FAN8402D (KA3081D)

3-Phase BLDC Motor Driver

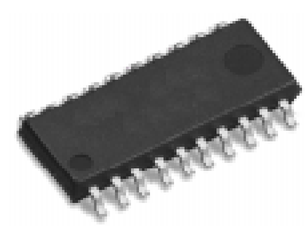
Features

- Commutation FG, PG is executed by 1-hall
- Soft switching at output terminal reduces switching impulse.
- 3-phase full wave BLDC motor driver.
- Voltage reference (Uses band gap circuit)
- Built-in thermal shut-down (TSD) circuit

Description

FAN8402D is a bipolar integrated circuit used to drive 3-phase brushless DC motor in full wave mode using 1-hall sensor. FAN8402D uses 1-hall for commutation and PG generation. It is a special circuit for soft switching using 1-hall reduces the EMI and eliminates snubber. The FG is generated by BEMF.

20-SOP-300



Typical Applications

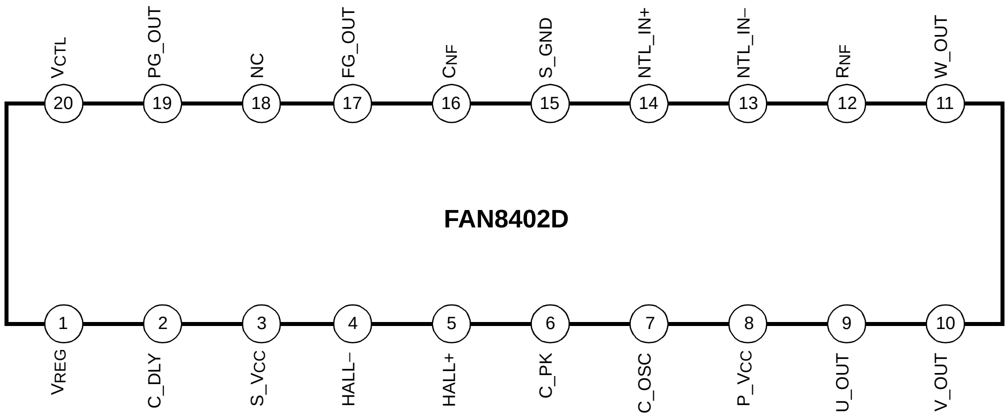
- Video Cassette recorder (VCR) cylinder (drum) motor
- Other 3-phase BLDC motor

Ordering Information

Device	Package	Operating Temp.
FAN8402D	20-SOP-300	–25°C ~ +75°C
FAN8402DTF	20-SOP-300	–25°C ~ +75°C

Rev. 1.0.0
February. 2000.

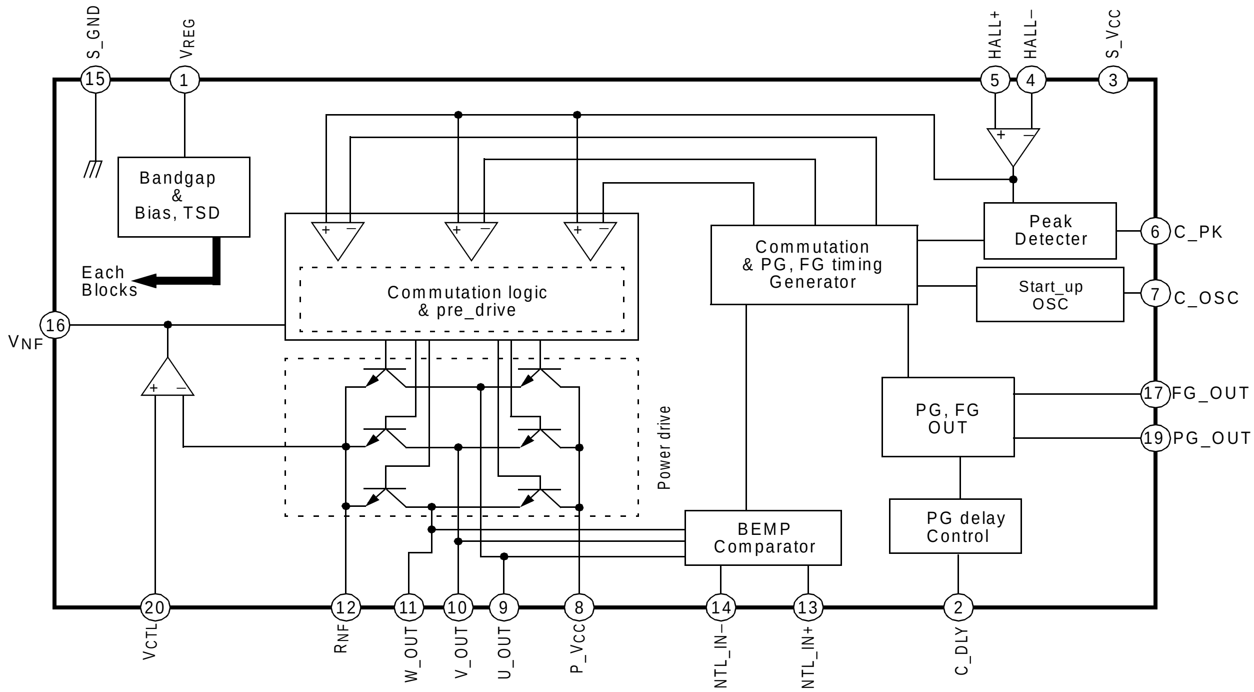
Pin Assignments



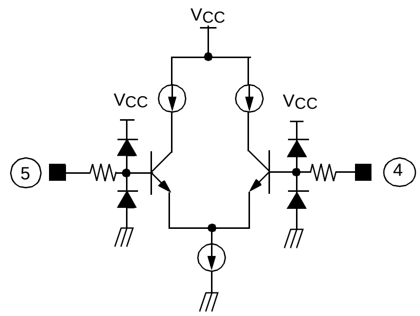
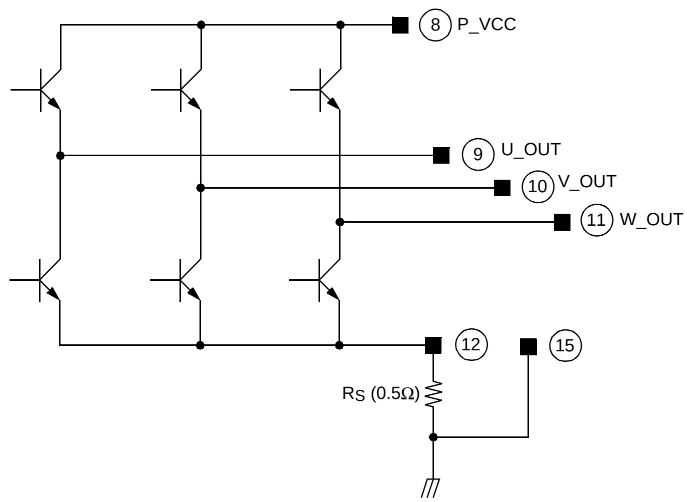
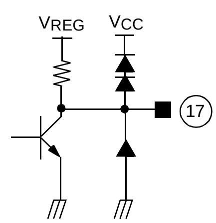
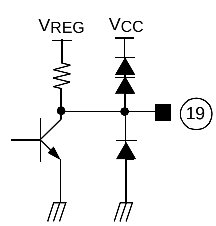
Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	V_{REG}	Regurator output
2	C_DLY	PG. delay
3	S_V_{CC}	Signal V_{CC}
4	HALL–	Hall- input
5	HALL+	Hall+ input
6	C_PK	Peak detector of hall signal
7	C_OSC	Start-up oscillator
8	P_V_{CC}	Power V_{CC}
9	U_OUT	U-phase output
10	V_OUT	V-phase output
11	W_OUT	W-phase output
12	R_{NF}	Output current sensing
13	NTL_IN–	Input from the neutral point of the motor coils.
14	NTL_IN+	Input from the neutral point of the motor coils.
15	S_GND	Signal ground
16	C_{NF}	Phase compensation
17	FG_OUT	FG. output
18	NC	-
19	PG_OUT	PG. output
20	V_{CTL}	Output current control

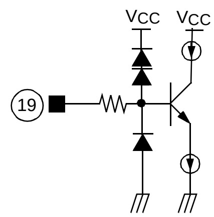
Internal Block Diagram



Equivalent Circuits

<table>
<tr><th>Description</th><th>Pin No.</th><th>Internal circuit</th></tr>
<tr><td>Hall input</td><td>5,4</td><td>
</td></tr>
<tr><td>Output &
Current detection</td><td>9,10,11
8,12</td><td>
</td></tr>
<tr><td>FG Output</td><td>17</td><td>
</td></tr>
<tr><td>PG Output</td><td>19</td><td>
</td></tr>
</table>

Equivalent Circuits (Continued)

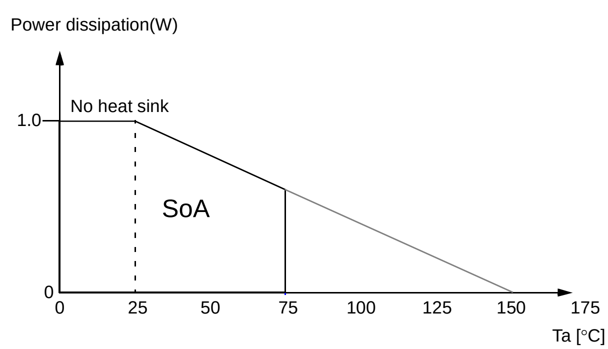
Description	Pin No.	Internal circuit
Voltage control reference	20	

Absolute Maximum Ratings (Ta=25°C)

Parameter	Symbol	Value	Unit	Remark
Supply voltage (Signal)	V_{CCmax}	20	V	-
Maxium Output current	I_{Omax}	1.0 note1	A / Phase	
Regulator output current	I_{REGmax}	10	mA	
Power dissipation	P_d	1.0 note2	W	No heat sink
Junction temperature	T_J	150	°C	-
Operating temperature	T_{OPR}	–20 ~ +75	°C	Ambient temperature (Ta)
Storage temperature	T_{STG}	–40 ~ +155	°C	

NOTES:
1. Duty 1 / 100, pulse width 500µs
2. 1) When mounted on glass epoxy PCB (76.2 × 114 × 1.57mm)
   2) Power dissipation reduces 9.6mW / °C for using above Ta=25°C.
   3) Do not exceed Pd and SOA(Safe Operating Area).

Power Dissipation Curve

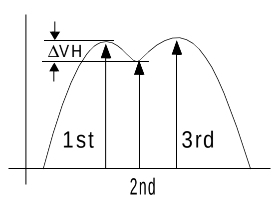


Recommened Operating Conditions (Ta=25°C)

Parameter	Symbol	Min.	Typ.	Max	Unit
Operating supply voltage(Signal)	S_V_{CC}	4.5	5.0	5.5	V
Operating supply voltage(Power)	P_V_{CC}	8	12	18	V

Electrical Characteristics

(Measured in test circuit, P_V_{CC}=12V, Ta=25°C)

Parameter	Symbol	Conditions	Min.	Typ.	max.	Unit
TOTAL						
Supply voltage	V_{CC}	-	8.0	-	18	V
Supply current (1)	I_{CC1}	P_V_{CC}=12V, V_{REG}=open, V_{CTL}=0V	-	11.2	17	mA
Supply current (2)	I_{CC2}	P_V_{CC}=12V, V_{REG}=open, V_{CTL}=0V	-	11.5	17	mA
REGURATOR						
V_{REG} output voltage (2)	V_{REG2}	P_V_{CC}=12V, I_{REG}=0mA	4.7	5.0	5.3	V
V_{REG} output voltage (5)	V_{REG5}	P_V_{CC}=12V, I_{REG}=10mA	4.7	5.0	5.3	V
START-UP OSCILLATOR						
C_OSC operation frequency	OSC_FEQ	C_OSC=47nF	6	8	10	Hz
C_OSC charging current	OSC_ICH	C_OSC=47nF	–0.5	–2	–3.5	µA
C_OSC discharging current	OSC_IDC	C_OSC=47nF	1	3	5	µA
C_OSC low threshold voltage	OSC_THL	C_OSC=47nF	0.2	0.5	0.8	V
C_OSC high threshold voltage	OSC_THH	C_OSC=47nF	2.7	3.0	3.3	V
VOLTAGE CONTROL						
V_{CTL} start voltage	V_{CTL_ST}	V_{CTL}=0~2V When I_O=25mA	1.01	1.26	1.51	V
V_{CTL} input voltage range	V_{CTL_IN}	V_{REG}	0	-	V_{REF}	V
V_{CTL} input bias current	V_{CTL_BI}	V_{CTL}=2.0V	-	1.0	1.5	µA
Gain	GM	R_{NF}=0.47Ω, V_{CTL}=0~2V	0.38	0.45	0.52	A
HALL INPUT						
Input hall signal Min. voltage [note]	V_{H_MIN}		300	-	-	mVp-p
PG hall 1'st Min. voltage [note]	V_{H_P1}		60	-	-	mVo-p
PG hall 2'nd Min. voltage [note]	V_{H_P2}		55	-	-	mVo-p
PG hall 3'rd Min. voltage [note]	V_{H_P3}		75	-	-	mVo-p
PG hall 1'st-2'nd level [note]	ΔV_H		5	-	-	mVo-p
FG (FREQUENCY GENERATOR), PG (PHASE GENERATOR)						
FG, PG high level	FG_PG_H	-	4.5	-	-	V
FG, PG low level	FG_PG_L	-	-	-	0.5	V

Notes:
The note in the chart means items calculated and approved in design not the items proven by actual test results.

Electrical Characteristics (Continued)

(Measured in test circuit, P_V_{CC}=12V, Ta=25°C)

Parameter	Symbol	Conditions	Min.	Typ.	max.	Unit
TSD						
Temp. threshold note	TSD_T	-	130	150	-	°C
Temp. hysteresis note	TSD_H	-	20	30	-	°C
OUTPUT						
Output saturation voltage (Upper)	V_{SU1}	V_{CTL}=4V, I_O=600mA, R_{NF}=0.47Ω, R_L=10Ω	-	1.0	1.5	V
Output saturation voltage (Under)	V_{SD1}		-	0.4	0.7	V
NTL_IN- input voltage range	V_{NTL_IN-}	-	0	-	V_{CC}	V
C_{NF} voltage	V_{CNF}	V_{CTL}=2V	1	-	-	V
C_PK frequency	CPK_{FRQ}	C_PK=100Ω + 0.1µF	0.8	1	1.2	kHz
C_CK voltage level	CPK_V	C_PK=100Ω + 0.1µF HALL– =0.25V	0.4	-	-	Vp-p
C_DLY						
C_DLY charging current	I_{C_DLY}	C_DLY=4nF	-20	-30	-40	µA

Notes:
The note in the chart means items calculated and approved in design not the items proven by actual test results.

Application Information

1. SYSTEM BLOCK DIAGRAM

The figure 1 shows concept of soft switching for 3-phase output with a hall sensor.

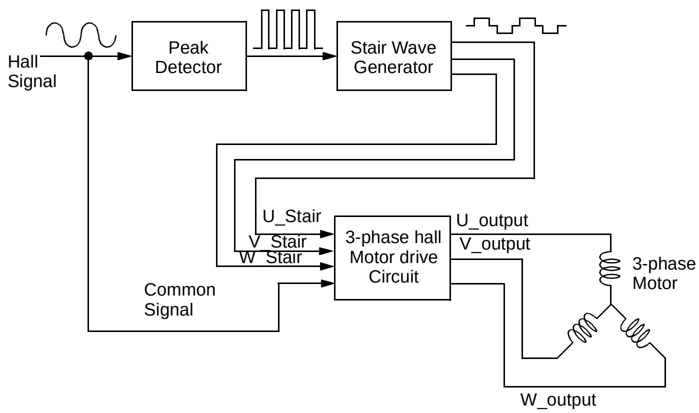


Figure 1.

- Peak detector
  Generates clock pulses at the peak points of the hall signal.
- Stair wave generator
  Generates 3 stair wave signals 120 degree apart from the clock pulses.
- 3-phase motor drive circuit
  Controls output currents to operate 3-phase motor using the vol
- tage difference between the 3 stair wave signals and FG hall signal.

2. STRUCTURE OF BLDC MOTOR

Consists of main and sub magnets. For every main magnet there are 3 submagnets as shown in Fig 2.
Sub-magnet takes hall signal and goes through 6 gradual filtering steps purifying in order to operate 3-phase motor with one hall sensor.

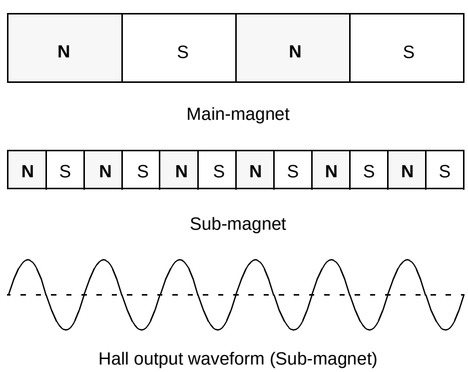
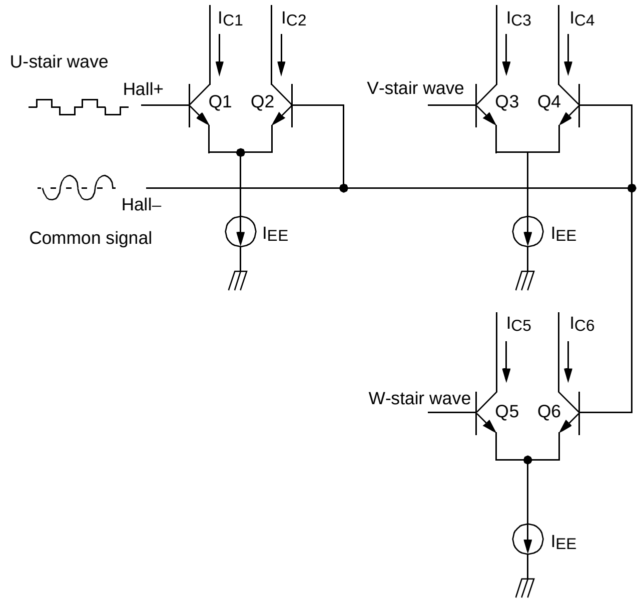


Figure 2.

3. PRINCIPLE OF OPERATION

Input circuit of 3-phase motor drive with soft-switching function is shown as the figure 3.



Hall–: Hall common signal taken from sub-magnet.
Hall+: Stairwave signal with 120 degree wave angle difference from one signal.

Figure 3.

Next the figure 4 shows common signal (Hall signal) and each individual stairwave at its own position.

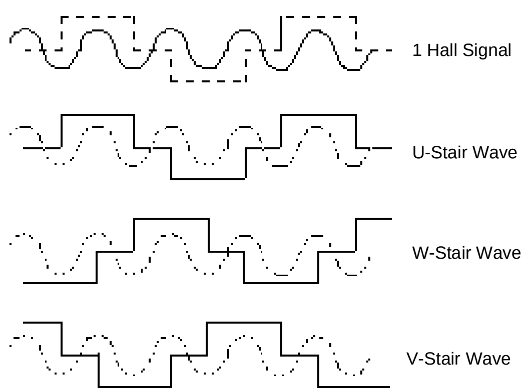


Figure 4.

Figure 5 shows hall signal and stairwave signal position.
The section where the difference between hall signal and stairwave is within 100mV.

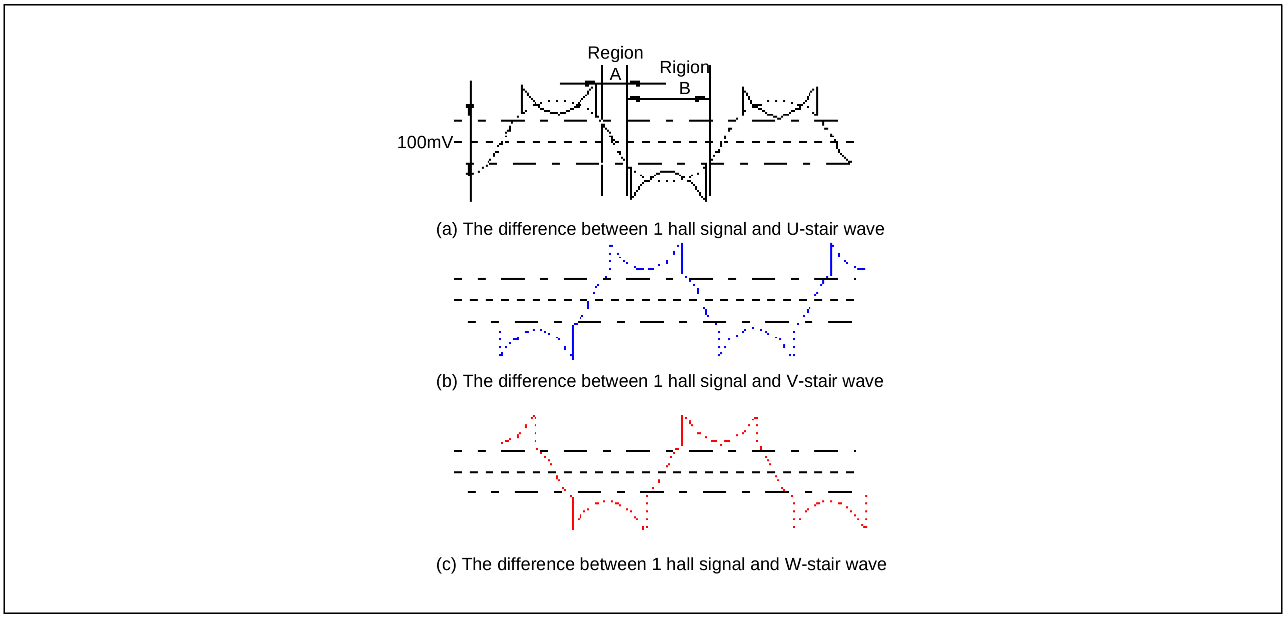


Figure 5.

4. PEAK DETECTOR

Hall signals and stairwave signals made from peak detectors's output rotate the motor.
The peak detector circuit is shown in Fig 6.

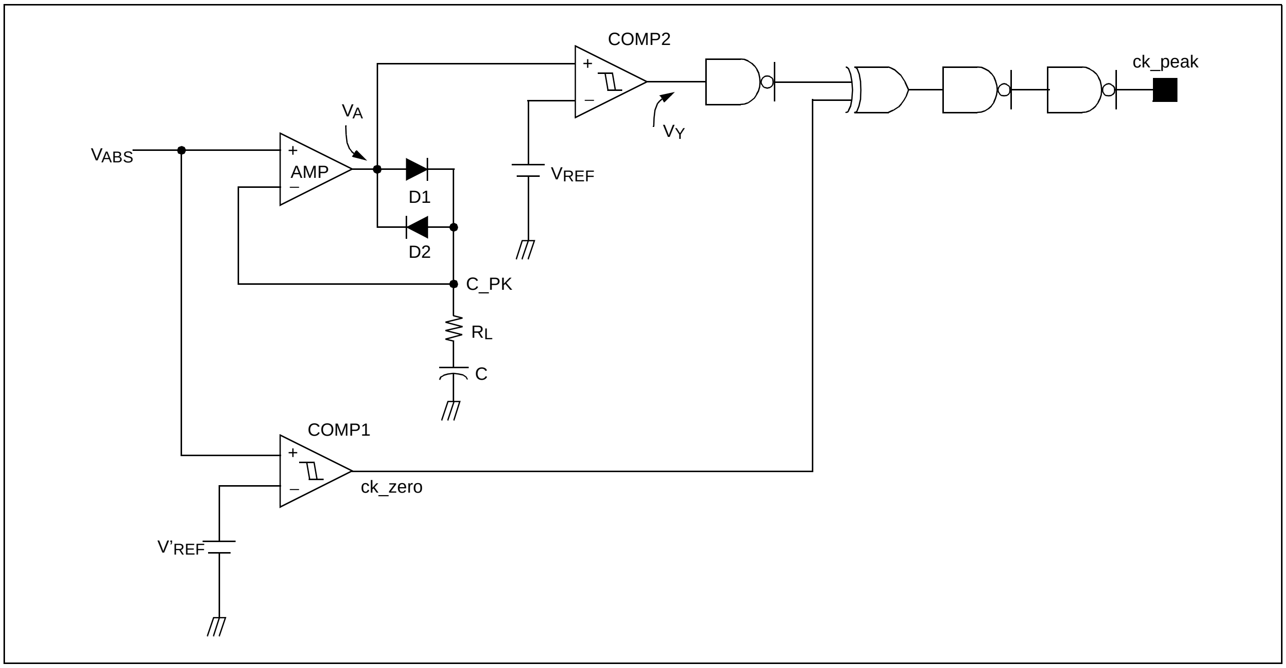


Figure 6.

V_{ABS} in the figure 6 is a signal from twice amplified hall signal and hall bias at 2.5 volt as standard voltage as you see in the figure 7.

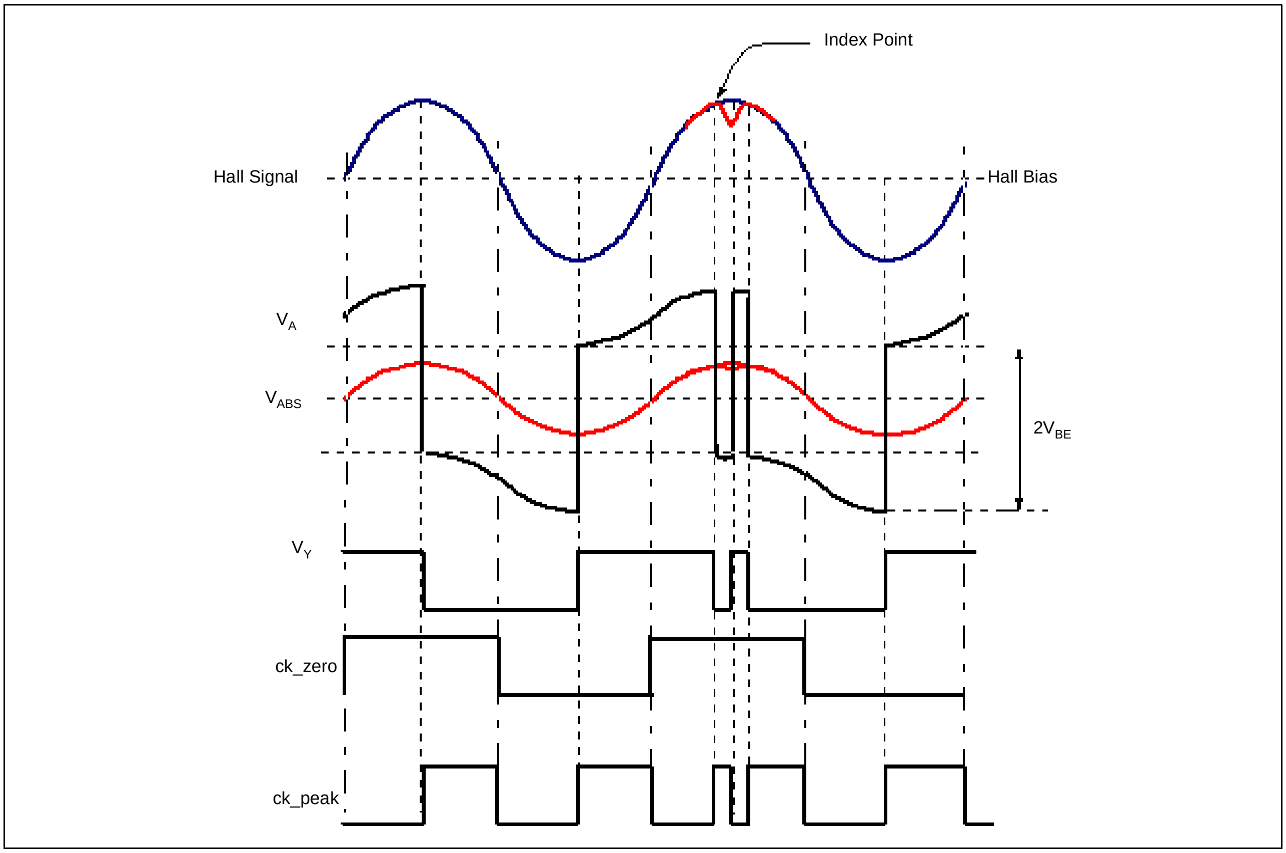


Figure 7.

5. DRIVE OUTPUT

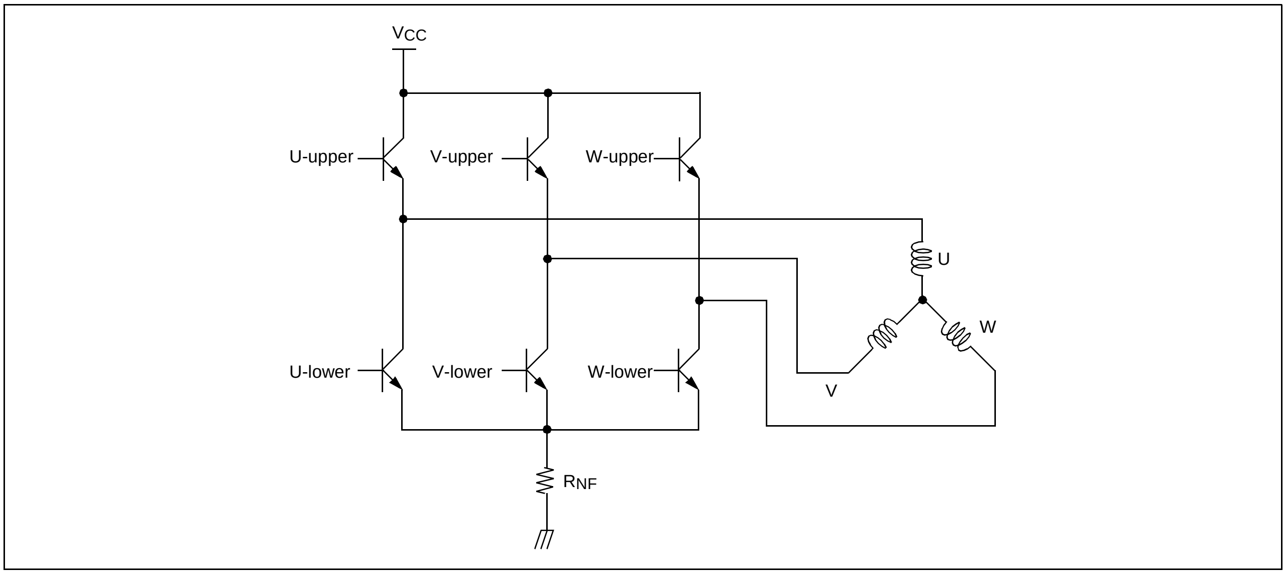


Figure 8.

The figure 8 shows the 3-phases of the BLDC motor.

The upper power TRs in output group operate in linear area and the lower group work in saturation area.

6. VOLTAGE CONTROL & CURRENT SENSING

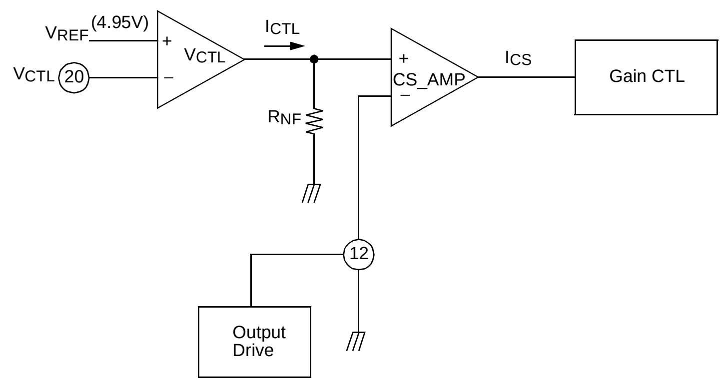
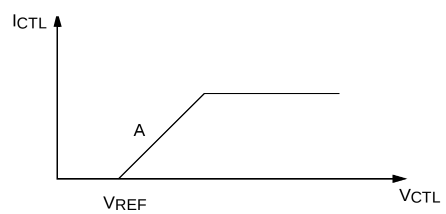


Figure 9.

The circuit in the figure 9 outputs I_{CTL} current when V_{CTL} (Control voltage from servo) is larger than the value of V_{REF}. The V-I characteristic of this circuit is shown in the figure 10.

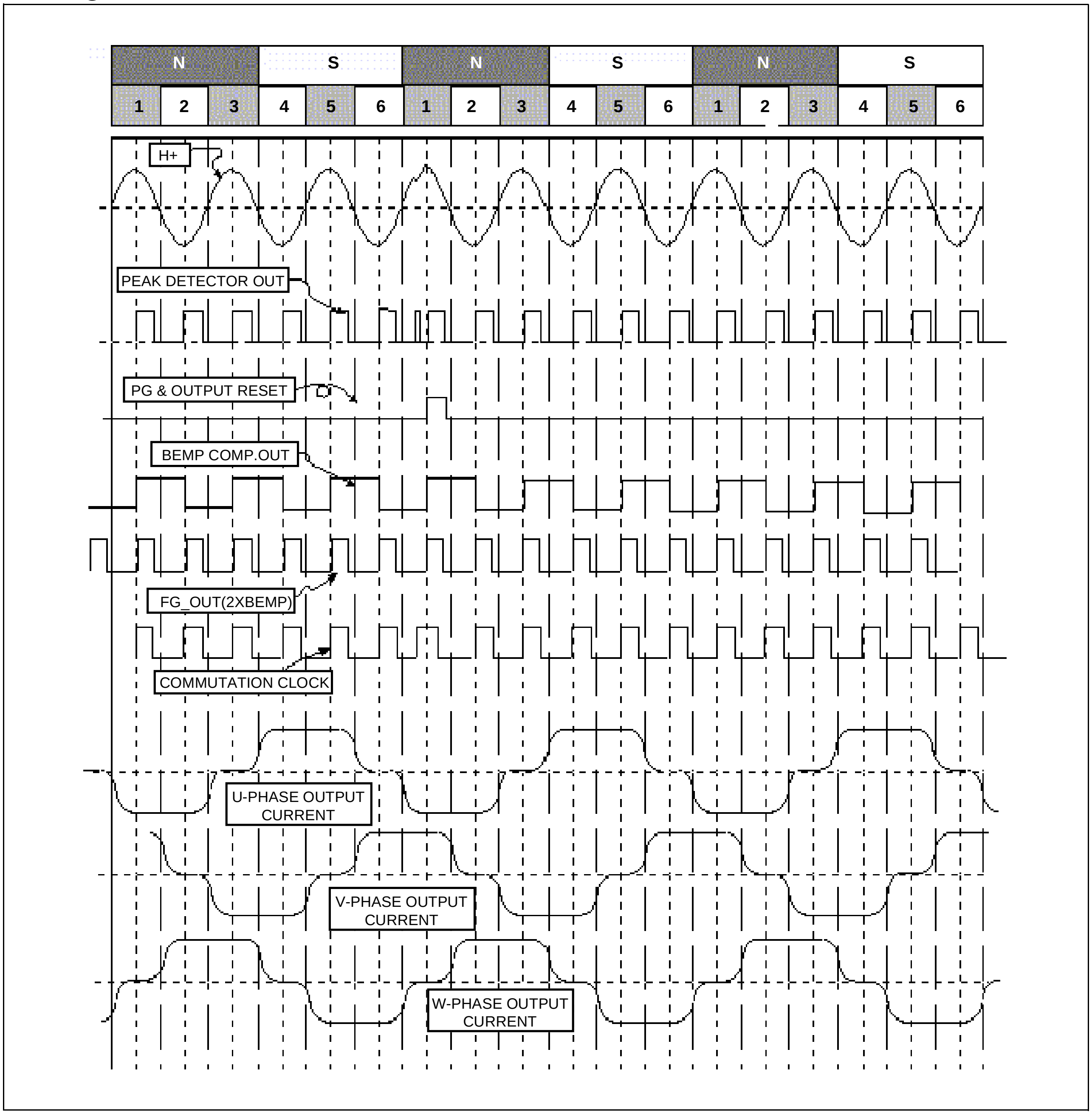


$$A : Slop = \frac{I_{CTL}}{V_{CTL}} = 93u(A/V)$$

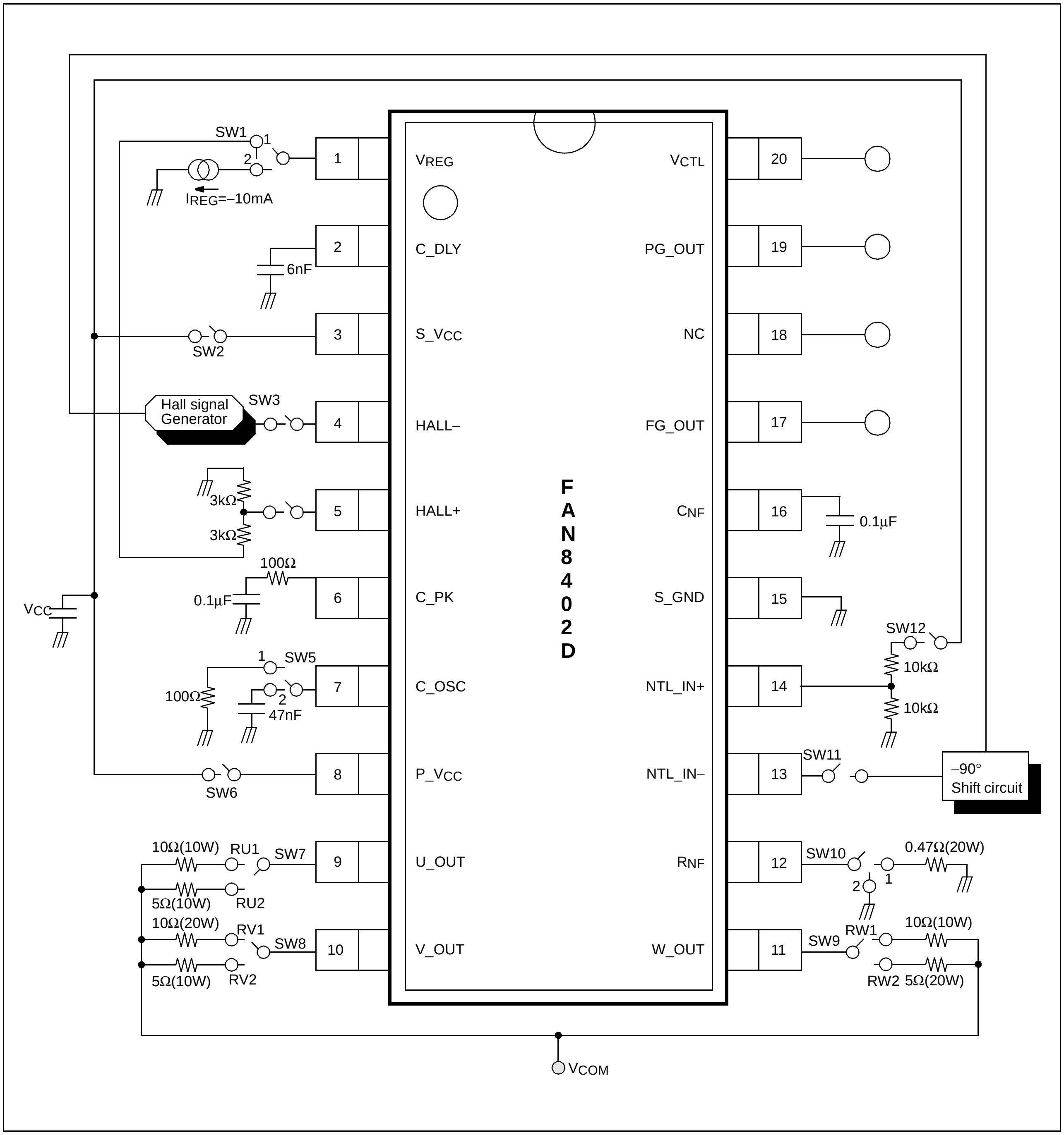
Figure 10.

The CS-AMP terminal amplifies by getting inputs from output terminal getting I_{CTL} and R_{NF} voltages.
R_{NF} resistance feedbacks the current in output terminal.

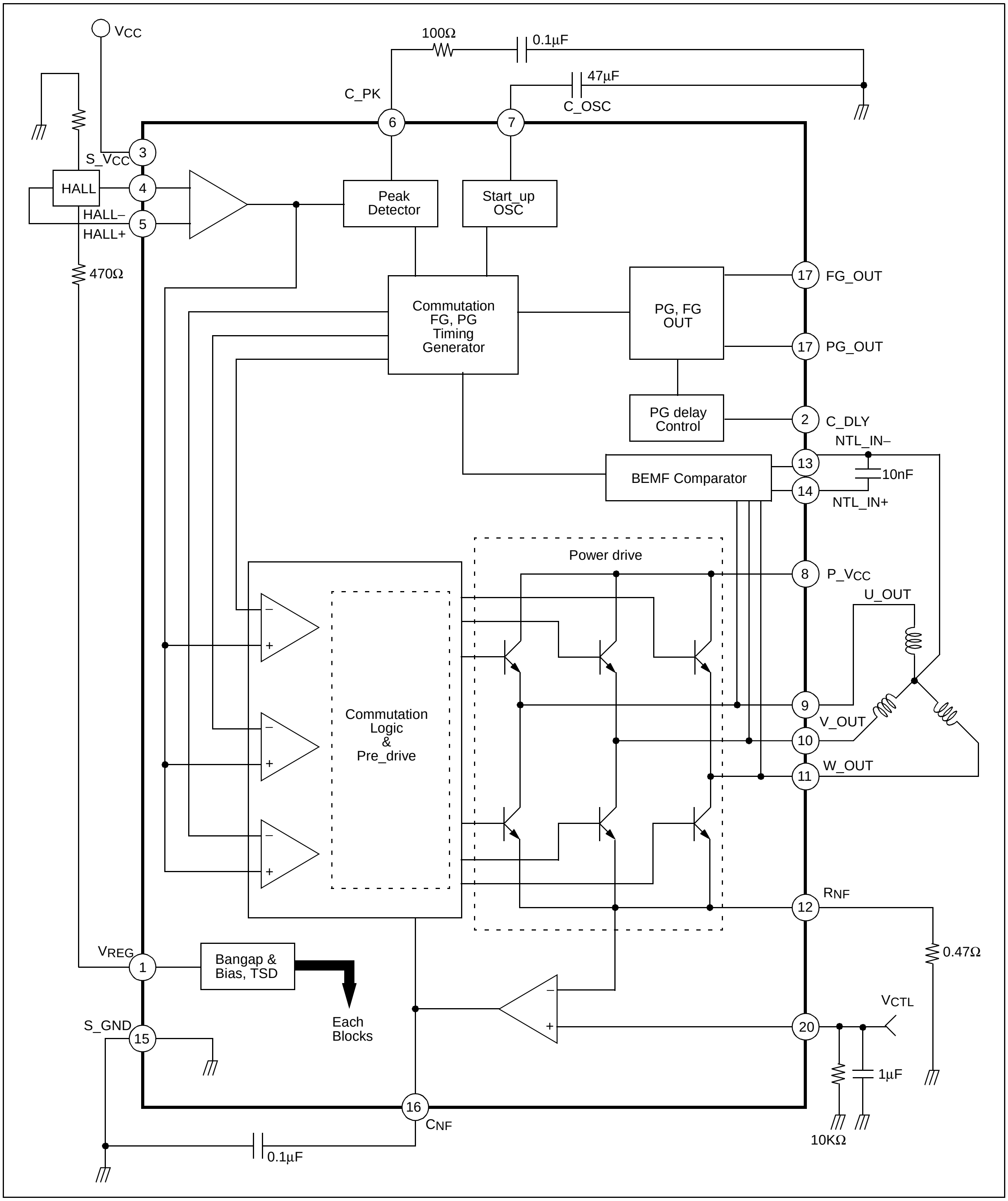
Timing Chart



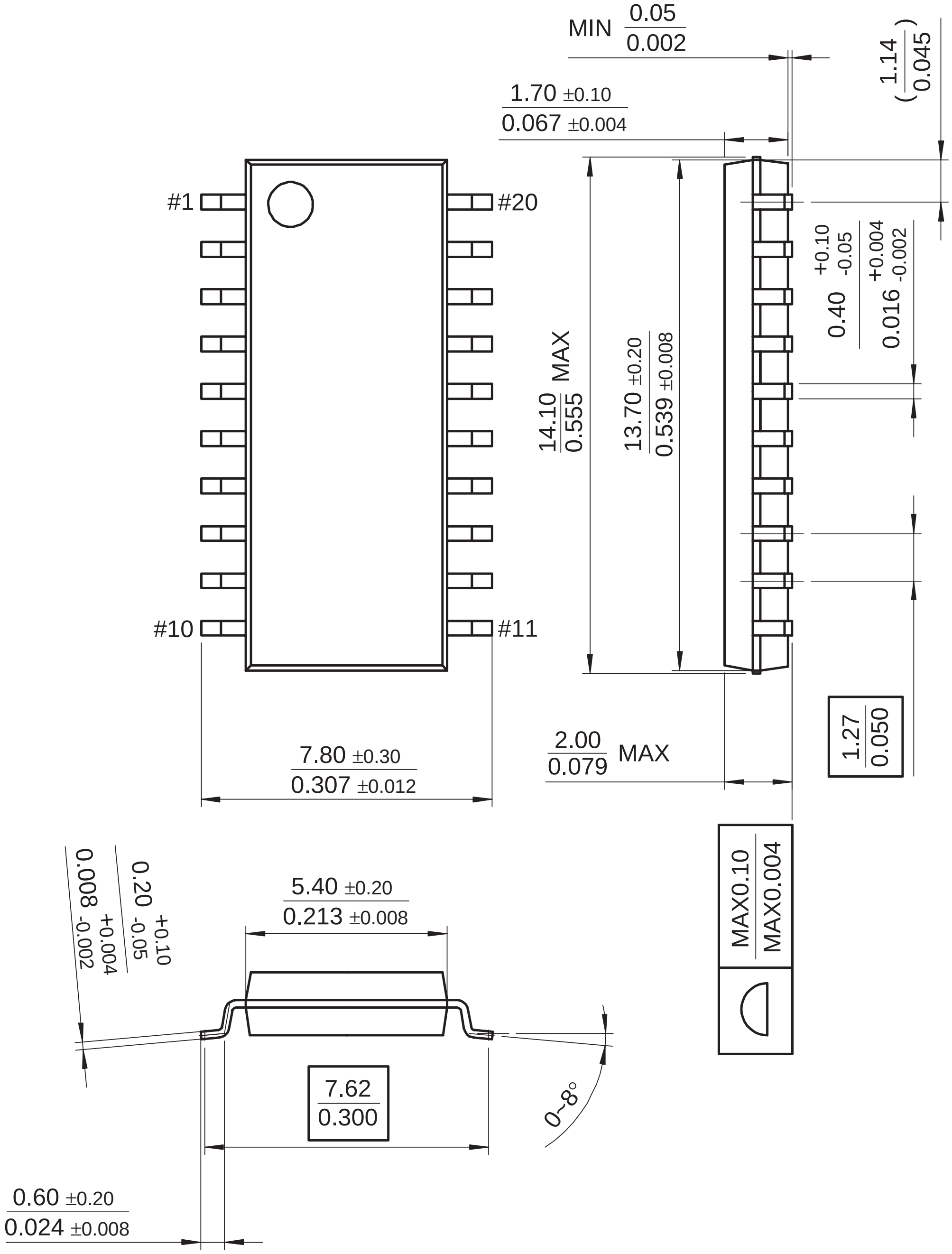
Test Circuits



Typical Application Circuits



20-SOP-300



MIN 0.05 / 0.002
1.14 / 0.045
1.70 ±0.10 / 0.067 ±0.004
#1
#20
#10
#11
14.10 / 0.555 MAX
13.70 ±0.20 / 0.539 ±0.008
0.40 +0.10 -0.05 / 0.016 +0.004 -0.002
1.27 / 0.050
2.00 / 0.079 MAX
7.80 ±0.30 / 0.307 ±0.012
MAX0.10 / MAX0.004
0.20 +0.10 -0.05 / 0.008 +0.004 -0.002
5.40 ±0.20 / 0.213 ±0.008
7.62 / 0.300
0~8°
0.60 ±0.20 / 0.024 ±0.008

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