FAN8623

12V Spindle Motor and Voice Coil Motor Driver

Features

Spindle Motor Driver

- Soft commutation
- Spindle brake after retract
- Adjustable brake delay time
- 1.2A max. current power driver
- Low output saturation voltage: 1.5V typical @1.2A
- PWM decoder & filter for soft commutation
- The external circuit (ASIC) based start-up, commutation and motor speed control
- Advanced control accuracy by dual gain slop

Voice Coil Motor Driver

- Trimmed low offset current
- 1.2A max. current power driver
- Automatic retract with constant voltage output
- Class AB linear amplifier with no dead zone
- Low output saturation voltage: 0.8V typical @1.0A
- Internal full bridge with VPNP(Vertical PNP) & NPN transistors

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%

Others

- Can be used with 5Volt and 3.3Volt control signals(CNTL1,CNTL2 & CNTL3) for ASIC Interface

Package

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

Typical Application

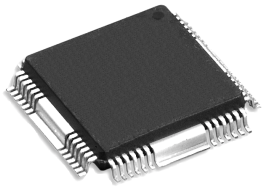
- Hard disk drive (HDD)

Description

The FAN8623 is an ASIC combination chip, designed for the HDD application, It includes the following functions: spindle motor drive, voice coil motor drive, retract and power management.

To drive and control the spindle, the external ASIC provides the appropriate control signals (Start up, commutation, speed control) to the FAN8623. The spindle motor is monitored by the FG output and the motor speed control is accomplished via the PWMSP input. The ASIC controls the voice coil motor current via PWMH and PWML inputs and the power management circuit monitors the power supply voltages.

48-QFPH-1414



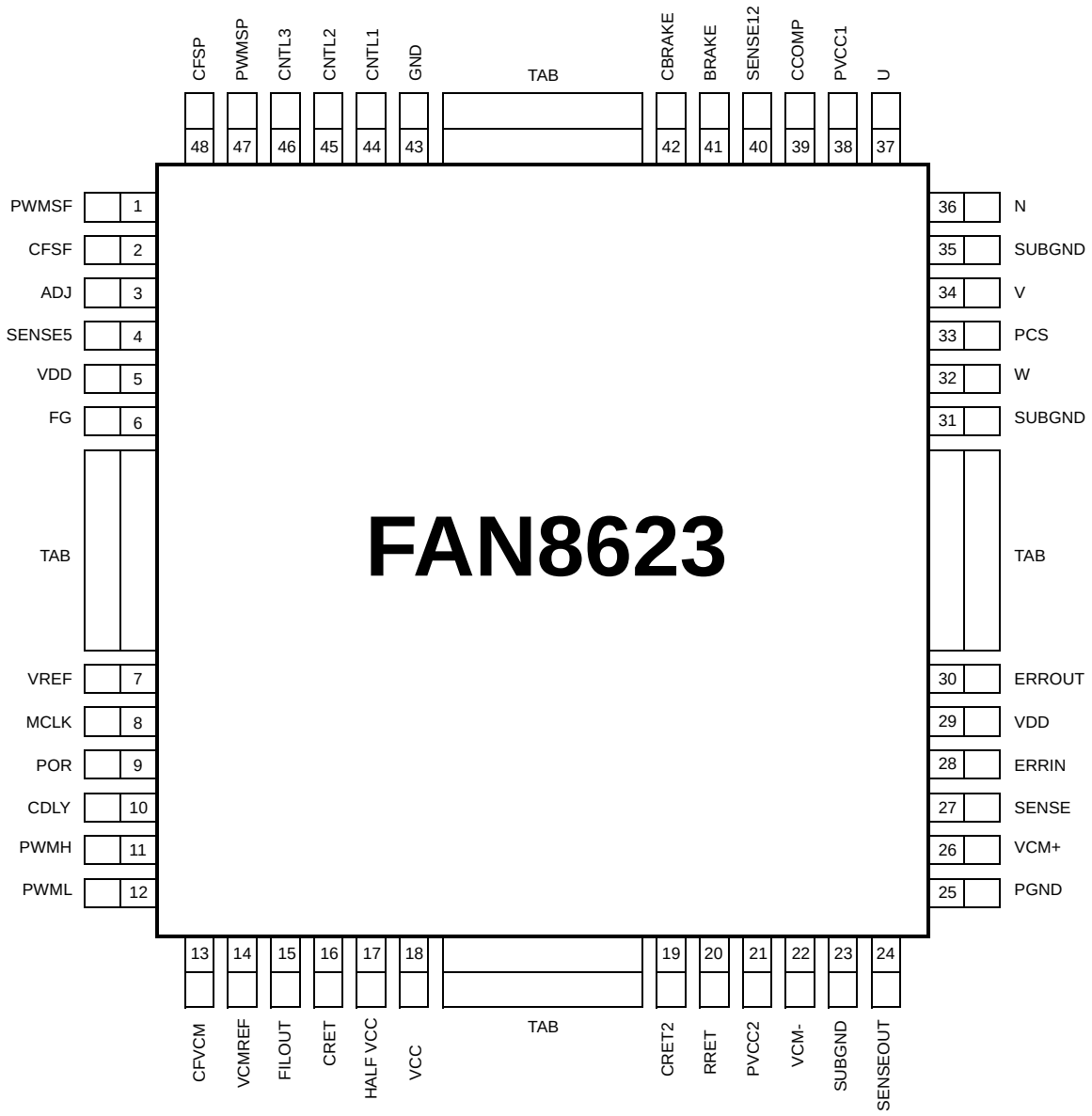
Ordering Information

Device	Package	Operating Temp.
FAN8623	48-QFPH-1414	0 ~ 70°C

Preliminary Specification

Rev. 0.9.2
May. 2000.

Pin Assignments



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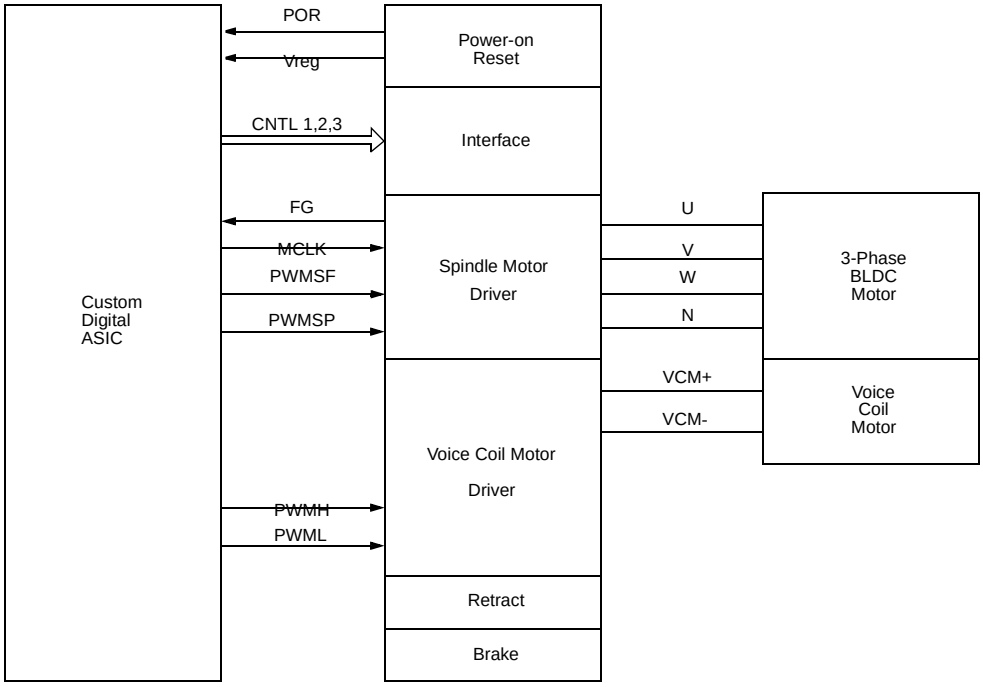
Pin Definitions

Pin Number	Pin Name	IO	Pin Function Description
1	PWMSF	I	PWM input for spindle soft commutation
2	CFSF	-	Capacitor for spindle PWM soft commutation filter
3	ADJ	-	Reference voltage adjustable
4	SENSE5	-	Adjustable threshold voltage to 5V
5	VDD	-	5V power supply
6	FG	O	Frequency generation to spindle speed
7	VREF	O	Voltage reference output for ASIC power
8	MCLK	I	Clock from ASIC for commutation
9	POR	O	Fault output(Power On Reset & Thermal Shut Down)
10	CDLY	-	Delay capacitor for power on reset
11	PWMH	I	PWM signal input (MSB)
12	PWML	I	PWM signal input (LSB)
13	CFVCM	-	Filter capacitor for VCM PWM control
14	VCMREF	O	Voltage reference output for VCM
15	FILOUT	O	VCM PWM output
16	CRET	-	Delay capacitor for retract
17	HALFVCC	O	1/2 VCC pin
18	VCC	-	12V power line
19	CRET2	-	Power for VCM retract
20	RRET	-	Adjustable retract voltage
21	PVCC2	-	12V power line for VCM output
22	VCM(-)	O	VCM negative output
23	SUBGND	-	Ground
24	SENSEOUT	O	VCM current sense Amplifier output
25	PGND	-	Ground
26	VCM(+)	O	VCM positive output
27	SENSE	I	VCM current sense Amplifier input
28	ERRIN	I	VCM error Amplifier negative input
29	VDD	-	5V power supply
30	ERROUT	O	VCM error Amplifier output
31	SUBGND	-	Ground
32	W	O	Spindle motor W phase output

Pin Definitions (Continued)

Pin Number	Pin Name	IO	Pin Function Description
33	PCS	O	Spindle soutput current sensing
34	V	O	Spindle motor V phase output
35	SUBGND	-	Ground
36	N	-	Spindle motor neutral point
37	U	O	Spindle motor U phase output
38	PVCC1	-	12V power line for spindle
39	CCOMP	-	Spindle output control compensation
40	SENSE12	-	Adjustable for threshold voltage to 12V
41	BRAKE	O	Dynamic brake
42	CBRAKE	-	Back-EMF charging capacitor for brake power
43	GND	-	Ground
44	CNTL1	I	Control input for spindle and brake
45	CNTL2	I	Control input for start-up clock and soft commutation
46	CNTL3	I	Control input for VCM Amplifier & retract
47	PWMSP	I	PWM input for spindle speed control
48	CFSP	-	Filter capacitor for spindle PWM control

Internal Block Diagram



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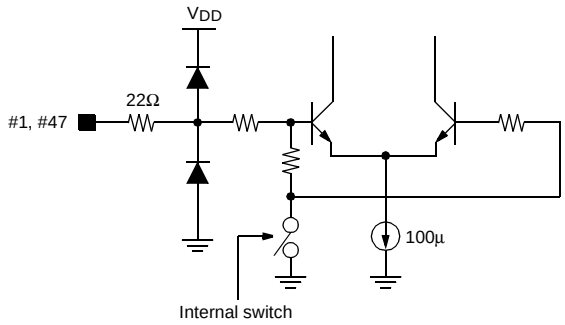
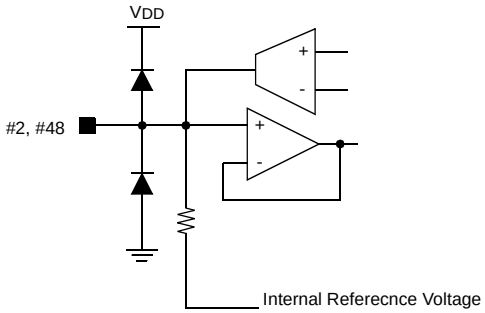
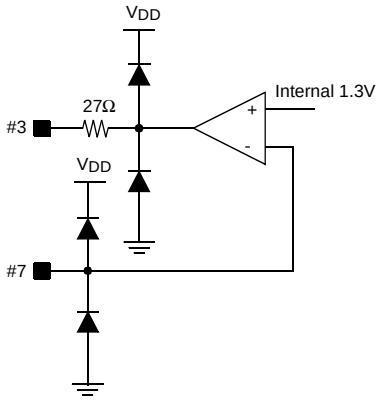
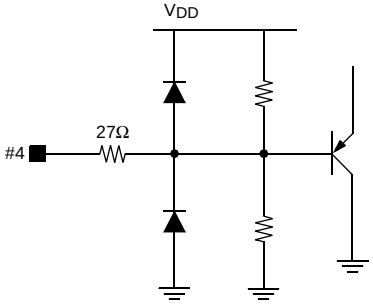
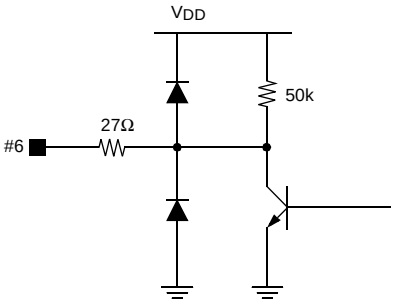
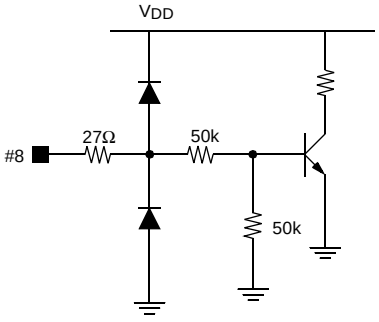
Equivalent Circuits

PWM decoder filter input of Spindle part	PWM decoder filter Capacitor of Spindle part
	
Regulator part	**Sense5 input**
	
FG output	**MCLK input**
	

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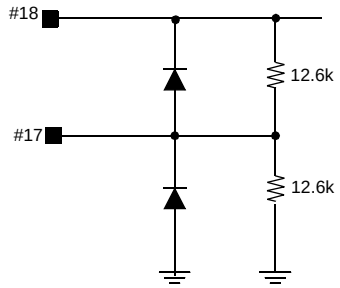
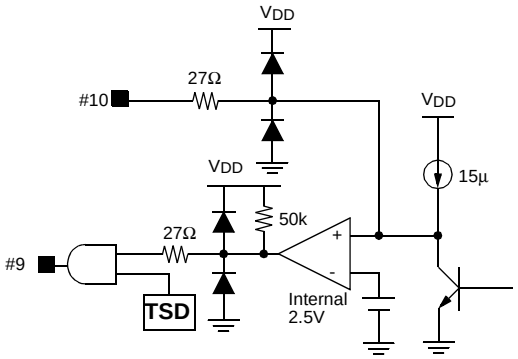
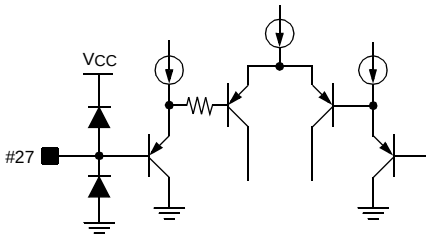
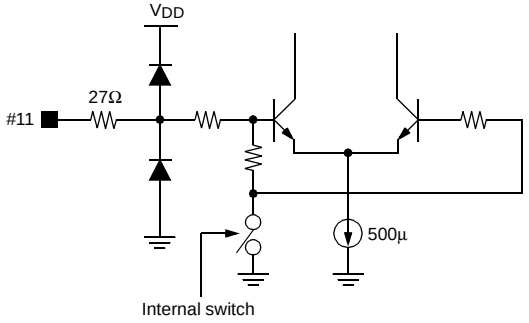
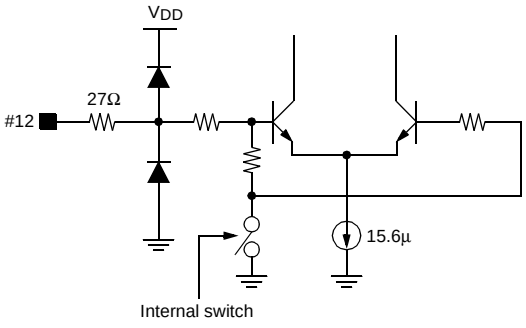
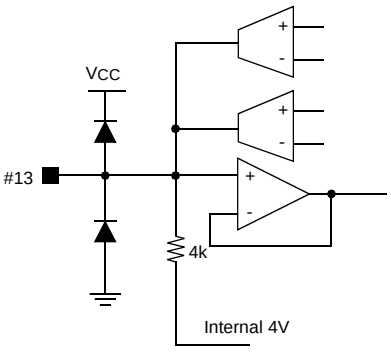
Equivalent Circuits (Continued)

VCM power amplifier reference	Power on reset part
	
VCM current sense input	**VCM PWM high input**
	
VCM PWM low input	**VCM PWM filter Capacitor**
	

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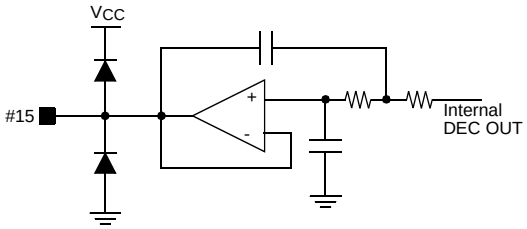
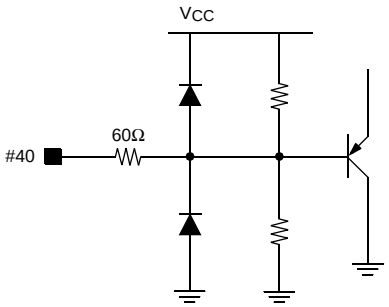
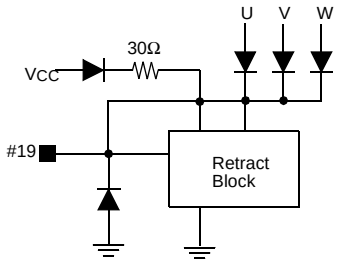
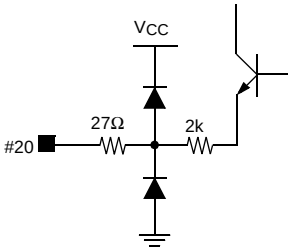
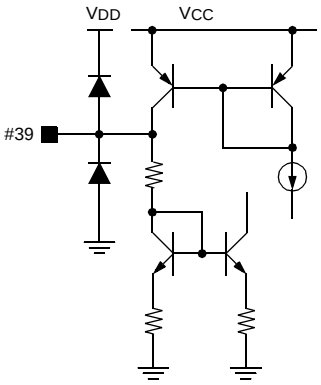
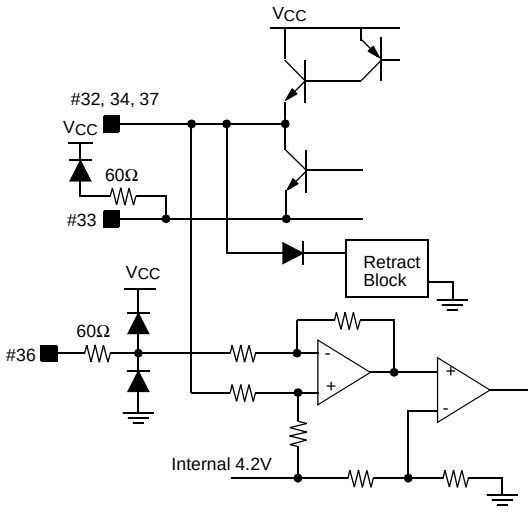
Equivalent Circuits (Continued)

Filtered VCM PWM command output	Sense12 input
	
Capacitor for retract power	**Maximum retract current set input**
	
Spindle motor output compensation Capacitor	**Spindle motor output and Back-EMF sensing part**
	

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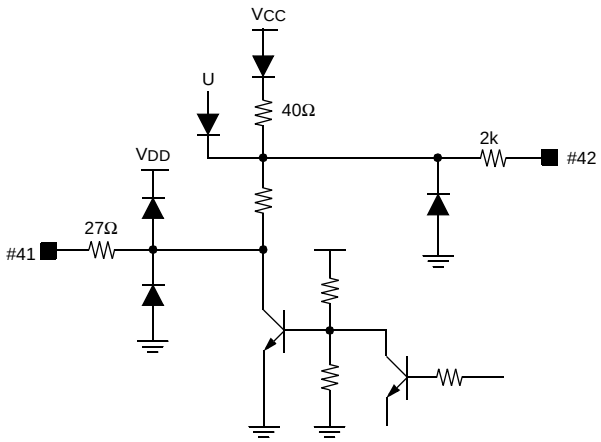
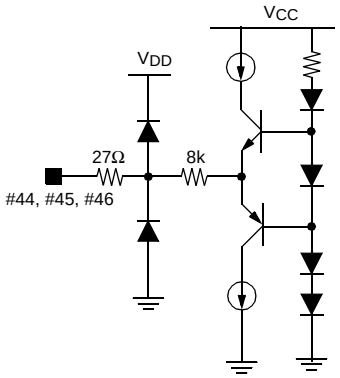
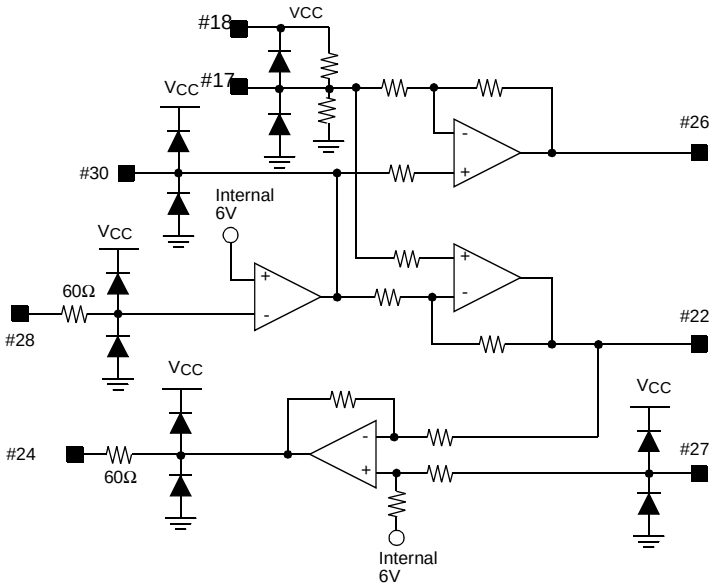
Equivalent Circuits (Continued)

Dynamic brake part	CNTL1, 2, 3 input
	
VCM output and control part	
	

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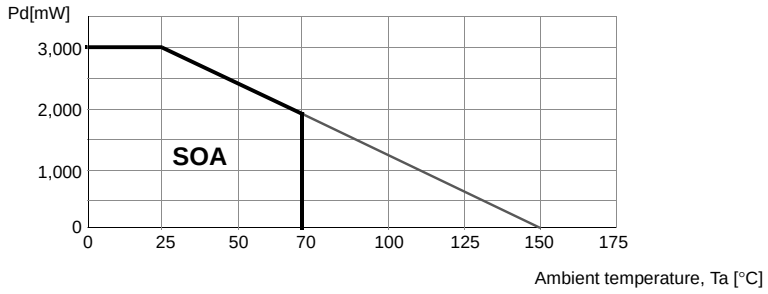
Absolute Maximum Ratings (Ta = 25°C)

Parameter	Symbol	Value	Unit
Maximum signal block supply voltage for 5V line	V_{DDMAX}	6.0	V
Maximum signal block supply voltage for 12V line	V_{CCMAX}	15.0	V
Maximum power block supply voltage for 12V line	PV_{CCMAX}	15.0	V
Maximum output current of Spindle motor	I_{SOMAX}	1.2	A
Maximum output current of VCM	I_{VOMAX}	1.2	A
Power dissipation	P_D	3.0 note	W
Storage temperature	T_{STG}	-55 ~ 125	°C
Maximum junction temperature	T_{JMAX}	150	°C
Operating ambient temperature	T_A	0 ~ 70	°C

Notes:

1. Power dissipation is reduced 16mW / °C for using above Ta=25°C.
2. Do not exceed Pd and SOA(Safe Operation Area).

Power Dissipation Curve



Recommended Operating Conditions (Ta = 25°C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}, PV_{CC1}, PV_{CC2}	10.8	12.0	13.2	V
Supply voltage for logic part	V_{DD}	4.5	5.0	5.5	V

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Electrical Characteristics

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
SUPPLY CURRENT(1)						
5V line supply current 1	I_{DD1}	Brake Mode (CNTL1= Low)	–	55	65	mA
5V line supply current 2	I_{DD2}	Stand by	–	20	25	mA
5V line supply current 3	I_{DD3}	Normal Mode (CNTL1 = CNTL3 = High)	–	20	25	mA
5V line supply current 4	I_{DD4}	Retract Mode (CNTL3=Low)	–	20	25	mA
12V line supply current 1	I_{CC1}	Brake Mode (CNTL1 =Low)	–	7	12	mA
12V line supply current 2	I_{CC2}	Stand by	–	9	15	mA
12V line supply current 3	I_{CC3}	Normal Mode (CNTL1 = CNTL3 = High)	–	30	50	mA
12V line supply current 4	I_{CC4}	Retract Mode (CNTL3 =Low)	–	9	14	mA
POWER MONITOR						
Threshold voltage level for 12V	V_{TH12}	V_{CC}=Sweep, V_{DD}=5V	9.1	9.45	9.8	V
Hysteresis on 12V comparator	V_{HYS12}	V_{CC}=Sweep, V_{DD}=5V	100	200	300	mV
Adjustable pin voltage for 12V	V12	V_{CC}=12V, V_{DD}=5V	3.0	3.2	3.4	V
Threshold voltage level for 5V	V_{TH5}	V_{CC}=12V, V_{DD}=Sweep	3.7	4.05	4.4	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	2.90	3.23	3.55	V
POWER ON RESET GENERATOR						
Charging current for POR Capacitor	I_{CPOR}	V_{CC}=12V, V_{DD}=5V	-17.0	-13.5	-10.0	uA
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	4.5	–	V_{DD}	V
Output low voltage	V_{POL}	V_{CC}=12V, V_{DD}=5V	0	–	0.5	V
Power on reset delay(2)	Td_{POR}	C_{DLY}=220nF	–	40	–	ms
CONTROL INPUT(3)						
Logic control input 1 HIGH voltage	V_{CTL1H}	-	2.07	–	–	V
Logic control input 1 HIGH current	I_{CTL1H}	CNTL1 = High	65	100	160	uA
Logic control input 1 LOW voltage	V_{CTL1L}	-	–	–	1.43	V
Logic control input 1 LOW current	I_{CTL1L}	CNTL1= Low	-200	-165	-130	uA

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Electrical Characteristics (Continued)

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
RUNNING MODE CHECK						
Back-EMF threshold voltage(2)	V_{BTH}	–	65	80	95	mV
FG output high voltage	V_{FGH}	–	4.5	–	–	V
FG output low voltage	V_{FGL}	–	–	–	0.5	V
Running mode check	RM1	U=V=W=5V, N=100Hz	-	100	–	Hz
SPINDLE FG GENERATION						
FG frequency	FG	U,V,W=120° shift pulse(100Hz)	–	300	–	Hz
FG duty	D_{TFG}	U,V,W=120° shift pulse(1KHz)	45	50	55	%
SPINDLE PWM CONTROL						
PWM high level input voltage(2)	V_{SPMH}	–	3.0	–	–	V
PWM low level input voltage(2)	V_{SPML}	–	–	–	2.0	V
High input current at PWMSP	I_{PSP1}	PWMSP=100%	100	150	200	uA
CFSP voltage2(100% duty of PWMSP)	V_{SP2}	PWMSP=100%	1.5	1.7	1.9	V
Low input current at PWMSP	I_{PSP2}	PWMSP=0%	-200	-150	-100	uA
CFSP voltage1(0% duty of PWMSP)	V_{SP1}	PWMSP=0%	3.1	3.3	3.5	V
CFSP voltage amplitude	V_{SPD}	–	1.2	1.6	2.0	V
CFSP voltage3 (50% of PWMSP)	V_{SP3}	PWMSP=50%	2.35	2.5	2.65	V
CFSP charging current	I_{CFSP1}	PWMSP=0%, CFSP=2.5V	-200	-150	-100	uA
CFSP discharge current	I_{CFSP2}	SPMSP=100%, CFSP=2.5V	100	150	200	uA
BRAKE						
CBrake output voltage	V_{BC}	–	11.0	–	–	V
Brake output high voltage	V_{BH}	(Test only)	–	V_{DD}	–	V
Brake output low voltage	V_{BL}	–	–	–	0.5	V

Electrical Characteristics (Continued)

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
SPINDLE PWM SOFT COMMUTATION						
PWM high level input voltage(2)	V_{SFMH}	–	3.0	–	–	V
PWM low level input voltage(2)	V_{SFML}	–	–	–	2.0	V
High input current at PWMSF	I_{PFP1}	PWMSF=100%	100	150	200	uA
CFSF voltage2(100% duty of PWMSF)	V_{SF2}	PWMSF=100%	2.60	2.75	2.90	V
Low input current at PWMSF	I_{PSF2}	PWMSF=0%	-200	-150	-100	uA
CFSF voltage1(0% duty of PWMSF)	V_{SF1}	PWMSF=0%	2.10	2.25	2.40	V
CFSF voltage amplitude	V_{SFD}	–	425	475	525	mV
CFSF voltage3 (50% of PWMSF)	V_{SF3}	PWMSF=50%	2.35	2.50	2.65	V
CFSF charging current	I_{CFSF1}	PWMSF=0%, CFSP=2.5V	-150	-100	-50	uA
CFSF discharge current	I_{CFSF2}	SPMSF=100%, CFSP=2.5V	50	100	150	uA
SPINDLE OUTPUT						
U saturation voltage_upper	V_{SU5U}	I_O = 1A	–	–	1.0	V
V saturation voltage_upper	V_{SU5V}	I_O = 1A	–	–	1.0	V
W saturation voltage_upper	V_{SU5W}	I_O = 1A	–	–	1.0	V
U saturation voltage_lower	V_{SV5L}	I_O = 1A	–	–	0.7	V
V saturation voltage_lower	V_{SU5L}	I_O = 1A	–	–	0.7	V
W saturation voltage_lower	V_{SU5L}	I_O = 1A	–	–	0.7	V
U output frequency	F_U	CNTL2=12KHz	–	1	–	KHz
V output frequency	F_V	CNTL2=12KHz	–	1	–	KHz
W output frequency	F_W	CNTL2=12KHz	–	1	–	KHz
Leakage current	I_{LQ}	–	-20	0	20	uA
Transconductance gain SPM	GM_{SP}	R_{PCS}=0.25Ω	–	0.85	–	A/V
CCOMP charging current1	I_{COMP1}	PWMSP=0%	-10	0	10	uA
CCOMP charging current2	I_{COMP2}	PWMSP=50%	-400	-300	-200	uA
CCOMP charging current3	I_{COMP3}	PWMSP=100%	-750	-630	-500	uA

Electrical Characteristics (Continued)

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
REGULATOR						
Adjustable PIN voltage	V_{ADJ}	–	1.29	1.31	1.33	V
Regulator output voltage	V_{REG}	–	3.1	3.3	3.5	V
Regulator line regulation(2)	R_{LINE}	–	–	–	2.0	%
Regulator load regulation(2)	R_{LOAD}	I_O = 500mA	–	–	2.0	%
VCM PWM CONTROL						
High PWMH input current	I_{PWMH1}	PWMH = 100%	36	48	60	uA
Low PWMH input current	I_{PWMH2}	PWMH = 0%	-200	-150	-100	uA
High PWML input current	I_{PWML1}	PWML = 100%	36	48	60	uA
Low PWML input current	I_{PWM2}	PWML = 0%	-200	-150	-100	uA
PWMH high level input voltage(2)	V_{PWMH1}	–	3.0	–	–	V
PWMH low level input voltage(2)	V_{PWMH2}	–	–	–	2.0	V
PWML high level input voltage(2)	V_{PWML1}	–	3.0	–	–	V
PWML low level input voltage(2)	V_{PWM2}	–	–	–	2.0	V
CFVCM voltage1	V_{CFVC1}	PWMH=100%,PWML=100%	–	8.5	–	V
CFVCM voltage5	V_{CFVC5}	PWMH=50%,PWML=50%	–	6.00	–	V
CFVCM voltage9	V_{CFVC9}	PWMH=0%,PWML=0%	–	3.5	–	V
PWM current ratio (VCM)	R_{PWM}	–	–	64	–	–
PWMH current variation	I_{VPWM}	–	1.03	1.25	1.37	mA
PWML current variation	I_{VPWM}	–	16.0	19.6	22.0	uA
VCM PWM FILTER						
Maximum phase shift(2)	DF	Measure at 500HZ, CFVCM=10nF	–	–	2	deg
Filter cut-off frequency(2)	F_{CO}	–	–	40	–	kHz
Filter attenuation at 1MHz(2)	a_{FILTER}	–	–	70	–	dB

Electrical Characteristics (Continued)

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
VCM REFERENCE VOLTAGE						
VCM reference voltage	V_{REF}	CNTL3= High	5.7	6.0	6.3	V
VCM ERROR AMPLIFIER						
Amplifier output high	V_{EOH}	–	10.8	–	–	V
Amplifier output low	V_{EOL}	–	–	–	1.2	V
Short circuit current(2)	I_{ESC}	–	8	–	–	mA
Input offset voltage(2)	V_{OSE}	–	-15	0	15	mV
Error amplifier open loop gain(2)	A_{VE}	–	–	80	–	dB
Unit gain bandwidth(2)	BG_E	–	–	2	–	MHz
VCM SENSE AMPLIFIER						
Amplifier output high	V_{SOH}	–	10.8	–	–	V
Amplifier output low	V_{SOL}	–	–	–	1.2	V
Short circuit current(2)	I_{SSC}	–	10	–	–	mA
Input offset voltage(2)	V_{OSE}	–	-15	0	15	mV
Unit gain bandwidth(2)	BG_S	–	–	2	–	MHz
Sense amplifier voltage gain(2)	A_{VS}	–	–	12	–	dB
VCM POWER AMPLIFIER						
Power Amplifier gain	A_{PO}	–	–	21.6	–	dB
Power Amplifier output high voltage	V_{POH}	–	11.0	–	–	V
Power Amplifier output low voltage	V_{POL}	–	–	–	1.0	V
Input offset voltage(2)	V_{OSE}	–	-15	0	15	mV
Unit gain bandwidth(2)	BG_P	–	–	2	–	MHz

Electrical Characteristics (Continued)

(Ta=25°C, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
VCM AMPLIFIER TOTAL						
VCM offset current	I_{OSVCM}	PWMH=PWML=50% duty	–20	0	20	mA
VCM transconductance gain	GM_{VCM}	–	–	0.45	–	A/V
VCM+ saturation voltage lower	V_{VMS1}	I_O=700mA	–	–	0.6	V
VCM- saturation voltage upper	V_{VMS2}	Rvcm=15Ω	–	–	0.6	V
VCM+ saturation voltage upper	V_{VMS3}	Rvcm=15Ω	–	–	0.6	V
VCM- saturation voltage lower	V_{VMS4}	Rvcm=15Ω	–	–	0.6	V
Leakage current power Amplifier1	I_{VCML1}	–	-20	0	20	uA
RETRACT						
Min. operating voltage of CRET2	V_{CRET2}	CRET2=Sweep	–	–	3.6	V
Source voltage	V_{SRC}	CRET2=5V	–	–	1.2	V
Sinking saturation voltage	V_{RTSAT}	CRET2=5V	–	–	0.5	V
Retract voltage	V_{RCT}	Rret=10.0KΩ	–	0.5	–	V
Power transistor leakage	I_{LRET}	–	–10	0	10	uA
THERMAL SHUT DOWN						
Operating temperature	TSD	–	–	150	–	°C
Thermal hysteresis	T_{HYS}	–	–	30	–	°C

Notes:

1. No Spindle or VCM Load.
2. Guaranteed by Design.
3. Logic control input2 & 3 spec's are equal to logic control input1.

Application Information

Spindle Motor Drive Circuit

The FAN8623 is a combination chip consisting of spindle motor and voice coil motor designed for HDD system. According to the spindle conditions, the digital ASIC provides optimum control signals (Start-up, commutation, speed control, and commutation mode) to the FAN8623.

Back-EMF (BEMF) signal of the spindle motor is fed back to ASIC via FG line. The MCLK and PWM signals are used to determine the commutation timing and to control the spindle speed, respectively.

Spindle Driver

The spindle includes both low and high side drivers (H-bridge) for a three-phase sensorless brushless DC motor. To reduce the saturation voltage, the vertical PNP transistor is used as the high side driver.

Frequency Generation (FG)

FG stands for Frequency Generation. It is the output signal to the ASIC.
It contains important information about the motor speed.
According to the FG frequency, the digital ASIC provides different motor clock signals to the motor drive IC via MCLK.
It checks the motor speed to send the VCM enable signal via CNTL3.

FG frequency (Hz), motor speed (rpm) and pole number are directly related as shown below in the three phase motor.

FG frequency(Hz) = motor speed(rpm) × pole number / 2 × 3 / 60

In a typical application,(8 pole motor)

FG frequency = 5400 × 8 /2 × 3 / 60 = 1080 Hz

MCLK & Mask

The MCLK is a motor clock used as the standard clock signal for the proper commutation timing of the spindle motor. It is supplied by the ASIC.

As shown in table 1, it has different delay times depending on the mode of the spindle.

	MCLK (Td)	MASK	Commutation
Start-up mode	2ms (External ASIC)	1ms	Hard
Acceleration mode	FG(n-1) / 2	FG(n-1) / 4	Hard
Running mode	FG(n-1) / 32	344.45ms	Soft

Table 1.

After the FG_Edge signal detection, the MCLK occurs after a half FG_Edge delay time in the acceleration mode and 1/ 32 FG_Edge delay time in the soft commutation mode.

Mask

When the coil current is abruptly changed in a short time interval, a spark voltage occurs. This spark voltage mixes with the FG output to give the wrong spindle information to the ASIC. To eliminate the spark voltage from the FG output, the masking circuit is needed.

$$Vcoil = -L\frac{di}{dt}$$

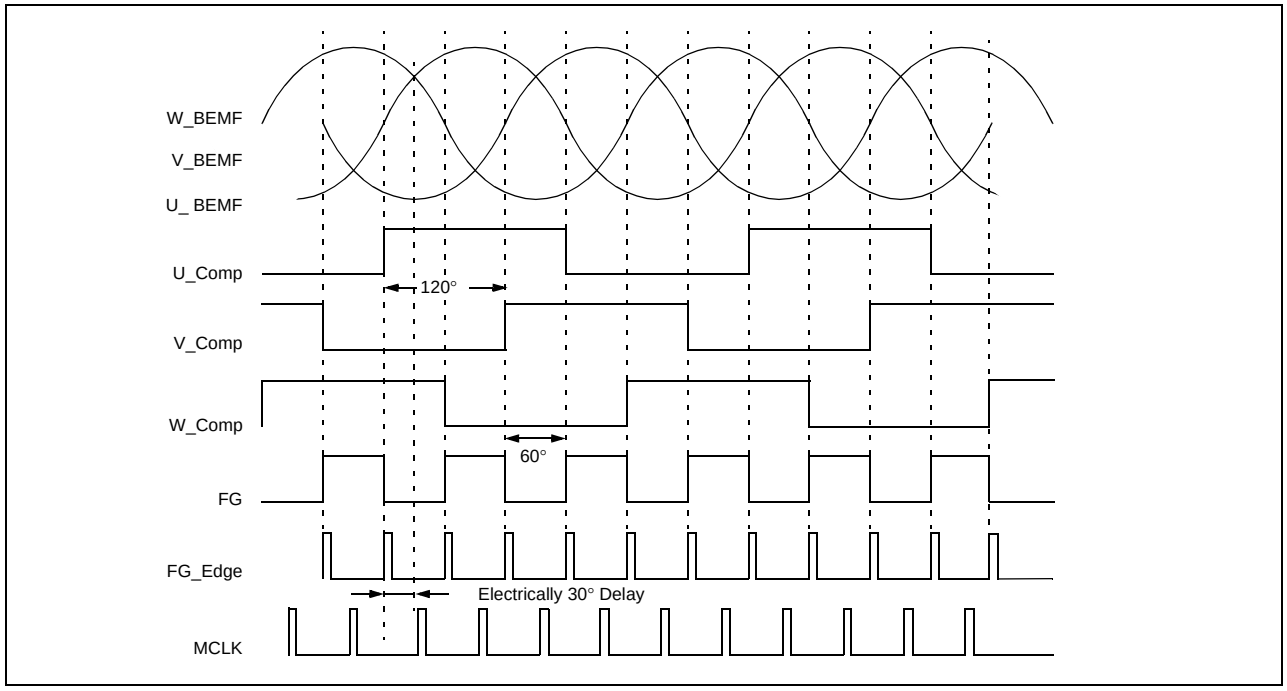


Figure 1. BEMF, FG, and MCLK in the acceleration mode

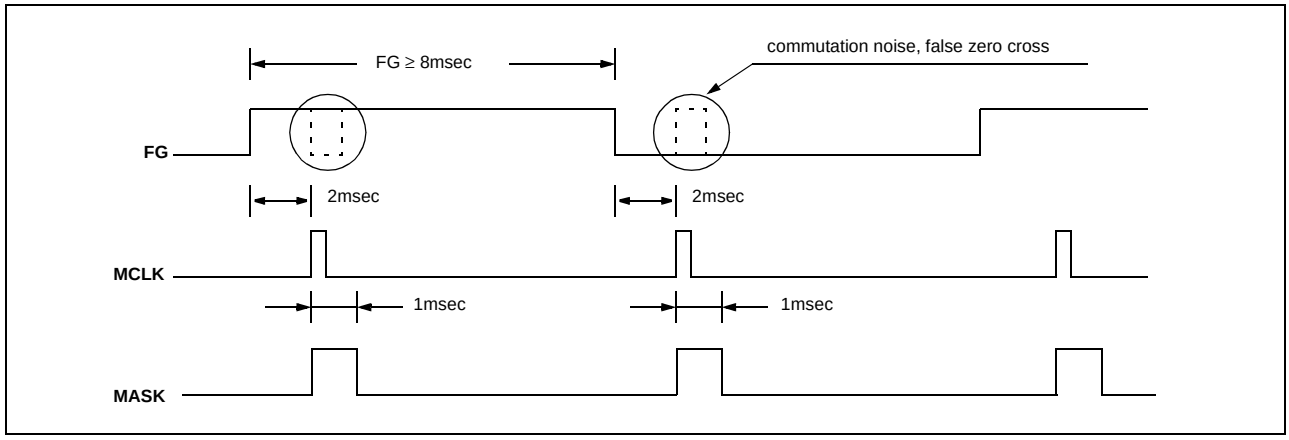


Figure 2. MCLK vs MASK in the start-up mode

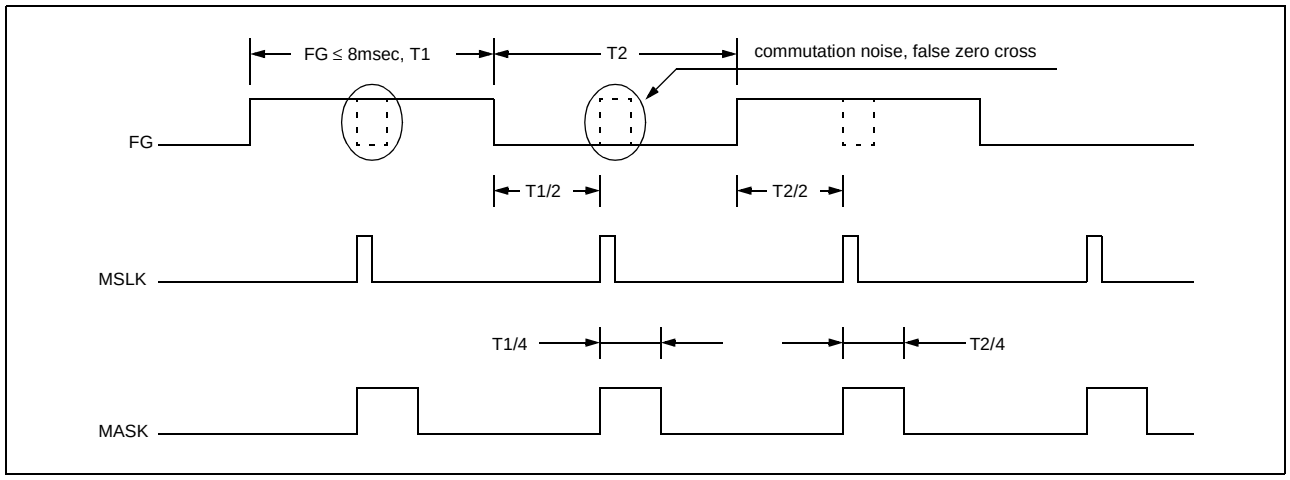


Figure 3. MCLK vs MASK in the acceleration mode

Preliminary Specification

PWMDEC and Speed Control

Motor speed is measured by the ASIC via the FG output. The digital ASIC compares FG frequency with the target motor speed and sends the speed compensation signal to the PWMSP input of the FAN8623. This PWM signal is internally filtered and is converted into DC voltage through the built-in PWM Decoder Filter. The analog output of the filter depends on the duty of the PWM signal. The filter is a 3rd order, low-pass filter. The first pole location of the filter is determined by the external capacitor connected to pin(48) CFSP.

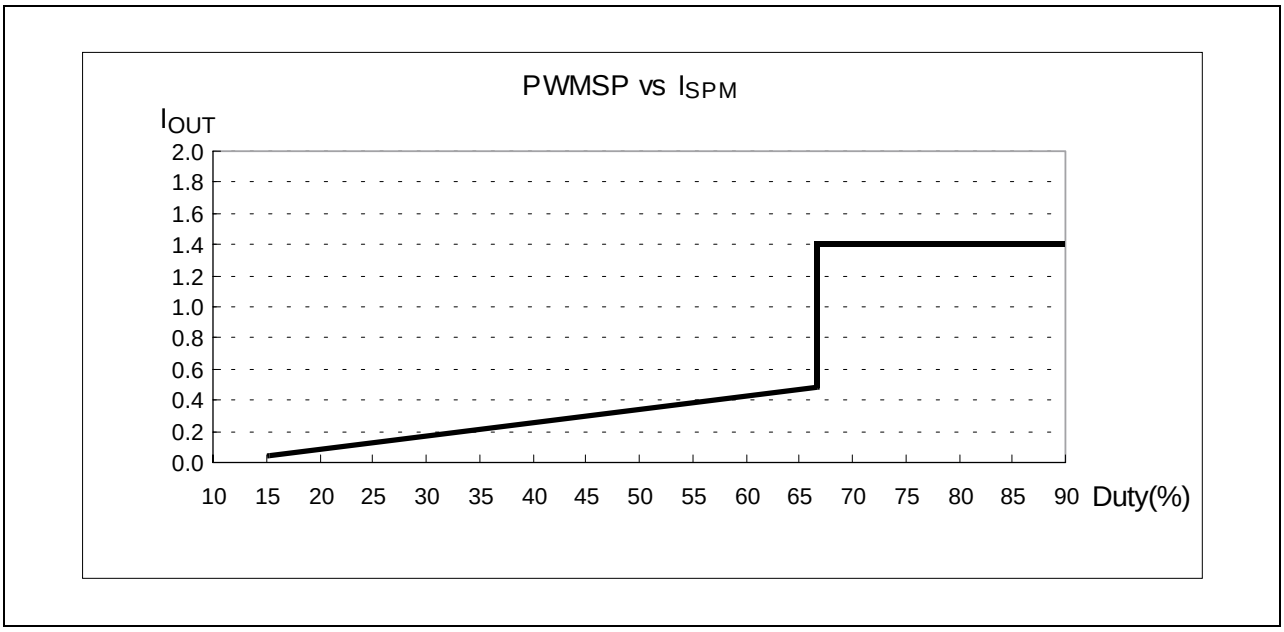


Figure 4. Spindle current vs PWMSP duty variation (R33 = 0.25Ω)

Start-up Mode

In the sensorless BLDC motor the Back-EMF is used to determine the rotor position.

At standstill condition, there is no Back-EMF voltage and no FG output. There is no information about the motor position.

To drive the spindle in the start-up mode, the digital ASIC sends the spindle enable signal via CNTL1 and supplies the HIGH or OPEN signal via CNTL2 to be used as commutation signal of the spindle motor.

The digital ASIC continuously provides HIGH or OPEN signal until the Back-EMF generated is large enough to produce the FG signal for 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, the ASIC resets all signals sent and retries the spindle.

	CNTL1(1)		CNTL2(2)	CNTL3(3)	
	SPM driver	Brake	Commutation	VCM driver	Retract
High	1	0	Hard	1	0
Open (Floating)	0	0	Hard	0	0
Low	0	1	Soft	0	1

Notes:
1. CNTL1: Spindle motor control
2. CNTL2: commutation mode control
3. CNTL3; VCM control
4. “1”: Enable; “0”: disable;

Acceleration Mode

When the Back-EMF detected is large enough to determine motor position, the mode is changed from start-up to acceleration. The ASIC sends the optimum commutation timing signal via MCLK according to the FG input.

By using the Back-EMF, the spindle 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 after the FG_Edge.

Running Mode

The running mode is when the spindle motor speed arrives within ± 1% of the target speed. The commutation 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 commutation using the current slope of the motor may reduce audiable noise, EMI (Electromagnetic Interference) and spark voltage which is generated on the motor coil at the commutation.

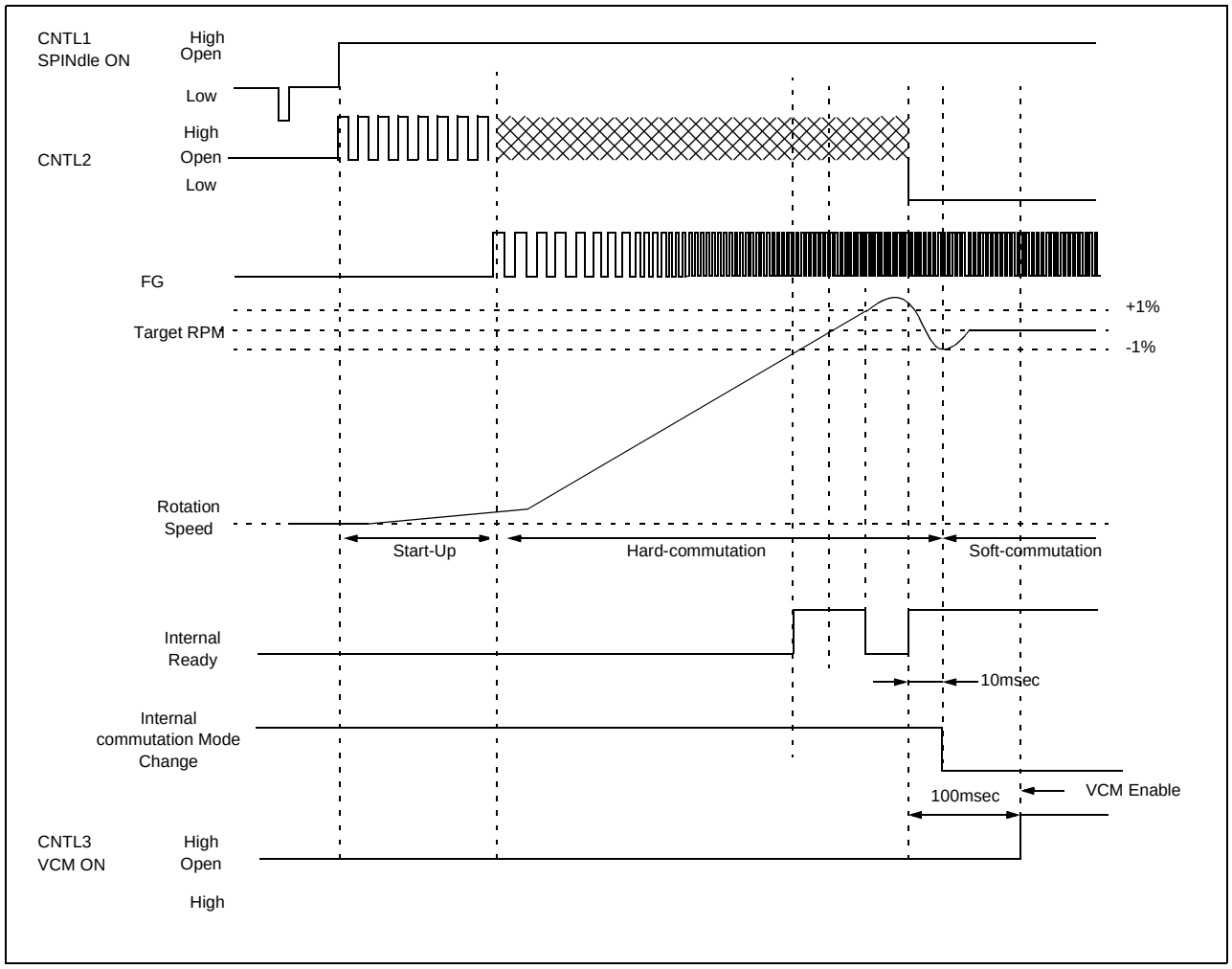


Figure 5. Motor start-up sequence

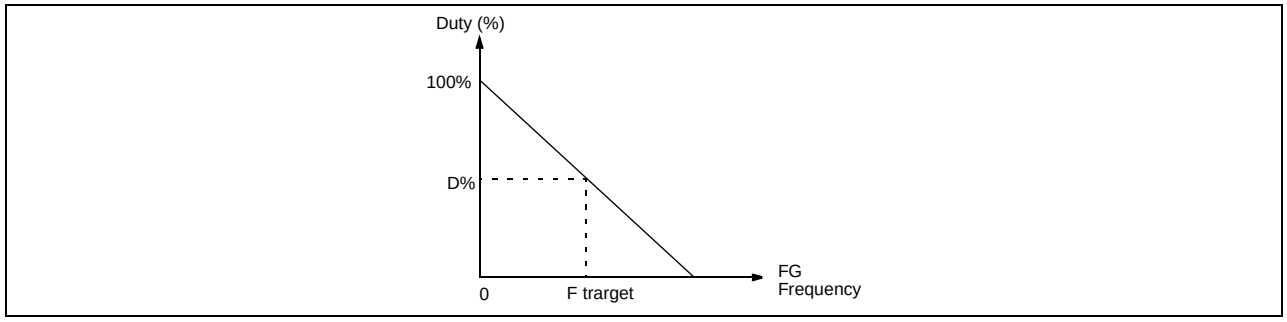


Figure 6. FG vs PWMSP duty variation

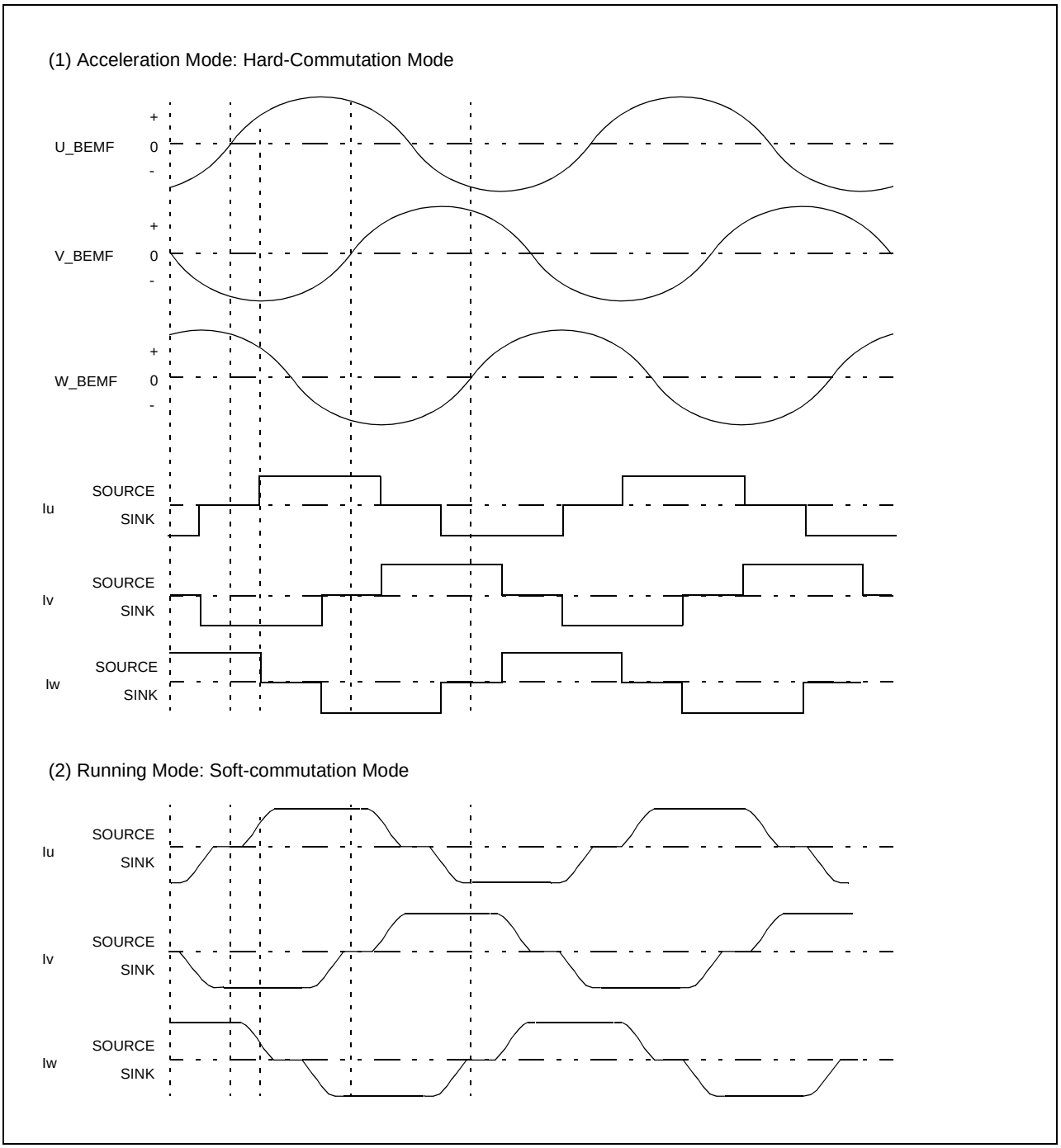


Figure 7. Acceleration and running the spindle motor

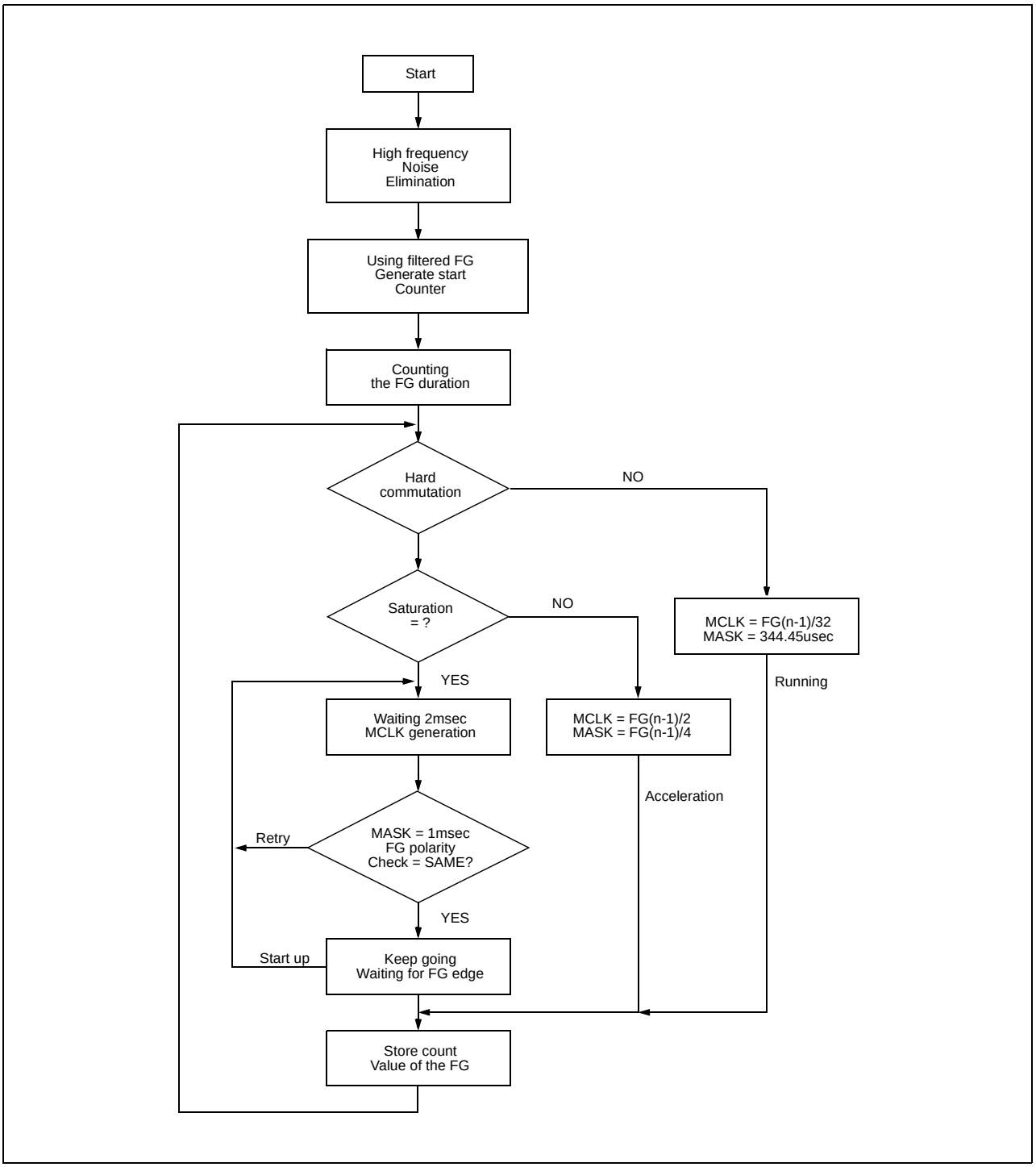


Figure 8. MCLK generation flow chart

Voice Coil Motor

VCM Driver

The voice coil motor driver is linear, class AB, H-bridge type driver, It includes all power transistors. After the VCM is enabled via CNTL3, the VCM current level is controlled by two PWM signals. The input voltage level at pin PWMH weighs, at a maximum, 64 times more than the input voltage at pin PWML. These PWM signals are filtered by an internal second-order low-pass filter and converted into PWMOUT (DC Voltage). The filter PWMOUT depends only on the duty cycle and not on the logic level. The PWM Filter's pole is adjustable by pin CFVCM connected to the external capacitor.

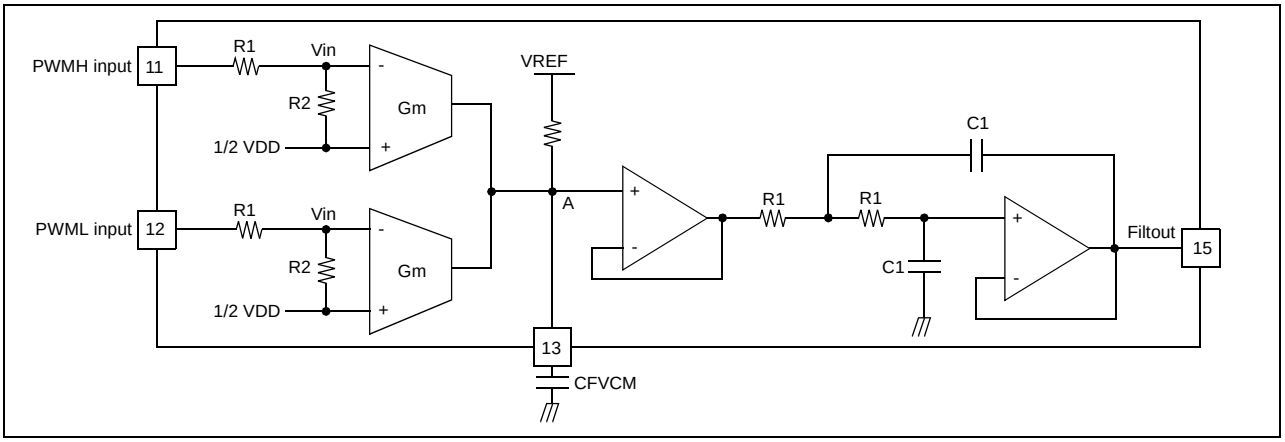


Figure 9. PWM decoder & filter schematic 2

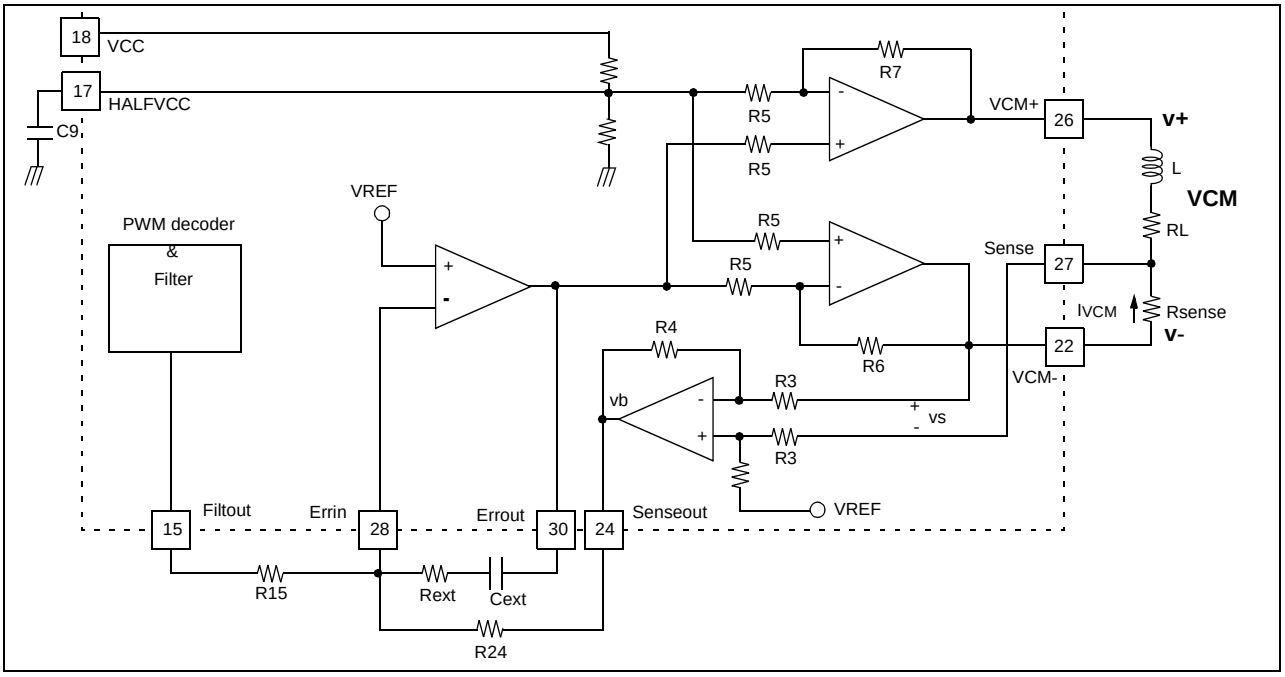


Figure 10. VCM driver schematic

The transconductance of VCM amplifier gain, Gm, is:

$$Gm = \frac{I_{VCM}}{Vin} = \frac{2 \cdot Aerror \cdot Apower \cdot R24}{2 \cdot R15 \cdot Rsense \cdot As \cdot Aerror \cdot Apower + (R15 + R24)(Z_{VCM} + Rsense)}$$

$$Gm = \frac{Aloop}{1 + Aloop}\left(\frac{R24}{R15}\frac{1}{Rsense}\frac{1}{As}\right)$$

$$Aloop = \frac{2 \cdot R15 \cdot As \cdot Aerror \cdot Apower}{(R15 + R24)(Z_{VCM} + Rsense)}$$

Therefore Aloop >>1,

$$Gm \cong \frac{R24}{R15} \cdot \frac{1}{Rsense} \cdot \frac{1}{As} \cdot 2$$

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

if R15 = R24, Rsense = 1Ω

1 / AS = 0.45

VCM current (I_{VCM}) is:

$$Imotor = 4 \times \left[(PWMH - 0.5) + \frac{1}{64}(PWML - 0.5)\right] \times \frac{R24}{R15} \times \frac{1}{Rsense} \times \frac{1}{AS}$$

Notes:
PWMH = 1 when 100% duty
PWMH = 0.5 when 50% duty
PWMH = 0 when 0% duty

Retract Circuit

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

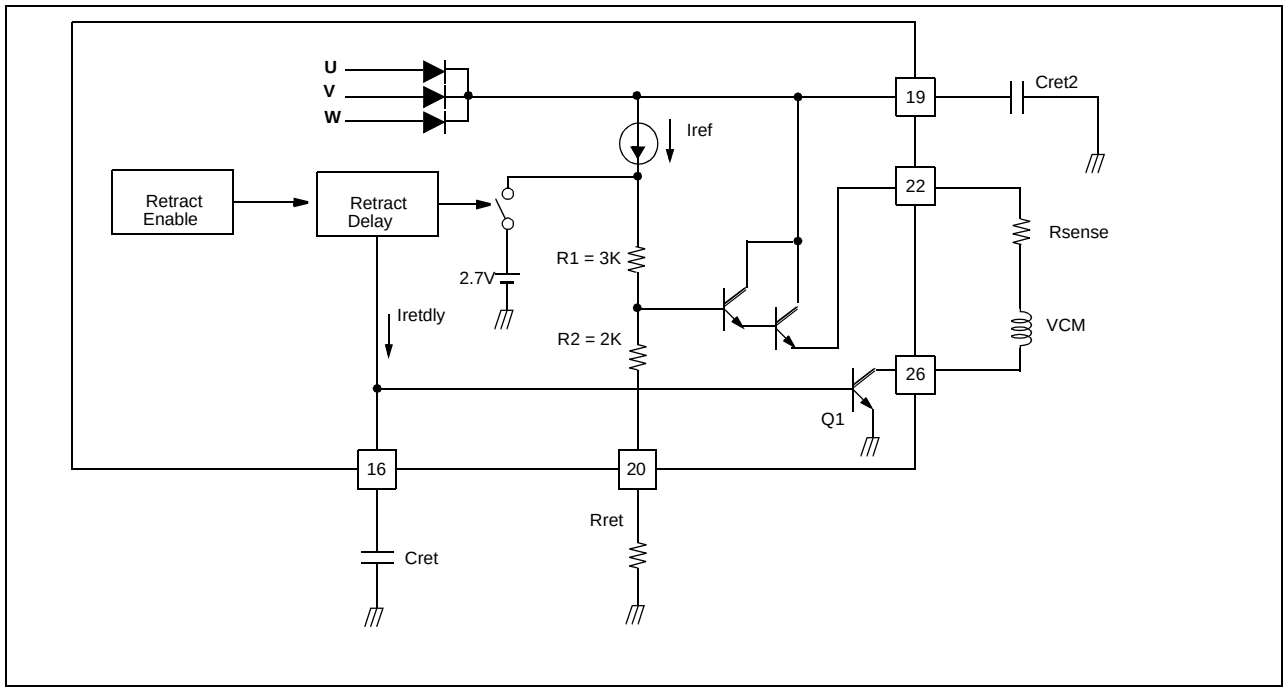


Figure 11. Retract block schematic

$$Iretdly = 10[\mu A]$$

$$V_{Q1,SAT} = 0.2[V]$$

$$Vret = \frac{(R2,Rret)}{R1 + R2 + R_{RET}} \cdot 2.7 - 2V_{BE} - V_{Q1,SAT}[V]$$

$$Tdly = \frac{Cret \cdot V_{BE}}{Iretdly}$$

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.

$$Tdly = CDLY\frac{Vth}{I}, (Vth = 2.5V, I = 14\mu A)$$

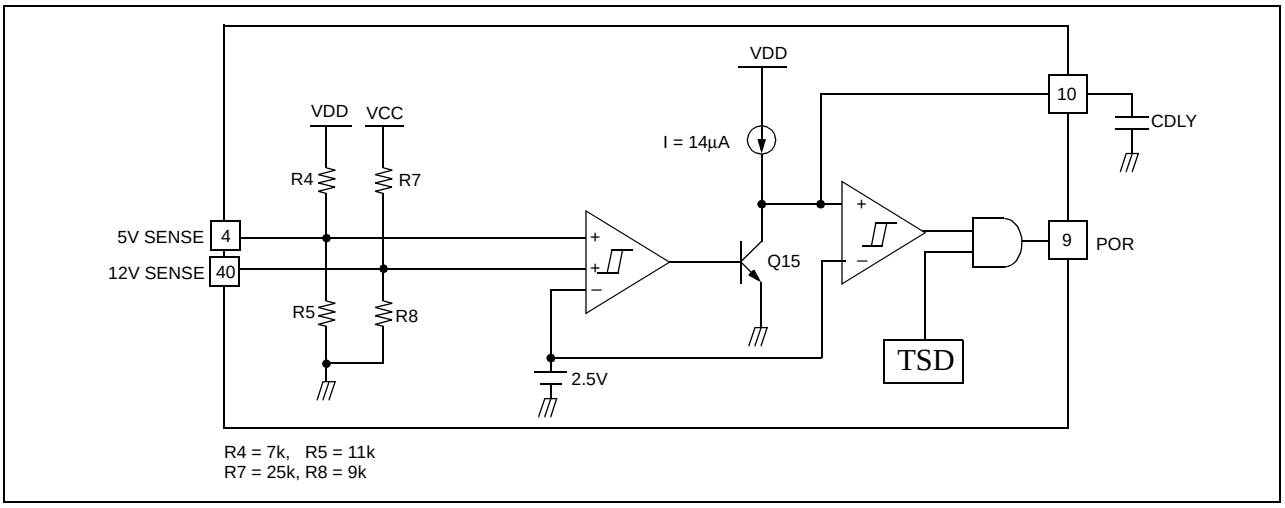


Figure 12. Power on reset block schematic

Power On Reset

The power-on reset circuit monitors the voltage level of both +5V or +12V power supplies and chip temperature (thermal shut down). The power-on reset circuit disables the spindle, and the whole VCM circuit when the power supply voltage level drops below the reference voltage.

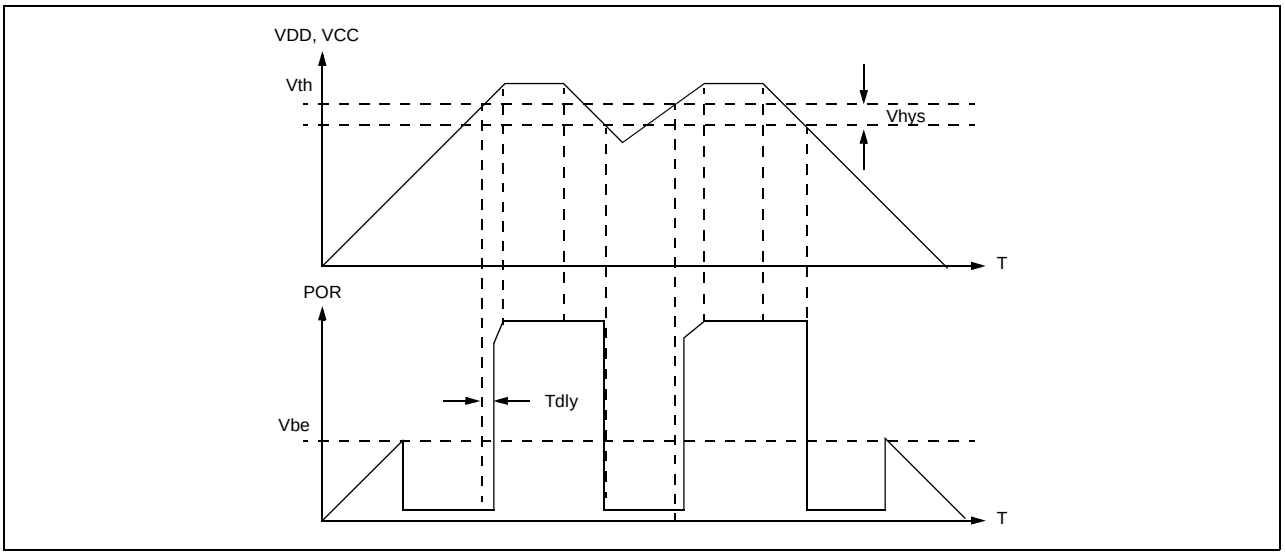


Figure 13. Power on reset function

$$Vhys = 53mV$$

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

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

Default (pin4, pin42 : not connected)

$$VDD, th \cong 4.1V$$
$$VCC, th \cong 9.4V$$

$$VDD;Vhys(5V) = \frac{7k + 11k}{11k} \times 53mV \cong 90mV$$

$$VDD;Vhys(12V) = \frac{25k + 9k}{9k} \times 53mV \cong 200mV$$

Regulator

The FAN8623 includes the voltage regulator for ASIC and other circuits. It consists bias circuit, the band gap reference and the external NPN power transistor. The regulator voltage can be adjusted by the external resistor, R3a, R3b.

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

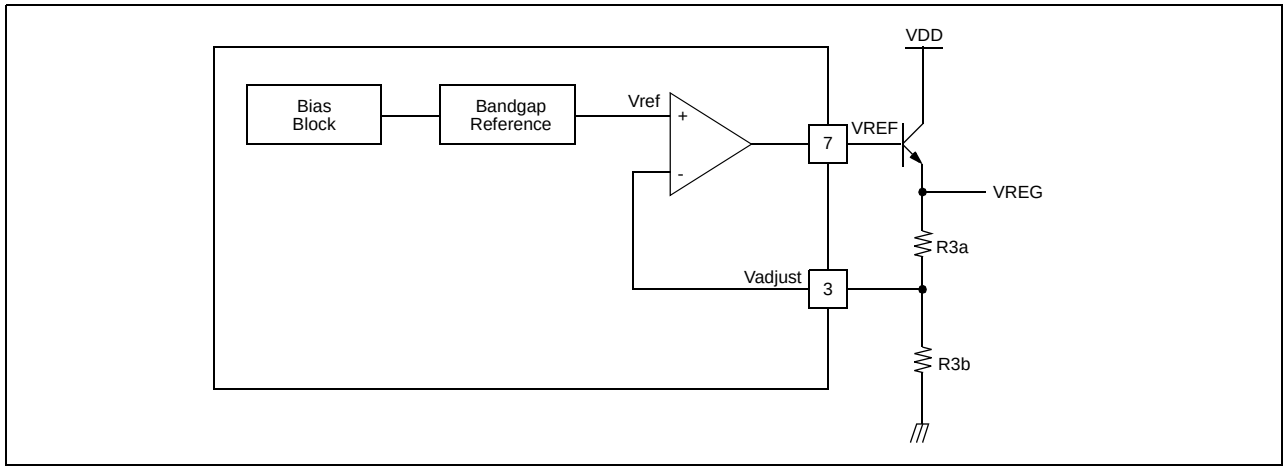


Figure 14. low drop regulator schematic

if R3a = 20k, R3b = 13k

$$Vreg = Vref\left(1 + \frac{R3a}{R3b}\right) = 1.3 \times \left(1 + \frac{20k}{13k}\right) = 3.3V$$

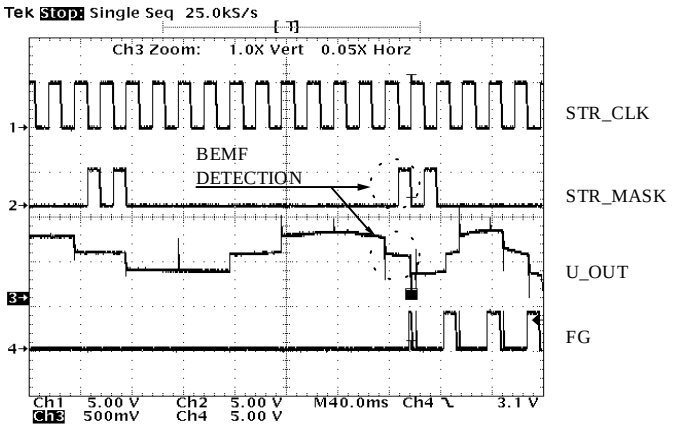


Figure 15. Start-up mode

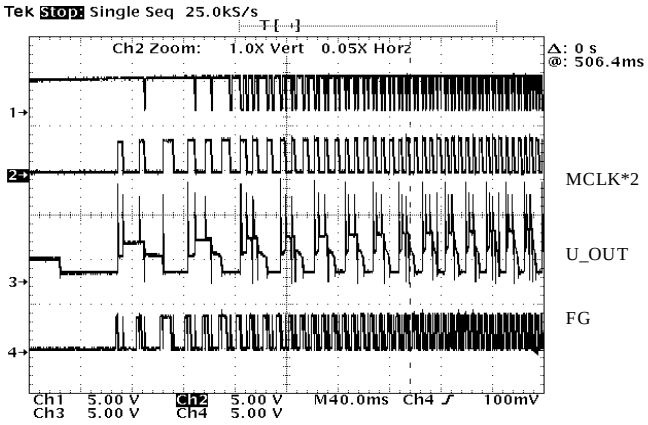


Figure 16. Acceleration mode 1

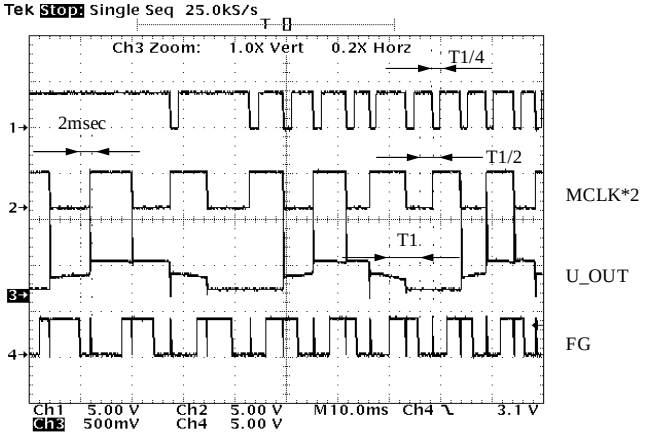


Figure 17. Acceleration mode 2

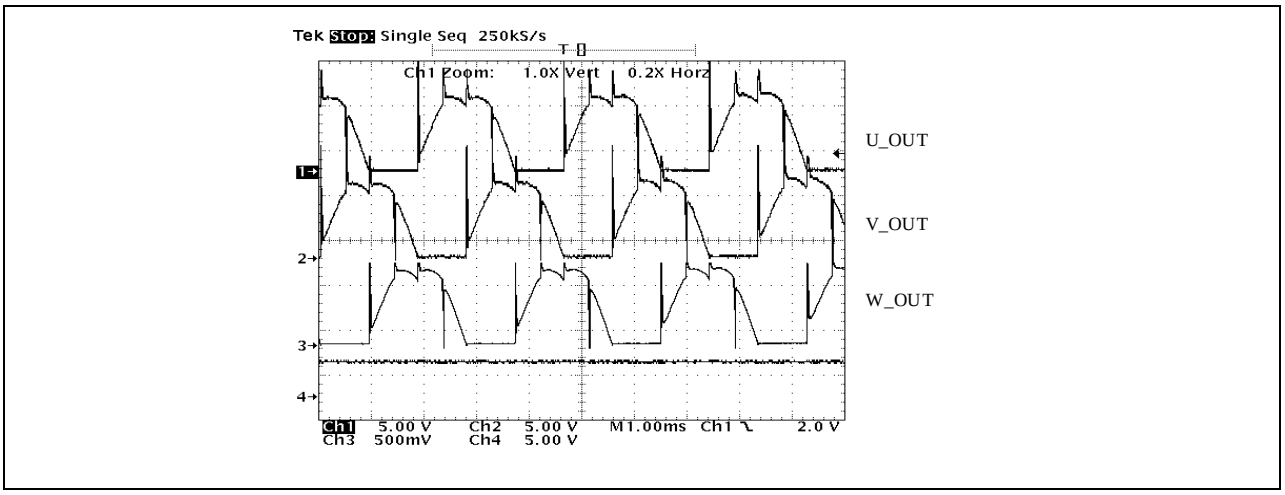


Figure 18. Output in hard-commutation mode

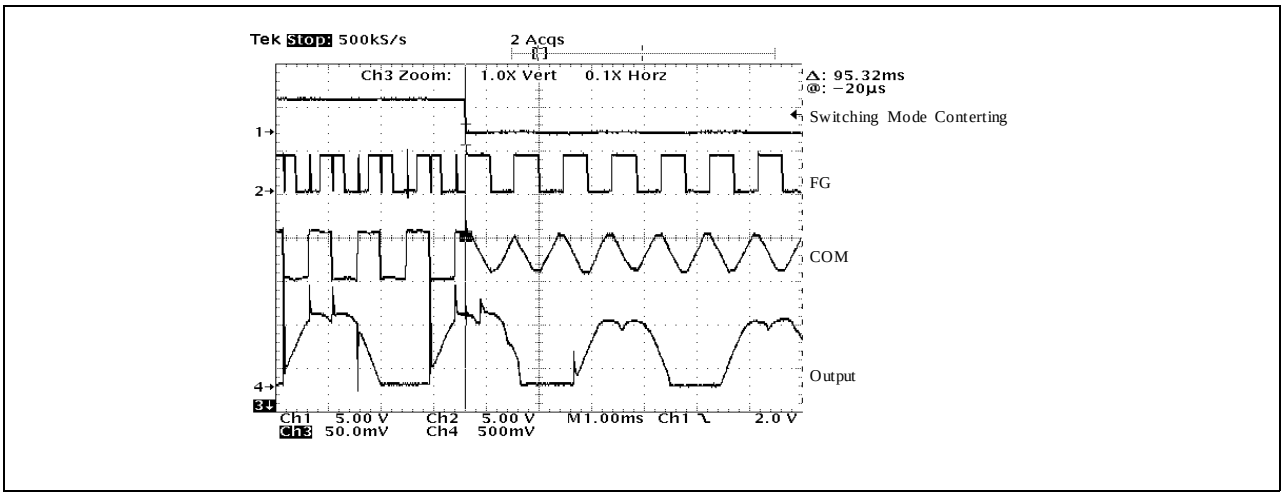


Figure 19. commutation mode converting

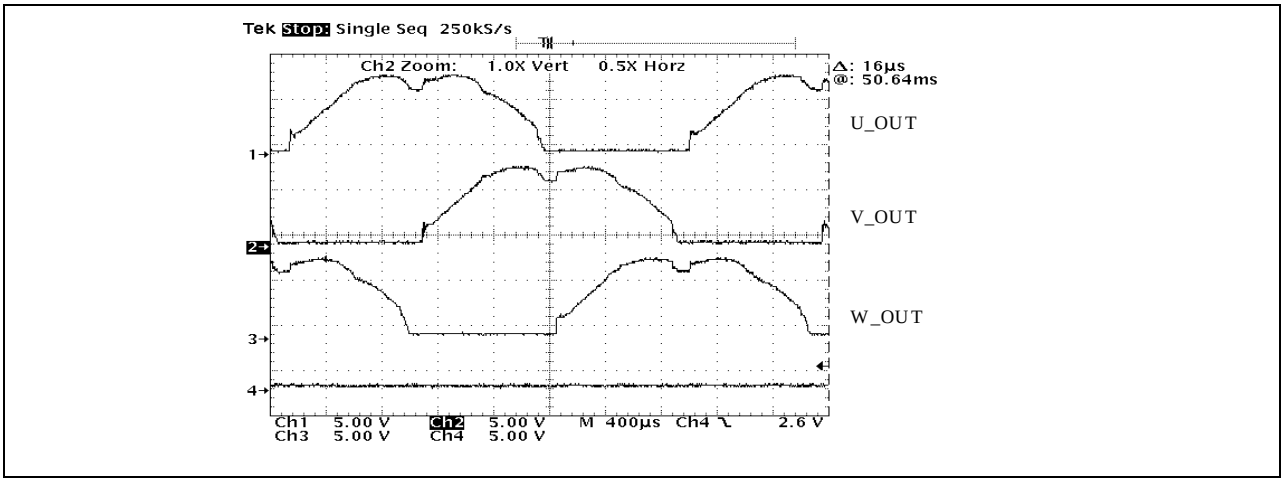


Figure 20. Soft-commutation mode

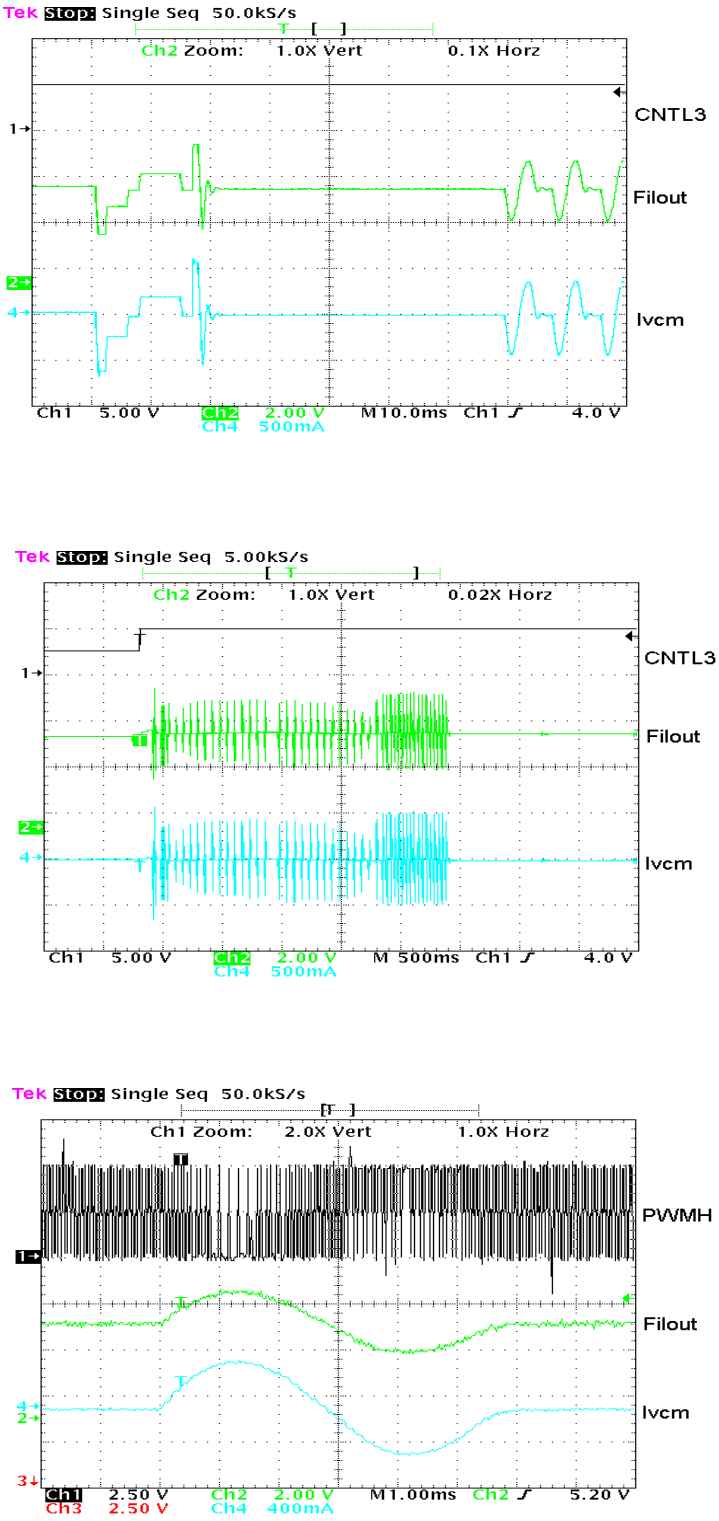
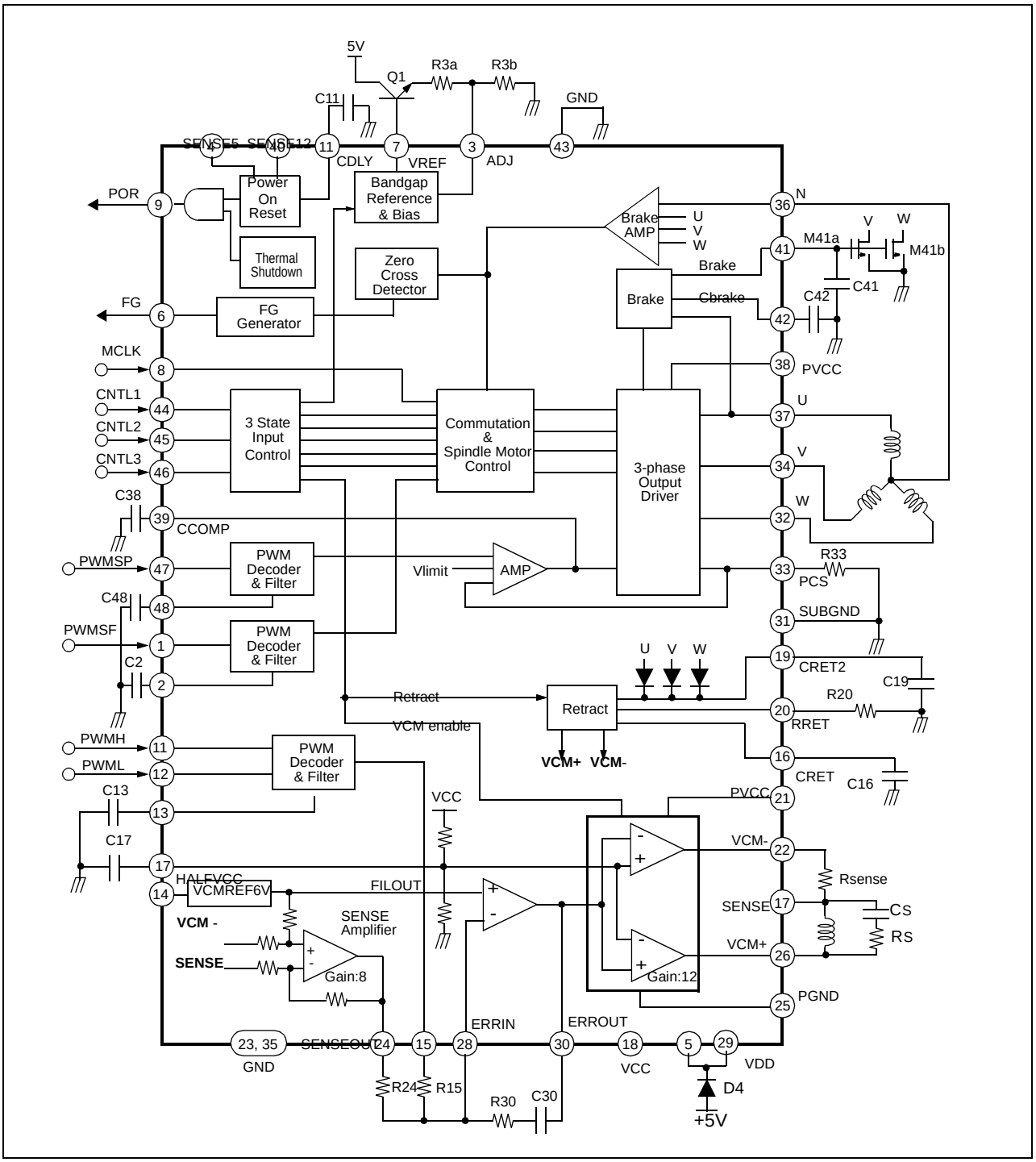


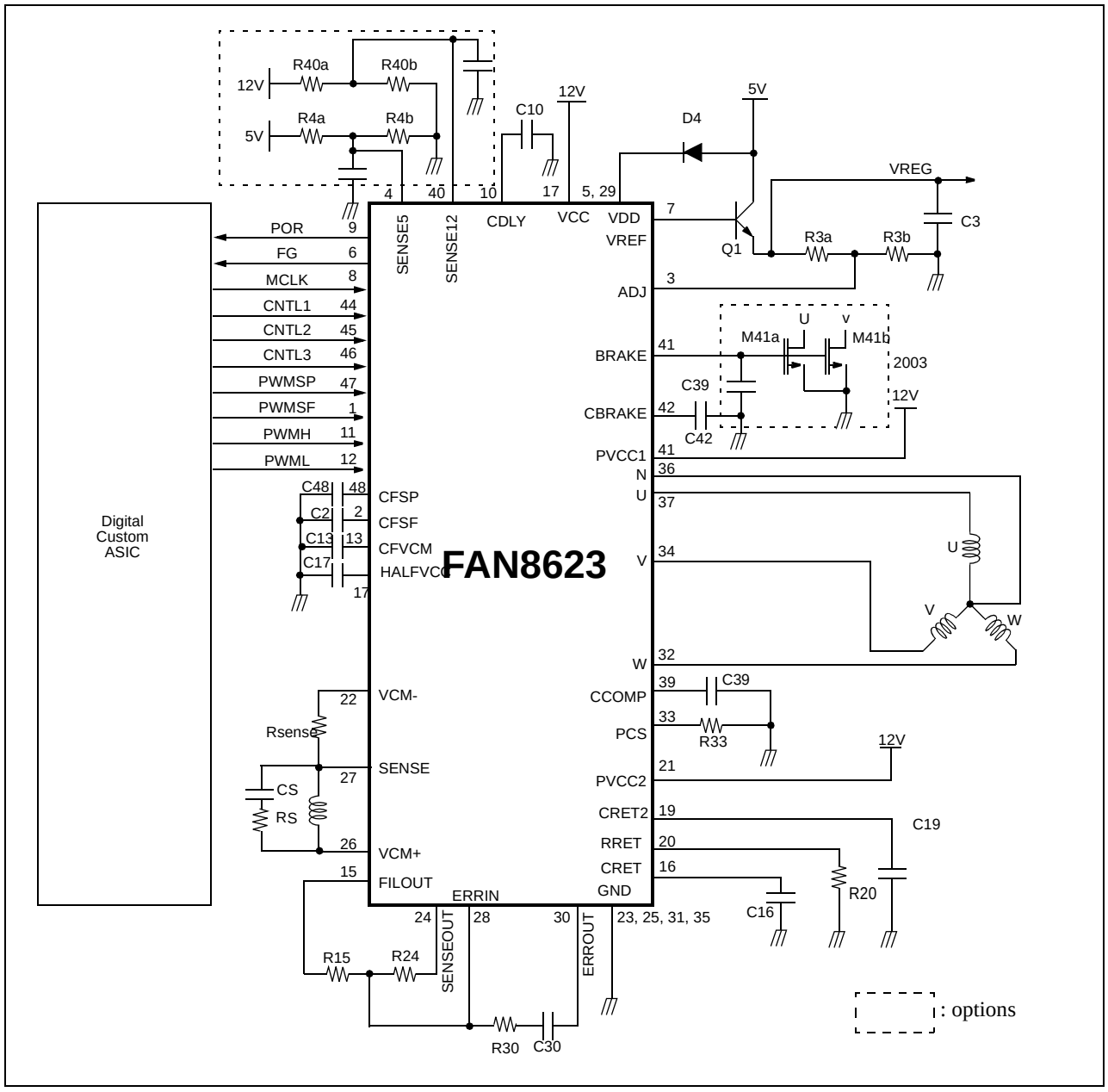
Figure 21. VCM recalibration flow

Preliminary Specification

Typical Application Circuits



Application Circuits



Preliminary Specification

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