
HA13536F

Three-Phase Brushless DC Motor Driver IC

HITACHI

ADE-207-111B (Z)
3rd Edition
July 1996

Description

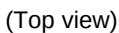
The HA13536F is a 3-phase brushless DC motor driver IC with digital speed control. It is being developed for direct drive of the spindle motor of 5 V floppy disk drives with a height of 3/4" or less. It has the following functions and features.

Functions

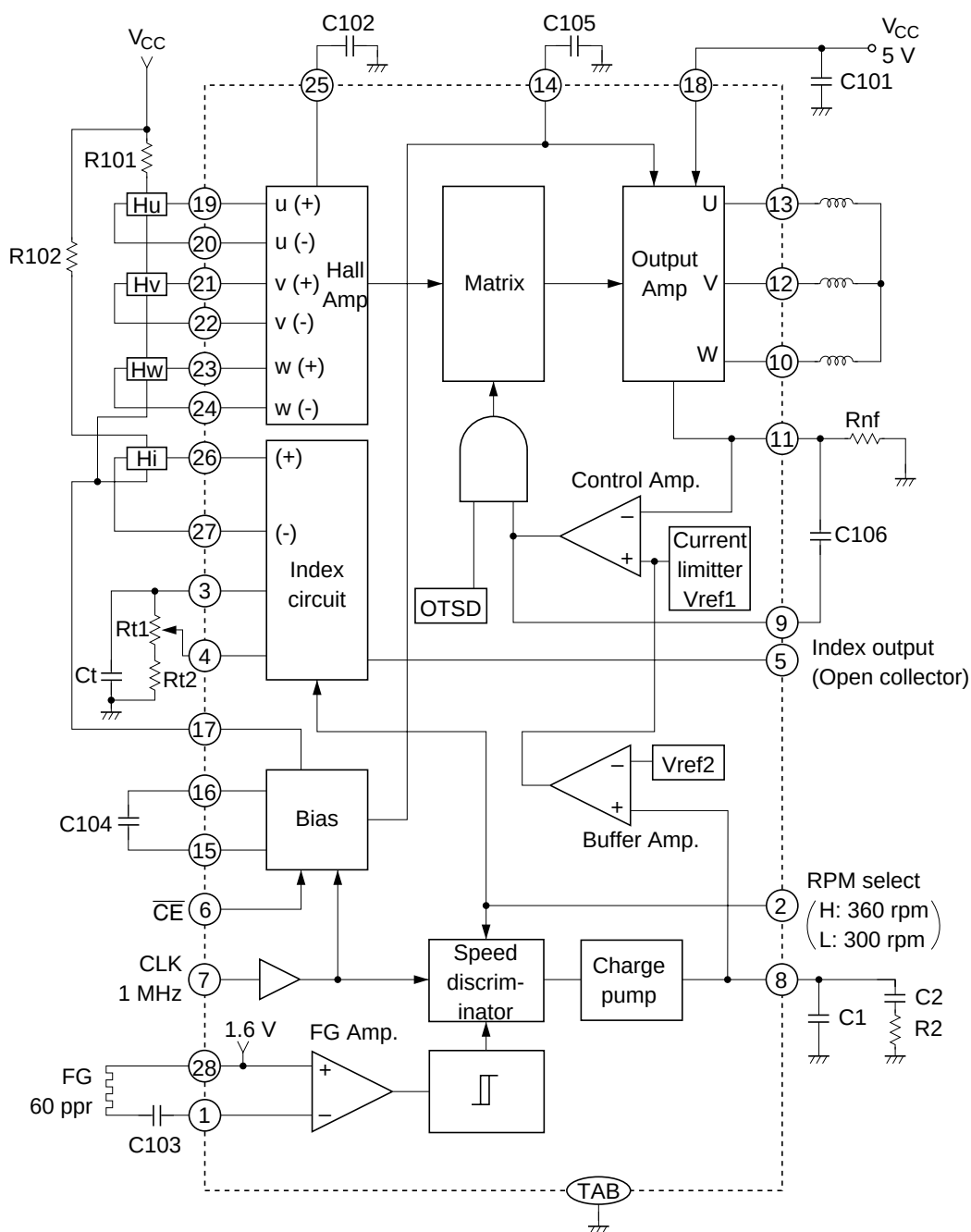
- 1.0 A per phase, 3-phase drive circuit (current driver)
- Digital speed control circuit
- FG Amp
- Index circuit
- Current limiter circuit
- Over-temperature shutdown circuit (OTSD)

Features

- Low saturation voltage, typically 1.15 V (at 0.7 A)
- Soft switching drive circuit
- No need for an output snubber circuit



Block Diagram



Note : Pin arrangement is preliminary specification.

Pin Function

Pin Number	Pin Name	Function	Pin Voltage
1	FG (–) input	FG Amp. (–) input terminal	
2	RPMSEL	Change terminal for motor rotation speed “L” → 300 rpm, “H” → 360 rpm	$V_{TH} = 1.4 \text{ V Typ}$
3	Index adjustment	Terminal to set up burst time of index circuit	0 V Min, 1.2 V Max
4	Index Vreg	Output terminal for fixed voltage of index circuit	1.5 V Typ
5	Index output	Index output terminal (Open collector)	$V_{OL} = 0.14 \text{ V Typ}$ (@ $I_o = 2 \text{ mA}$)
6	$\overline{CE}$	Chip enable terminal “L”: enable, “H”: disable	$V_{TH} = 1.4 \text{ V Typ}$
7	CLK input	CLK input terminal	$V_{TH} = 1.4 \text{ V Typ}$
8	C-PUMP output	Speed error Integration and Phase compensation of speed control	
9	Phase compensation	To prevent the parastic oscillation of output, insert the capacitor between pin 9 and pin 11.	
10	W phase output	W phase output	
11	Current detection	Output current detection and terminal which is connected with phase compensation capacitor for current control.	
12	V phase output	V phase output	
13	U phase output	U phase output	
14	Bias output	Bias output terminal	
15	Bias (+) pin	Bias (+) pin terminal	
16	Bias (–) pin	Bias (–) pin terminal	
17	Hall bias	Hall bias terminal $\overline{CE} = \text{“L”} \rightarrow \text{Bias}$, $\overline{CE} = \text{“H”} \rightarrow \text{High impedance}$	2.2 V Typ (@ $I = 10 \text{ mA}$)
18	V_{CC}	Power supply	4.25 V Min, 6.5 V Max
19	U phase (+) input	U phase (+) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
20	U phase (–) input	U phase (–) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
21	V phase (+) input	V phase (+) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
22	V phase (–) input	V phase (–) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
23	W phase (+) input	W phase (+) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
24	W phase (–) input	W phase (–) input terminal	2.0 V Min, $V_{CC} - 0.5 \text{ V Max}$
25	AGC	Hall amp output wave form adjustment terminal (Insert capacitor C102 between GND)	

Pin Function (cont)

Pin Number	Pin Name	Function	Pin Voltage
26	Index (+) input	Index amp (+) input terminal	1.4 V Min, V _{CC} – 0.5 V Max
27	Index (–) input	Index amp (–) input terminal	1.4 V Min, V _{CC} – 0.5 V Max
28	FG (+) input	FG amp (+) input terminal	DC bias 1.6 V Typ

External Parts

Part Number	Recommended Value	Purpose	Notes
R2	—	Integration constant	1
R101	—	Hall bias	
R102	—	Index hall bias	
Rnf	—	Current detection and limitation	2
Rt1	0 to 50 kΩ	Index burst adjustment	3
Rt2	100 kΩ	Index pulse width setting	
C1, C2	—	Integration constants	1
C101	≥ 0.1 μF	Power supply bypass	4
C102	0.1 μF	AGC filter	5
C103	0.47 μF	FG amp. coupling	5
C104	0.1 μF	Bias	
C105	≥ 0.1 μF	Bias	7
C106	0.1 μF	Phase compensation	4
Ct	0.1 μF	Index setting	3, 6

Notes: 1. Determine the integration constants from the following formulas:

$$\omega_O \leq \frac{2\pi f_{FG}}{20} \quad (\text{rad/s})$$

$$R2 = \frac{1}{9.55} \frac{J\omega_O N_O \cdot Rnf}{K_T Gctl I_{cp}} \quad (\Omega)$$

$$C1 = \frac{1}{\sqrt{10}} \frac{1}{\omega_O R2} \quad (F)$$

$$C2 = 10C1 \quad (F)$$

In the above formulas:

ω_o = Time constant of servo loop

f_{FG} = FG frequency in Hz

N_o = Motor speed in rpm

J = Motor moment of inertia in $\text{kg}\cdot\text{cm}\cdot\text{s}^2$

K_T = Motor torque constant in $\text{kg}\cdot\text{cm}/\text{A}$

R_{nf} = Current detection in Ω

G_{ctl} = Control amp gain (see Electrical Characteristics)

I_{cp} = Charge pump output current (see Electrical Characteristics)

2. The current limiter operates according to the following formula:

$$I_{OMAX} = \frac{V_{ref1}}{R_{nf}} \quad (\text{A})$$

where V_{ref1} is the current limiter reference voltage (see Electrical Characteristics)

3. The burst time t_1 is defined as follows:

$$t_1 \approx -Ct \times Rt1' \times \ln(1 - V_{th1}(L) / V_{reg}) \quad (\text{RPM select input low})$$

$$t_1 \approx -Ct \times Rt1' \times \ln(1 - V_{th1}(H) / V_{reg}) \quad (\text{RPM select input high})$$

where $Rt1'$ is resistance value inter 3 to 4 pin.

4. Place as close to the IC as possible.

5. Determine C102 and C103 according to the following formulas:

$$C102 \geq \frac{200}{N_o P} \quad (\mu\text{F})$$

$$C103 \geq \frac{100}{f_{FG}} \quad (\mu\text{F})$$

where

P = Number of motor poles

6. The index pulse width t_2 is determined as follows:

$$t_2 \approx -Ct \times Rt2' \times \ln(V_{th1} / V_{th2})$$

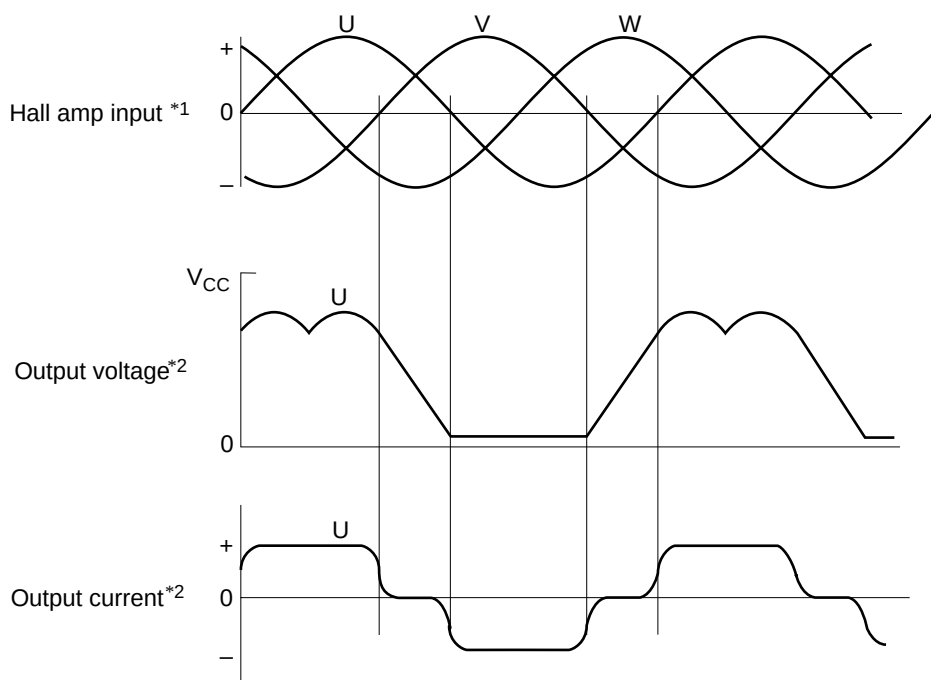
where V_{th2} is the threshold voltage (see Electrical Characteristics).

$Rt2'$: $Rt1(\text{max}) + Rt2$

7. If the circuit is affected by noise, a large capacitance value should be set.

Timing Waveforms

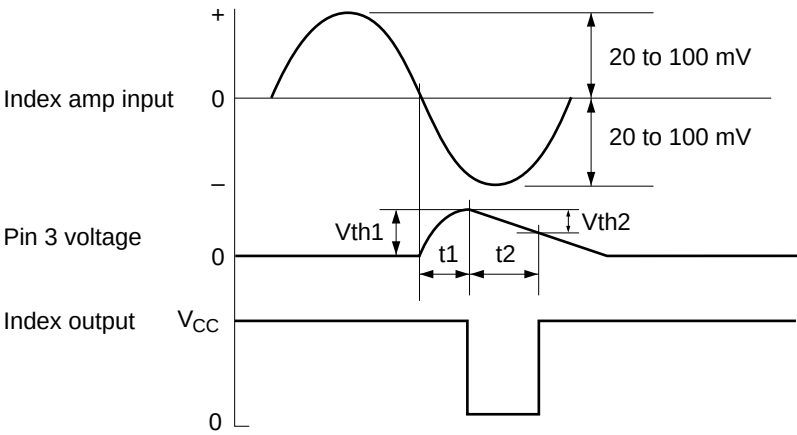
Hall Amp Input vs. Output Voltage and Current



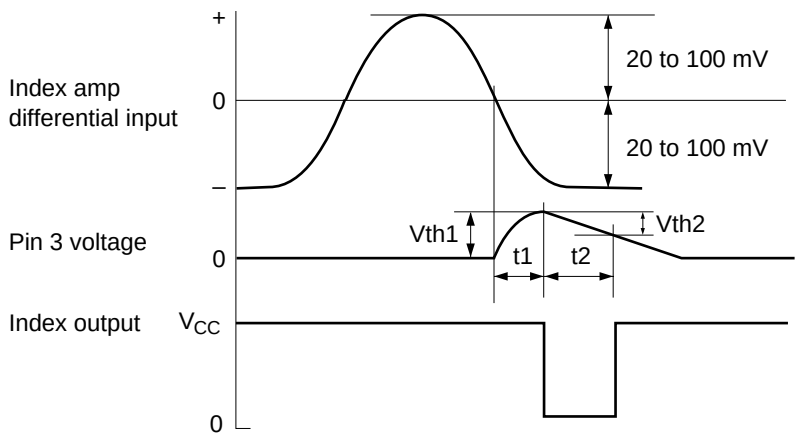
- Notes:
1. The input waveforms to the hall amp should be sine waves with a third harmonic content of less than 20%.
 2. Only the U phase output is shown.

Index Amp Input vs. Output

- Application 1



- Application 2



Absolute Maximum Ratings ($T_a = 25^{\circ}\text{C}$)

Item	Symbol	Value	Unit	Notes
Power supply voltage	V_{CC}	7	V	1
Input voltage	V_{in}	0 to $V_{CC} + 0.3$	V	2
Peak output current	I_{OP}	1.0	A	
Normal output current	I_O	0.7	A	
Power dissipation	P_T	1.5	W	3
Junction temperature	T_j	+150	$^{\circ}\text{C}$	1
Storage temperature range	T_{stg}	-55 to +125	$^{\circ}\text{C}$	

Notes: 1. The operating ranges is:

$$V_{CC} = 4.25 \text{ to } 6.5 \text{ V}$$

$$T_{jopr} = 0 \text{ to } +125^{\circ}\text{C}$$

2. Applied to the $\overline{CE}$, CLK, and RPM SEL pins.

3. Permissible value when $T_{pin} = 113^{\circ}\text{C}$ and thermal resistance is as follows:

$$\theta_{J-pin} \leq 25^{\circ}\text{C/W}$$

$$\theta_{J-a1} \leq 55^{\circ}\text{C/W} \text{ (when mounted on a metal substrate)}$$

$$\theta_{J-a2} \leq 80^{\circ}\text{C/W} \text{ (when mounted on a glass epoxy substrate)}$$

Electrical Characteristics (Ta = 25°C, V_{CC} = 5 V)

Item		Symbol	Min	Typ	Max	Unit	Test conditions	Pin Nos.	Notes
Quiscent current		I _{CCO}	—	—	0.45	mA	$\overline{CE} = H, V_{CC} = 6.5\text{ V}$	18	
		I _{CC}	—	9	13	mA	$\overline{CE} = L, V_{CC} = 6.5\text{ V}$		
Logic input	Input current I _{I1} (6 pin)		−80	—	2	μA	$\overline{VCE} = 0\text{ to }6.5\text{ V}$	2, 6, 7	
	Input current I _{I2} (2 pin)		−2	—	100	μA	V _{RPM} = 5.5 V		
	Input current I _{I3} (7 pin)		−2	—	450	μA	V _{CLK} = 5.5 V		
	Input low voltage	V _{IL}	0	—	0.8	V			
	Input high voltage	V _{IH}	2.0	—	5.5	V			
Logic out-put	Output low voltage	V _{OL}	—	—	0.4	V	I _O = 2 mA	5	
	Leakage current	I _{OH}	—	—	±10	μA	V _{CE} = 7.0 V		
Hall amp	Input resistance	R _{hi}	7	10	13	kΩ		19 to 24	
	Common-mode input voltage range	V _H	2.0	—	V _{CC} − 0.5	V			
	Differential input voltage range	V _h	30	—	160	mV _{pp}			
Output amp	Leakage current	I _{CER(H)}	0	—	5	mA	V _O = 7.0 V	10, 12, 13	1
		I _{CER(L)}	—	—	±100	μA	V _O = 0 V		
	Saturation voltage	V _{sat1}	—	1.15	1.65	V	I _O = 0.7 A		
		V _{sat2}	—	0.6	0.85	V	I _O = 0.35 A		
FG amp and de-tector	Input voltage range	V _{fg}	2	—	20	mV _{pp}		1, 28	
	Noise margin	nd	—	—	0.5	mV _{pp}	Differential Noise		
		nc	—	—	0.5	V	COMMON Noise		

Electrical Characteristics (Ta = 25°C, V_{CC} = 5 V) (cont)

Item		Symbol	Min	Typ	Max	Unit	Test conditions	Pin Nos.	Notes
Speed discriminator and charge pump	Number of counts	N	—	1666.5	—	—	PRMSEL = L		
			—	1388.5	—	—	PRMSEL = H		
	Operating frequency	f _{CLK}	0.9	1.0	1.1	MHz		7	
	Leakage current	I _{off}	—	—	±50	nA	V ₈ = 0.8 V	8	
	Output current	I _{cp+}	7	10	13	μA	Speed reduction full scale		
		I _{cp−}	−7	−10	−13	μA	Acceleration full scale		
Current control	Threshold voltage	V _{ref2}	0.55	0.63	0.71	V		8	2
	Voltage gain	G _{ctl}	−12	−10	−8	dB		11	
	Current limiter voltage	V _{ref1}	157	175	193	mV	R _{NF} = 0.47 Ω		
Index circuit	Input voltage (common)	V _{index}	1.4	—	V _{CC} − 0.5	V		26, 27	3
	Input voltage (different)	V _{index}	40	—	300	mV _{pp}			
	Hysteresis	hys	—	14	—	mV			
	Input current		—	—	±2	μA		3	
	Threshold voltage	V _{th1}	0.60 × V _{reg}	0.64 × V _{reg}	0.68 × V _{reg}	V	RPM select = L		
			0.54 × V _{reg}	0.58 × V _{reg}	0.62 × V _{reg}	V	RPM select = H		
	Ct discharge threshold voltage	V _{th2}	0.50 × V _{reg}	0.54 × V _{reg}	0.58 × V _{reg}	V	RPMSEL = L	3	3
			0.44 × V _{reg}	0.48 × V _{reg}	0.52 × V _{reg}	V	RPMSEL = H		
		Bias	V _{reg}	1.3	1.5	1.7	V	I _O = −0.2 mA	4
Hall bias	Output voltage	V _{hb}	1.9	2.2	2.5	V	I _h = 10 mA, $\overline{\text{CE}}$ = L	17	

Electrical Characteristics (Ta = 25°C, V_{CC} = 5 V) (cont)

Item		Symbol	Min	Typ	Max	Unit	Test condi- tions	Pin Nos.	Notes
Hall bias	Leakage current	Ihof	—	—	±10	μA	$\overline{CE} = H, V_{hb} = 7.0\text{ V}$	17	
OTSD	Operating temperature	Tsd	125	150	—	°C			4

- Notes:
- 1. Total of sink and source.
 - 2. See figure 1. $G_{ctl} = \Delta V_{rnf} / \Delta V_{cp}$.
 - 3. Refer to the timing chart.
 - 4. Design parameter only (No test).

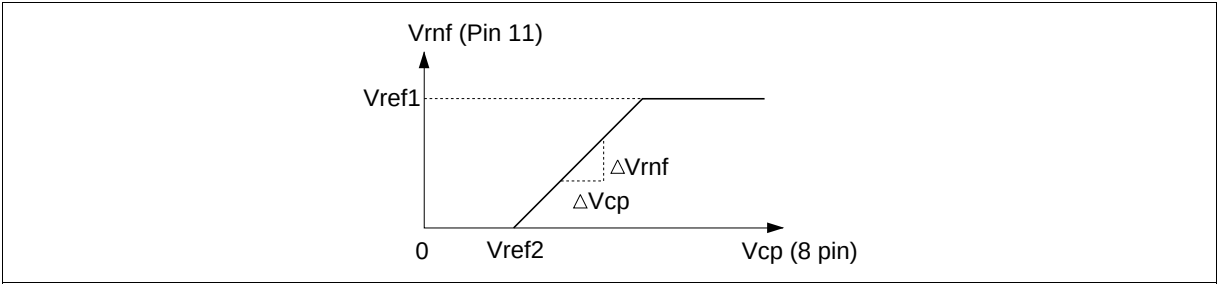
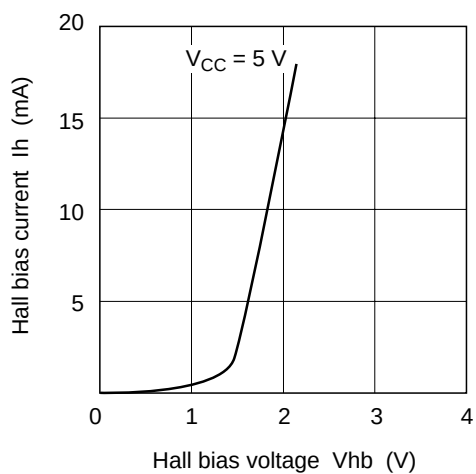
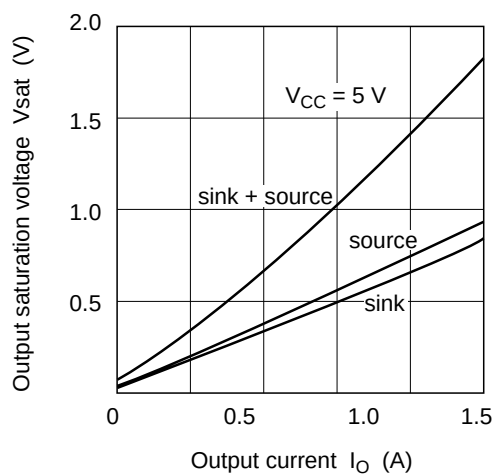
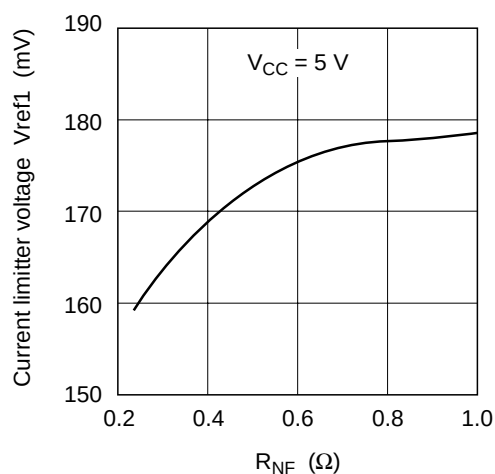
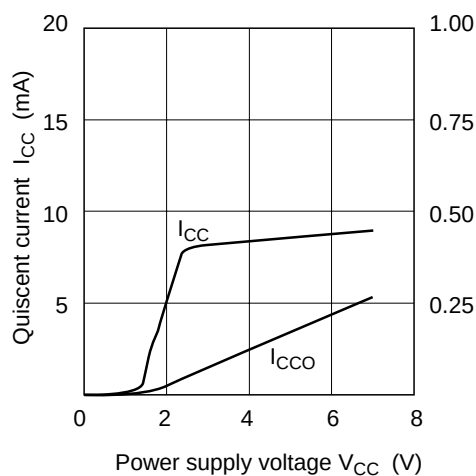
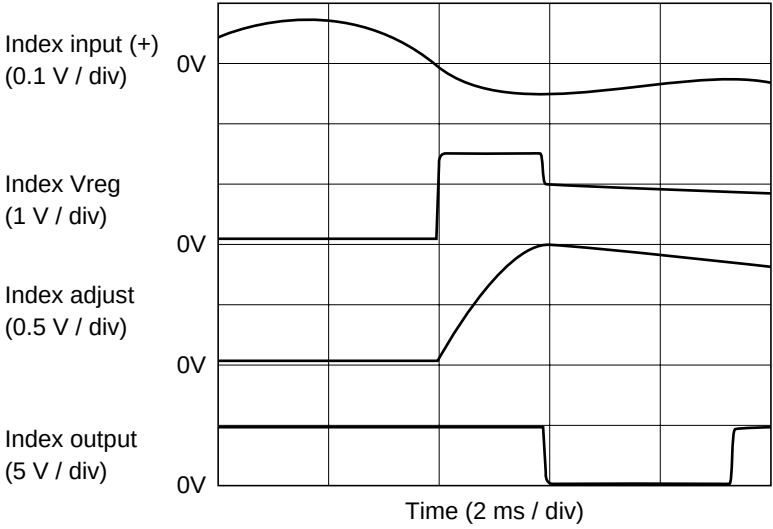
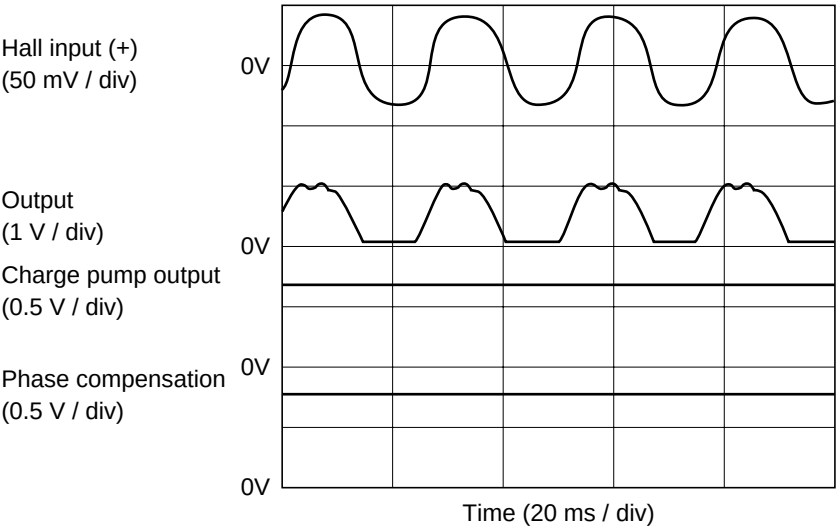


Figure 1

Reference Data

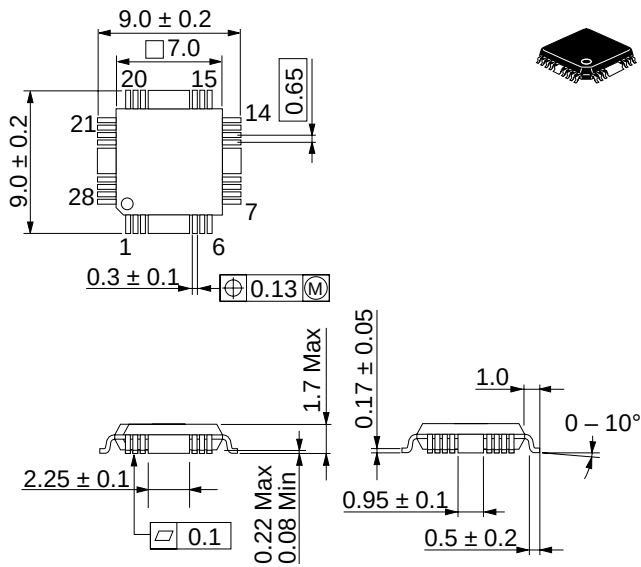


Mount Waveform Characteristics



Package Dimensions

Unit: mm



Hitachi code	FP-28T
EIAJ code	—
JEDEC code	—

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