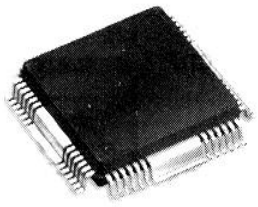
SPINDLE & VOICE COIL MOTOR ONE CHIP DRIVER

The KA3121 is a monolithic IC and an one-chip IC which is spindle motor driver, voice coil motor driver for the HDD motors. includes the following functions: retract and power management.
The spindle motor condition is monitored by the Ready output and the motor speed control is accomplished by internal PLL. The external digital ASIC controls the voice coil motor current via PWMH and PWML inputs and the power management circuit always monitors the power supply voltages.

48-QFPH-1414



FEATURES

SPINDLE MOTOR DRIVE PART

- Hard / soft switching
- Spindle motor brake after retract
- Adjustable brake delay time
- 2.0A maximum current capability
- Low output saturation voltage: 1V typical @1.6A using vertical PNP high side.
- Soft switching generator for soft switching
- Back EMF processing for sensorless motor commuation

VOICE COIL MOTOR DRIVE PART

- Trimmed low offset current
- 1.2A maximum current capability
- Programmable seek and tracking following mode with adjustable current loop gain
- Automatic power down retract function
- Linear class AB output with low crossover distortion delay
- Low output saturation voltage: 1V typical @1.0A
- Internal full bridge with vertical PNP & NPN
- Intelligent retract (Reduced bouncing)

ORDERING INFORMATION

Device	Package	Operating Temperature
KA3121	48-QFPH-1414	0 ~ 70°C

POWER MONITORING

- Power on reset with delay
- Hysteresis on both power comparators
- Over temperature & over current shut down
- 5V and 12V power monitor threshold accuracy ±2%

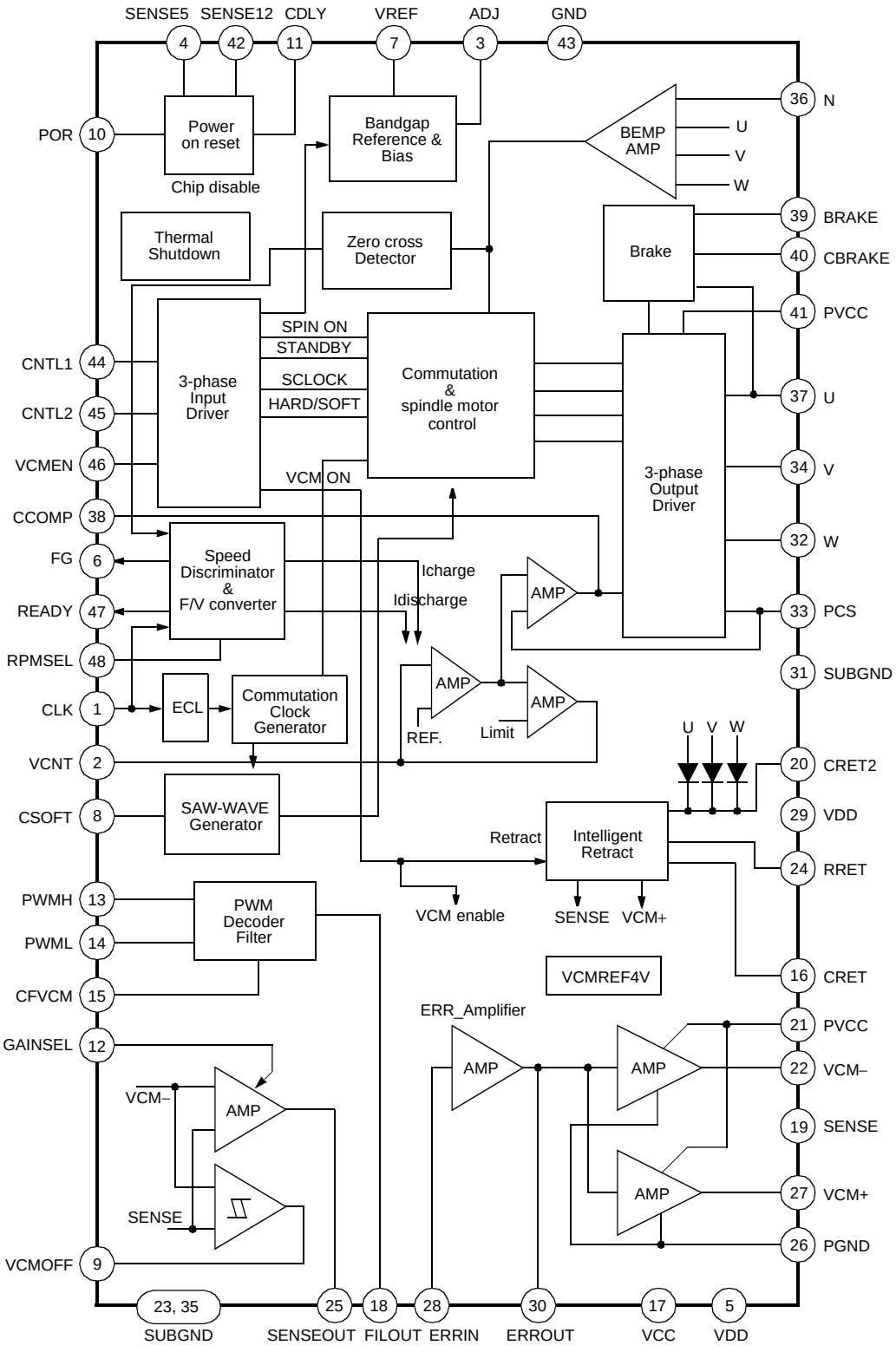
PACKAGE

- 48QFPH (48 pin quad flat package heat-sink)

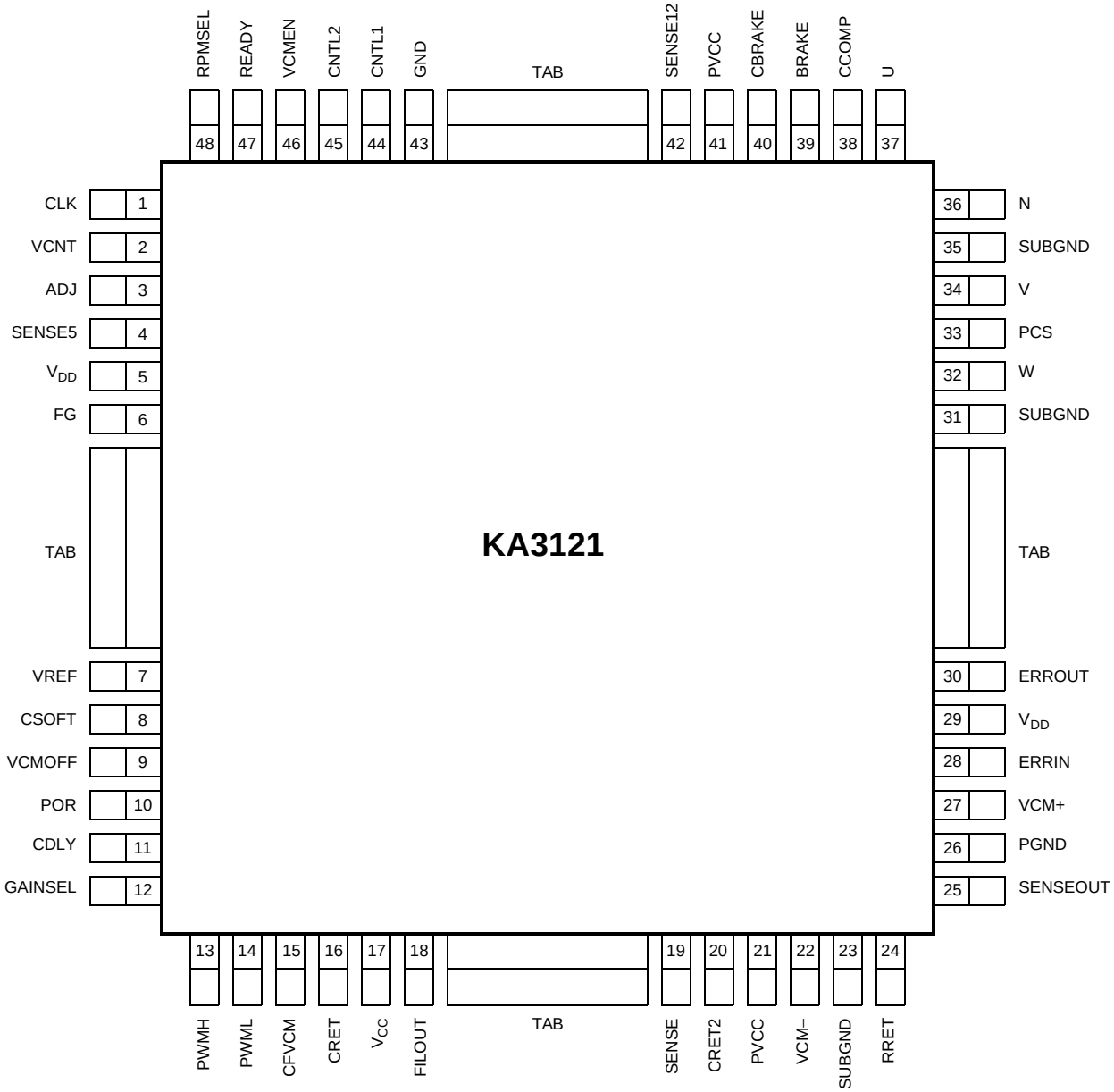
APPLICATION

- Hard disk drive (HDD) products

BLOCK DIAGRAM



PIN CONFIGURATION



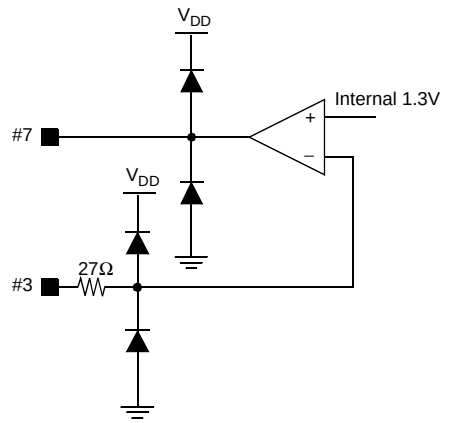
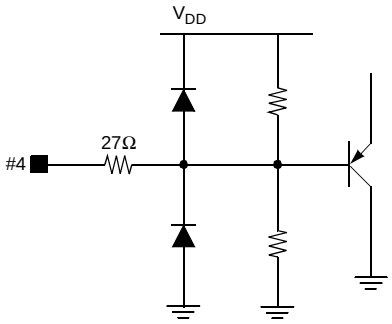
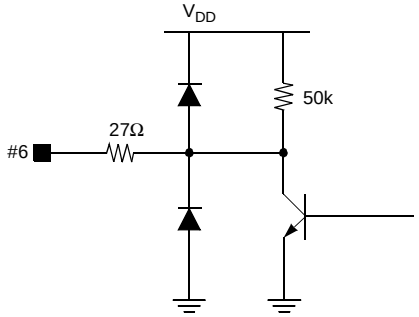
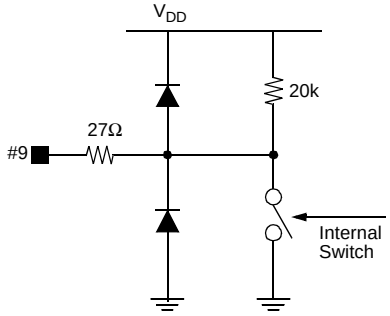
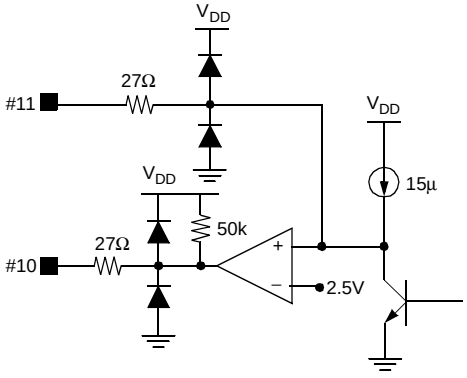
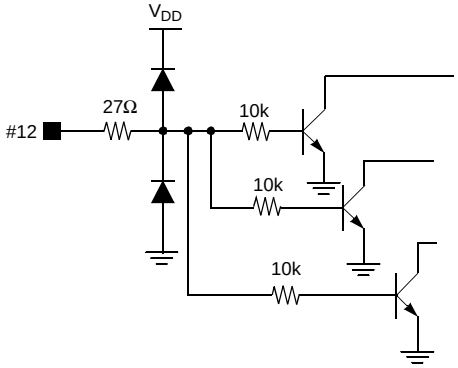
PIN DESCRIPTION

Pin No.	Symbol	I/O	Description
1	CLK	I	System reference clock
2	VCNT	–	Capacitor F/V converter for speed control
3	ADJ	I	Adjustable pin of reference voltage
4	SENSE5	I	Adjustable pin for 5V power line sensing
5	V_{DD}	–	5V power line
6	FG	O	Frequency generation for spindle motor rotation speed
7	VREF	O	Reference voltage output
8	CSOFT	–	Capacitor to make wave for soft switching
9	VCMOFF	O	VCM output offset monitoring pin
10	POR	O	Power on reset output
11	CDLY	–	Power on reset delay with capacitor
12	GAINSEL	I	VCM power amplifier gain selection input
13	PWMH	I	PWM signal input (MSB) for VCM
14	PWML	I	PWM signal input (LSB) for VCM
15	CFVCM	–	Filter capacitor for VCM PWM control
16	CRET	–	Capacitor for delayed retract
17	V_{CC}	–	12V power line
18	FILOUT	O	VCM PWM output
19	SENSE	I	Sensing point to be connected to VCM sensing resistor
20	CRET2	–	Power for retract
21	PVCC	–	12V power line for VCM output
22	VCM–	–	VCM output to be connected to sensing resistor
23	SUBGND	–	VCM power transistor ISO ground
24	RRET	I	Adjustable pin for retract current set
25	SENSEOUT	O	VCM current sense amplifier output
26	PGND	–	Power ground for VCM
27	VMC+	–	VCM output to be connected to voice coil motor
28	ERRIN	I	VCM error amplifier input
29	V_{DD}	–	5V power supply
30	ERROUT	O	VCM error amplifier output pin for compensation
31	SUBGND	–	spindle motor power transistor ISO ground
32	W	O	spindle motor W-phase output

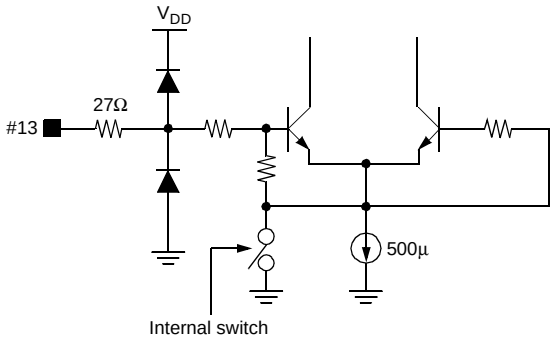
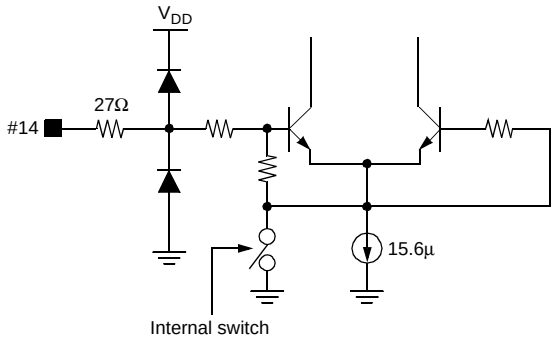
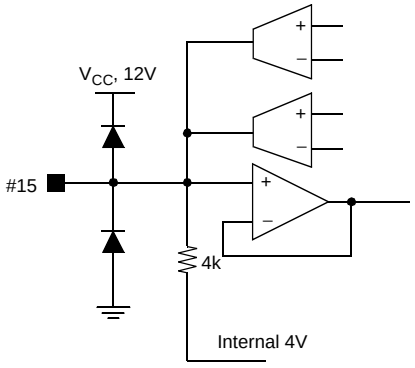
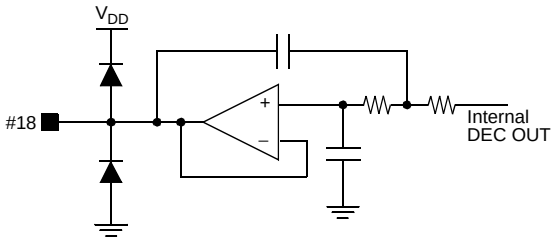
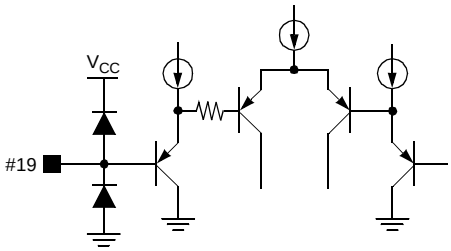
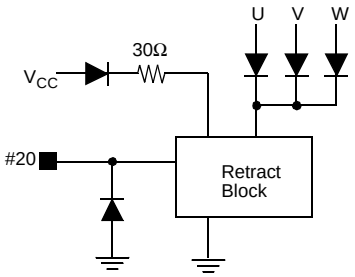
PIN DESCRIPTION (Continued)

Pin No.	Symbol	I/O	Description
33	PCS	O	Spindle motor current sensing
34	V	O	spindle motor V-phase output
35	SUBGND	–	spindle motor power transistor ISO ground
36	N	I	spindle motor neutral point
37	U	O	spindle motor U-phase drive output
38	CCOMP	–	Compensation of spindle motor output control
39	BRAKE	O	Dynamic brake pin for MOSFET drive
40	CBRAKE	–	Back-EMF charging pin for brake power
41	PVCC	–	12V power line for spindle motor output
42	SENSE12	I	Adjustable pin for 12V power line sensing
43	GND	–	Ground
44	CNTL1	I	Control input for spindle motor and brake
45	CNTL2	I	Control input for start-up clock and VCM & retract
46	VCMEN	I	VCM enable input independent of spindle motor
47	READY	O	Output of speed lock detector for SPM speed
48	RPMSEL	I	Spindle motor target RPM selection

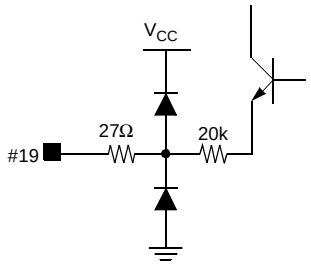
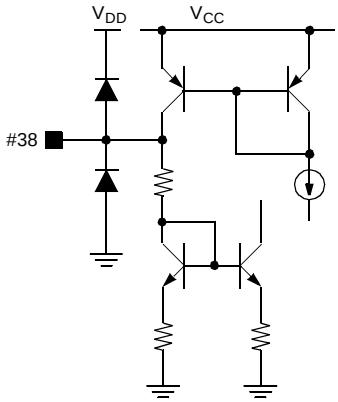
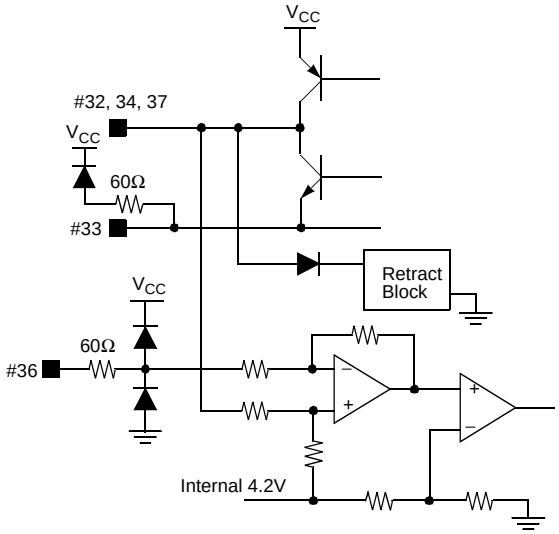
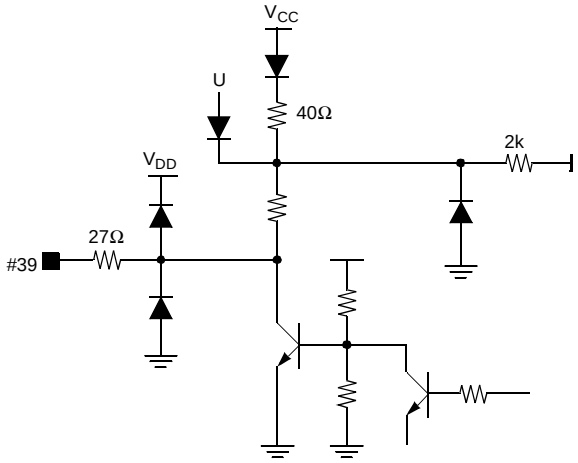
EQUIVALENT CIRCUITS

Regulator part	SENSE5 input
	
FG output	**VCM offset compensation output**
	
Power on reset part	**VCM gain selection input**
	

EQUIVALENT CIRCUITS (Continued)

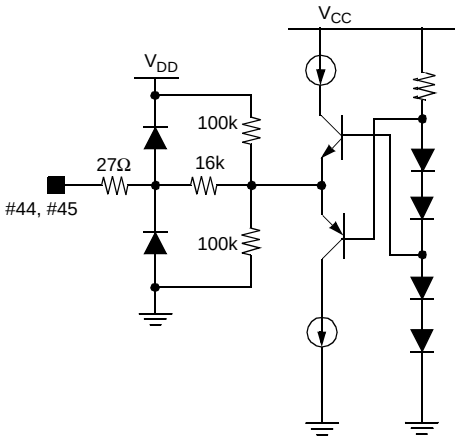
VCM PWM high input	VCM PWM low input
	
VCM PWM filter Capacitor	**Filtered VCM PWM command output**
	
VCM current sense input	**Capacitor for retract power**
	

EQUIVALENT CIRCUITS (Continued)

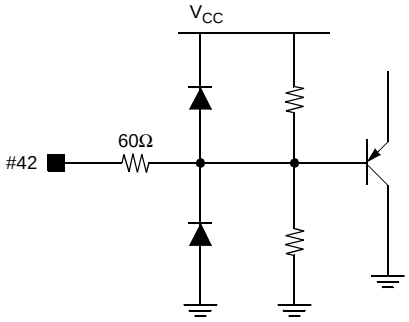
Max. retract current set input	Spindle motor output compensation Capacitor
	
spindle motor output and Back-EMF sensing part	**Dynamic brake part**
	

EQUIVALENT CIRCUITS (Continued)

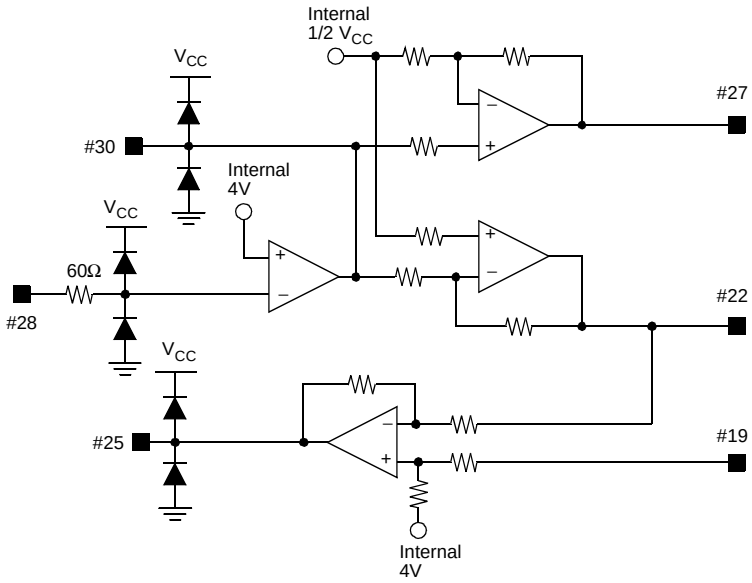
CNTL1, 2 input



SENSE12 input



VCM output and control part

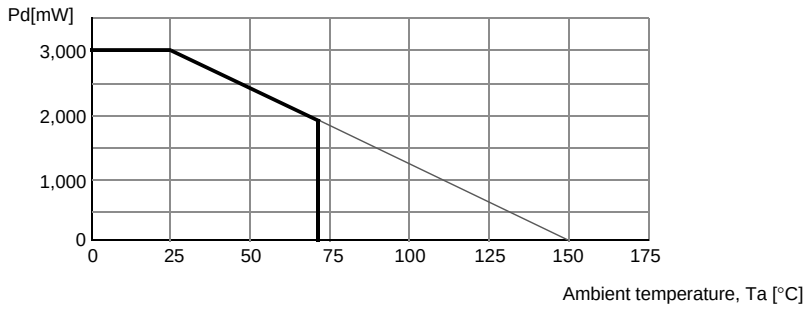


ABSOLUTE MAXIMUM RATING (Ta=25°C)

Characteristics	Symbol	Value	Unit
Maximum signal block supply voltage for 5V line	V_{DDMAX}	6	V
Maximum signal block supply voltage for 12V line	V_{CCMAX}	15	V
Maximum power block supply voltage for 12V line	PV_{CC}	15	V
Maximum output current	I_{OMAX}	2	A
Power dissipation	P_D	3.0 note	W
Storage temperature	T_{STG}	–55 ~ 125	°C
Maximum junction temperature	T_J	150	°C
Operating ambient temperature	T_A	0 ~ 70	°C

NOTE:

1. When mounted on 50mm × 50mm × 1mm PCB (Phenolic resin material)
2. Power dissipation is reduced 16mV / °C for using above Ta=25°C.
3. Do not exceed Pd and SOA.



RECOMMENDED OPERATING CONDITIONS

Characteristics	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}, PV_{CC}	10.8	12.0	13.2	V
Supply voltage in logic part	V_{DD}	4.5	5.0	5.5	V

ELECTRICAL CHARACTERISTICS

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Test conditions	Min.	Typ.	Max.	Unit
SUPPLY CURRENT						
5V line supply current 1	I_{DD1}	CNTL1=0V, CNTL2=0V	1	3	5	mA
5V line supply current 2	I_{DD2}	CNTL1=CNTL2=2.5V	1	3	5	mA
5V line supply current 3	I_{DD3}	CNTL1=5V, CNTL2=2.5V, VCMEN=0V	5	8	10	mA
5V line supply current 4	I_{DD4}	CNTL1=2.5V, CNTL2=0V	1	2	3	mA
12V line supply current 1	I_{CC1}	CNTL1=0V, CNTL2=0V	15	20	25	mA
12V line supply current 2	I_{CC2}	CNTL1=CNTL2=2.5V	5	8	10	mA
12V line supply current 3	I_{CC3}	CNTL1=5V, CNTL2=2.5V, VCMEN=0V	10	15	20	mA
12V line supply current 3	I_{CC4}	CNTL1=2.5V,CNTL2=0V	1	2	3	mA
POWER MONITOR						
Threshold voltage1 level for 12V	V_{TH12}	V_{CC}=Sweep, V_{DD}=5V	9.1	9.5	9.9	V
Threshold voltage2 level for 12V	V_{TH12B}	V_{CC}=Sweep, V_{DD}=5V	9.0	9.25	9.6	V
Hysteresis on 12V comparator	V_{HYS12}	V_{CC}=Sweep, V_{DD}=5V	120	240	360	mV
Adjustable pin voltage for 12V	V12	V_{CC}=12V, V_{DD}=5V	3.1	3.3	3.5	V
Threshold voltage1 level for 5V	V_{TH5}	V_{CC}=12V, V_{DD}=Sweep	4.3	4.5	4.7	V
Threshold voltage2 level for 5V	V_{TH5B}	V_{CC}=12V, V_{DD}=Sweep	4.2	4.4	4.6	V
Hysteresis on 5V comparator	V_{HYS5}	V_{CC}=12V, V_{DD}=Sweep	50	100	150	mV
Adjustable pin voltage for 5V	V5	V_{CC}=12V, V_{DD}=5V	2.75	2.9	3.05	V
POWER ON RESET GENERATOR						
Charging current for POR Capacitor	I_{CPOR}	V_{CC}=12V, V_{DD}=5V	8.5	12.5	17.0	µA
POR threshold voltage	V_{THPOR}	CDLY=Sweep	2.3	2.5	2.7	V
Output high voltage	V_{POH}	V_{CC}=12V, V_{DD}=5V	4.0	4.8	5.0	V
Output low voltage	V_{POL}	V_{CC}=12V, V_{DD}=5V	0	0.2	0.5	V

ELECTRICAL CHARACTERISTICS (Continued)

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Test conditions	Min.	Typ.	Max.	Unit
CONTROL INPUT						
Logic control input1 MED voltage	V_{CTL10}	CNTL1=2.5V	2.3	2.5	2.7	V
Logic control input2 MED voltage	V_{CTL20}	CNTL1=2.5V	2.3	2.5	2.7	V
Logic control input1 MED current	I_{CTL10}	CNTL1=2.5V	–5	0	5	µA
Logic control input2 MED current	I_{CTL20}	CNTL1=2.5V	–5	0	5	µA
Logic control input1 high voltage	V_{CTL1H}	CNTL1=Sweep	3.4	3.8	4.2	V
Logic control input1 high current	I_{CTL1H}	CNTL1=5V	70	90	100	µA
Logic control input1 low voltage	V_{CTL1L}	CNTL1=Sweep	0.8	1.2	1.6	V
Logic control input1 low current	I_{CTL1L}	CNTL1=0V	–110	–90	–70	µA
Logic control input2 high voltage	V_{CTL2H}	CNTL2=5V	3.4	3.8	4.2	V
Logic control input2 high current	I_{CTL2H}	CNTL2=Sweep	70	90	100	µA
Logic control input2 low voltage	V_{CTL2L}	CNTL2=0V	0.8	1.2	1.6	V
Logic control input2 low current	I_{CTL2L}	CNTL3=5V	–110	–90	–70	µA
SPINDLE FG GENERATOR						
FG frequency	FG	U, V, W=120° shift pulse	2.9	3.0	3.1	kHz
FG duty	D_{TTG}	U, V, W=120° shift pulse	45	50	55	%
Soft switching FG high voltage	V_{SCMHI}	U, V, W=120° shift pulse	2.68	2.75	2.82	V
Soft switching FG low voltage	V_{SCMLO}	U, V, W=120° shift pulse	2.18	2.25	2.32	V
Soft switching FG charging current	I_{SCMCH}	U, V, W=120° shift pulse	42	50	58	µA
Soft switching FG discharging current	I_{SCMDC}	U, V, W=120° shift pulse	42	50	58	µA
SPINDLE READY						
READY output high voltage	V_{RDHI}	Shift pulse, CNTL1=5V	4.5	4.8	5.0	V
READY output low voltage	V_{RDLO}	Shift pulse, CNTL1=5V	0	0.2	0.5	V
SPINDLE RPMSEL						
RPMSEL input high voltage	V_{RPHI}	–	1.4	–	–	V
RPMSEL input high current	I_{RPHI}	–	10	14	18	µA
RPMSEL input low voltage	V_{RPLO}	–	–	–	1.4	V
RPMSEL input low current	I_{RPLO}	–	–5	0	0	µA

ELECTRICAL CHARACTERISTICS (Continued)

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Test conditions	Min.	Typ.	Max.	Unit
SPEED CONTROL						
VCNT charging current	I_{VCCH}	Shift pulse, CNTL1=5V	–60	–50	–40	µA
VCNT discharging current	I_{VCDC}	Shift pulse, CNTL1=5V	40	50	60	µA
BRAKE						
CBrake output voltage	V_{BC}	V_{CC}=12V, V_{DD}=5V	11.0	11.3	11.5	V
Brake output high voltage	V_{BH}	CNTL1=0V	4.8	4.9	5.0	V
Brake output low voltage	V_{BL}	CNTL1=2.5V	0	0.2	0.5	V
SPINDLE OUTPUT						
U saturation voltage_upper5	V_{SU5U}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
V saturation voltage_upper5	V_{SV5U}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
W saturation voltage_upper5	V_{SW5U}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
U saturation voltage_lower5	V_{SU5L}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
V saturation voltage_lower5	V_{SV5L}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
W saturation voltage_lower5	V_{SW5L}	R_U=R_V=R_W=5Ω	0.2	0.3	0.5	V
U output frequency	F_U	CNTL2=12kHz	0.9	1	1.1	kHz
V output frequency	F_V	CNTL2=12kHz	0.9	1	1.1	kHz
W output frequency	F_W	CNTL2=12kHz	0.9	1	1.1	kHz
Leakage current	I_{SPL}	–	–50	0	50	µA
Transconductance gain_U	GM_U	R_U=R_V=R_W=5Ω	0.7	0.8	0.9	A/V
Transconductance gain_V	GM_V	R_U=R_V=R_W=5Ω	0.7	0.8	0.9	A/V
Transconductance gain_W	GM_W	R_U=R_V=R_W=5Ω	0.7	0.8	0.9	A/V
CCOMP charging current	I_{COMP}	VCTL=5V	–400	–500	–600	µA
REGULATOR						
Adjustable pin voltage	V_{ADJ}	V_{DD}=5V	1.2	1.3	1.4	V
Regulator line regulation	R_{LINE}	V_{DD}=Sweep	0	0.1	0.5	%
Regulator load regulation	R_{LOAD}	I_O=Sweep	0	0.1	0.5	%

ELECTRICAL CHARACTERISTICS (Continued)

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Test conditions	Min.	Typ.	Max.	Unit
VCM PWM CONTROL						
High PWMH input current	I_{PWMH1}	PWMH=5V	100	113	130	µA
Low PWMH input current	I_{PWMH2}	PWMH=5V	–130	–113	–100	µA
High PWML input current	I_{PWML1}	PWML=5V	100	113	130	µA
VCM PWM CONTROL						
Low PWML input current	I_{PWML2}	PWML=0V	–130	–113	–100	µA
CFVCM charge / discharge current1	I_{CFVCM1}	PWMH=0V, PWML=0V	–530	–516	–500	µA
CFVCM voltage1	V_{CFVCM1}	PWMH=0V, PWML=0V	5.9	6.06	6.3	V
CFVCM charge / discharge current5	I_{CFVCM5}	PWMH=PWML=2.5V	–10	0	10	µA
CFVCM voltage5	V_{CFVCM5}	PWMH=PWML=2.5V	3.8	4.0	4.2	V
CFVCM charge / discharge current9	I_{CFVCM9}	PWMH=PWML=5V	–530	–516	–500	µA
CFVCM voltage9	V_{CFVCM9}	PWMH=PWML=5V	1.7	1.94	2.1	V
PWM current ratio	R_{PWM}	–	31	32	33	–
PWMH current variation	I_{VPWMH}	–	0.95	1	1.05	mA
PWML current variation	I_{VPWML}	–	29	31.3	34	µA
VCM OFFSET COMPARATOR						
VCM reference voltage	V_{REF4V}	V_{CC}=12V, V_{DD}=5V, CNTL3=5V	3.8	4	4.2	V
Offset comparator offset voltage	V_{OCOS}	ERRIN=Sweep	20	30	40	mV
Offset comparator hysteresis	V_{OCHYS}	ERRIN=Sweep	20	30	40	mV
Offset comparator high voltage	V_{OCH}	ERRIN=Sweep	4.5	4.8	5.0	V
Offset comparator low voltage	V_{OCL}	ERRIN=Sweep	0	0.2	0.5	V
VCM POWER AMPLIFIER						
Power Amplifier gain1	A_{PO1}	ERRIN=Sweep	16	17	18	–
Power Amplifier gain1	A_{PO2}	ERRIN=Sweep	16	17	18	–
Power Amplifier output high voltage1	V_{POH1}	ERRIN=Sweep	11.5	11.8	12.0	V
Power Amplifier output high voltage2	V_{POH2}	ERRIN=Sweep	11.5	11.8	12.0	V
Power Amplifier output low voltage1	V_{POL1}	ERRIN=Sweep	0	0.2	0.5	V
Power Amplifier. output low voltage2	V_{POL2}	ERRIN=Sweep	0	0.2	0.5	V

ELECTRICAL CHARACTERISTICS (Continued)

(Ta=25°C, unless otherwise specified)

Characteristic	Symbol	Test conditions	Min.	Typ.	Max.	Unit
VCM ERROR AMPLIFIER						
Amplifier output high voltage	V_{EOH}	PWMH=Sweep, PWML=2.5V	10.8	11.2	11.5	V
Amplifier output low voltage	V_{EOL}	PWMH=Sweep, PWML=2.5V	0.5	0.8	1.2	V
Amplifier output offset voltage	V_{OS}	PWMH=Sweep, PWML=2.5V	–20	0	20	mV
Short circuit current	I_{ESC}	PWMH=Sweep, PWML=2.5V	8	10	15	mA
VCM AMPLIFIER TOTAL						
VCM offset voltage	V_{OSVCM}	PWMH=PWML=2.5V	–5	0	5	mV
VCM transconductance gain high	GM_{VH}	ERRIN=Sweep, GAINSEL=5V	0.47	0.50	0.53	A/V
VCM transconductance gain low	GM_{VL}	ERRIN=Sweep, GAINSEL=5V	0.1	0.3	0.5	A/V
VCM+ saturation voltage lower	V_{VMS5}	ERRIN=2V, R_{VCM}=10Ω	0.1	0.3	0.5	V
VCM– saturation voltage upper	V_{VMS6}	ERRIN=2V, R_{VCM}=10Ω	0.1	0.3	0.5	V
VCM+ saturation voltage upper	V_{VMS7}	ERRIN=6V, R_{VCM}=10Ω	0.1	0.3	0.5	V
VCM– saturation voltage lower	V_{VMS8}	ERRIN=6V, R_{VCM}=10Ω	0.1	0.3	0.5	V
Leakage current power Amplifier1	I_{VCML1}	–	–50	0	50	µA
Leakage current power Amplifier2	I_{VCML2}	–	–50	0	50	µA
RETRACT						
Min. operating voltage of CRET2	V_{CRET2}	CRET2=Sweep	10.8	11.2	11.5	V
Source voltage	V_{SRC}	CRET2=5V	0.5	0.8	1.2	V
Sinking saturation voltage	V_{RTSAT}	CRET2=5V	–20	0	20	mV
VCM retract sinking current2	I_{RCT2}	Rret=4.2kΩ	8	10	15	mA
THERMAL SHUT DOWN						
Operating temperature	T_{SD}	–	3.8	4	4.2	V
Thermal hysteresis	T_{HYS}	–	20	30	40	mV

APPLICATION INFORMATION

The KA3121 is a combination chip consisting of spindle motor and voice coil motor designed for HDD system.

SPINDLE MOTOR DRIVE PART

The Spindle motor driver drives the Brushless DC Motor (BLDCM) that is used to spin the disk. It contains the power drivers (2.0A, max) for the 3 phases of the motor, which is both the low and high side drivers (H–bridge). To reduce the output transistors saturation voltage, the vertical PNP transistor is used as the high side driver. The commutation timing and sequencing for the driver outputs is determined by the commutation control circuit. The driver outputs are also connected to comparators. They are used for back EMF sensing. The outputs of the Back-EMF comparators are connected to the zero cross detector and commutation & spindle motor control function block. The zero crossings in this signals are used to determine the timing of the commutation and measurement of spindle motor speed.

FREQUENCY GENERATION (FG) & READY

FG stands for Frequency Generation. Representing the current spindle motor speed frequency, it contains important information about the motor speed and motor spin. VCM enable when the READY signal output is High . FG frequency (Hz), motor speed (rpm) and pole number are directly related as shown below in the three phase motor. FG frequency calculation equation is as follow;

FG frequency = motor speed $\times$ pole number $\times$ 3 / 120

For example in a typical application,
Target speed = 5, 400[RPM], motor polenumber = 8[poles]
FG frequency = 5400 $\times$ 8 $\times$ 3 / 120 = 1080Hz

SPINDLE MOTOR SPEED CONTROL

Motor speed is measured by the speed reference clock via the masked FG signal which is proportional to motor speed. The speed discriminator compares FG frequency with the target motor speed (Speed reference clock) and sends signal to the buffer amplifier input by the F/V output as pulse signals (I_{CHARGE} /$I_{DISCHARGE}$) .
This F/V output signals internally compare the buffer amplifier reference voltage. And then the signals control CVCNT voltage by the charging or discharging the external capacitor connected the CVCNT pin .

Spindle motor(SPM) current controlled compares buffer output voltage via motor current which is sensing the external resistor connected the PCS pin.

The sense amplifier detetmines maximum output current during the start-up.

The Back-EMF is used in the sensorless BLDC motor driver to determine the rotor position. The detected rotor position is a very important information to control the motor speed and the commutation timing.

At standstill condition, there is no back-EMF voltage and no FG output. There is no information about the motor position. However the spindle motor must be started up at standstill.

To drive the spindle motor at the start-up mode, the control signal CNTL1 input is High and CNTL2 to be used as start up clock.

The control signal CNTL1 is continuously provides HIGH signal until the Back-EMF generated is enough large to produce the FG signal i.e. the spindle motor can be driven by the self commutation. During a fixed time, if the back-EMF generated is too small and the spindle motor is not driven by the self commutation, retry the start-up.

Table 1. Pin setup truth table

	CNTL1(1)		**CNTL2(2)**		**GAINSEL**	
	SPM driver	Brake	Ready Off	Ready On	SPM driver	VCM gain
High (5V)	1	0	Start-up clock High	VCM On	Normal	0.125
Open (Floating)	0	0	Start-up clock Low	VCM Off	x	x
Low (0V)	0	1	x	Retract On	Start up(3) Hold	0.5

NOTES:
1. CNTL1: Spindle motor control
2. CNTL2: Start-up clock & VCM Amplifier control
3. Test only
4. “1”: Enable; “0”: disable; “S/W”: switching

ACCELERATION MODE

When the Back-EMF detected is enough to be used as the information of motor position, the mode is changed from start-up to acceleration. The Back-EMF amplifier sends the commutation timing signal via MCLK according to the commutation clock generator output.

By using the back-EMF, the spindle motor is self-commuted at acceleration and running modes. During the motor drive, the spindle motor is commuted at that point which is electrically 30° delayed controlled by commutation clock generator.

RUNNING MODE

It is called to the running mode when the spindle motor speed arrives within ± 1% of the target speed. The switching mode, commutation delay time, MCLK delay time (Td) and masking time are changed at the running mode. The spindle motor speed is controlled by PWM signal within ± 0.01%. The soft switching using the current slope of the motor may reduce noise, EMI (Electromagnetic Interference) and spark voltage which is generated on the motor coil at the switching.

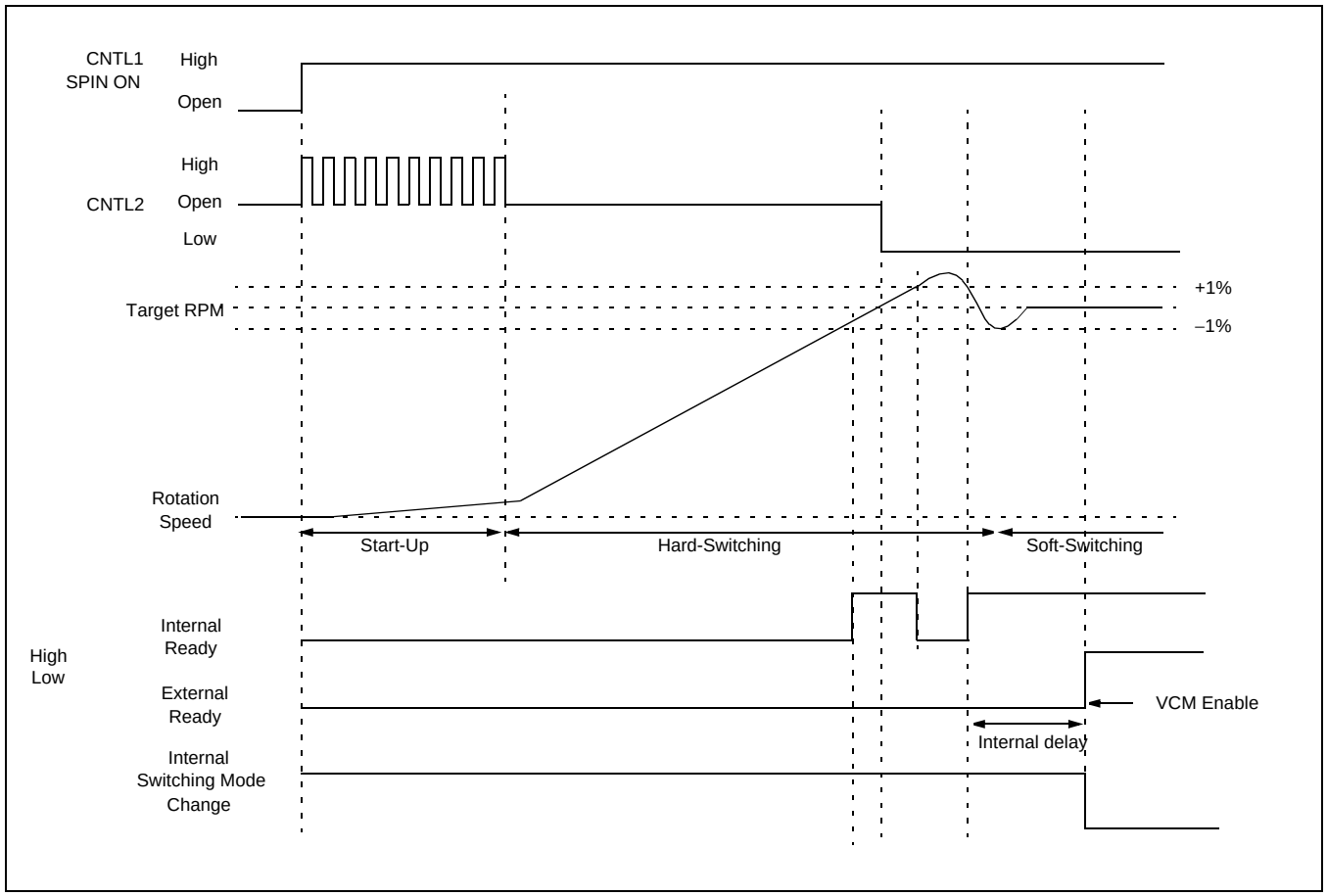


Figure 1. Motor start-up sequence

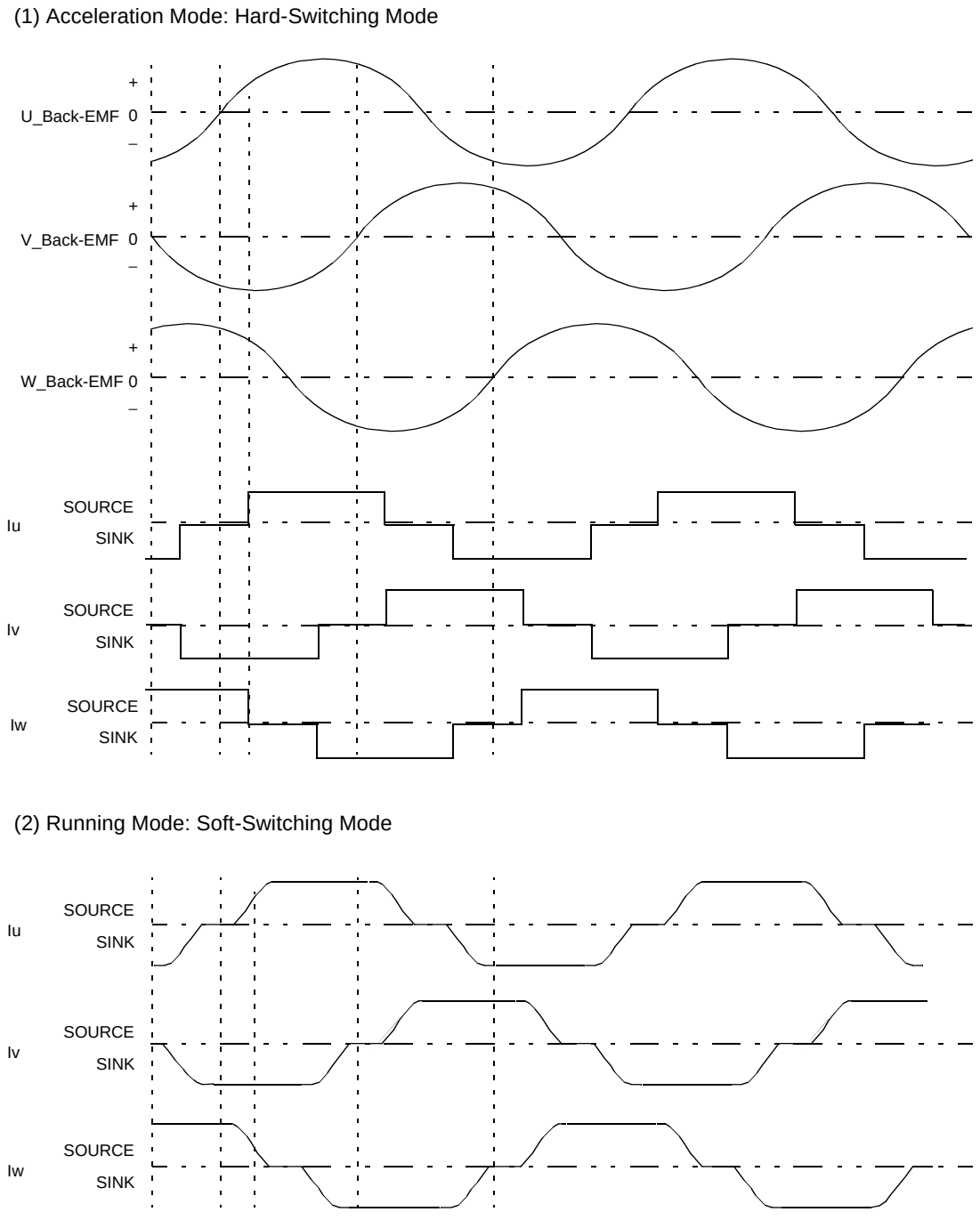


Figure 2. Acceleration and running the spindle motor

VOICE COIL MOTOR

VCM driver

The voice coil motor driver is the linear, class AB, H–bridge type driver, and it includes all power transistor. After the VCM is enabled via VCMEN, the VCM current level is controlled by two PWM signals. The input voltage level at pin PWMH weighs, at a maximum, 32 times more than the input voltage at pin PWML. These PWM signals are filtered by an internal 2nd–order low-pass filter and converted into PWMOUT (DC Voltage). The filter PWMOUT depends only on the duty factor and not on the logic level. The PWM Filter's pole is adjustable by pin CFVCM connected to the external capacitor.

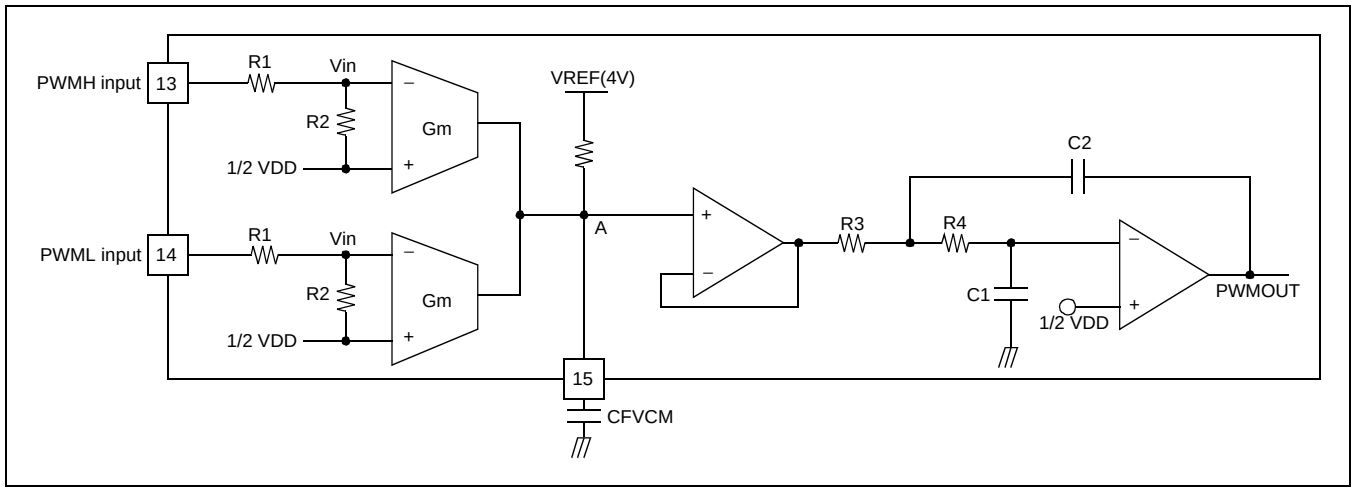


Figure 3. PWM decoder & filter schematic

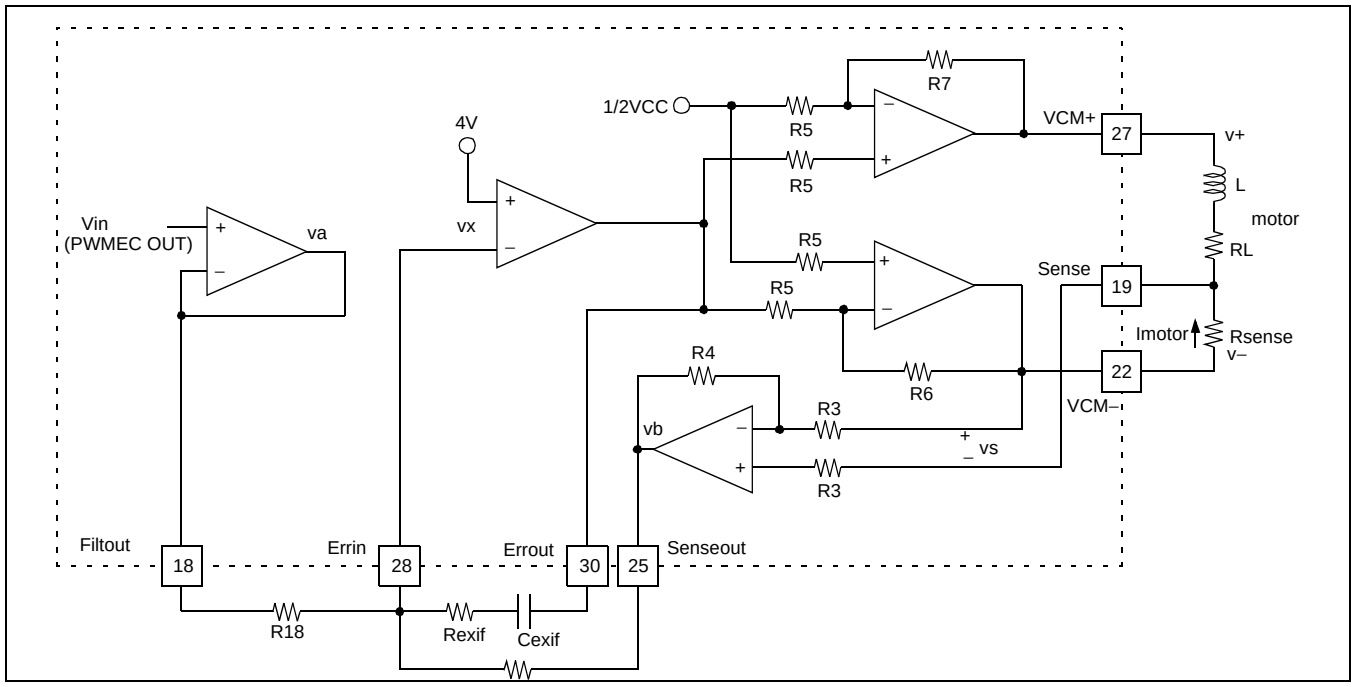


Figure 4. VCM driver schematic

The transconductance of VCM AMPLIFIER gain, Gm, is:

$$Gm = \frac{Imotor}{Vin} = \frac{2 \cdot Aerror \cdot Apower \cdot R25}{2 \cdot R18 \cdot Rsense \cdot As \cdot Aerror \cdot Apower + (R18 + R25)(Zmotor + Rsense)}$$

$$Gm = \frac{Aloop}{1 + Aloop}\left(\frac{R25}{R18}\frac{1}{Rsense}\frac{1}{As}\right)$$

$$Aloop = \frac{2 \cdot R18 \cdot As \cdot Aerror \cdot Apower}{(R18 + R25)(Zmotor + Rsense)}$$

Therefore Aloop >>1,

$$Gm \cong \frac{R25}{R18} \cdot \frac{1}{Rsense} \cdot \frac{1}{As}$$

The Transconductance (Gm) can be adjusted by selecting the external components R18, R25 and sense resister Rsense.

if R18 = 15k, R25 = 15k, Rsense = 1
GAINSEL = 0(0V), 1 / AS = 0.5
Gm = 0.5
GAINSEL = 1(5V), 1 / AS = 0.125
Gm = 0.125

VCM current (Imotor) is:

GAINSEL = 0(0V)

$$Imotor = 4 \times \left[(PWMH - 0.5) + \frac{1}{64}(PWML - 0.5)\right] \times \frac{R25}{R18} \times \frac{1}{Rsense} \times 0.5$$

GAINSEL = 1(5V)

$$Imotor = 4 \times \left[(PWMH - 0.5) + \frac{1}{64}(PWML - 0.5)\right] \times \frac{R25}{R18} \times \frac{1}{Rsense} \times 0.125$$

Recommended value PWMH(100%) = 1
R18 = R25 = 15k PWMH(50%) = 0.5
Rsense = 1 PWMH(0%) = 0

RETRACT CIRCUIT

The retract function is the operation where the VCM moves from the data zone to the parking zone when off normal state power and abnormal power interrupt cause the spindle motor to stop.

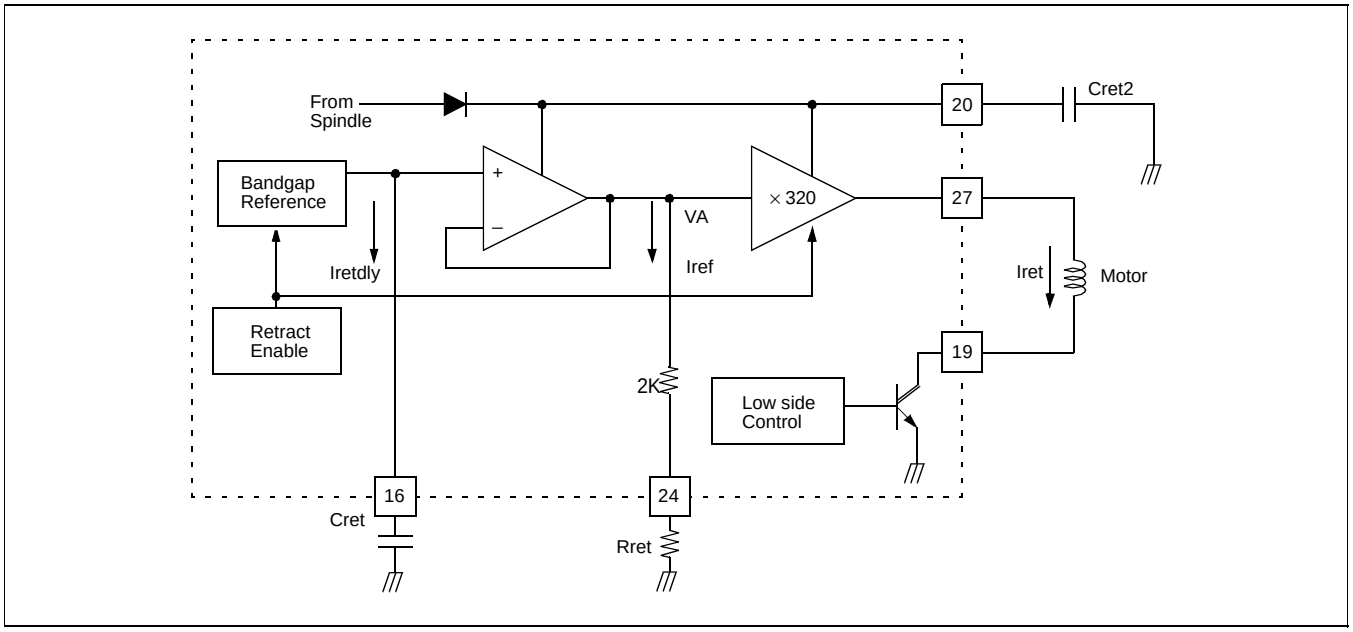


Figure 5. Retract block schematic

$$VA = 2.0V$$

$$Iref = \frac{VA}{Rret + 2k}$$

$$Iret = Iref \times 320$$

$$Tretdly = \frac{Cret \times 2.0V}{Iretdly(= 100\mu)}$$

POWER MANAGEMENT FEATURES

LOW POWER INTERRUPT

The low power interrupt operation occurs when the power supply voltage (5V,12V) level drops below each threshold voltage. The threshold voltage (Vth) and time delay (Tdly) may be adjustable by the external component value.

$$Tdly = CDLY\frac{Vth}{I},(Vth = 2.5V, I = 14.0\mu A)$$

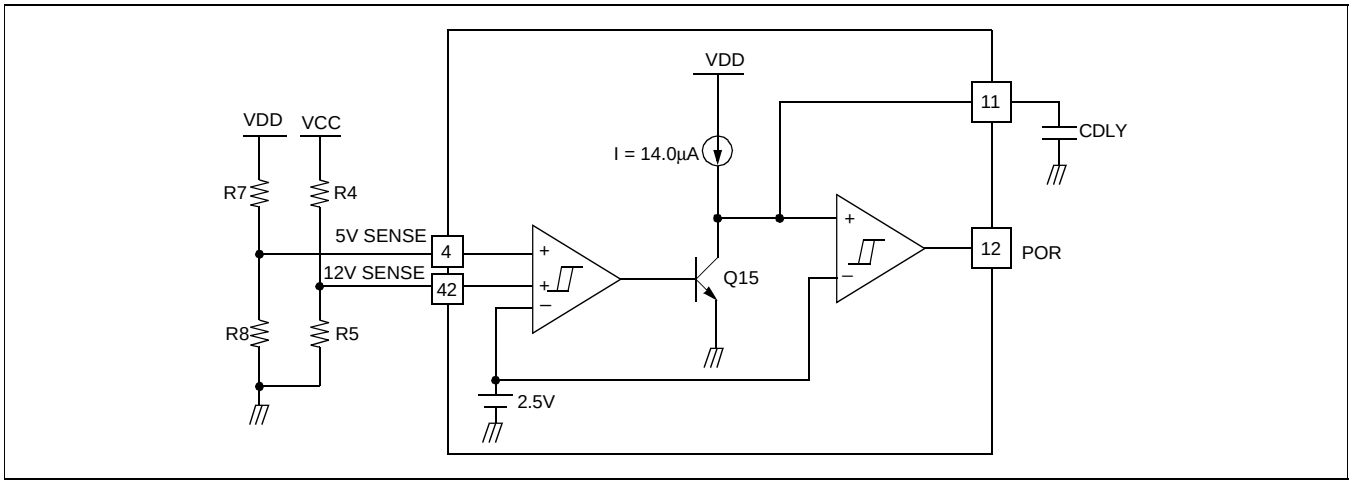


Figure 6. Power on reset block schematic

POWER ON RESET

The power-on reset circuit monitors the voltage level of both +5V and +12V power supplies. The power–on reset circuit disables the spindle motor out block, the whole VCM block, and the digital ASIC when the power supply voltage level drops below the reference voltage.

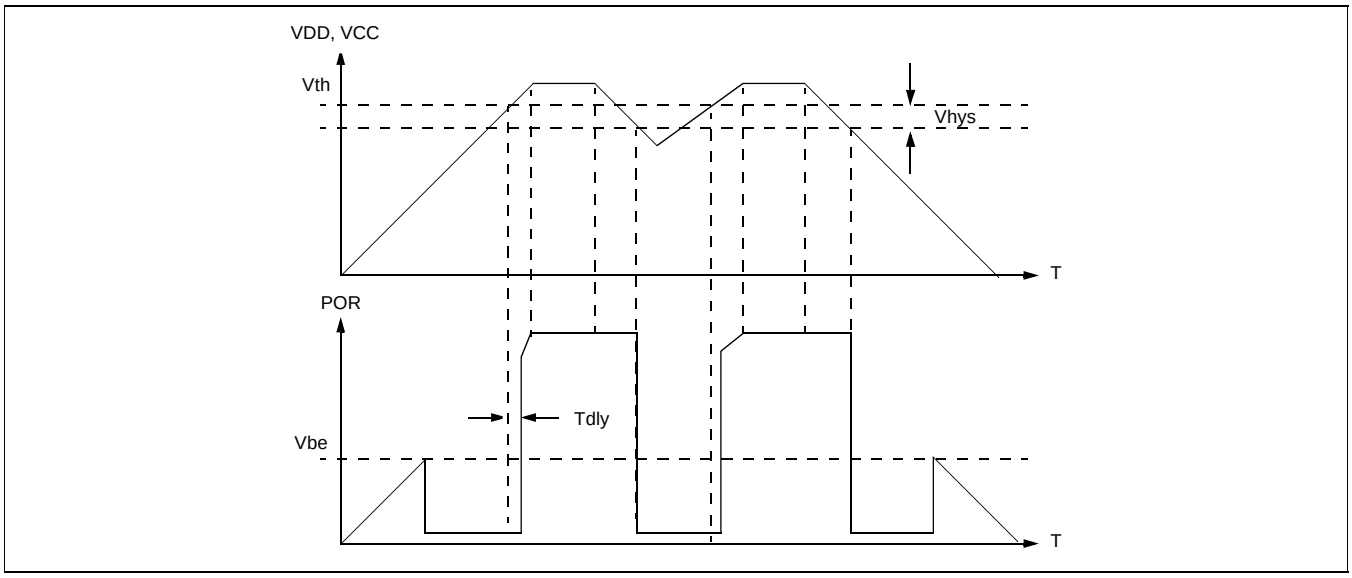


Figure 7. Power on reset function

$$Vhys = 4.2mV$$

$$VDD;Vhys(5V) = \frac{R4 + R5}{R5} \times Vhys$$

$$VCC;Vhys(12V) = \frac{R7 + R8}{R8} \times Vhys$$

Default (pin4, pin42 : not connected)

$$VDD, th \cong 4.1V$$

$$VCC, th \cong 9.4V$$

REGULATOR

The KA3121 includes the regulator block which supplies power of the digital ASIC. It consists of the bias block, the band gap reference, the error Amplifier and the external NPN power Tr. The regulator voltage can be adjusted by the external resistor, R3a, R3b..

$$Vreg = Vref\left(1 + \frac{R3a}{R3b}\right), Vref = 1.3V$$

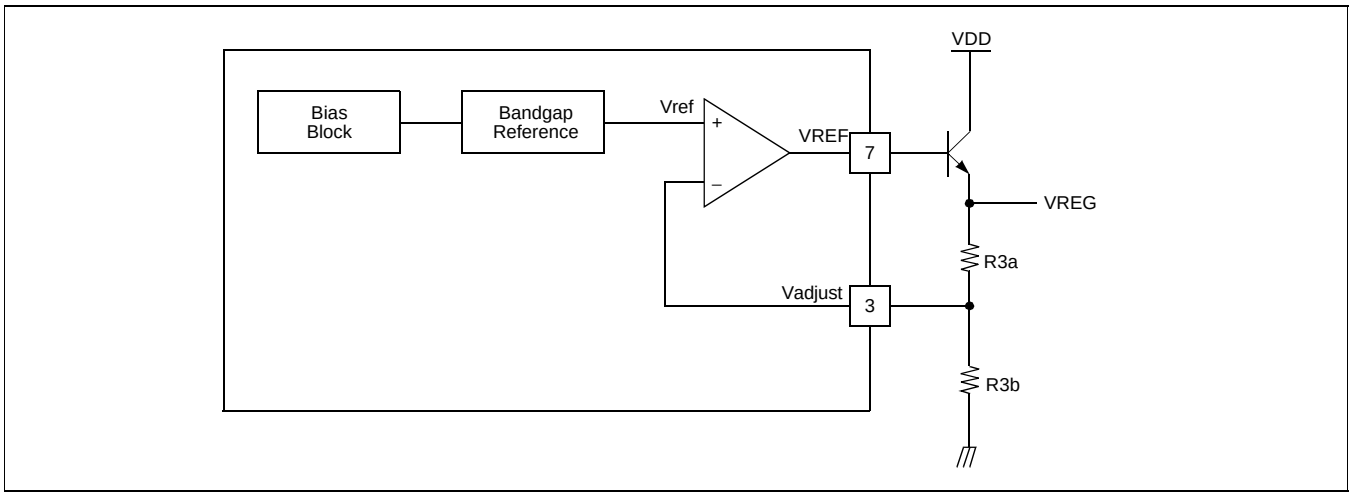


Figure 8. Regulator schematic

if R3a = 15k, R3b = 10k

$$Vreg = Vref\left(1 + \frac{R3a}{R3b}\right) = 1.3 \times \left(1 + \frac{15k}{10k}\right) = 3.25V$$

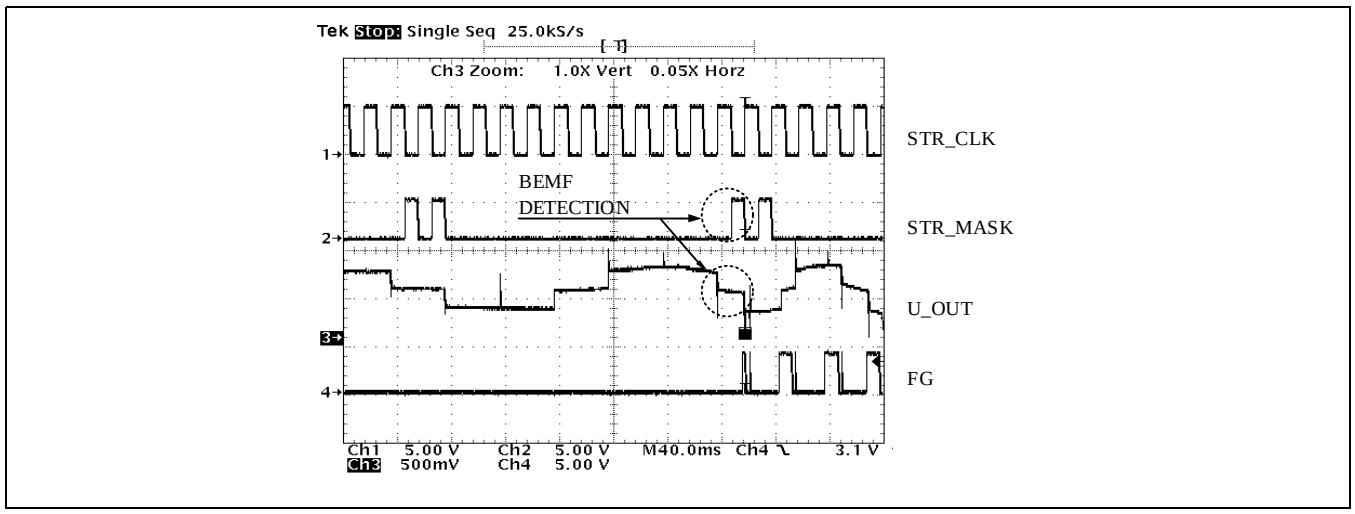


Figure 9. Start-up mode

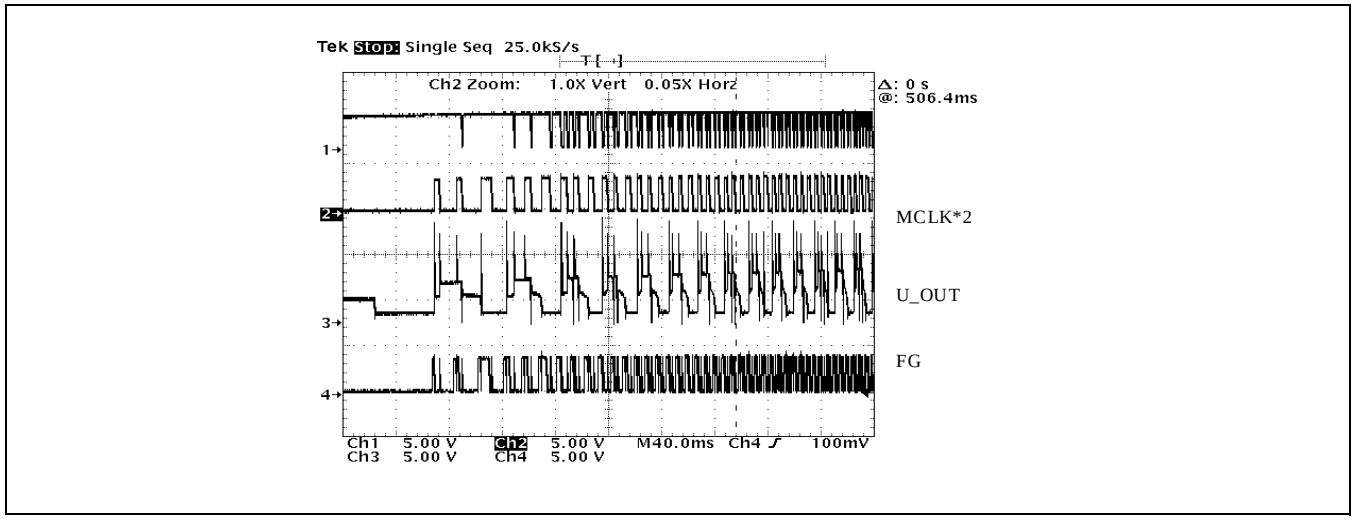


Figure 10. Acceleration mode 1

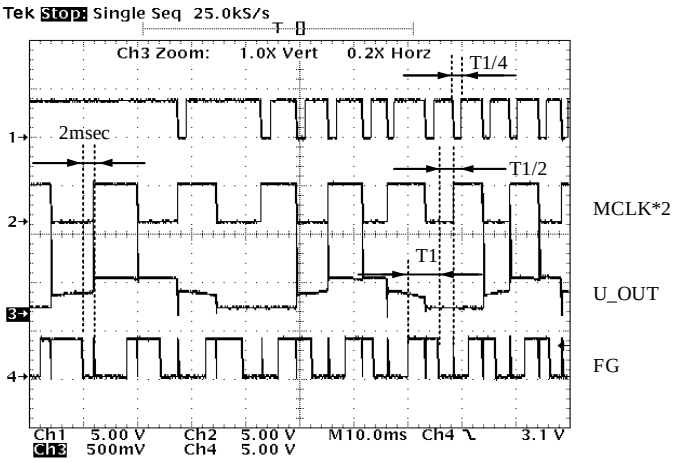


Figure 11. Acceleration mode 2

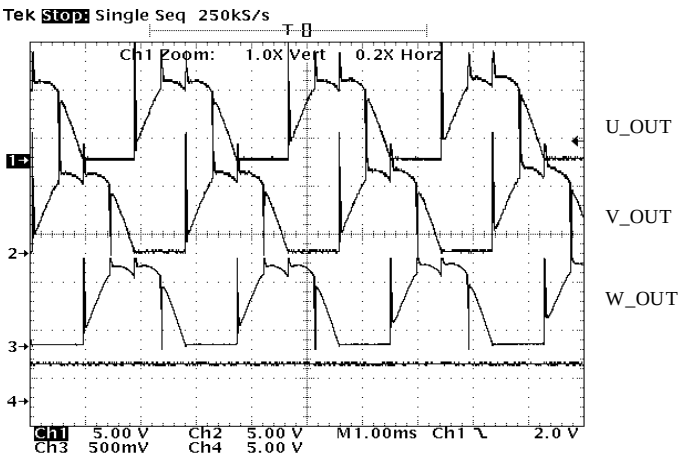


Figure 12. Output in hard-switching mode

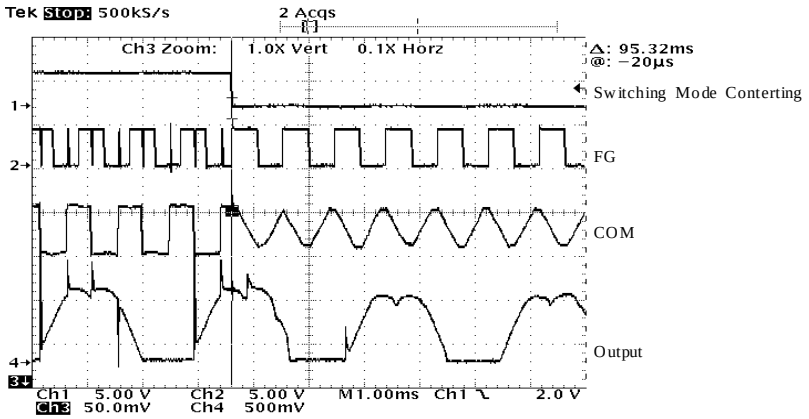


Figure 13. Switching mode converting

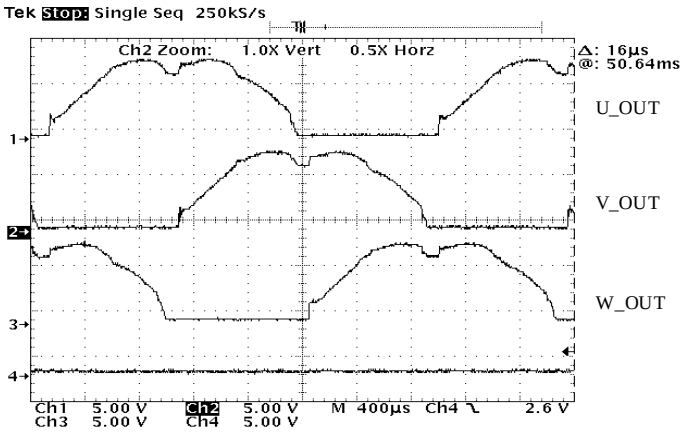
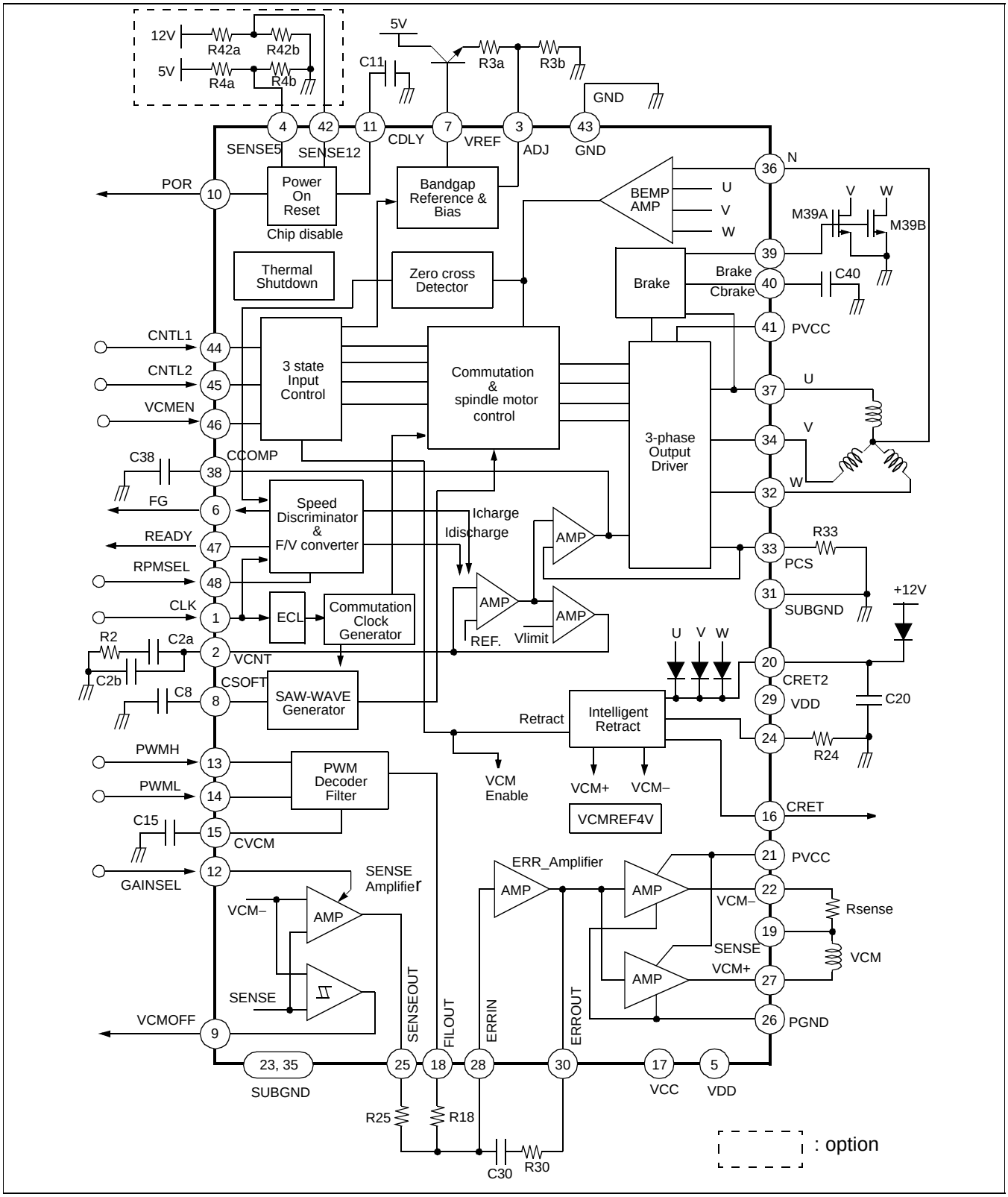
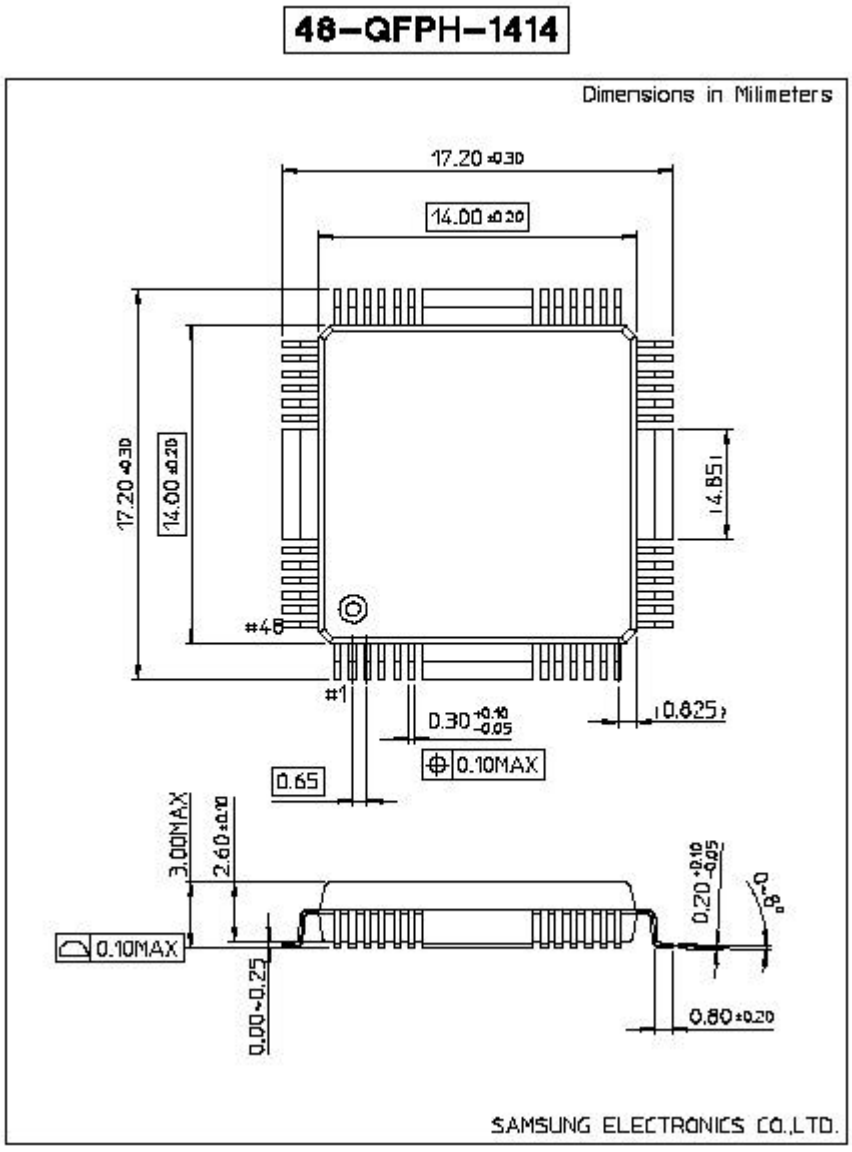


Figure 14. Soft-switching mode

APPLICATION CIRCUIT



PACKAGE DIMENSION



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