HA16671MP, HA16672MP

Voice Coil Motor (VCM) Servo Controller

Description

The HA16671MP and HA16672MP are VCM servo controllers for hard disk head positioning. Three chips can make up a control system for the HA13447 VCM driver: the HA16670MP for position signal generation, and the HA16671MP and HA16672MP servo controllers.

The HA16671MP is composed of a speed detection circuit, current integrating circuit, phase compensator, op amp filter, etc.

The HA16672MP, on the other hand, contains an 8-bit DAC, and can output target speed, target acceleration, and external force compensation values based on data from a microprocessor.

Functions

- Position signal differentiation
- Current integration
- 1/4 track detection
- Fine track detection
- 8-bit DAC
- Sample and hold circuit
- Op amp for filter design

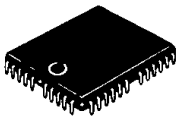
Features

- Two power supply design (+5 V, +12 V)
- Compact surface-mount package (SMP)
- Feed forward compensation for low-error speed control
- Compensation based on acceleration and external force data can be added to the speed control loop
- Digital signals can be/directly linked to a microprocessor
- External op amps not needed

Ordering Information

Type No.	Package
HA16671MP, HA16672MP	MP-44

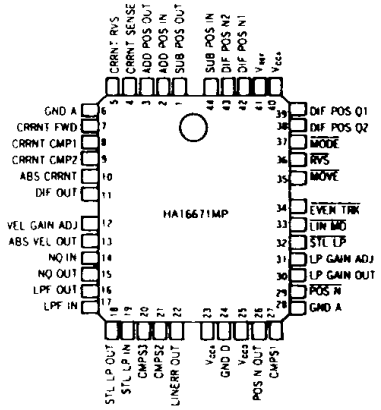
HA16671MP, HA16672MP



(MP-44)

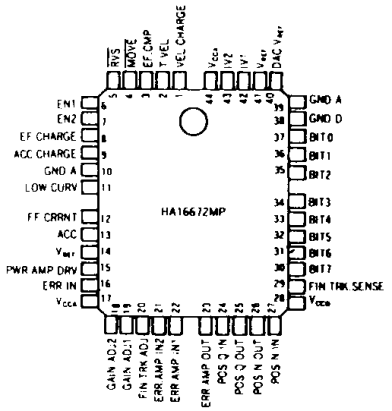
Pin Assignments

• HA16671MP



(Top View)

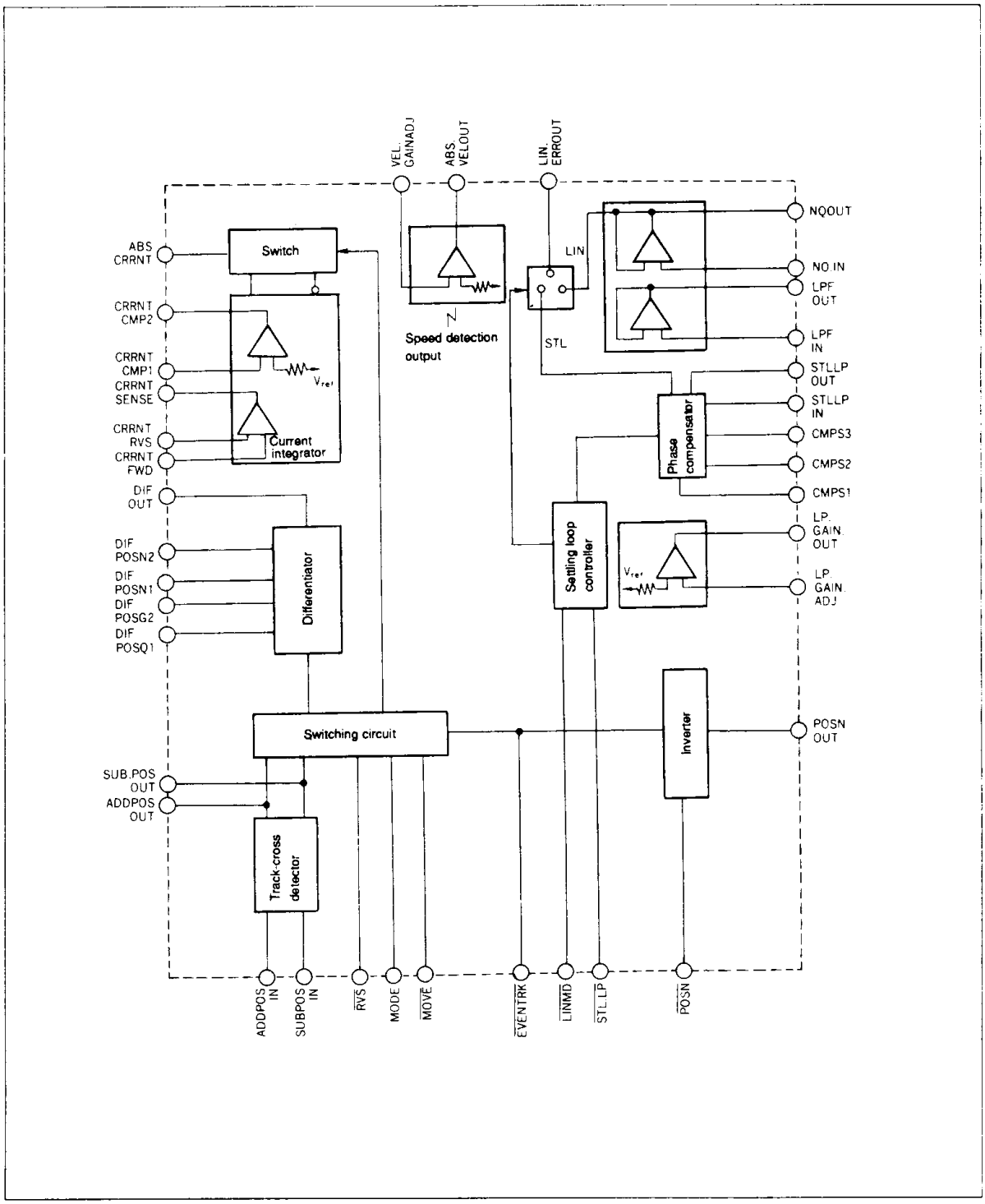
• HA16672MP



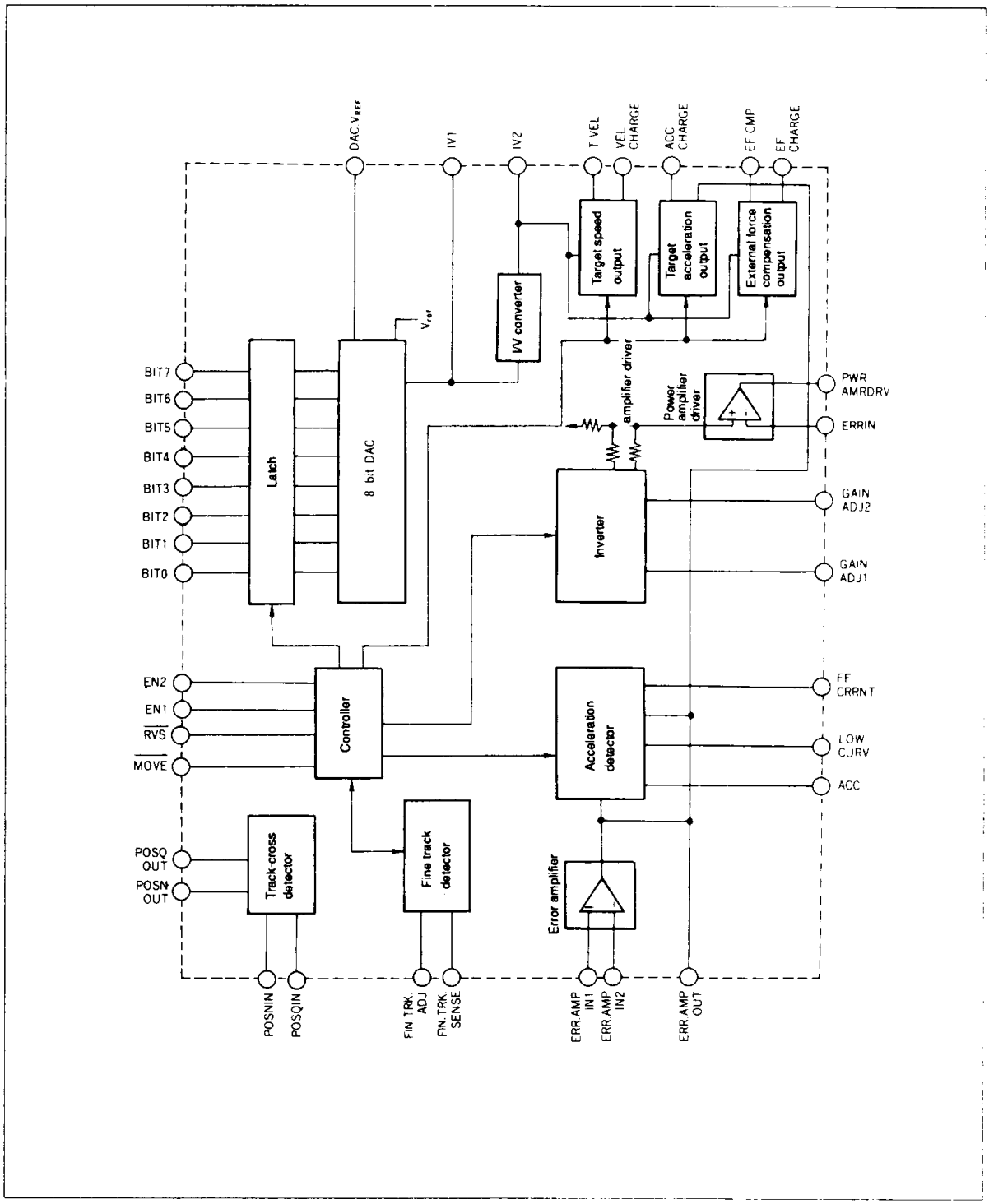
(Top View)

Block Diagram

HA16671MP



HA16672MP


DAC V_{REF}
IV1
IV2
T VEL
VEL CHARGE
ACC CHARGE
EF CMP
EF CHARGE
Target speed output
Target acceleration output
External force compensation output
I/V converter
V_{ref}
amplifier driver
Power amplifier driver
PWR AMRDRV
ERRIN
BIT7
BIT6
BIT5
BIT4
BIT3
BIT2
BIT1
BIT0
Latch
8 bit DAC
Inverter
GAIN ADJ2
GAIN ADJ1
EN2
EN1
RVS
MOVE
Controller
Acceleration detector
FF CRRNT
LOW CURV
ACC
POSQ OUT
POSN OUT
Track-cross detector
Fine track detector
Error amplifier
POSNIN
POSQIN
FIN TRK ADJ
FIN TRK SENSE
ERR AMP IN1
ERR AMP IN2
ERR AMP OUT

Pin Descriptions

HA16671MP

Type	Pin No.	Name	Function
Power supply	23, 40	V_{CCA}	+12 V power supply (analog)
	25	V_{CCD}	+5 V power supply (logic)
	6,28	GNDA	Analog GND
	24	GNDD	Logic GND
Input	41	V_{REF}	Op amp reference voltage
	37	MODE	Position signal differentiation mode select Low: 2-phase servo mode High: 1-phase servo mode
	35	$\overline{\text{MOVE}}$	Position signal differentiation select Low: On High: Off
	36	$\overline{\text{RVS}}$	Position signal differentiation and current integrating inverter
	33	$\overline{\text{LIN MD}}$	Positioning phase compensation control select Low: On High: Off
	32	$\overline{\text{STL LP}}$	Settling compensation control
	34	$\overline{\text{EVEN TRK}}$	Positioning signal inverter
	2	ADD POS IN	Comparator signals for the position signal differentiation circuit
	44	SUB POS IN	
	29	$\overline{\text{POS N}}$	Positioning signal converter signal circuit
	31	LP GAIN ADJ	Op amp input for positioning signal gain adjustment
	17	LPF IN	Op amp input for positioning compensation active filter
	14	NQ IN	
	39	DIF POS Q1	Op amp input for positioning signal differentiation
	42	DIF POS N1	
	27	CMPS1	Op amp input for positioning signal phase compensation
	7	CRRNT FWD	Op amp input for voice coil motor drive current detection
	5	CRRNT RVS	
	8	CRRNT CMP1	Op amp input for current integration
	12	VELGAIN ADJ	Op amp input for speed signal detection
Outputs	1	SUB POS OUT	Comparator signals for the position signal differentiation circuit
	3	ADD POS OUT	
	26	POS N OUT	Positioning signal inverter
	30	LP GAIN OUT	Op amp output for positioning signal gain adjustment
	18	STL LP OUT	Op amp output for positioning phase compensation
	16	LPF OUT	Op amp output for positioning compensation active filter
	15	NQ OUT	
	11	DIF OUT	Positioning signal differentiation signal
	10	ABS CRRNT	Motor drive current integration signal
	13	ABS VEL OUT	Speed signal output
	22	LINERR OUT	Positioning compensation signal
External compo-nents	21	CMP S2	Positioning integration constant
	20	CMP S3	
	19	STL LP IN	Settling compensation circuit constant
	38	DIF POS Q2	Position signal differentiation constant
	43	DIF POS N2	
	9	CRRNT CMP2	Motor drive current integration constant

HA16672MP

Type	Pin No.	Name	Function
Power supply	17, 44	V_{CCA}	+12 V power supply (analog)
	28	V_{CCD}	+5 V power supply (logic)
	10, 39	GNDA	Analog GND
	38	GNDD	Logic GND
Inputs	14, 41	V_{REF}	Reference voltage
	4	MOVE	DAC latch and analog control signals
	5	RVS	Analog switch control signal; High: FWD; Low: RVS
	37–30	BIT0–BIT7	DAC inputs; BIT0: LSB; BIT7: MSB
	6	EN1	Sample and hold control signal
	7	EN2	

	—	VEL	ACC	EF
ENT1	0	1	0	1
ENT2	0	0	1	1

	27	POSN IN	Microprocessor comparator (+) signal
	24	POSQ IN	Microprocessor comparator (+) signal
	22	ERR AMP IN1	Non-inverting op amp input for speed error signal generation
	21	ERR AMP IN2	Inverting op amp input for speed error signal generation
	19	GAIN ADJ1	Inverting op amp input for gain control
	16	ERR IN	Inverting op amp input for VCM control signal generation
	40	DAC V_{REF}	DAC reference current
	20	FIN.TRK.ADJ	Fine track width voltage level
Outputs	29	FIN.TRK.SENSE	Comparator output for microprocessor control and seek control
	23	ERR.AMP.OUT	Op amp output for speed error signal
	2	T.VEL	Target speed signal
	3	EF.CMP	External force compensation signal
	11	LOW.CURV	Acceleration signal
	12	FF.CRRNT	Acceleration signal
	13	ACC	Acceleration signal (for monitor)
	18	GAIN ADJ2	Op amp output for gain control
	15	PWR.AMP.DRV	Op amp output for VCM control
	26	POS N OUT	Comparator output for microprocessor control
	25	POS Q OUT	Comparator output for microprocessor control
External compo-nents	1	VEL CHARGE	Sample and hold capacitors
	9	ACC.CHARGE	
	8	EF.CHARGE	

Principles of Operation

Track Following: Figure 1 shows the feedback loop for tracking. The loop holds the position error at zero by using a quadratic lowpass filter, notch filter, and lead/lag phase compensation to eliminate resonance from VCM mechanical vibrations.

Settling Control: Vibration is greatest when the VCM moves from seek to tracking. To reach a stable, stationary state as quickly as possible, the IC increases the bandwidth by switching a filter (shown with dotted lines in figure 1) into the control loop.

Speed Detection and Seek: The actual speed is determined using the bandwidth division technique, which involves differentiating the position signal and integrating the current. Seek operation is carried out according to a speed profile which minimizes head movement. Figure 2 shows the speed control loop.

Track Crossing Detection: From the two position signals POSN and POSQ, four signals (N>0, Q>0, N+Q>0, –N+Q>0, corresponding to POSN OUT, POSQ OUT, ADD POS OUT, SUB POS OUT) are created and output.

DAC and Sample and Hold: Target speed, acceleration, and external force compensation data is input from the microprocessor as a time series, and converted into an analog signal. These signals are used as the target speed, target acceleration, and external force compensation values.

End Acceleration Detection: End acceleration detection reduces the variance of actual speed by adding acceleration data to the control loop.

Fine Track Detection: Whether or not the head is on-track is detected by the position signal input into a window comparator. The on-track window can be adjusted externally.

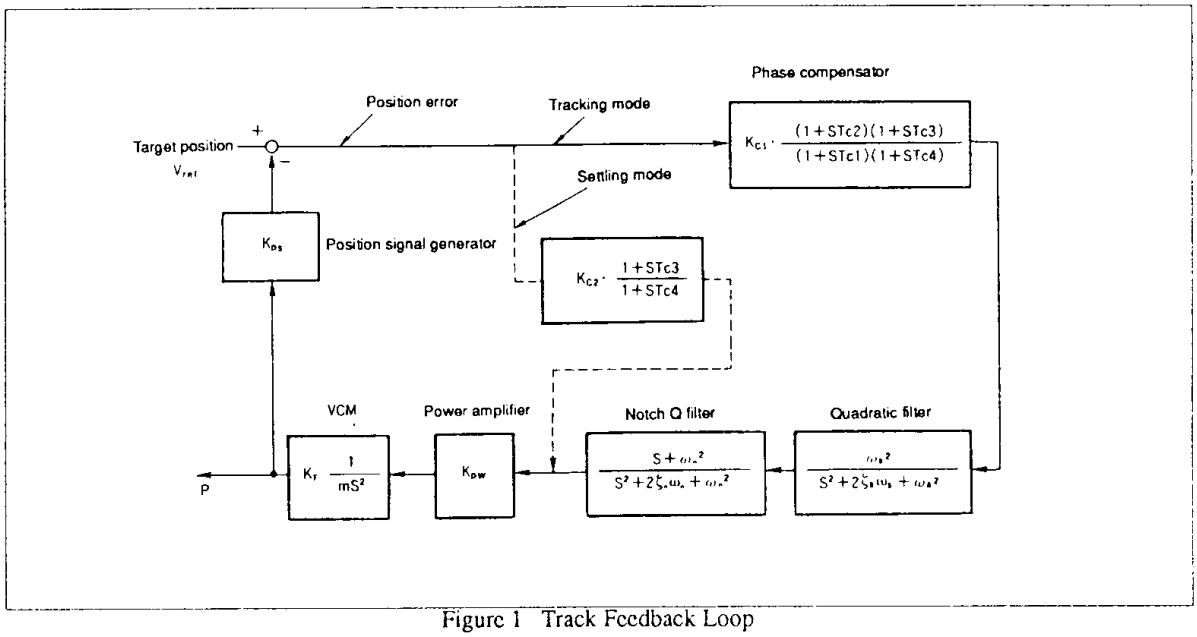


Figure 1 Track Feedback Loop

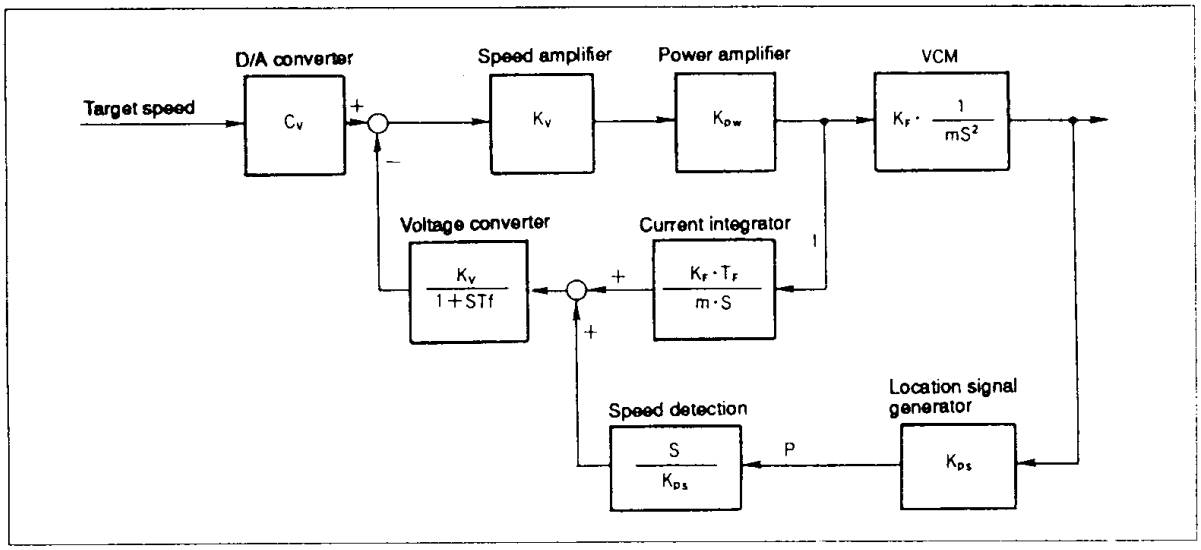


Figure 2 Speed Control Loop

Absolute Maximum Ratings

HA16671MP

Parameter	Symbol	Rating	Unit	Pins
Power supply voltage 1	V_{CCA}	15.0	V	V_{CCA}
Power supply voltage 2	V_{CCD}	7.0	V	V_{CCD}
Input voltage 1	V_{I1}	7.0	V	Note 1
Input voltage 2	V_{I2}	V_{CCA} – 1.5	V	Note 2
Differential input voltage	$V_{IN\ (DIFF)}$	V_{CCA} – 1.5	V	CURRNT FWD
				CURRNT RVS
In-phase input voltage	V_{CM}	–0.3 to	V	CURRNT FWD
		V_{CCA} – 1.5		CURRNT RVS
Input current	I_I	1.5	mA	Note 3
Output current 1	I_{OCL}	3.2	mA	Note 4
Output current 2	I_{OCH}	–400	µA	Note 5
Output current 3	I_{OAMP}	2.0	mA	Note 6
Operating temperature	T_{opr}	0 to +70	°C	
Storage temperature	T_{stg}	–55 to +125	°C	

HA16672MP

Parameter	Symbol	Rating	Unit	Pins
Power supply voltage 1	V_{CCA}	15.0	V	V_{CCA}
Power supply voltage 2	V_{CCD}	7.0	V	V_{CCD}
Input voltage 1	V_{I1}	7.0	V	Note 7
Input voltage 2	V_{I1}	V_{CCA} – 1.5	V	Note 8
Input current	I_{IDAC}	3.0	mA	DAC V_{REF}
Output current 1	I_{OCL}	3.2	mA	Note 9
Output current 2	I_{OCH}	–400	µA	Note 10
Output current 3	I_{OAMP}	±2.0	mA	Note 11
Output current 4	I_{ODAC}	3.0	mA	I_{V1}
Output current 5	I_{OIV}	±12.0	mA	I_{V2}
Operating temperature	T_{opr}	0 to +70	°C	
Storage temperature	T_{stg}	–55 to +125	°C	

The absolute maximum ratings are limiting values, to be applied individually, beyond which the device may be permanently damaged. Functional operation under any of these conditions is not guaranteed. Exposing a circuit to its absolute maximum rating for extended periods of time may affect the device's reliability.

Notes:

1. V_{REF}, $\overline{RVS}$, MODE, $\overline{MOVE}$, $\overline{EVEN}$ $\overline{TRK}$, $\overline{LIN}$ $\overline{MD}$, $\overline{STLLP}$
2. ADDPOSIN, SUBPOSIN, LPGAINADJ, CMPS1, LPFIN, NQIN, VELGAINADJ, CRRNTCMP1, DIFPOSN1, DIFPOSQ1, $\overline{POSN}$, CMPS2, CMPS3, STLLPIN
3. $\overline{POSN}$, CMPS2, CMPS3, STLLPIN
4. When SUBPOSOUT, and ADDPOSOUT outputs are low.
5. When SUBPOSOUT and ADDPOSOUT outputs are high.
6. LPGAINOUT, STLLPOUT, LPFOUT, NQOUT, ABSVELOUT, CRRNTCMP2, DIFPOSN2, DIFPOSQ2, CURRNTSENSE
7. V_{REF}, FINTRKADJ, BIT0–BIT7, EN1, EN2, $\overline{RVS}$, $\overline{MOVE}$
8. POSNIN, POSQIN, ERRAMPIN1, ERRAMPIN2, GAINADJ1, ERRIN
9. When POSNOUT, POSQOUT, and FINTRKSENSE outputs are low.
10. When POSNOUT, POSQOUT, and FINTRKSENSE outputs are high.
11. ERRAMPOUT, GAINADJ2, PWRAMPDRV, ACC, TVEL, EFCMP, LOWCURV, FFCRRNT

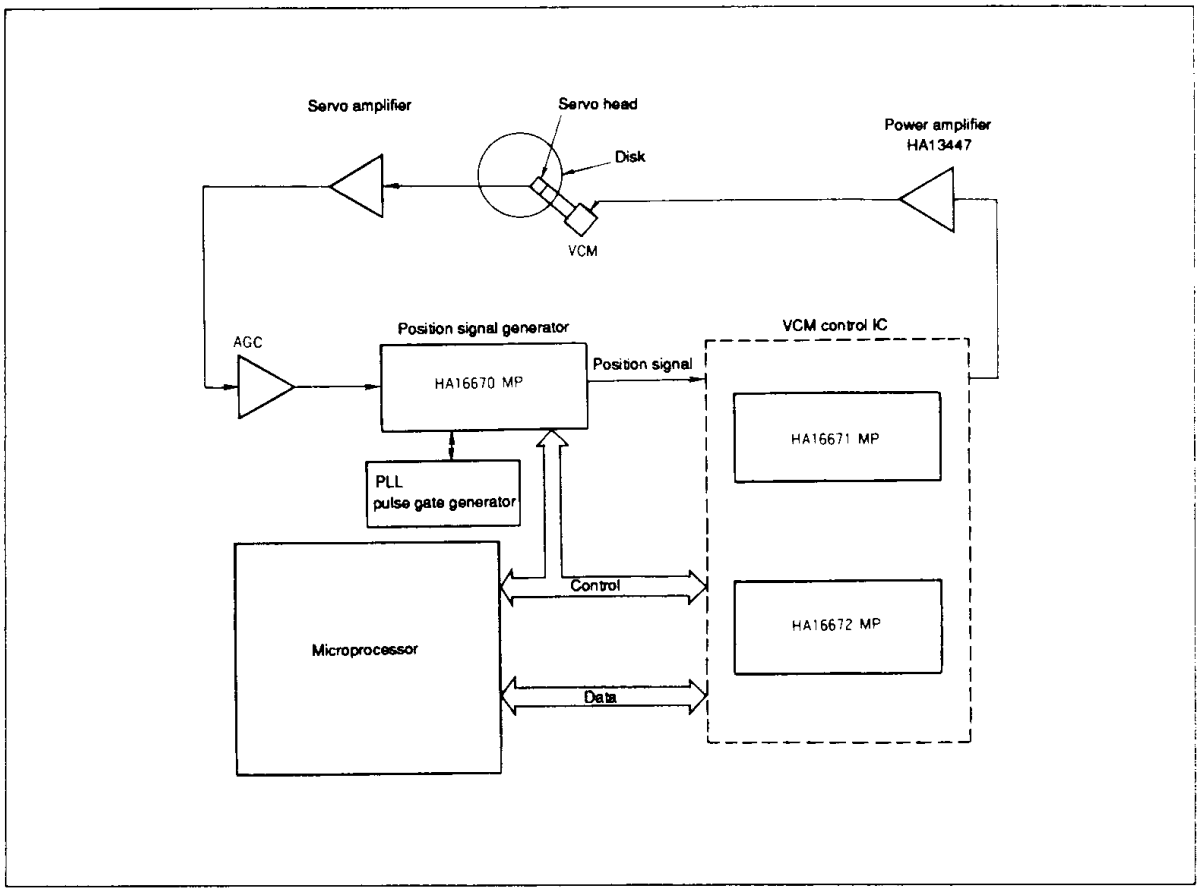
Electrical Characteristics (V_{CCA} = 12.0 V, V_{CCD} = V_{REF} = 5.0 V, T_a = 25°C, unless otherwise specified)

Parameter		Symbol	Min	Typ	Max	Unit	Test Conditions	Notes
Power supply	Operating voltage 1	V_{CCOAP}	10.8	12.0	13.2	V		1
	Operating voltage 2	V_{CCDOP}	4.5	5.0	5.5	V		
	V_{REF} voltage	V_{REFop}	4.5	5.0	5.5	V		
	Current consumption	I_{CCA1}	—	18.4	23.9	mA	V_{CCA} = 13.2 V, V_{CCD} = 5.5 V	2
		I_{CCD1}	—	3.7	4.1	mA	V_{CCA} = 13.2 V, V_{CCD} = 5.5 V	
		I_{CCA2}	—	28	43	mA	V_{CCA} = 13.2 V, V_{CCD} = 5.5 V	3
		I_{CCD2}	—	9	15	mA	V_{CCA} = 13.2 V, V_{CCD} = 5.5 V	
Logic block	Input low voltage	V_{IL}	—	—	0.8	V		
	Input high voltage	V_{IH}	4.0	—	—	V		
DAC block	Resolution		—	8.0	—	bit		
(HA16672MP)	Phase error	ER	–0.19	0	0.19	% FS		
	Settling time	t_s	—	1.8	—	µs	All bits on → off ± 1/2LSB	
	Output voltage range	I_{OR}	0	—	2.1	mA	DAC, I_{REF} = 2 mA	
	Input current 1	I_{ODAC1}	1.42	1.49	1.57	mA	I_{REF} = 1.5 mA, All bits high	
	Input current 2	I_{ODAC2}	—	0	3.0	µA	I_{REF} = 1.5 mA, All bits low	
	Reference voltage	I_{DREF}	1.0	—	2.0	mA		
Op amp block	Input bias current	I_B	—	300	700	nA		4
	Input offset voltage	V_{IO}	—	(3.0)	7.7	mV		
	Output offset voltage	V_{OS}	—	(3.0)	9.0	mV		
	Maximum output voltage	V_{OCMI}	9.8	—	—	V		
	Minimum output voltage		—	—	1.82	V		
	Slew rate	SR	1.0	2.4	—	V/µs		
Analog switch	On resistance	R_{ON}	300	500	750	Ω		
	Turn on time	t_{ON}	—	0.4	1.0	µs		
	Turn off time	t_{OFF}	—	0.4	1.0	µs		

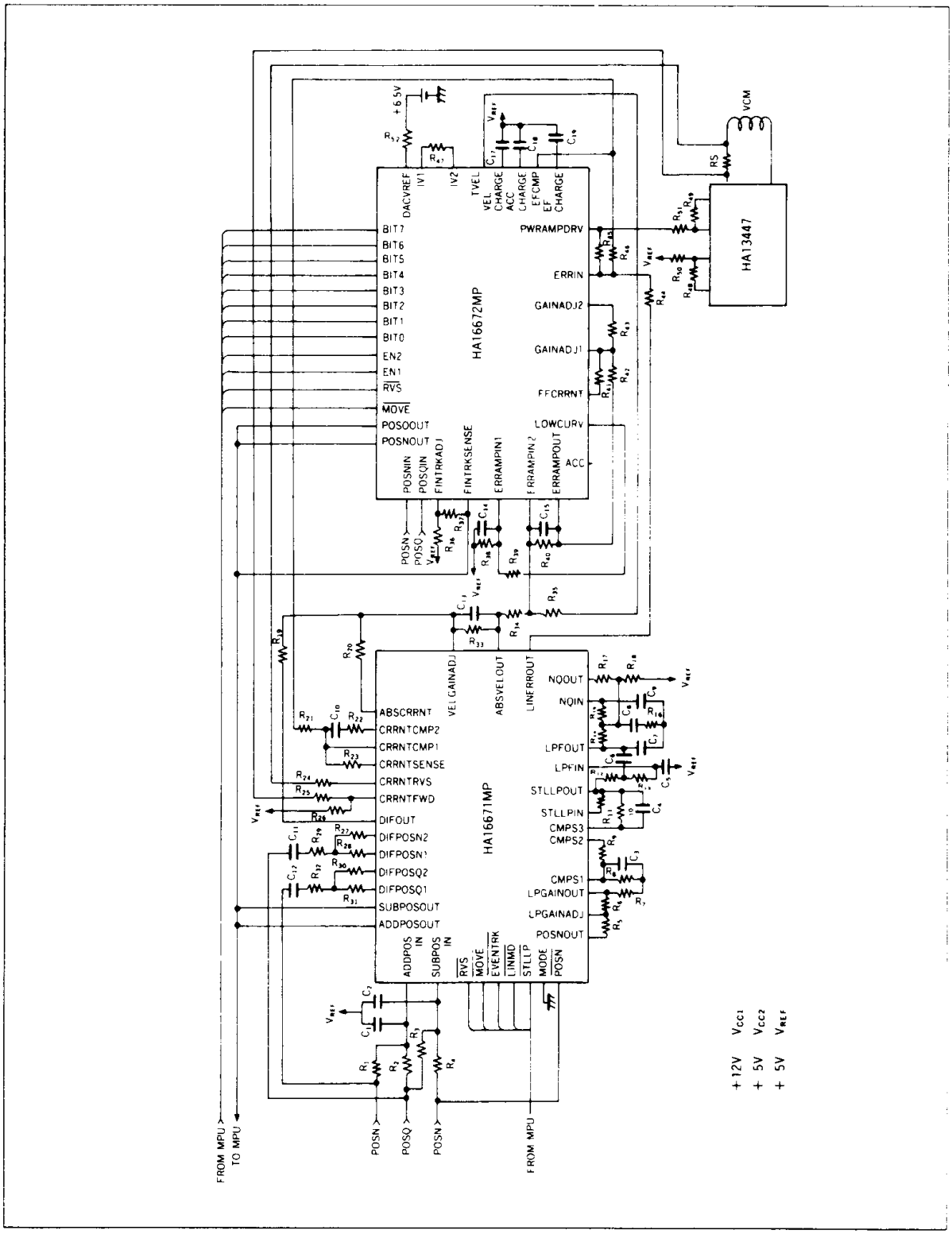
Notes:

1. Common to HA16671MP and HA16672MP.
2. Applies to HA16671MP.
3. Applies to HA16672MP.
4. Characteristic values of the op amp and analog switch included in the HA16671MP and HA16672MP.
5. Values in parentheses are preliminary.

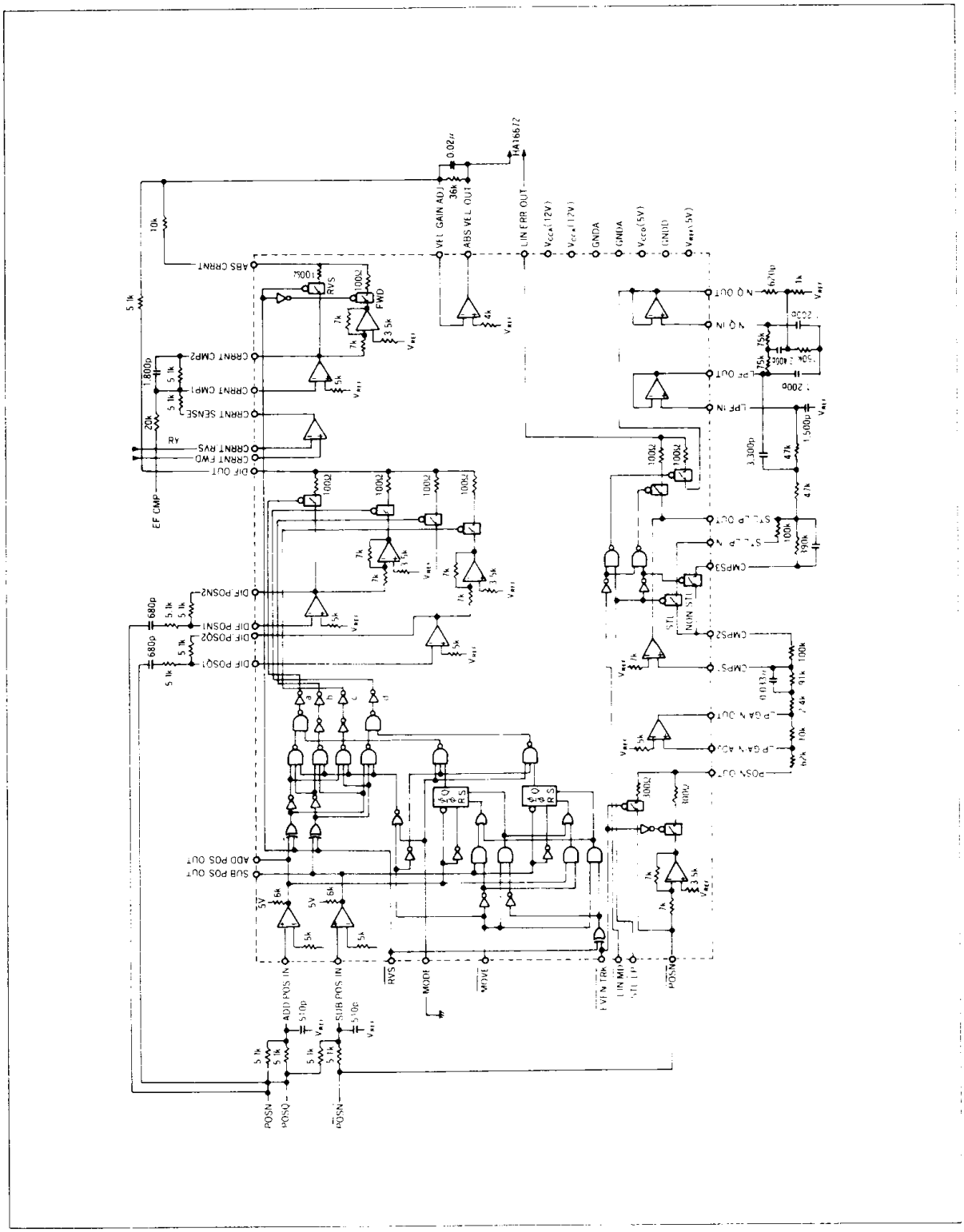
Example


Servo amplifier
Servo head
Disk
VCM
Power amplifier
HA13447
AGC
Position signal generator
HA16670 MP
Position signal
VCM control IC
HA16671 MP
PLL
pulse gate generator
Control
HA16672 MP
Microprocessor
Data

Phase Servo Mode Circuit Example



HA16671MP Internal Circuit



HA16672MP Internal Circuit

