 1
PWM_1	O	Disc motor driving PWM output 1. −
PWM_2	O	Disc motor driving PWM output 2. +
DOTX	O	Output of digital interface
ACRCY	I	Clock accuracy input
TEST	I	Test control input. Normal = 0
DOBSEL	I	Data bit select 18bit = 1
$DASEL_1$	I	DAC interface format select 1
$DASEL_2$	I	DAC interface format select 2
$DASEL_3$	I	DAC interface format select 3
$DASEL_4$	I	DAC interface format select 4
MSD	I	Microcomputer interfece serial data input
MCK	I	Microcomputer interface shift cloc input
$\overline{MLA}$	I	Microcomputer interface data latch clock
$\overline{ACLR}$	I	Microcomputer interface register clear input
$\overline{HFD}$	I	High frequency signal detect
HF	I	High frequency signal input
IREF	I	Current referance
TLC	O	Output from slicon level control
LPF	I/O	PLL loop filter
LOCK/ DRD	O	Lock status/Disc rotation down signal output
SYCLK	O	Frame lock status output. Lock = 1
V_{DD2}	I	V_{DD} for data slicer and VCO
DRD	O	Disc rotation down signal output.
EFFK	O	EFM frame clock output duty ≒ 50 %
SCINT	O	Interrupt output of subcode Q
SQRO	O	Subcode Q register output
SQRCK	I	Subcode Q register
SCOR	O	Subcode sync output. $S_0 + S_1$
CRCF	O	Subcode Q CRC check flag output. CROCK = 1
SCCK	I	Shift clock input for serial subcode data output
V_{SS2}	I	Ground. 0V
$SCOE_2$	I	Enable input of subcode T~Wch output. 0 : High Z
$SCOE_1$	I	Enable input of subcode P~Sch output. 0 : High Z
SBCW	O	Subcode Wch output
SBCV	O	Subcode Vch output
SBCU	O	Subcode Uch output
SBCT	O	Subcode Tch output
SBCS	O	Subcode Sch output
SBCR	O	Subcode Rch output

Name	I/O	Function
SBCQ	O	Subcode Qch output
SBCP	O	Subcode Pch output. Pch~Wch serial data output
$\overline{RAS}$	O	Row address strobe to RAM
NC	−	NO CONNECTION
RDB_2	I/O	Data input/output 2 to RAM
NC	−	NO CONNECTION
RDB_1	I/O	Data input/output 1 to RAM
RDB_4	I/O	Data input/output 4 to RAM
$\overline{CAS}$	O	Column address strobe signal output to RAM
RDB_3	I/O	Data input/output 3 to RAM
$\overline{WE}$	O	Write enable output to RAM
NC	−	NO CONNECTION
RAD_1	O	Address output 1 to RAM
RAD_2	O	Address output 2 to RAM
RAD_3	O	Address output 3 to RAM
RAD_7	O	Address output 7 to RAM
RAD_4	O	Address output 4 to RAM
RAD_5	O	Address output 5 to RAM
RAD_6	O	Address output 6 to RAM
RAD_0	O	Address output 0 to RAM
EST_2	O	Error status 2, Error to be interpolated detected at C2
EST_1	O	Error status 1, Error detected at C1
V_{DD1}	I	Power supply 5V
DOFK	O	OSC frame clock output. 7.35kHz, duty=50%
FSCK	O	Clock output 44.1kHz (fs)
C846	O	Clock output. 8 4672MHz
C423	O	Clock output. 4 2336MHz
C16MI	I	1/2 divider input with internal feedback resistor
C8MO	O	1/2 divider output
X_I	I	Crystal oscillator input with internal feedback resistor
X_O	O	Crystal oscillator output
DO_1	O	Dual DAC Rch serial data output
V_{SS1}	I	Ground 0V
DSCK	O	Data shift clock to DAC
LRCK	O	Lch/Rch clock to DAC or APTL clock
DO_2	O	Dual DAC Lch serial data output
WDCK	O	Word clock to DAC or APTL clock
DLRCK	O	Lch/Rch clock
APTL	O	DAC sampling clock Lch
APTR	O	DAC sampling clock Rch

ABSOLUTE MAXIMUM RATINGS (Ta = 25℃, unless otherwise noted)

Symbol	Parameter	Conditions	Ratings	Uniit
V_{DD}-V_{SS}	Supply voltage		−0.3～+7.0	V
V_I	Input voltage	(R_P = 0 Ω)	V_{SS}-0.3≦ V_I ≦ V_{DD}+0.3	V
V_O	Output voltage	(R_P = 0 Ω)	V_{SS}-0.3≦ V_O ≦ V_{DD}	V
V_P	Pull up voltage		V_P≦ V_{DD} + 2mA * R_P	V
T_{opr}	Operating temperature		−10～+70	℃
T_{stg}	Storage temperature		−40～+125	℃
P_d	Power dissipation		350	mW

R_P : Pull up resistor

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Test conditions	Applied pin	Limits			Unit
				Min	Typ	Max	
V_{DD}	Supply voltage			4.5	5.0	5.5	V
V_{IH1}	High-level input voltage 1		2)	V_{DD} *0.5	−	V_{DD}	V
V_{IH2}	High-level input voltage 2		1)	V_{DD} *0.7	−	V_{DD}	V
V_{IL1}	Low-level input voltage 1		2)	V_{SS}	−	V_{DD} *0.08	V
V_{IL2}	Low-level input voltage 2		1)	V_{SS}	−	V_{DD} *0.3	V
f_{OSC}	Oscillation frequency (X'tal)			−	8.46	−	MHz
f_{VCO}	Oscillation frequency (VCO)			−	8.64	−	MHz

Note 1. Applied pin
1) DASEL1～DASEL4, ACRCY, DOBSEL, TEST
2) $\overline{HFD}$, SCOE1, SCOE2, SCCK, MSD, MCK, $\overline{MLA}$, $\overline{ACLR}$, RDB1～RDB4, SQRCK

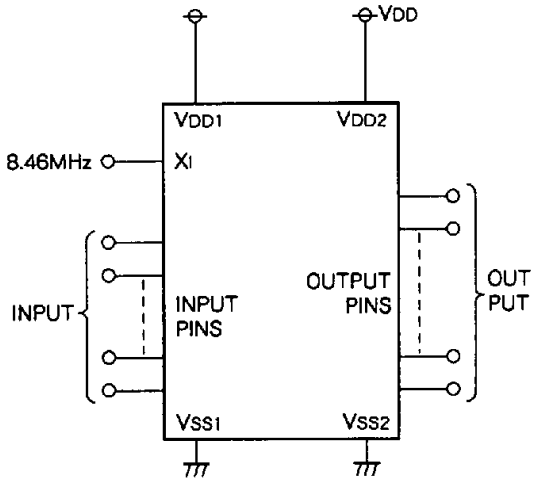
ELECTRICAL CHARACTERISTICS (Ta = 25℃, V_{DD} = 5V, unless otherwise noted)

Symbol	Parameter	Test conditions	Applied pin	Test circuit	Limits			Unit
					Min	Typ	Max	
V_{DD}	Supply voltage	T_a = − 10～+ 70℃		1	4.5	5.0	5.5	V
I_{DD}	Circuit control	f_{OSC} = 8.4672MHz f_{VCO} = 8.6436MHz		2	−	18	40	mA
V_{OH}	High-level output voltage	V_{DD}=4.5V, I_{OH}= −0.8mA	3)	3	3.5	−	−	V
V_{OL}	Low-level output voltage	V_{DD}=4.5V, I_{OL}= 0.8mA	3)	3	−	−	0.4	V
I_{IH}	High-level intput current	V_{IH}= 4.5V	4)	4	−	−	2	μA
I_{IL}	Low-level intput current	V_{IL}= 0.5V	4)	4	−	−	− 2	μA
I_{OZH}	Off state high-level output current	V_{OH}= 4.5V	5)	5	−	−	2	μA
I_{OZL}	Off state low-level output current	V_{OL}= 0.5V	5)	5	−	−	− 2	μA
f_{VCO1}	VCO (EFFK) free running frequency	V_{LPF}= 1.0V		6	−	−	3.0	kHz
f_{VCO2}		V_{LPF}= 2.5V		6	7.8	9.5	−	kHz
f_{VCO3}		V_{LPF}= 4.0V		6	9.5	−	−	kHz

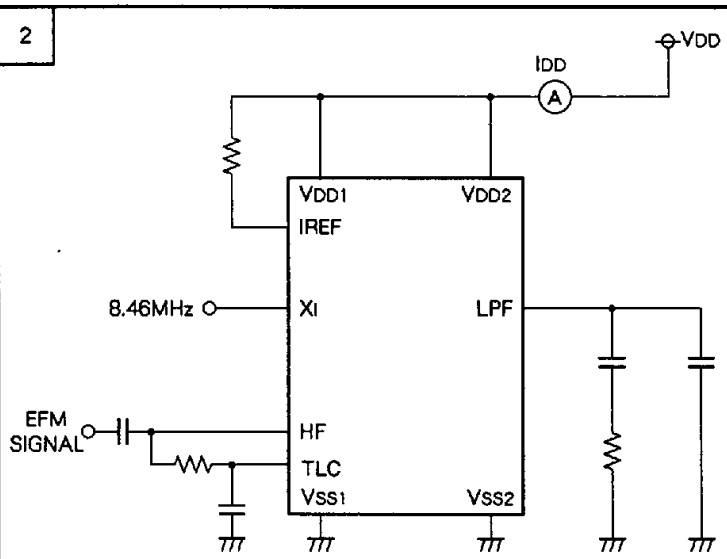
Note 2. Applied pin
3) Output and input/output pin except XO, TLC, LPF
4) Input pin except XI, C16MI, IREF
5) RDB1～RDB4, SBCP～SBCW

TEST CIRCUIT

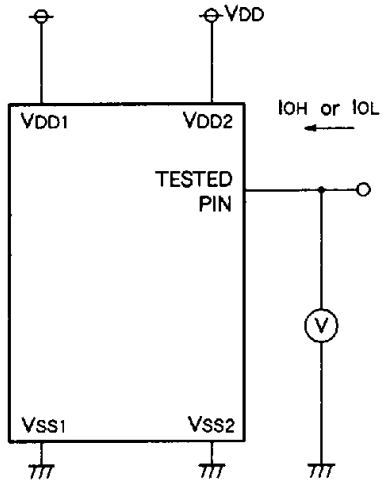
1



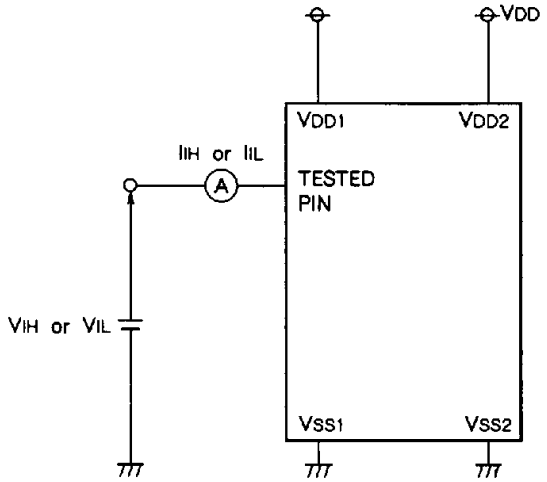
2



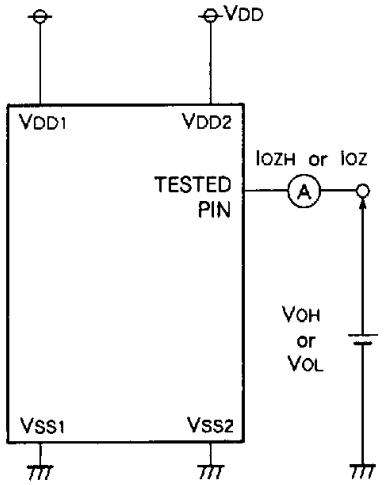
3



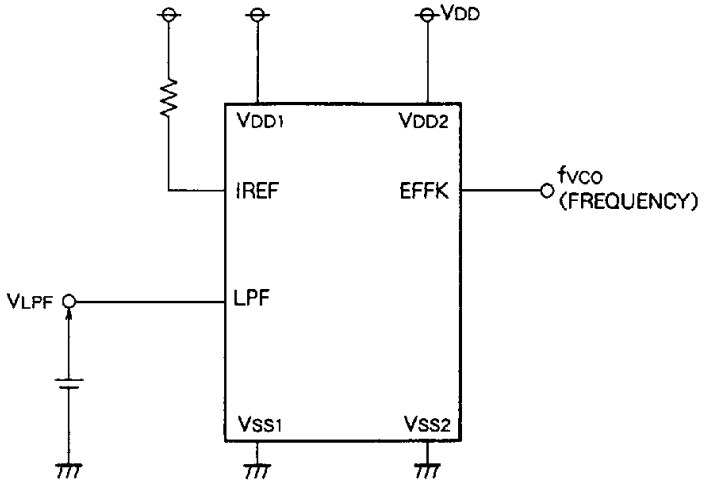
4



5



6



FUNCTIONAL DESCRIPTION

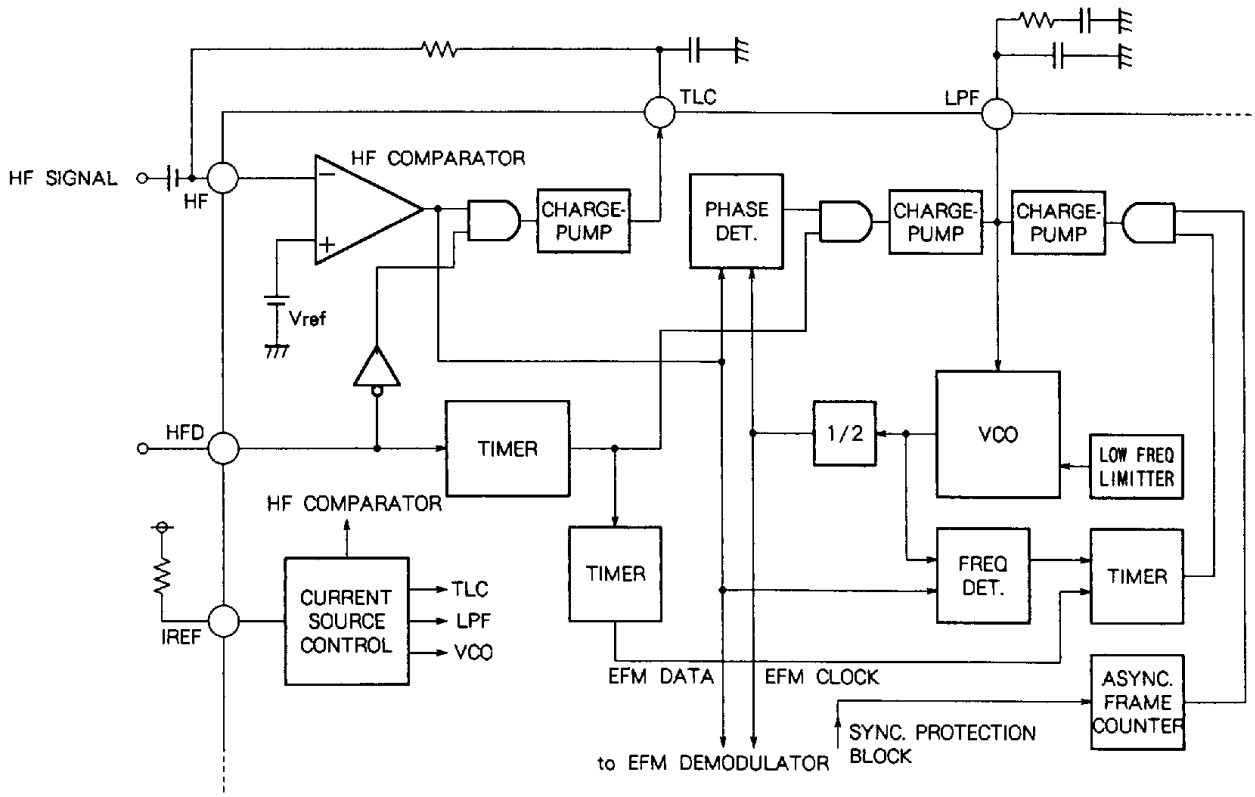
1. Data slicing/PLL

The M50423FP has an analog front-end for incoming HF (EFM) signal. Using CMOS-Analog technology, the front-end comprises an automatic slice level control circuit and EFM-PLL circuit with internal adjust-free VCO. The block-diagram shows the analog front-end. The HF signal is sliced by the HF comparator and a DC level is feed back from TLC to HF through the external CR. If HFD goes High because of a defect an disc, then TLC time off and holds the DC level.

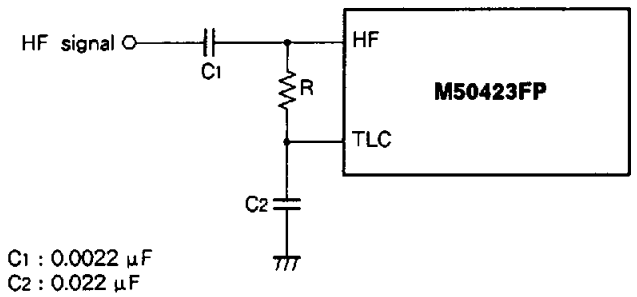
EFM-PLL extracts the EFM clock signal from the HF signal. The PLL circuit has a phase/frequency comparator not provides the M50423FP with a wide capture/lock range. There is no need to adjust the VCO. LPF is the charge-pump output and same-time control voltage input to the VCO. LPF turns off when HFD goes High.

IREF is the reference current input used to determine the current of charge pumps TLC and LPF, operating point of HF comparator, and VCO free running frequency. If IREF is connected to a noisy power supply through a resistor, VCO is modulated and the error-rate increases. Therefore, power supply noise at IREF must be held to a minimum.

BLOCK DIAGRAM (Data slicing/PLL)



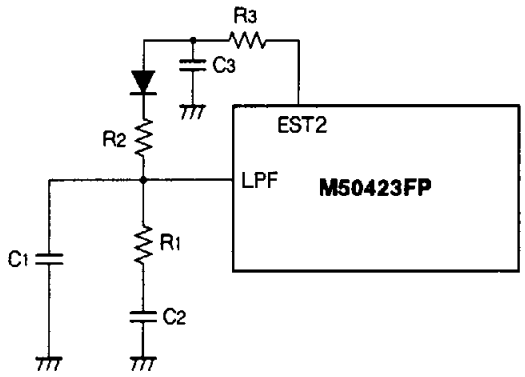
(1) Automatic slice level control



C1 : 0.0022 µF
C2 : 0.022 µF
R : 33k Ω
Vin : HF0.5VP-P Min

The slice level control circuit is formed by connecting a resistor and capacitors to the HF (High-Frequency signal input) and TLC (slice level control oputput) pins.

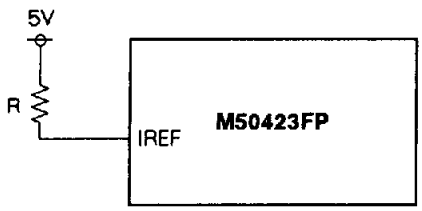
(2) PLL



C1 : 470pF
C2 : 0.15 µF
C3 : 1 µF
R1 : 2.2k Ω
R2 : 2.2M Ω
R3 : 1k Ω

Since the adjustment-free VCO is built in, the adjustment-free PLL circuit can be formed by connecting a resistor and capacitors to the LPF (low-pass filter) pin.

(3) Reference current



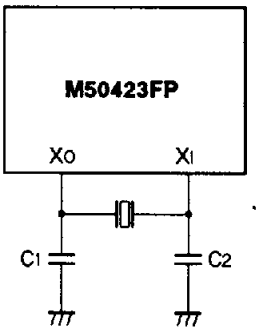
R : 120k Ω

A resistor must be connected between the IREF pin and V_{DD} in order to set the reference current used in determining the current values of the TLC pin and LPF pin, the comparator operating current of the slice level control circuit, and the VCO free-run frequency.

2. Demodulation/Decoding

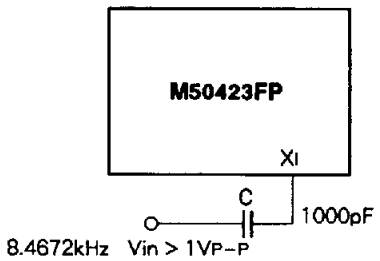
The EFM signal converted to logic level and the EFM clock extracted from the EFM signal are input to the demodulator and decoder block. The EFM demodulator must be synchronized to the EFM clock. The decoder uses the clock from the X'tal oscillator. Jitter between the EFM signal and output of the decoder is absorbed by external RAM.

(1) Clock generator



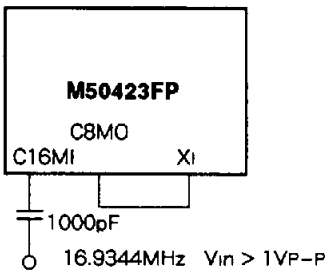
X'tal : 8.4672MHz
C1 : 30pF
C2 : 30pF

(a) The oscillation circuit can be formed by connecting a X'tal oscillator (8.4672MHz) and load capacitors to pins XI and XO.



(b) When the system contains a clock (8.4672MHz), the clock can be input to pin XI via a capacitor without using the X'tal oscillator.

If the input signal is logic level, the capacitor is not necessary



(c) When the system contains a clock (8.4672 × 2 = 16.9344MHz), the internal 1/2 divider can be used by connecting pin XI to pin C8MO and inputting the clock to pin C16MI via a capacitor.

The 1/2 divider between C16MI and C8MO can be used for any purpose, independent of other functions.

(2) Frame Synchronization

EFM demodulating is done by Programmable Logic Array conversion table. The demodulator must be synchronized to EFM signal for each frame. The frame sync protection circuit holds the synchronization and prevents false synchronization of the demodulator when bit-slipping or missynchronization occurs.

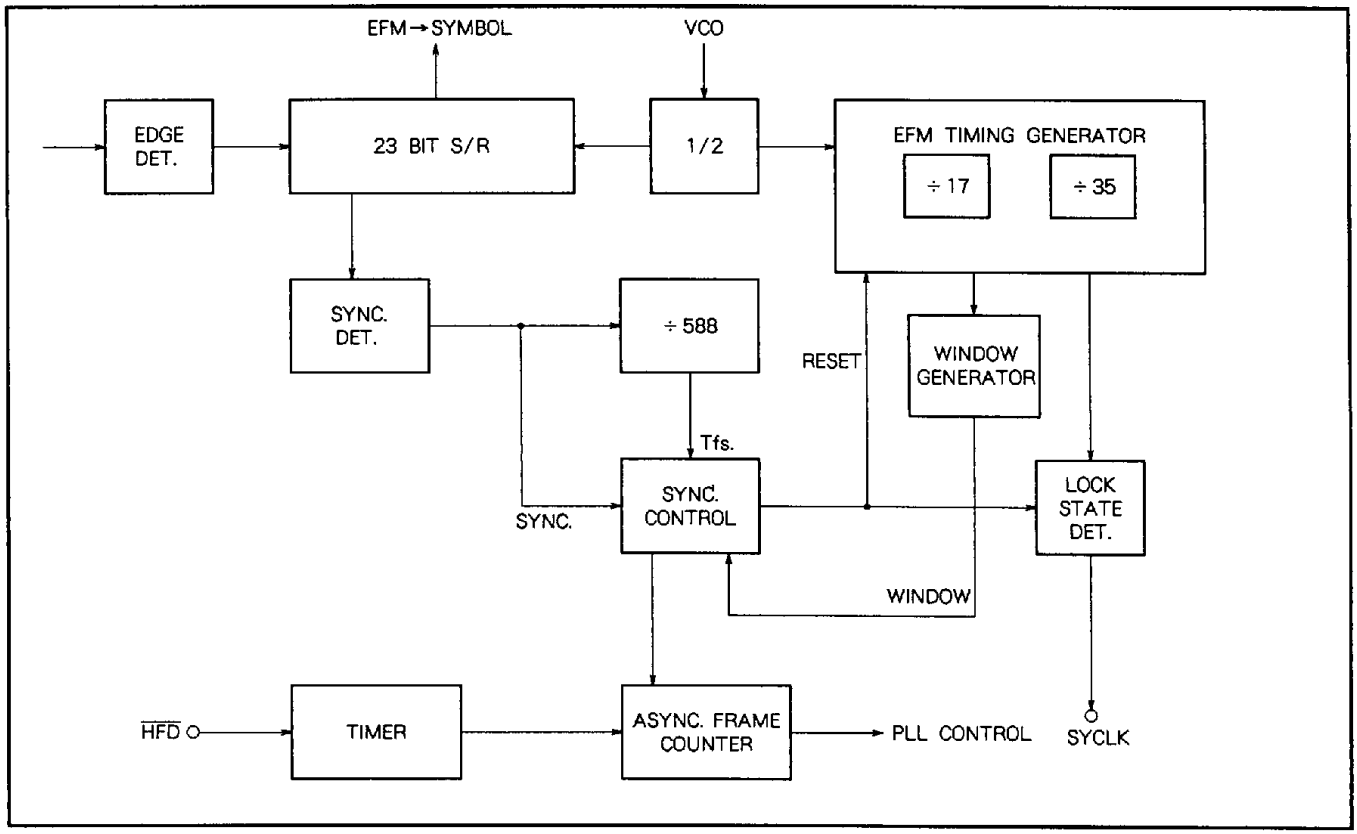


Fig. 1 Frame synchronization block diagram

The generating condition of the counter reset signal (Reset) in the EFM timing generator is indicated as follows:

Reset = (Sync * Tfs) + (Sync * Window)

* : Logical product

\+ : Logical sum

Sync : Synchronizing signal

Tfs : Detection signal of synchronizing signal space = 588

Window : Window signal ± 7ck

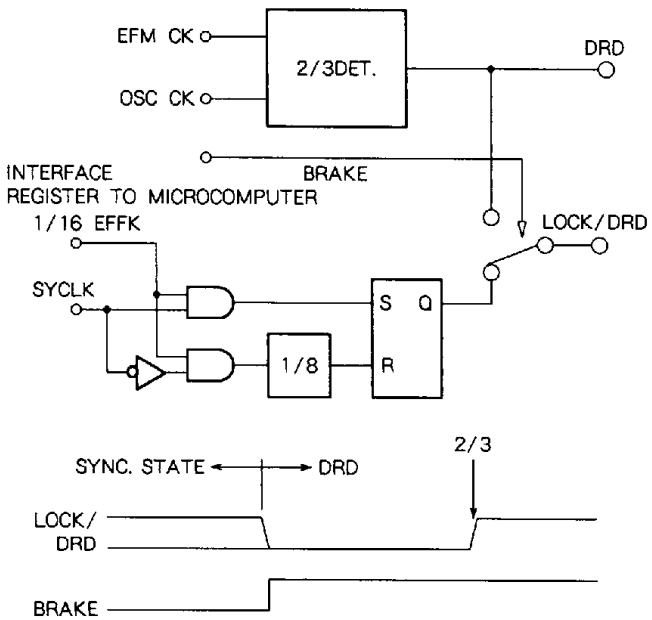
In the synchronous state, sync and Tfs generate simultaneously and sync comes to the center of the window. At this time, 1 is output to the SYCLK pin.

Frame sync status is output to SYCLK pin.

The SYCLK output includes some bounce even when the sync pattern is lost because of a defect an the disc. Hence, there is a need for debouncing the sync status signal for it to be monitored by the system control microcomputer.

Debouncing is in the M50423FP by monitoring the frame sync status at 1/16 EFM frame clock intervals and then outputting the result to the LOCK/DRD pin. If the monitored status is locked then output is High. Eight continuous unlocked outputs becomes Low.

LOCK/DRD pin outputs DRD signal (see Sec. 3) when the discmotor is braking by the command from microcomputer. The following pages contain the block diagram and the output timing.



(3) Subcode demodulation

Among data converted from 14-bits EFM signal to 8-bit symbols, subcodes P, Q, R, S, T, U, V and W are output to pins SBCP - SPCW respectively. When the subcode synchronizing patterns S_0 or S_1 is detected as synchronizing signal of subcode data, the synchronizing signals are output to the SCOR pin.

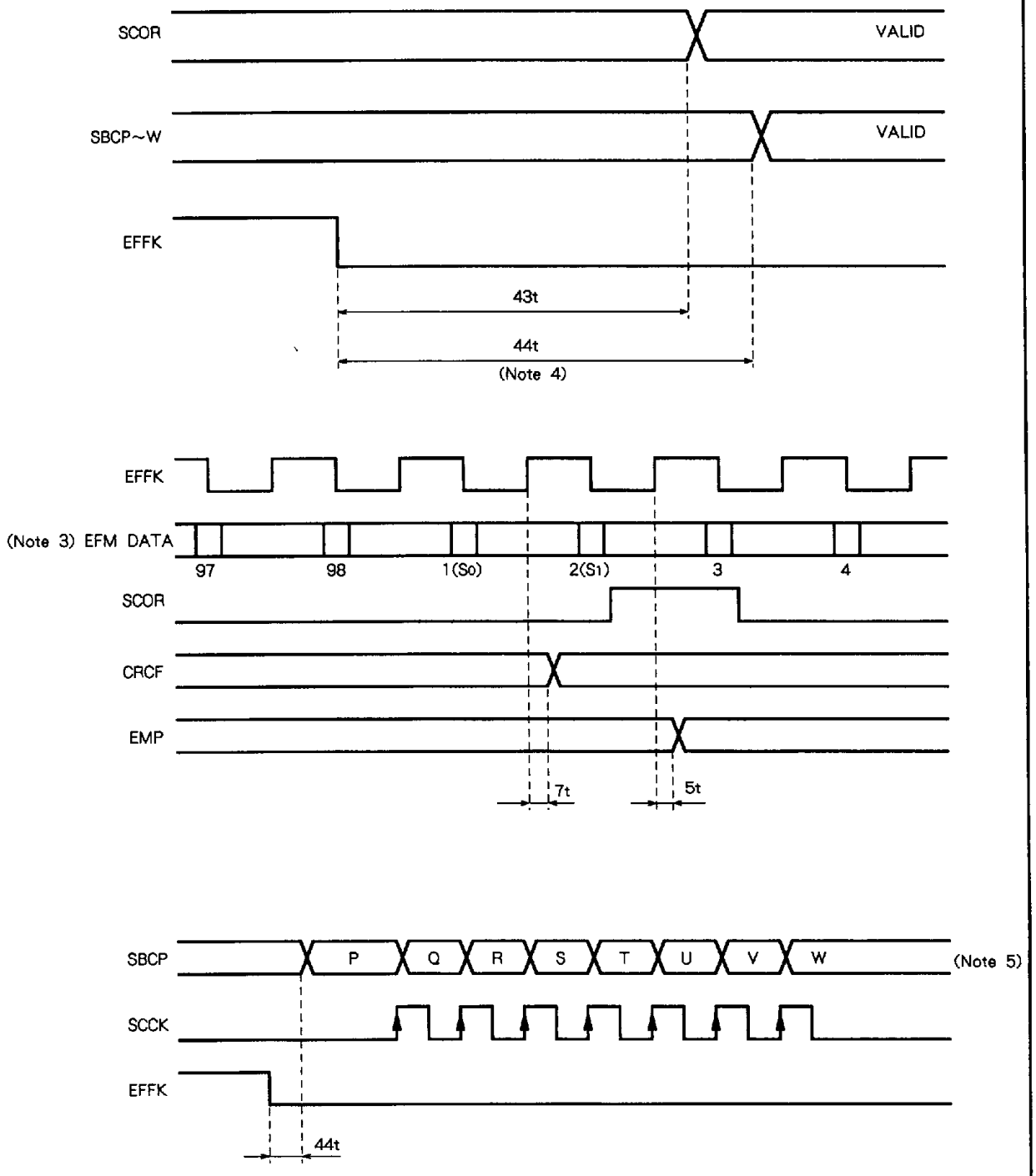
Pins SBCP - SBCW are a Three - State output system controlled by pins, $SCOE_1$ and $SCOE_2$ as shown in the table below.

A CRC check is made for the Q channel data, and if the data is correct, a 1 is output to the CRCF pin. The EMP pin displays whether or not emphasis is present. The subcode data is not only output in parallel, but also can be obtained serially via SBCP, by inputting a clock to SCCK.

Subcode output timing are shown Fig. 2.

SUBCODE DEMODULATION

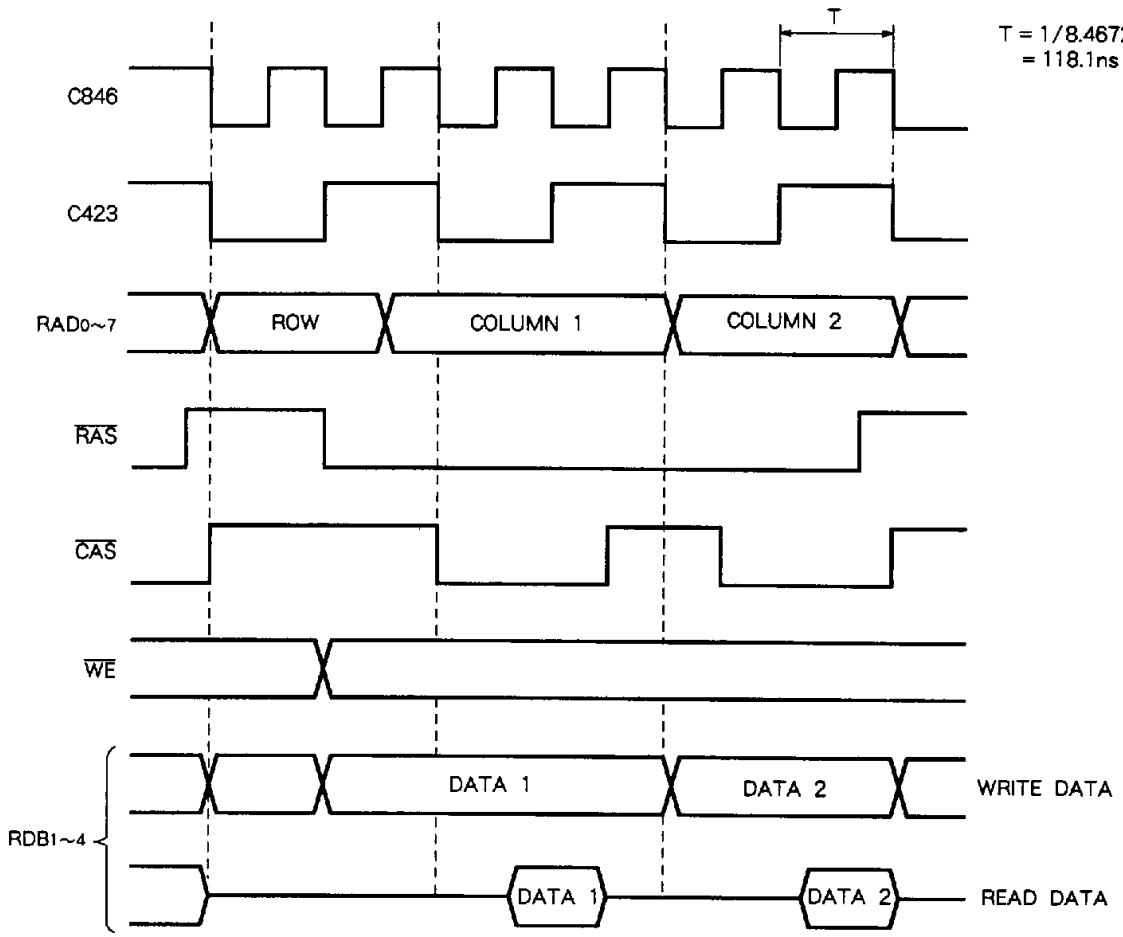
$SCOE_1$	$SCOE_2$	SBCP	SBCQ	SBCR	SBCS	SBCT	SBCR	SBCV	SBCW
0	0	High-impedance				High-impedance			
1	0	P	Q	R	S	High-impedance			
0	1	High-impedance				T	U	V	W
1	1	P	Q	R	S	T	U	V	W



Note 3. Subcode block No. in the EFM data
4. t : Oscillating frequency (VCO)
(typically : 1/8.6436MHz = 115.7ns.)
5. When input frequency to SCCK is more than 8ck, SBCP becomes 0.

Fig. 2 Subcode output timing

(a) Symbol data/flag, read/write timing



(b) C1/C2 flag, read/write timing

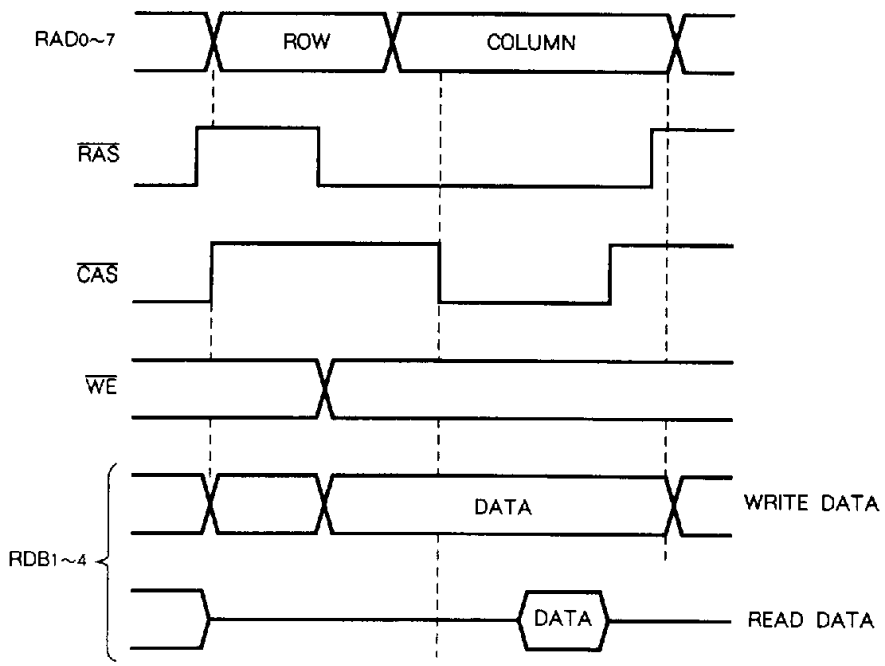


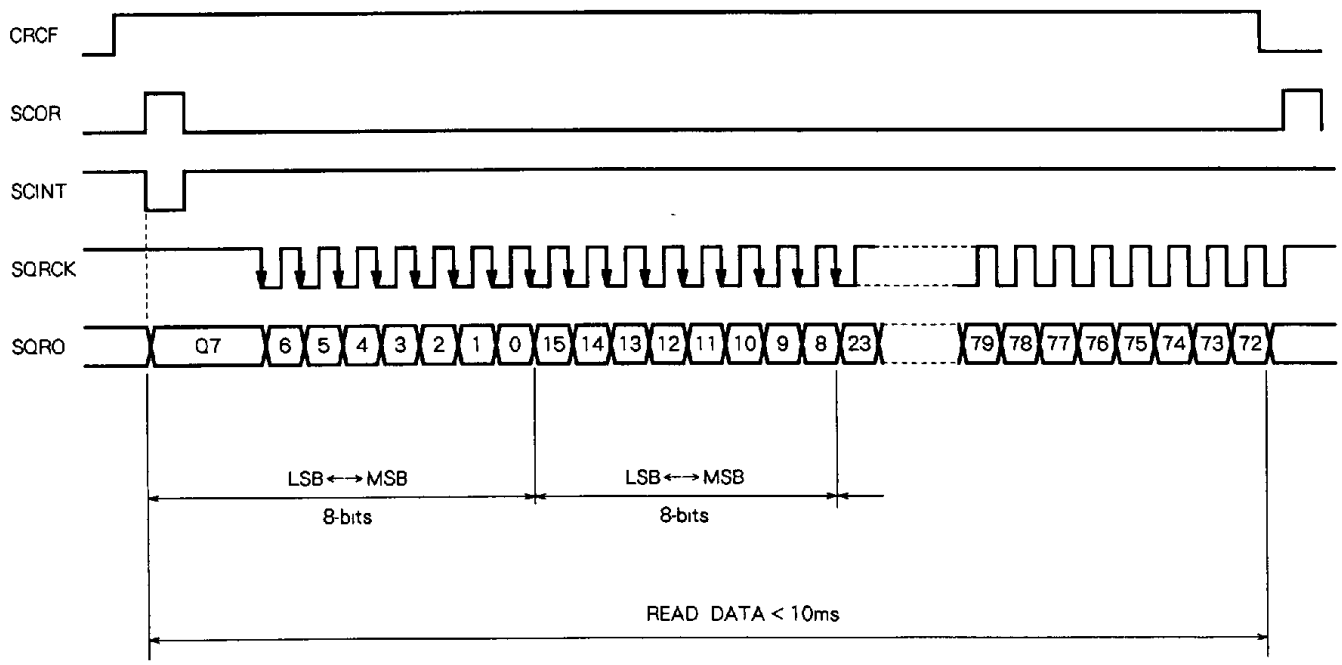
Fig. 3 RAM interface timing

(4) Subcode Q register

Subcode Q-channel data are output to SBCQ pin.

The M50423FP stores the Q data in an 80-bit shift register and if CRC is OK, the system control microcomputer can access the Q data from the SBCQ pin by inputting the read-out clock to SQRCK pin. If the CRC check is OK, the M50423FP outputs the interrupt signal to the micro-computer from SCINT, synchronaized with SCOR (Subcode sync.) signal.

Timing chart



(5) RAM interface/CIRC decoding

A 64K (4 × 16K) / 256K (4 × 64K) dynamic RAM is needed as the external memory for temporary storage to process CIRC decoding (C1 decoding, C2 decoding, unscramble and de-interleave) and output interpolation.

By using a 64K/256K RAM, jitter is absorbed up to ±8 frames (max.).

Fig. 3 shows the timing for reading from and writing to the RAM.

Dowing CIRC decoding, double error correction is used for both C1 and C2 decoding.

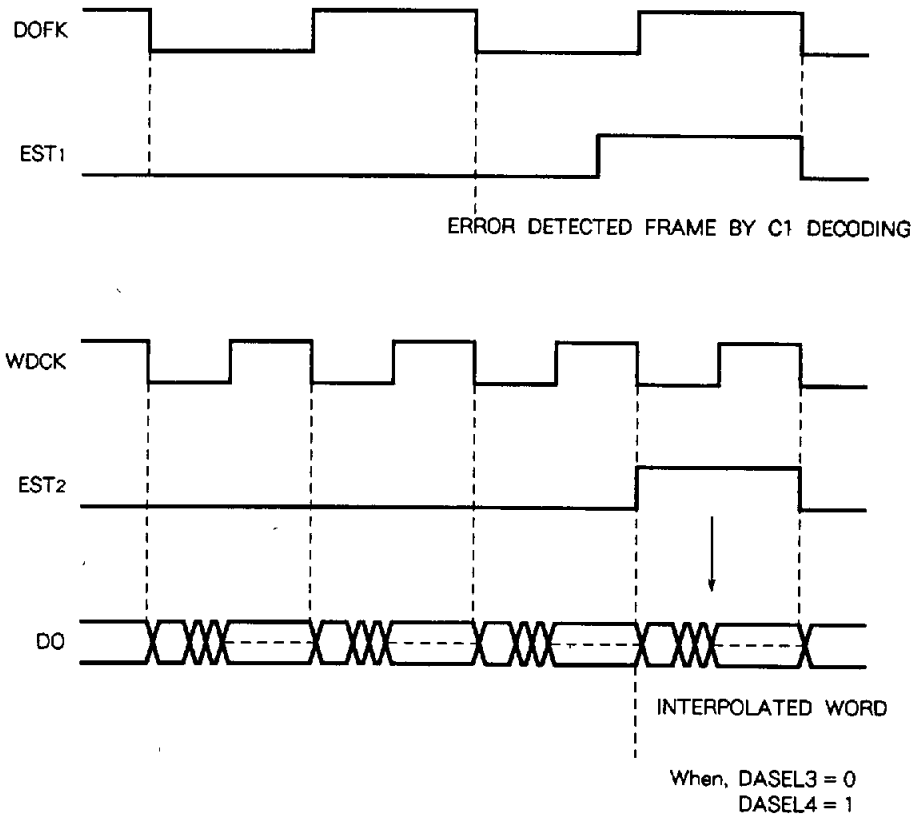
When correction is not possible, average interpolation or pre-hold interpolation is perfomed.

Error states which are detected during decoding are output to pins EST_1 and EST_2.

When an error is detected by C1 decoding, 1 is output to pin EST_1. When an error word is judged incorrectable by C2 decoding, a "1"is output to pin EST_2.

The output timings for pins EST_1 and EST_2 are as follows:

Timing chart

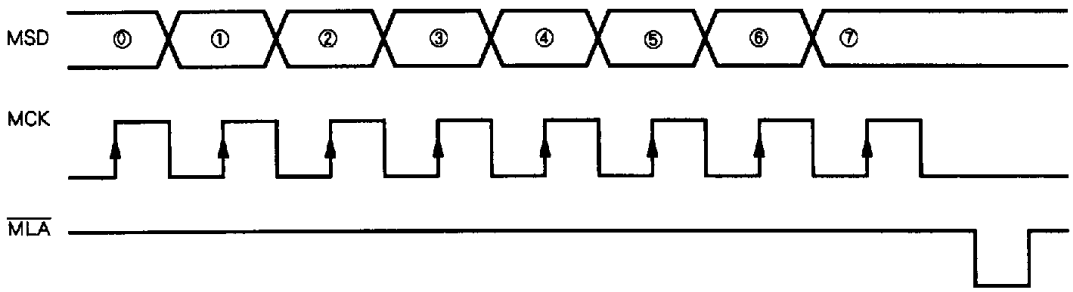


3. Microcomputer Interface

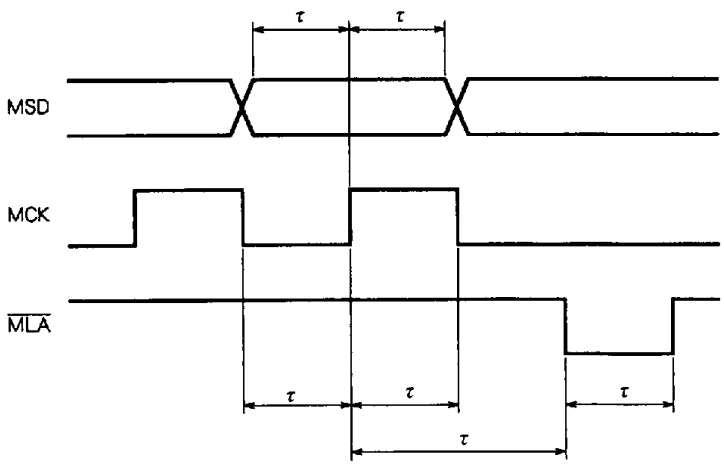
CLV servo, MUTE, and ATT system are controlled by serial commands from the microcomputer.

The timing, names, and functions of each control register are as follows :

Timing chart



⓪ DUMMY (Don't care)	X
① S/S(START/STOP) register	start = 1
② BCON(BRAKECONTROL) register	enable = 1
③ BRAK (BRAKE) register	brake = 1
④ ATT (ATTENUATE) register	−12dB = 1
⑤ $\overline{\text{MUTE}}$ register	muting = 0
⑥ S/S timer reset register	reset = 1
⑦ IC code	M50423FP = 1



τ min : 500ns

Function of microcomputer interface register

Register No.	Register name	Function	Operation		Note
			0	1	
⓪	DUMMY	Don't care	–	–	
①	S/S (START/STOP)	Controls START/STOP of the disk motor	DISC MOTOR STOP (OFF)	DISC MOTOR START (ON)	0 by $\overline{ACLR}$
②	BCON (BRAKECONTROL)	Determines if BRAKE control is necessary	BRAKE 0.3sec.	BRAKE is controlled by BRAK register	0 by $\overline{ACLR}$
③	BRAK (BRAKE)	Controls BRAKE	BRAKE OFF (MOTOR OFF)	BRAKE ON	When BCON = 1
④	ATT (ATTENUATE)	Sets attenuation (−12dB)	0dB	− 12dB	When MUTE = 1
⑤	MUTE	Sets the muting	$-\infty$ dB	0dB	0 by $\overline{ACLR}$
⑥	S/S timer reset	Resets the S/S timer which sets the time of KICK and BRAKE to 0.3sec.	S/S timer enable	S/S timer disable	1 by $\overline{ACLR}$
⑦	IC code	Distinguishes the command to the M50423FP	–	Excuting command	0 is code for M51564P

Examples of system control are as follows :

Operation \ Register name	⓪ DUMMY	① S/S	② BCON	③ BRAK	④ ATT	⑤ $\overline{MUTE}$	⑥ S/S timer reset	⑦ IC code
								0
MUTE						0		1
ATT					1	1		1
0.3sec.KICK→CLV		1					0	1
0.3sec.BRAKE→MOTOR OFF		0	0				0	1
BRAKE		0	1	1			0	1
MOTOR OFF		0	1	0			0	1
0.3sec. timer disable							1	1
MOTOR off (without 0.3sec. BRAKE)		0	0				1	1
CLV (without 0.3sec. KICK)		1	0				1	1
The following is example of the most simplified system control sequence.								
STOP		0	0	0	0	0	1	1
0.3sec. KICK→CLV		1	0	0	0	0	0	1
PLAY		1	0	0	0	1	0	1
FF/FR		1	0	0	1	1	0	1
PLAY		1	0	0	0	1	0	1
0.3sec. BRAKE→STOP		0	0	0	0	0	0	1

* The blanks mean "Don't care" or that other commands can be used simultaneously
* KICK period can be extended by repetition of start procedure.
* The software developed on the M50421P/M50422P can be utilized on the M50423FP (upward compatible).
  However, when using this software, the following functions on the M50423FP are not available : subcode Q-register, subcode Q-interrupt signal LOCK/DRD output.

When the M50423FP detects that the number of rotations is less than 2/3 that of the normal play state, it output the disc rotation deterioration signal to the DRD pin.

By using this signal in the following stop sequence, the disc can be correctly stopped.

Operation or μ-COM Operation \ Register name	⓪ DUMMY	① S/S	② BCON	③ BRAK	④ ATT	⑤ $\overline{MUTE}$	⑥ S/S timer reset	⑦ IC code
PLAY		1	0	0	0	1	0	1
BRAKE		0	1	1	0	0	0	1
($\overline{HFD}$: H checking by microcomputer)								
(Measuring t_{DRD} (DRD : 0→1) after BRAKE start								
(Stop $\overline{HFD}$ checking and) additional BRAKE time 2 × t_{DRD}								
MOTOR OFF		0	1	0	0	0	0	1

The DRD signal is output to both the DRD pin and also the LOCK/DRD pin during the braking period.

In order to re-initiative the microcomputer interface register execute $\overline{ACLR}$ (M50423FP clear) immediately after turning the power on.

4. Digital filter

The M50423FP converts the sampling frequency of audio data from 44.1kHz (fs) to 88.2kHz (2fs) or 176.4kHz (4fs) by an overflow limited, FIR linear-phase digital filter.

Digital filter selection is done using pins DASEL1~DASEL4. Table1 shows the digital filter and DAC interface mode. Digital filter pass mode with no interpolation of umcorrectable data is designed for non-audio applications such as CD-ROM or CD-1. The digital filter pass mode with interpolation is used external precision digital filter applications.

Fig. 4 (a) shows the characteristics of the 2fs digital filter.

Fig.4 (b) shows the characteristics of the 4fs digital filter.

5. D-A Converter Interface

The M50423FP has many different DAC Interface formats. The desired format is selected using pins DASEL1~DASEL4.

Timing signals, data and clock automatically change to correspond to which digital filter, fs (pass) / 2fs/ 4fs, is chosen.

If the 4fs digital filter mode is selected then the dual DAC mode and 18-bits data out mode are available.

Table 1 shows the interface modes.

Fig. 5 (a) ~Fig. 5 (e) show the timings if interface to DAC.

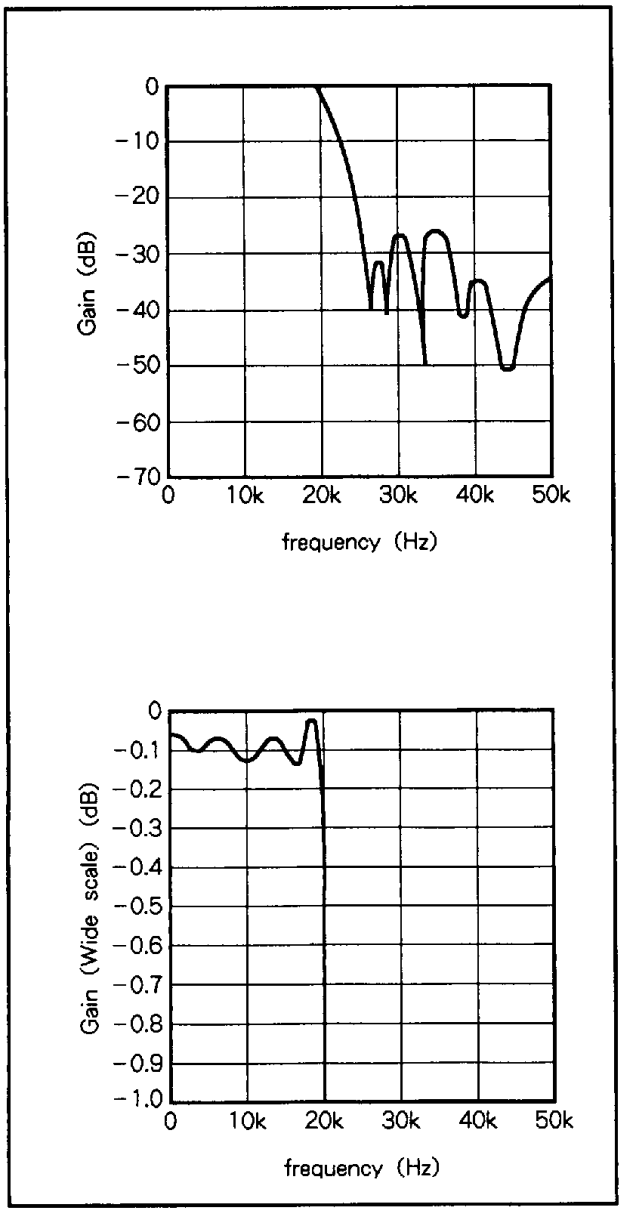


Fig. 4 (a) Frequency characteristics of the digital filter (Sampling frequency 88.2kHz:2fs)

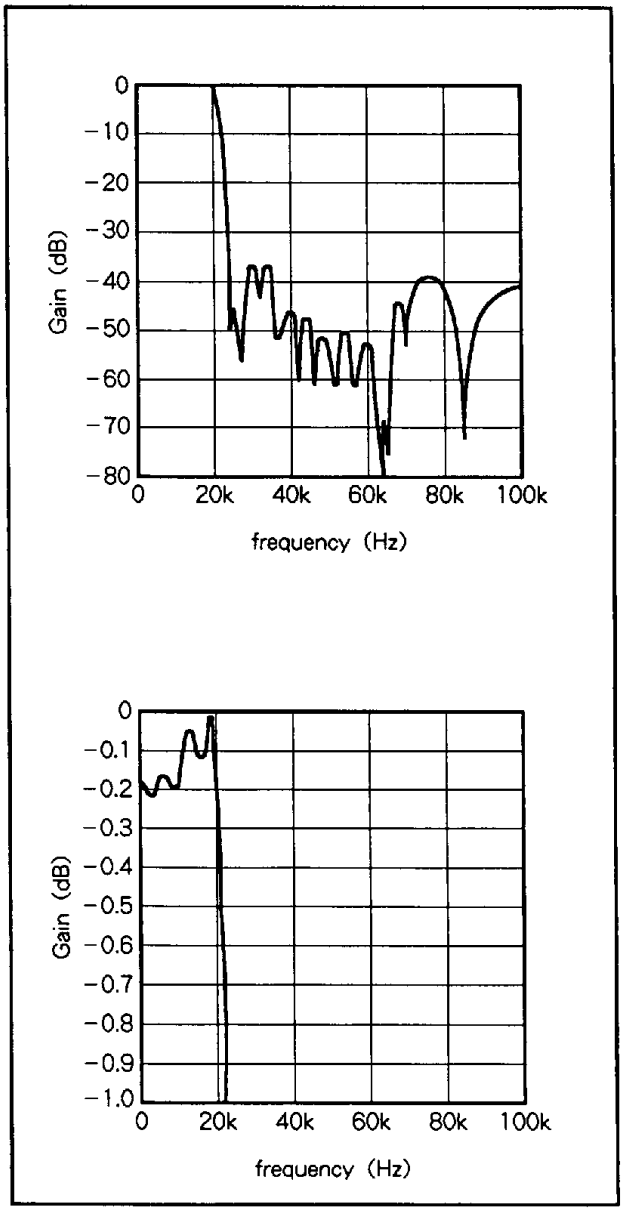


Fig. 4 (b) Frequency characteristics of the digital filter (Sampling frequency 176.4kHz:4fs)

Table 1 DAC interface modes

MODE	DASEL 1	DASEL 2	DASEL 3	DASEL 4	DF	MSB/LSB 1st	Note	Timing chart
1	0	0	0	0	2fs	MSB 1st		Fig. 5 (a)
2	0	0	0	1	(fs)	MSB 1st	Bypass filter	Fig. 5 (a)
3	1	0	0	0	2fs	LSB 1st		Fig. 5 (b)
4	1	0	0	1	(fs)	LSB 1st	Bypass filter	Fig. 5 (b)
5	1	0	1	0	4fs	MSB 1st		Fig. 5 (c)
6	1	0	1	1	4fs	MSB 1st	Dual DAC	Fig. 5 (d)
7	0	1	0	1	(fs)	MSB 1st	No interpolation	Fig. 5 (a)
8	1	1	0	0	2fs	MSB 1st		Fig. 5 (e)
9	1	1	0	1	(fs)	MSB 1st	Bypass filter	Fig. 5 (e)

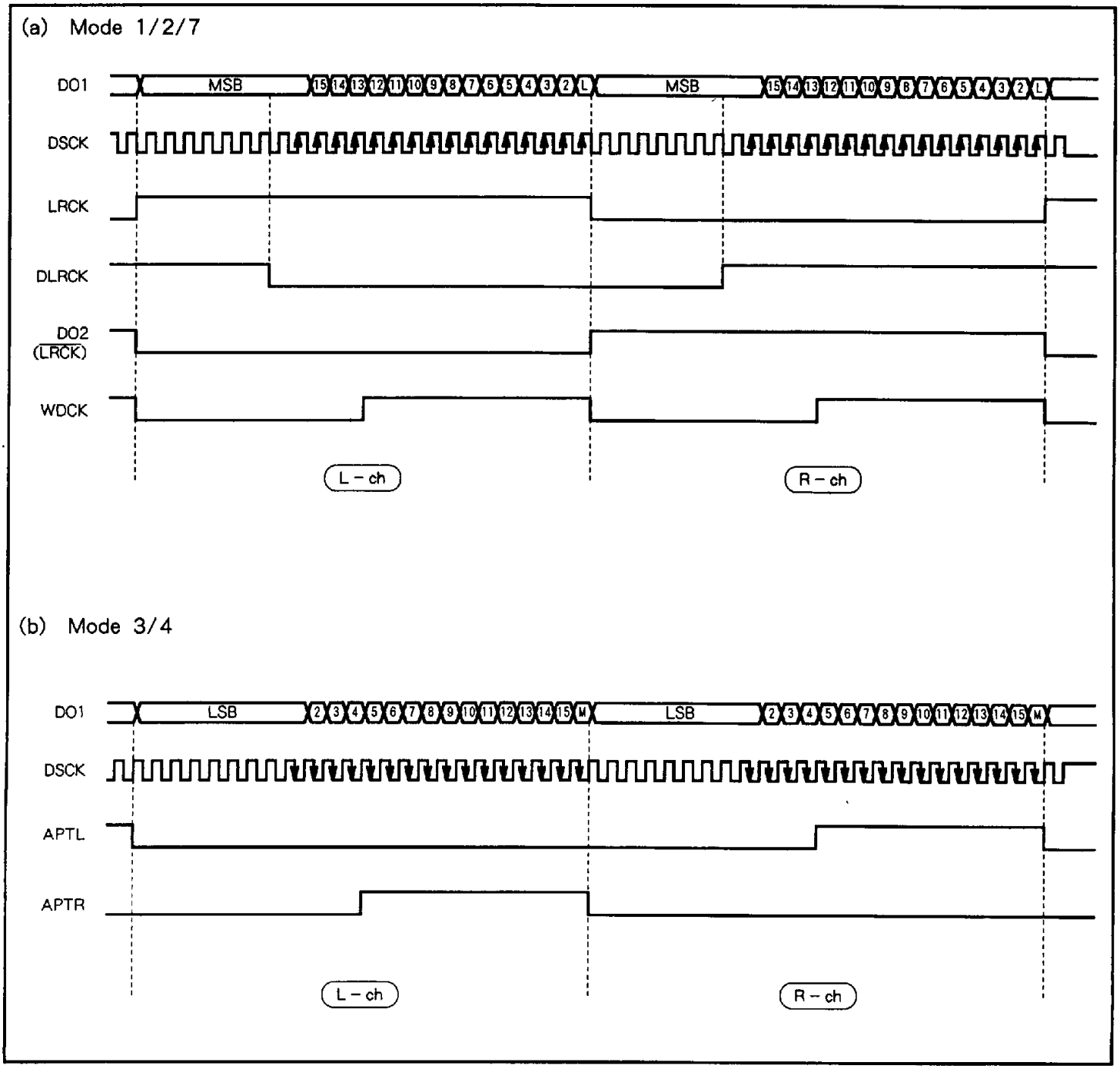


Fig. 5 DAC interface timing chart

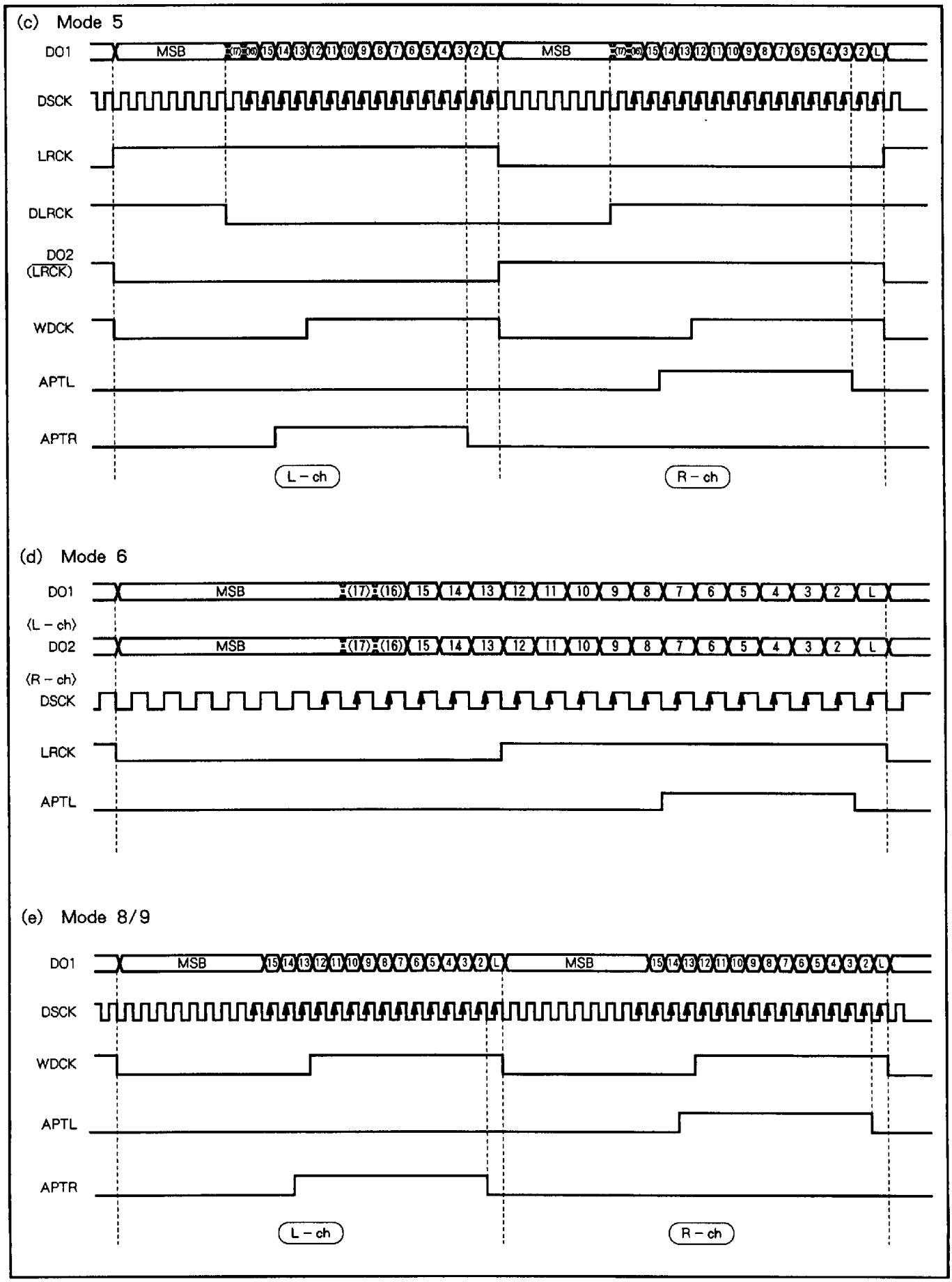


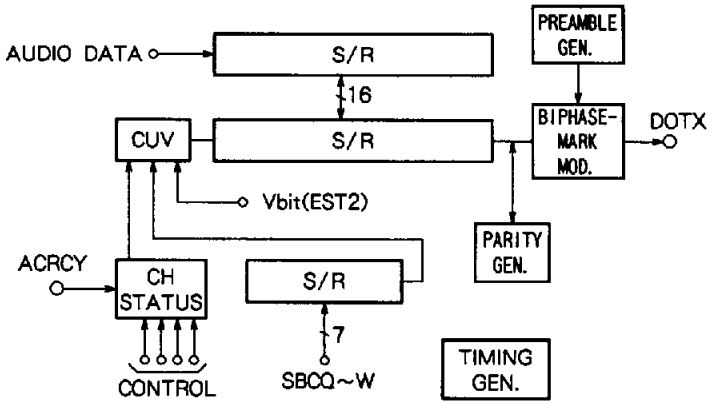
Fig. 5 DAC interface timing chart

6. Digital Interface output

The M50423FP outputs digital interface signal conforming to EIAJ CP-340 or IEC formats.

The block diagram shows the digital interface and Fig. 6 shows the timings. Channel status clock accuracy can handle variable pitch control and can be set using the ACRCY pin.

The clock accuracy is level II when ACRCY pin is Low, and level III when ACRCY pin is High.



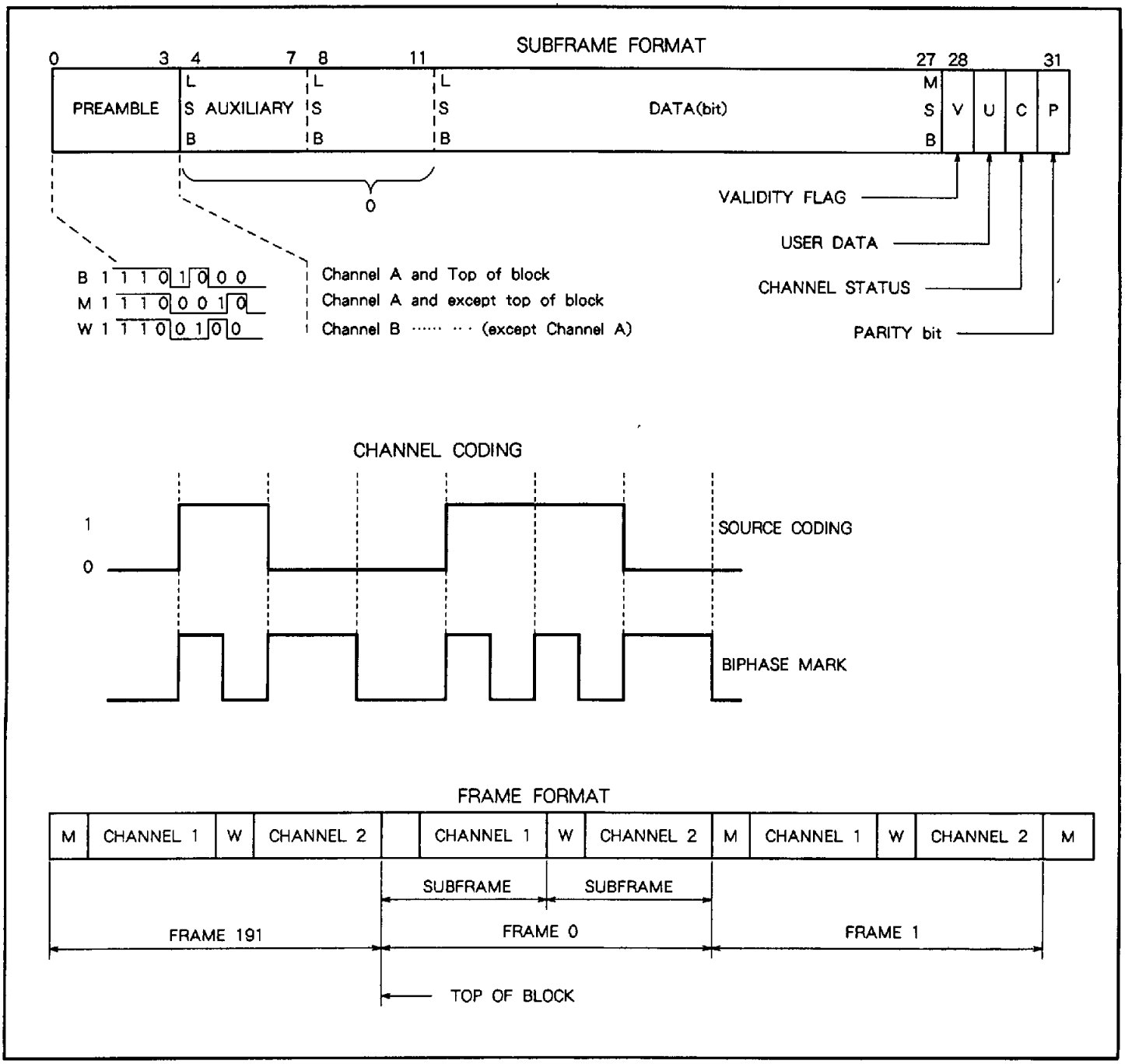


Fig. 6 Timing

7. CLV servo control circuit

CLV servo control circuit operates using two signals. The first is the frequency difference beween EFM-clock and X'tal -clock. The second is the phase difference beween write-frame address and read-frame address of the external 64K or 256K RAM. Motor control signals are output to PWM_1 (− signal) and PWM_2 (+ signal).

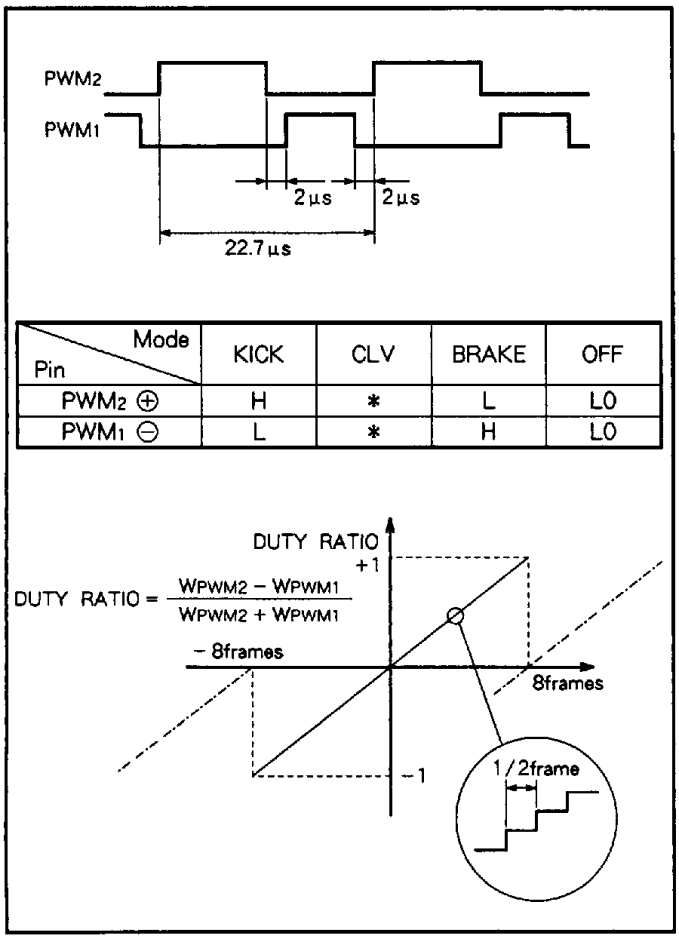
Because these singals are internally phase compensated, the CLV servo control circuit can be easily composed using current drivers on pins PWM_1 and PWM_2.

Fig. 7 shows the CLV wave form and its duty cycle when the CIRC decoding block addressing write-frame address and the read-frame address exceeds ± 8frames.

When this occurs the duty cycle of the CLV waveforms will be reset to 0.

The disc motor can be driven by PWM waveforms directly or it can be driven by an analog signal that can be generated by integrating the PWM waveforms.

By using an analog signal, it is possible to adjust the servo loop-gain by varying direct external component values. But in the case of PWM waveforms, the servo loop-gain is determined by motor torque, and the rotating moment of the disc, turntable, and disc clamper.



Pin \ Mode	KICK	CLV	BRAKE	OFF
PWM_2 ⊕	H	*	L	LO
PWM_1 ⊖	L	*	H	LO

Fig. 7 CLV waveform