
HA13568AT/HA13568R

CD-ROM Combo Driver

HITACHI

ADE-207-261 (Z)

1st Edition

July 1998

Description

The HA13568AT and HA13568R are combination of Spindle, Focus, Tracking, Slide, Tray designed for CD-ROM and have following functions and features.

Features

- 1.5 A sensorless spindle driver
- 0.5 A BTL focus driver
- 0.5 A BTL tracking driver
- 1.5 A H bridge slide motor driver
- 0.5 A H bridge tray motor driver
- Over temperature shut down (OTSD)
- Voltage regulator control circuit

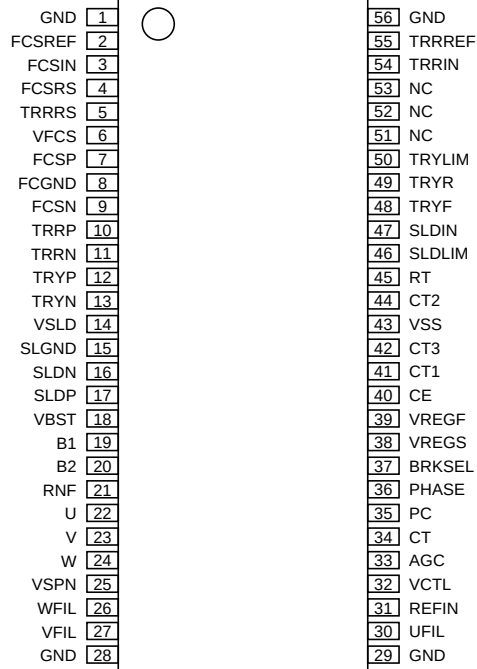
Functions

- Sensorless driver with self start
- Soft switching drive
- Snubberless
- Low output saturation voltage
- Direct PWM slide driver

HA13568AT/HA13568R

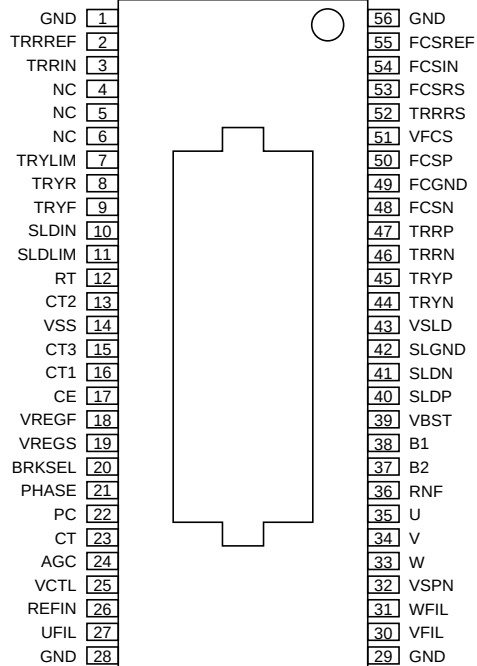
Pin Arrangement

• HA13568AT



(Top view)

• HA13568R



(Top view)

HA13568AT/HA13568R

Pin Description

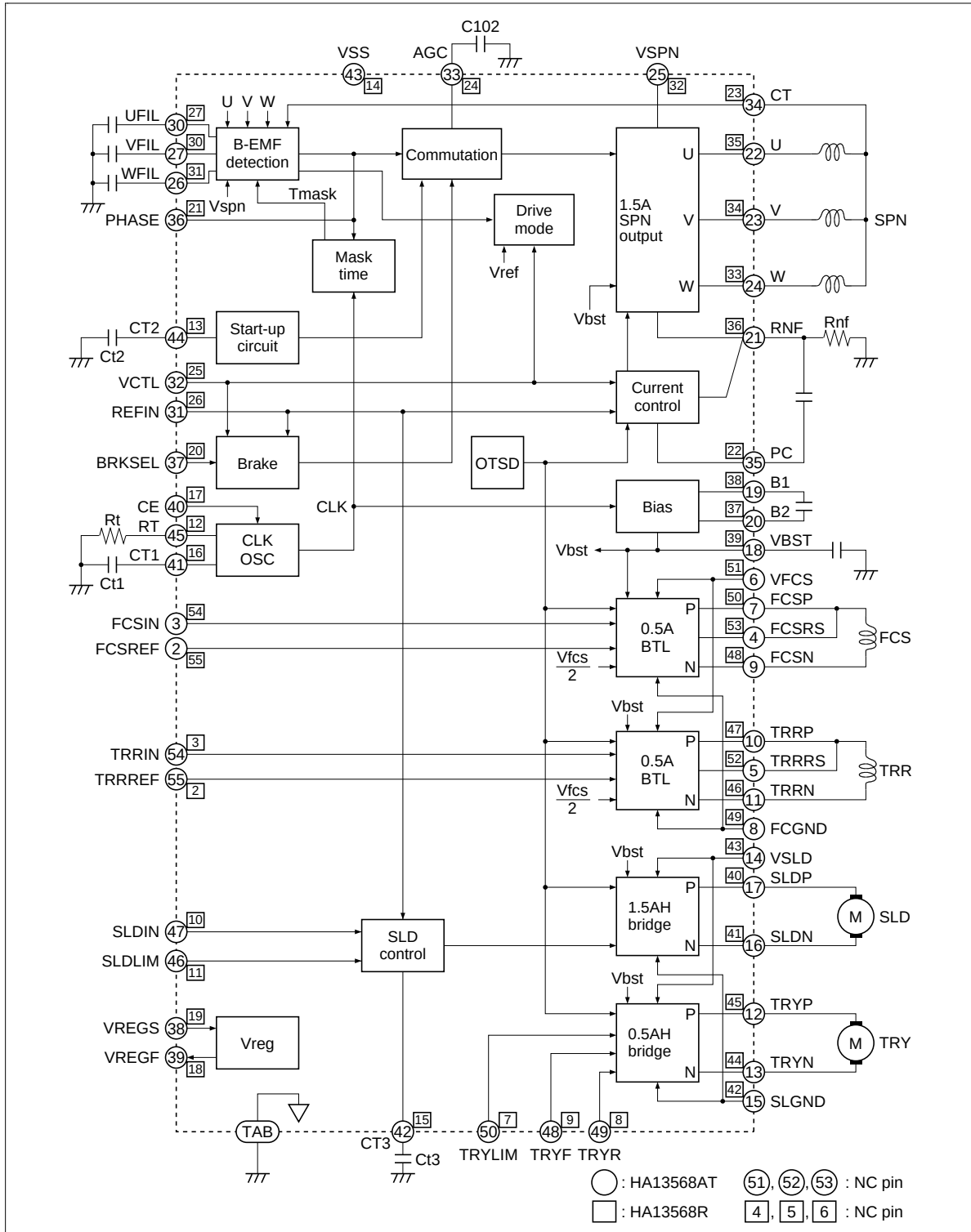
Pin No.		Pin Name	Function
HA13568AT	HA13568R		
2	55	FCSREF	FCS driver block reference voltage
3	54	FCSIN	FCS control input pin
4	53	FCSRS	FCS sense pin
5	52	TRRRS	TRR sense pin
6	51	VFCS	FCS driver and TRR driver power supply
7	50	FCSP	FCS driver P output
8	49	FCGND	FCS driver and TRR driver GND
9	48	FCSN	FCS driver N output
10	47	TRRP	TRR driver P output
11	46	TRRN	TRR driver N output
12	45	TRYP	TRY driver P output
13	44	TRYN	TRY driver N output
14	43	VSLD	SLD driver and TRY driver power supply
15	42	SLGND	SLD driver and TRY driver GND
16	41	SLDN	SLD driver N output
17	40	SLDP	SLD driver P output
18	39	VBST	Booster output pin. This circuit generates a voltage about 1.5 V above that of the VSPN pin.
19	38	B1	Booster pumping capacitor connection
20	37	B2	
21	36	RNF	Spindle driver current detection
22	35	U	U phase output
23	34	V	V phase output
24	33	W	W phase output
25	32	VSPN	Spindle and booster power supply
26	31	WFIL	W phase low pass filter. Connect a filter C to this pin during GND.
27	30	VFIL	V phase low pass filter. Connect a filter C to this pin during GND.
30	27	UFIL	U phase low pass filter. Connect a filter C to this pin during GND.
31	26	REFIN	Reference voltage of spindle and slide
32	25	VCTL	Spindle control input. Generates forward torque when a DC voltage higher than REFIN is applied, and brake when a DC voltage lower than REF is applied.
33	24	AGC	For AGC. Holds the level used for IC internal processing fixed even if the B-EMF level fluctuates due to the rotation speed.

HA13568AT/HA13568R

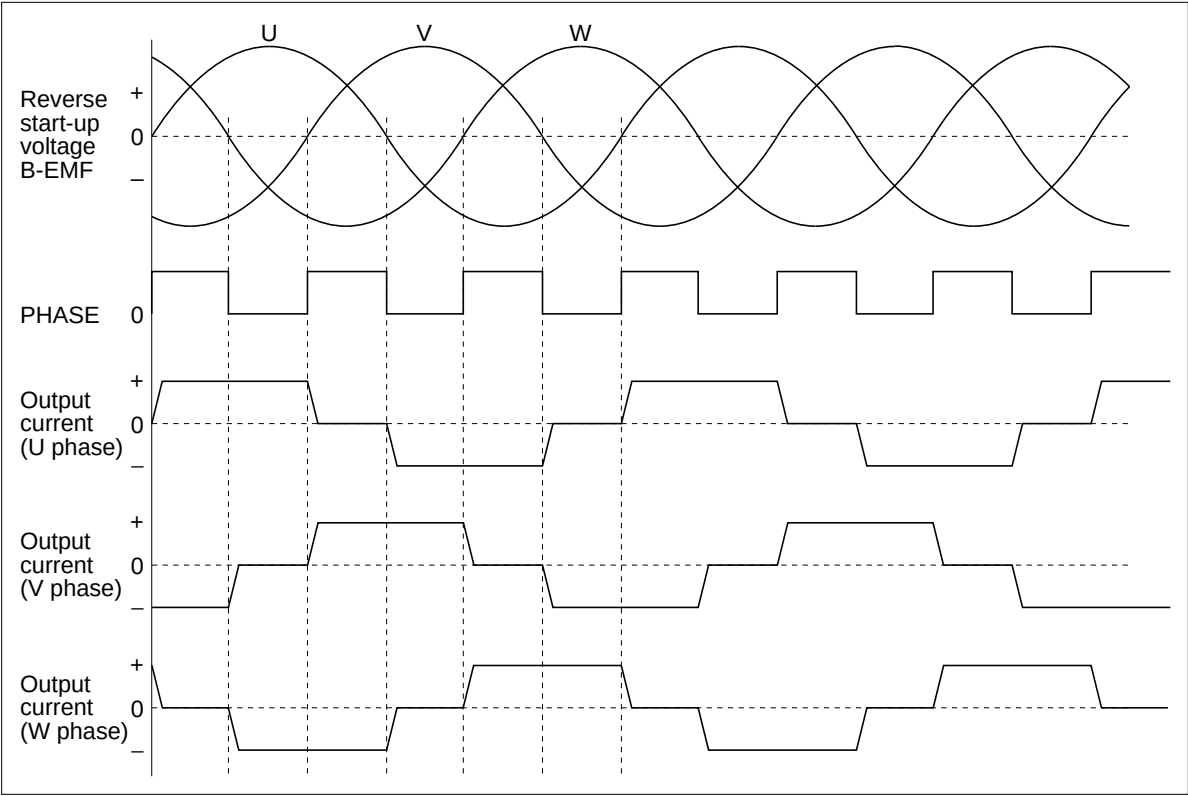
Pin Description (cont)

Pin No.		Pin Name	Function
HA13568AT	HA13568R		
34	23	CT	Spindle center tap
35	22	PC	Spindle driver phase compensation
36	21	PHASE	Outputs the B-EMF zero cross phase. Open corrector. (See the timing chart)
37	20	BRKSEL	To select the brake mode. Lo: Short brake, Hi: Reverse full brake (when forward torque input: BRKSEL = H)
38	19	VREGS	Voltage regulator sense pin (VREGS $\approx$ 3.3 V output)
39	18	VREGF	Voltage regulator force pin
40	17	CE	Chip enable. Input Hi: active
41	16	CT1	Time constant for clock oscillator circuit. The clock oscillator frequency is determined by the external capacitor and resistor Ct1 and Rt.
42	15	CT3	Time constant for PWM carrier oscillator. The carrier frequency is determined by the external capacitor and resistor Ct3 and Rt.
43	14	VSS	Control block power supply. 5 V
44	13	CT2	Time constant for start-up oscillator. The start-up oscillator frequency is determined by the external capacitor and resistor Ct2 and Rt.
45	12	RT	Reference voltage (3.3 V). The IC's internal reference current is determined by this voltage and the external resistor Rt.
46	11	SLDLIM	SLD output maximum duty setting
47	10	SLDIN	SLD control input pin
48	9	TRYF	TRY driver forward input
49	8	TRYR	TRY driver reverse input
50	7	TRYLIM	TRY output voltage setting pin
51	6	NC	No connection
52	5	NC	
53	4	NC	
54	3	TRRIN	TRR control input pin
55	2	TRRREF	TRR driver block reference voltage
1, 28, 29, 56, TAB			GND

Block Diagram

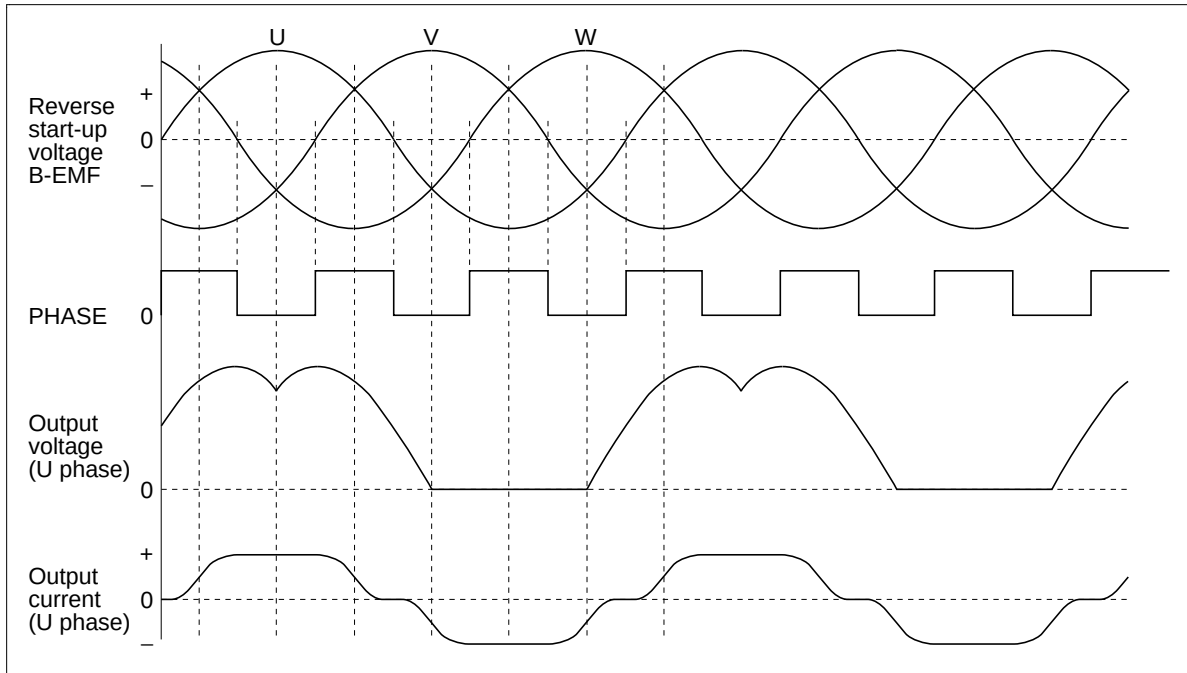


2. Acceleration (switching mode)



HA13568AT/HA13568R

3. Running (soft switching mode)



Truth Table

Table 1 Overall

CE	OTSD	SPN Driver	FCS Driver	TRR Driver	SLD Driver	TRY Driver
L	X	Z	Z	Z	Z	Z
H	ON	Z	Z	Z	Z	Z
	OFF	ON	ON	ON	ON	ON

Note: X: Option, Z: Hi impedance

Table 2 SPN Driver

BRKSEL	VCTL	SPN Driver
X	> REFIN	Forward torque
	REFIN	Z
L	< REFIN	Short brake
H	REFIN – 0.6 V	Reverse brake

Note: X: Option, Z: Hi impedance

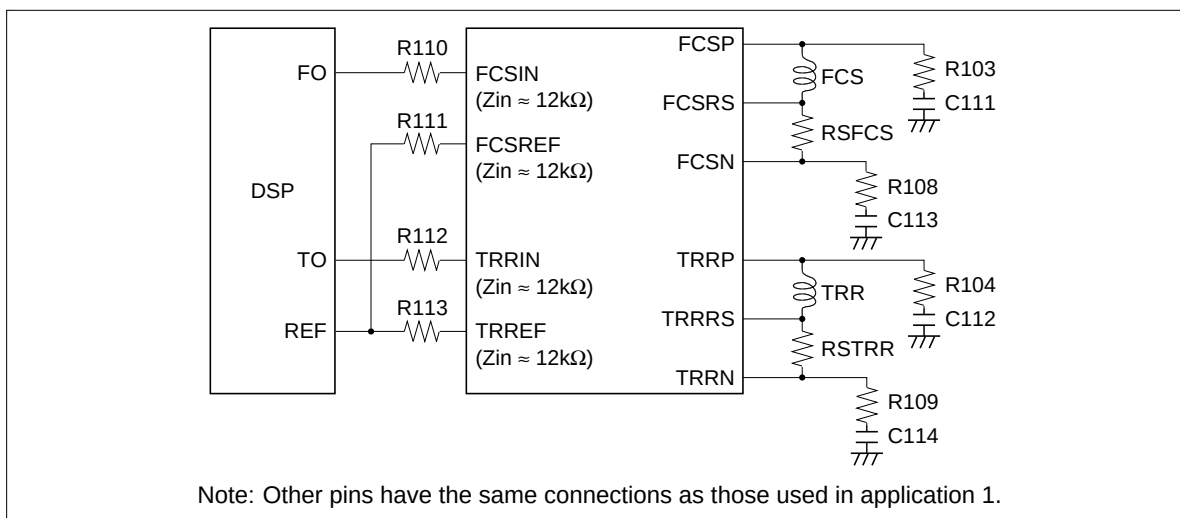
HA13568AT/HA13568R

Table 3 TRY Driver

TRYF	TRYR	P Output	N Output
L	L	Z	Z
L	H	L	H
H	L	H	L
H	H	H	H

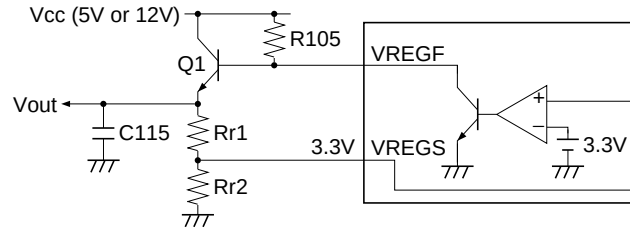
Note: Z: Hi impedance

2. FCS, TRR voltage drive



HA13568AT/HA13568R

3. When used at a voltage other than 3.3 V with a voltage regulator ($V_{out} = 3.3$ to $V_{cc} - 1$ V)



Note: Other pins have the same connections as those used in application 1.

External Components

Parts No.	Recommended Value	Recommended Range	Purpose	Note
R101	47 k Ω	≤ 47 k Ω	Filter for SPN driver control input	
R102	47 k Ω	≤ 47 k Ω	Filter for SLD driver control input	
R103	6.8 Ω	—	To stop FCS block oscillation	
R104	6.8 Ω	—	To stop TRR block oscillation	
R105	500 Ω	≥ 100 Ω	for Q1 bias	
R106	20 k Ω	—	for TRY driver output voltage setting	
R107	27 k Ω	—		
R108	6.8 Ω	—	To stop FCS block oscillation	
R109	6.8 Ω	—	To stop TRR block oscillation	
R110 to R113	20 k Ω	—	for BTL gain setting	7
Rnf	0.25 Ω	≥ 0.25 Ω	SPN driver current detection resistor	1
Rt1	1.8 k Ω	$Rt1 + Rt2 = 10$ k Ω	Reference current setting and SLD driver maximum duty setting	2, 5
Rt2	8.2 k Ω			
RSFCS	1 Ω	≥ 0.33 Ω	for FCS driver current sense	7
RSTRR	1 Ω	≥ 0.33 Ω	for TRR driver current sense	
Rr1	—	—	Voltage regulator division resistor	8
Rr2	—	—		
C101	0.1 μ F	≥ 0.1 μ F	for Power supply by passing	
C102	0.047 μ F		for B-EMF Amplitude AGC	
C103	0.01 μ F		for B-EMF filter	6
C104				
C105				
C106	0.22 μ F	≥ 0.22 μ F	for Booster pumping	

External Components (cont)

Parts No.	Recommended Value	Recommended Range	Purpose	Note
C107	0.47 μ F	$\geq 0.47 \mu\text{F}$	for Booster output smoothing	
C108	0.1 μ F		for SPN driver phase compensation	
C109	0.01 μ F		Filter for SPN control input	
C110	3300 pF		Filter for SLD control input	
C111	0.01 μ F	—	To stop FCS block oscillation	
C112	0.01 μ F	—	To stop TRR block oscillation	
C113	0.01 μ F	—	To stop FCS block oscillation	
C114	0.01 μ F	—	To stop TRR block oscillation	
C115	2.2 μ F		for Voltage regulator smoothing	
Ct1	150 pF	$\geq 120 \text{ pF}$	Time constant for CLK oscillation. Use a capacitor with good temperature characteristics.	3
Ct2	0.033 μ F		Time constant for start-up oscillation. Use a capacitor with good temperature characteristics.	4
Ct3	470 pF	$\geq 390 \text{ pF}$	PWM carrier oscillation time constant	5
Q1			Transistor for voltage regulator	

Note: 1. The output current maximum value I_{ospnmax} of SPN driver is controlled according to the following equation. However, V_{spncl} is the current limiter reference voltage. (See the electrical characteristics)

$$I_{\text{ospnmax}} = \frac{V_{\text{spncl}}}{R_{\text{nf}}}$$

2. The maximum duty D_{max} of SLD driver output is controlled according to the following equation.

$$D_{\text{max}} = \frac{V_{\text{rt}}}{V_{\text{hct3}} - V_{\text{lct3}}} \left(\frac{R_{\text{t2}}}{R_{\text{t}}} - \frac{V_{\text{lct3}}}{V_{\text{rt}}} \right) \times 100 (\%)$$

However,

$$R_{\text{t}} = R_{\text{t1}} + R_{\text{t2}}, \quad \frac{R_{\text{t2}}}{R_{\text{t}}} \geq \frac{V_{\text{lct3}}}{V_{\text{rt}}}$$

Where, V_{rt} : RT pin voltage (See the electrical characteristics)

V_{lct3} : CT3 pin low voltage ($\approx 1.3 \text{ V}$)

V_{hct3} : CT3 pin high voltage ($\approx 3.3 \text{ V}$)

Since $V_{\text{rt}} \approx V_{\text{hct3}}$, D_{max} is not limited at 100% when $R_{\text{t1}} = 0 \text{ W}$.

3. The CLK oscillation frequency is determined by the following equation.

$$f_{\text{clk}} = \frac{V_{\text{rt}}}{8 C_{\text{t1}} R_{\text{t}} \Delta V_{\text{ct1}}}$$

Where, V_{rt} : RT pin voltage (See the electrical characteristics)

ΔV_{ct1} : CT1 pin voltage amplitude ($\approx 1 \text{ V}$)

4. The Ct2 for start-up oscillation is determined by the following equation.

$$T_{c2} = \frac{1}{6} \sqrt{\frac{J}{P K_t I_{spnmax}}}$$

$$C_{t2} = \frac{T_{c2} V_{rt}}{8 R_t (V_{hct2} - V_{lct2})}$$

- Where, J : Spindle motor inertia (kg · cm · S²)
P : Number of spindle motor poles (Total number of S poles and N poles)
K_t : Spindle motor torque constant (kg · cm / A)
V_{hct2} : CT2 pin high voltage (≈ 3.3 V)
V_{lct2} : CT2 pin low voltage (≈ 1.3 V)

5. The PWM oscillation frequency f_{pwm} is determined by the following equation.

$$f_{pwm} = \frac{V_{rt}}{8 C_{t3} R_t (V_{hct3} - V_{lct3})}$$

- Where, V_{hct3} : CT3 pin high voltage (≈ 3.3 V)
V_{lct3} : CT3 pin low voltage (≈ 1.3 V)

6. The C103 to C105 for B-EMF filter are determined by the following equation.

$$\frac{21}{\pi \cdot R_{flt} \cdot N_o \cdot P} \leq C_{103} \leq \frac{35}{\pi \cdot R_{flt} \cdot N_o \cdot P}$$

- Where, R_{flt} : B-EMF detection output resistor (See the electrical characteristics)
N_o : Maximum rotation speed (rpm)

7. The FCS and TRR is determined by the following equation.

Voltage drive:

$$G_v = \frac{R_1}{R_{in} + R_2}$$

Current drive:

$$G_m = \frac{R_1}{((R_{in} + R_2) \cdot R_s)}$$

- Where, R₁ : Resistor of IC inside (≈30kΩ)
R₂ : Resistor of IC inside (≈7kΩ)
R_{in} : Resistor value inserted in the input (Ω)
(R110 to R113)
R_s : Current sense resistor (Ω)

8. The output voltage V_{out} of voltage regulator is determined by the following equation.

$$V_{out} = 3.3 \left(1 + \frac{R_{r1}}{R_{r2}} \right)$$

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit	Note
Supply voltage	Vss	7	V	1
SPN supply voltage	Vspn	15	V	1
FCS & TRR supply voltage	Vfcs	15	V	1
SLD & TRY supply voltage	Vsld	15	V	1
Input voltage	Vin	0 to Vss	V	2
	Vintrylim	Vss to Vsld	V	
SPN output current	Iospn	1.5	A	3
FCS & TRR & TRY output current	Iofcs	0.5	A	3
SLD output current	Iosld	1.5	A	3
Power dissipation	P _T	5	W	4
Junction temperature	Tj	160	°C	1
Storage temperature range	Tstg	−55 to +125	°C	

Note: 1. Operating voltage range is shown below.

Vss = 4.25 to 5.75 V

Vspn = 4.25 to 13.8 V

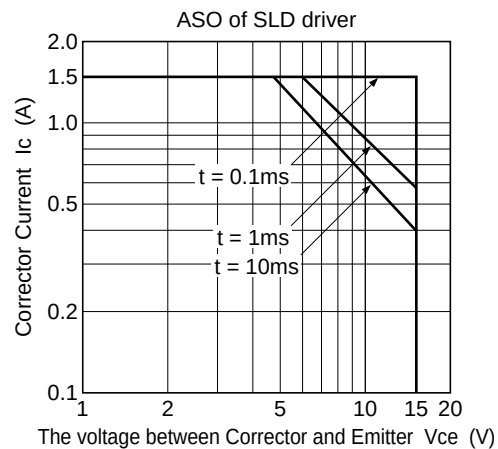
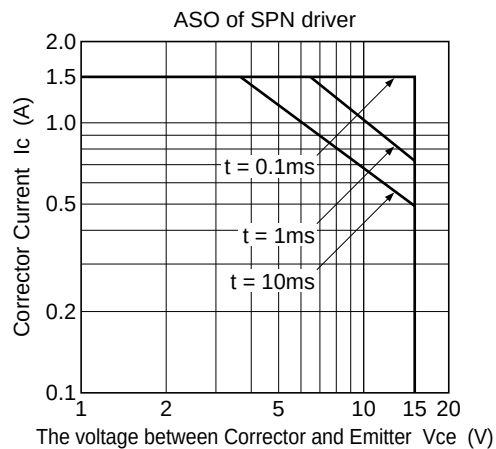
Vfcs = 4.25 to 13.8 V (However, the output high voltage is clamped at 7 V.)

Vsld = 4.25 to 13.8 V

Tjopr = 0 to +135°C

2. Applied to BRKSEL, VCTL, REFIN, CE, FCSIN, FCSREF, TRRIN, TRRREF, SLDIN, SLDLIM, TRYF and TRYR.

3. ASO (Area of Safety Operation) of each output transistor is shown below (TBD).



4. Thermal resistance is shown below.

$\theta_{j-tab} \leq 12^{\circ}\text{C} / \text{W}$ (back side tab soldering area is 70% or more)

$\theta_{j-a} \leq 25^{\circ}\text{C} / \text{W}$ (mounted on 4 layer multi glass-epoxy board, back side tab soldering area is 70% or more)

HA13568AT/HA13568R

Electrical Characteristics

(Ta = 25°C, Vss = 5 V, Vspn = 12 V, Vfcs = 5 V, Vsld = 12 V)

Item		Symbol	Min	Typ	Max	Unit	Test Conditions	Applicable Pins	Note
Quiescent current		I _{ss0}	—	0.7	0.9	mA	CE = L	VSS	
		I _{spn0}	—	—	0.2	mA		VSPN	
		I _{fcs0}	—	—	0.01	mA		VFCS	
		I _{sld0}	—	—	0.01	mA		VSLD	
		I _{ss1}	14	20	25	mA	CE = H, VCTL =	VSS	
		I _{spn1}	11	15	20	mA	FCSIN = TRRIN =	VSPN	
		I _{fcs1}	6	10	15	mA	SLDIN = REFIN,	VFCS	
		I _{sld1}	—	—	1.0	mA	TRYF = TRYR = L All load open	VSLD	
		I _{ss2}	20	33	60	mA	CE = H, VCTL =	VSS	
		I _{spn2}	11	30	50	mA	FCSIN = TRRIN =	VSPN	
		I _{fcs2}	7	10	15	mA	SLDIN = 5 V,	VFCS	
		I _{sld2}	−15	−1.0	1.0	mA	TRYF, TRYR = H, L, All load open	VSLD	
Logic input	Input current	I _{ince}	0	70	100	μA	V _{in} = 0 to 5 V	BRKSEL,	
		I _{in}	—	—	±10	mA		CE, TRYF,	
	Low level voltage	V _{il}	—	—	0.8	V		TRYR	
	High level voltage	V _{ih}	2.0	—	—	V			
Logic output	Low level voltage	V _{ol}	—	—	0.4	V	I _o = 1 mA	PHASE	
	Leak current	I _{cer1}	—	—	±10	μA	V _{ce} = 15 V		
SPN driver	Output saturation voltage	V _{satspn}	—	1.25	1.75	V	I _{ospn} = 1.0 A	U, V, W	1
	Leak current	I _{cer2}	1.3	2.2	3	μA	V _{ce} = 15 V		
	Current limiter voltage	V _{spncl}	238	265	292	mV	R _{nf} = 0.25 Ω	RNF	2
FCS driver	Input resistance	R _{infcs}	9.6	12	14.4	kΩ		FCSIN	
		R _{infcsref}	9.6	12	14.4	kΩ			
	Input voltage range	V _{infcs}	0	—	5	V			

Electrical Characteristics

(Ta = 25°C, Vss = 5 V, Vspn = 12 V, Vfcs = 5 V, Vsld = 12 V) (cont)

Item		Symbol	Min	Typ	Max	Unit	Test Conditions	Applicable Pins	Note
FCS driver	Output quiescent voltage	Vqfcs	2.375	2.5	2.625	V	FCSIN=FCSREF=2.5 V, VFCS=5 V	FCSP, FCSN	3
	Output offset voltage	Vosfcs	—	—	±20	μV			
	Output saturation voltage	Vsatfcs	—	1.0	1.4	V	Io = 0.33 A		1
	Voltage gain	Gvfcs	11.6	12.6	13.6	dB			4
	Gain band width	Bfcs	100	—	—	kHz	ΔGv = -3 dB		
TRR driver	Input resistance	Rintrr	9.6	12	14.4	kΩ		TRRIN	
		Rintrrref	9.6	12	14.4	kΩ			
	Input voltage range	Vintrr	0	—	5	V			
	Output quiescent voltage	Vqtrr	2.375	2.5	2.625	V	FCSIN=TRRREF=2.5 V, VFCS=5 V	TRRP, TRRN	3
	Output offset voltage	Vostrr	—	—	±20	mV	FCSIN = REF		
	Output saturation voltage	Vsatrrr	—	1.0	1.4	V	Io = 0.33 A		1
	Voltage gain	Gvtrr	11.6	12.6	13.6	dB			4
	Gain band width	Btrr	100	—	—	kHz	ΔGv = -3 dB		
SLD driver	Output saturation voltage	Vsatsld	—	1.5	2.0	V	Iosld = 0.75 A	SLDP, SLDN	1
	Leak current	Icer3	—	—	±100	μA	Vce = 15 V		
	Penetration current	Iovlap	—	—	100	mA		VSLD	8
	Transient response time	tplh1	—	—	5	μs		SLDP, SLDN	
		tphl1	—	—	5	μs			
TRY driver	Output saturation voltage	Vsattry	—	1.0	1.4	V	Iotry = 0.33 A	TRYP, TRYN	1
	Leak current	Icer3	—	—	±100	μA	Vce = 15 V		
	Penetration current	Iovlap	—	—	100	mA		VSLD	8
	Transient response time	tplh1	—	—	5	μs		TRYP, TRYN	
		tphl1	—	—	5	μs			
	Input current	Iintrylim	—	—	±5	μA	Vtrylim=7 to VSLD		
	Output voltage	Vlimtry	0.1	0.7	1.0	V	RL = 16Ω, Vtrylim = 7 V		9

HA13568AT/HA13568R

Electrical Characteristics

(Ta = 25°C, Vss = 5 V, Vspn = 12 V, Vfcs = 5 V, Vsld = 12 V) (cont)

Item		Symbol	Min	Typ	Max	Unit	Test Conditions	Applicable Pins	Note
SPN current control	Input current	linspn	—	—	±5.0	μA	Vctl = 0 to Vss–1V	VCTL,	2
	REF voltage range	Vref	1.6	—	3.0	V		REFIN	
	Dead zone voltage	Vdzspn	±50	—	±120	mV	Vref reference		
	Current control gain	Gctl	—	–12	±1.5	dB		RNF	
Drive mode	Change threshold	Vctl	—	0.5	±0.1	V	Vref reference	VCTL	5
	voltage	f _{PHASE}	—	≥f _{CT2}	±50%	Hz	SOFT SW mode	U, V, W	5
	SW ↔ SOFT SW		—	<f _{CT2}	–20%	Hz	SW mode		
B-EMF detection	Output resistance	Rflt	—	10	±20%	kΩ		UFIL, VFIL, WFIL	
	Threshold voltage of PHASE occurrence	Viemf	—	40	±50%	mVpp	VSPN ≥ Vss + 3V _F	U, V, W	6
			—	28	±50%	mVpp	VSPN ≤ Vss + 3V _F		
CLK	RT voltage	Vrt	3.135	3.30	3.465	V		RT	
OSC	CLK oscillation frequency	fclk	210	240	270	kHz	Rt = 10 kΩ, Ct1 = 82 pF	CT1	
Start-up circuit	Start-up oscillation frequency	fct2	437	485	534	Hz	Rt = 10 kΩ, Ct2 = 0.033 μF	CT2	
SLD control	Input current	linsld	—	—	±5.0	μA	Vsld = 0 to Vss–1V	SLDIN	
	Input voltage range	Vinsld	0	—	4.0	V			
	Limiter input current	Isldlim	—	—	±5.0	μA		SLDLIM	
	PWM oscillation frequency	fpwm	33	38	42.35	kHz	Rt = 10 kΩ, Ct3 = 470 pF		
	Control gain	D/V	80	90	100	%/V			7
	Offset voltage	Vossld	—	—	20	mV	SLDIN = REFIN		
Voltage regulator	Output sink current	Isinkreg	8.5	12.2	—	mA	VREGS = 4 V, VREGF = 4 V		
	Output voltage	Voutreg	3.135	3.30	3.465	V			
OTSD	Operating temperature	Tsd	135	160	—	°C			8
	Hysteresis	Thys	—	50	—	°C			

Note: 1. The output saturation voltage is the sum of the upper and lower saturation voltages.
2. See figure 1. Where,

$$G_{ctl} = 20 \log \frac{\Delta V_{rnf}}{\Delta V_{ctl}}$$

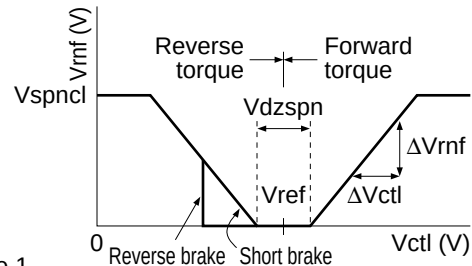


Figure 1

3. Where,

$$V_{qfcs} = \frac{V_{fcsp} + V_{fcsn}}{2}$$

$$V_{qtrr} = \frac{V_{trrp} + V_{trrn}}{2}$$

4. See figure 2. Where,

$$G_{vfc} = 20 \log \left(\frac{\Delta V_{fcsp}}{\Delta V_{fcsn}} \frac{\Delta V_{fcsn}}{\Delta V_{fcsin}} \right)$$

$$G_{vtr} = 20 \log \left(\frac{\Delta V_{trrp}}{\Delta V_{trrn}} \frac{\Delta V_{trrn}}{\Delta V_{trrin}} \right)$$

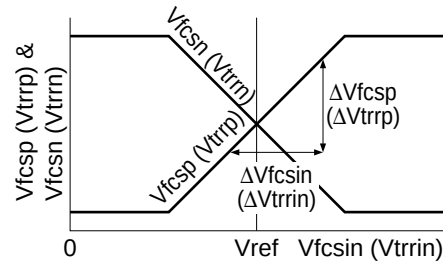


Figure 2

5. The circuit operates in soft switching drive mode only when the control input (Vctl) is lower than f_{CT2} and f_{PHASE} is higher than the threshold voltage. See figure 3.

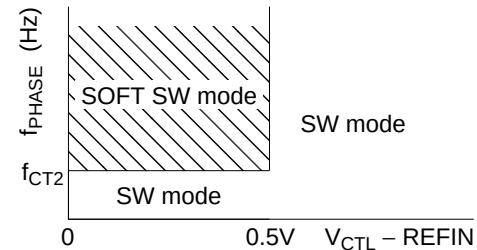


Figure 3

6. PHASE is output only when B-EMF exceeds the threshold voltage.

7. See figure 4. Where,

$$D/V = \frac{\Delta D}{\Delta V_{in}}$$

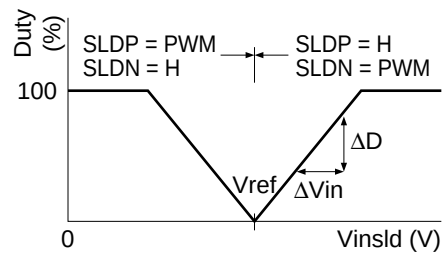
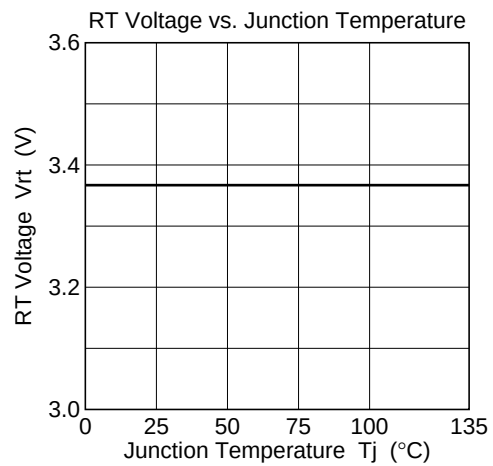
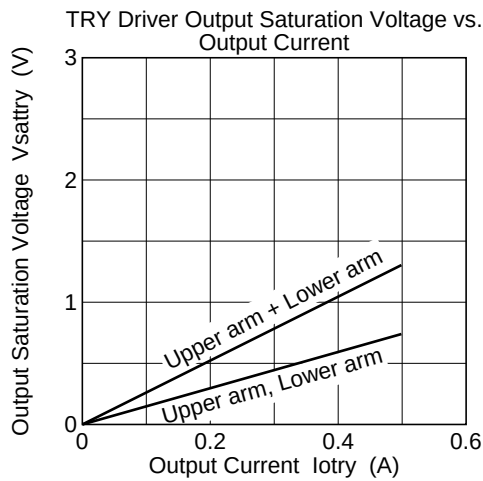
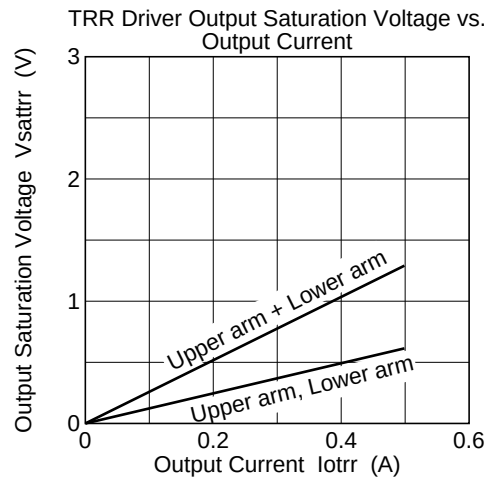
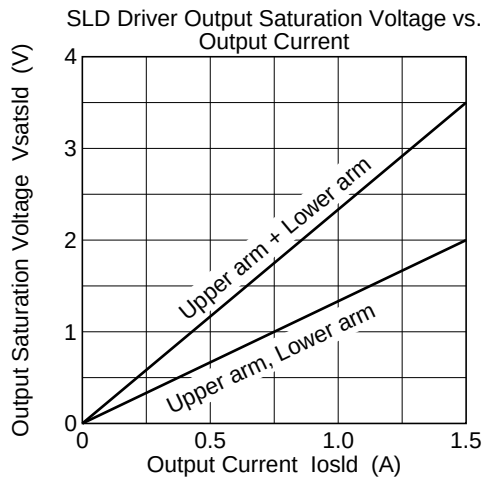
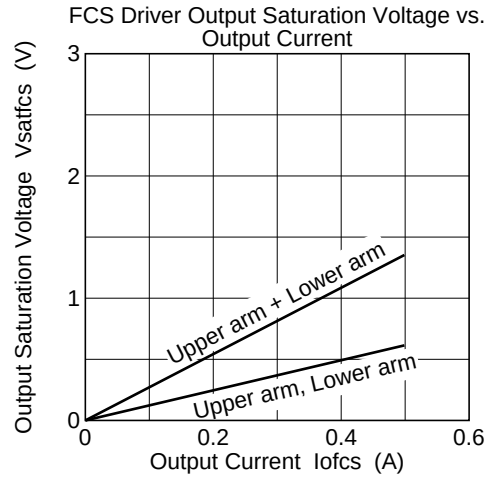
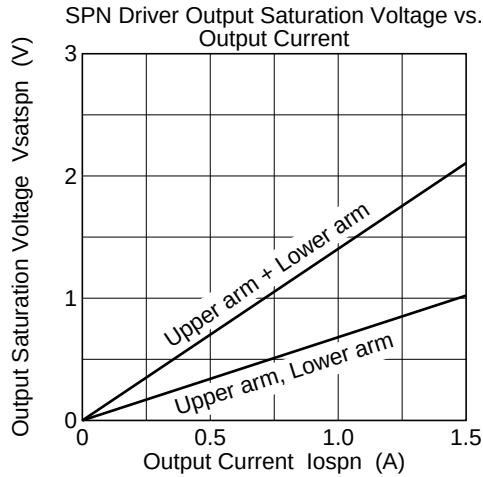


Figure 4

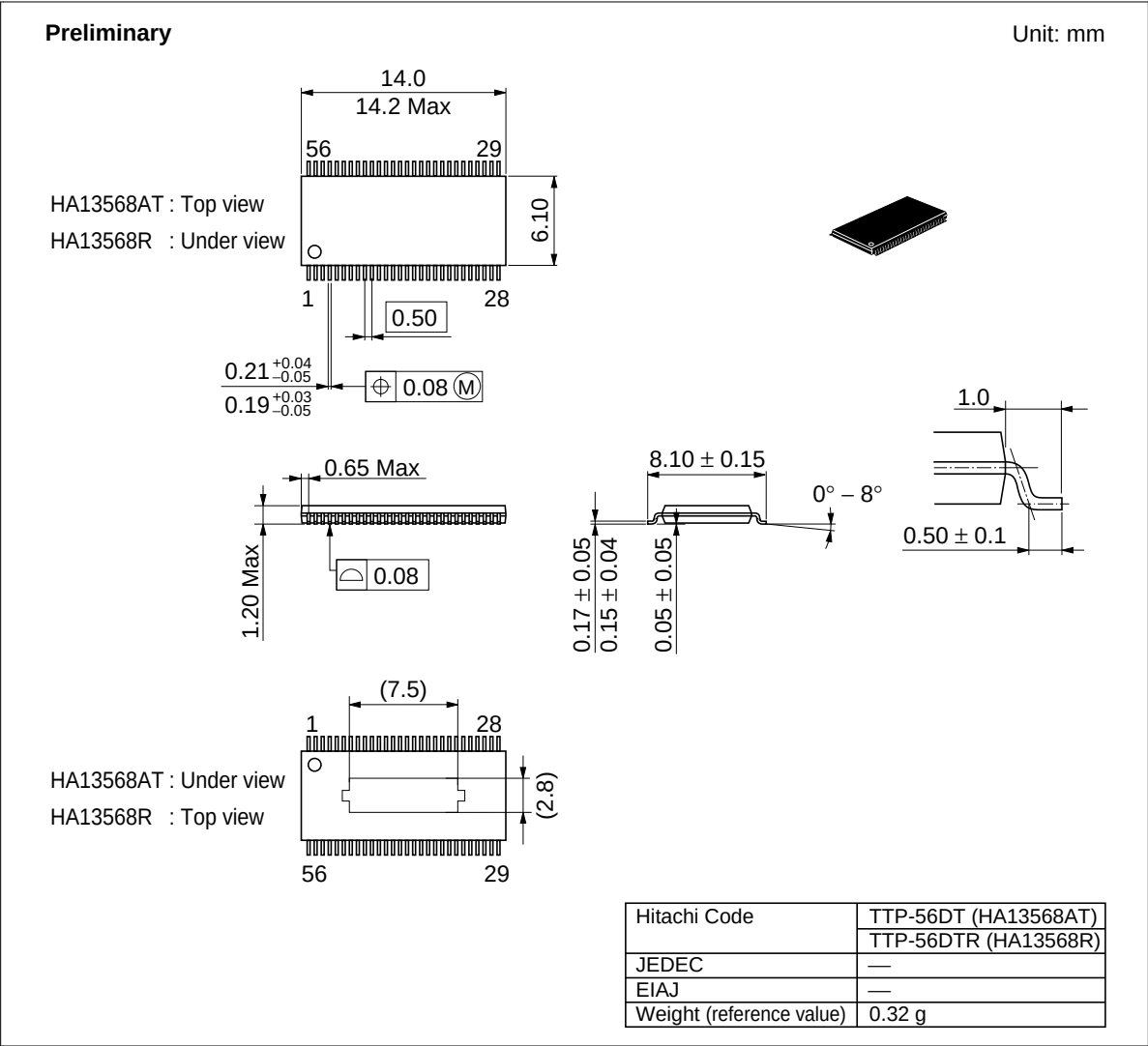
8. Design guide only.

9. $V_{limtry} = V_{TRYP} - V_{TRYLIM}$, or $V_{TRYN} - V_{TRYLIM}$

Reference Data



Package Dimensions



HA13568AT/HA13568R

Cautions

1. Hitachi neither warrants nor grants licenses of any rights of Hitachi's or any third party's patent, copyright, trademark, or other intellectual property rights for information contained in this document. Hitachi bears no responsibility for problems that may arise with third party's rights, including intellectual property rights, in connection with use of the information contained in this document.
2. Products and product specifications may be subject to change without notice. Confirm that you have received the latest product standards or specifications before final design, purchase or use.
3. Hitachi makes every attempt to ensure that its products are of high quality and reliability. However, contact Hitachi's sales office before using the product in an application that demands especially high quality and reliability or where its failure or malfunction may directly threaten human life or cause risk of bodily injury, such as aerospace, aeronautics, nuclear power, combustion control, transportation, traffic, safety equipment or medical equipment for life support.
4. Design your application so that the product is used within the ranges guaranteed by Hitachi particularly for maximum rating, operating supply voltage range, heat radiation characteristics, installation conditions and other characteristics. Hitachi bears no responsibility for failure or damage when used beyond the guaranteed ranges. Even within the guaranteed ranges, consider normally foreseeable failure rates or failure modes in semiconductor devices and employ systemic measures such as fail-safes, so that the equipment incorporating Hitachi product does not cause bodily injury, fire or other consequential damage due to operation of the Hitachi product.
5. This product is not designed to be radiation resistant.
6. No one is permitted to reproduce or duplicate, in any form, the whole or part of this document without written approval from Hitachi.
7. Contact Hitachi's sales office for any questions regarding this document or Hitachi semiconductor products.

HITACHI

Hitachi, Ltd.

Semiconductor & IC Div.

Nippon Bldg., 2-6-2, Ohte-machi, Chiyoda-ku, Tokyo 100-0004, Japan

Tel: Tokyo (03) 3270-2111

Fax: (03) 3270-5109

For further information write to:

Hitachi Semiconductor
(America) Inc.
2000 Sierra Point Parkway
Brisbane, CA. 94005-1897
U S A
Tel: 800-285-1601
Fax: 303-297-0447

Hitachi Europe GmbH
Continental Europe
Dornacher Straße 3
D-85622 Feldkirchen
München
Tel: 089-9 91 80-0
Fax: 089-9 29 30-00

Hitachi Europe Ltd.
Electronic Components Div.
Northern Europe Headquarters
Whitebrook Park
Lower Cookham Road
Maidenhead
Berkshire SL6 8YA
United Kingdom
Tel: 01628-585000
Fax: 01628-585160

Hitachi Asia Pte. Ltd.
16 Collyer Quay #20-00
Hitachi Tower
Singapore 049318
Tel: 535-2100
Fax: 535-1533

Hitachi Asia (Hong Kong) Ltd.
Unit 706, North Tower,
World Finance Centre,
Harbour City, Canton Road
Tsim Sha Tsui, Kowloon
Hong Kong
Tel: 27359218
Fax: 27306071

Copyright © Hitachi, Ltd., 1998. All rights reserved. Printed in Japan.