MITSUBISHI SEMICONDUCTORS

M63013FP

SPINDLE MOTOR AND 4CH ACTUATOR DRIVER

[FEATURES]

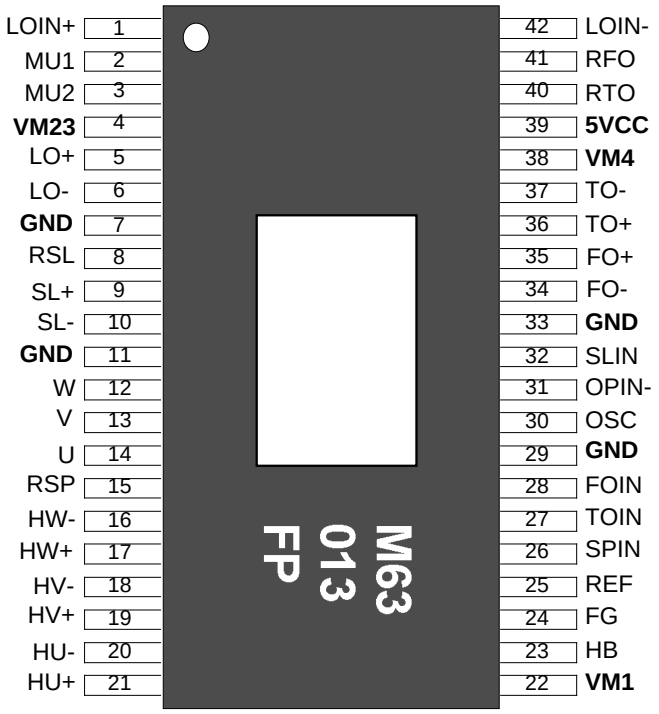
This IC is 1 chip driver IC for spindle motor and 4 channel actuators. All of the motor and actuator of optical disk drive system (CD-ROM etc.) can be drived by only this IC.

This IC has current control drive system for Focus, Tracking, Spindle and Slide channel drive, also has a direct PWM control system for Spindle and Slide channels drive due to reducing IC power dissipation.

This IC has three voltage supply terminals (for Spindle, Slide/Loading and Focus/Tracking) , and these voltage supply can be set separately.

Further more this IC has an operational amplifier for Slide input, FG amplifier, thermal shut down circuit, standby circuit, channel select function, reverse rotation detect circuit and Short braking select.

PIN CONFIGURATION (Top View)

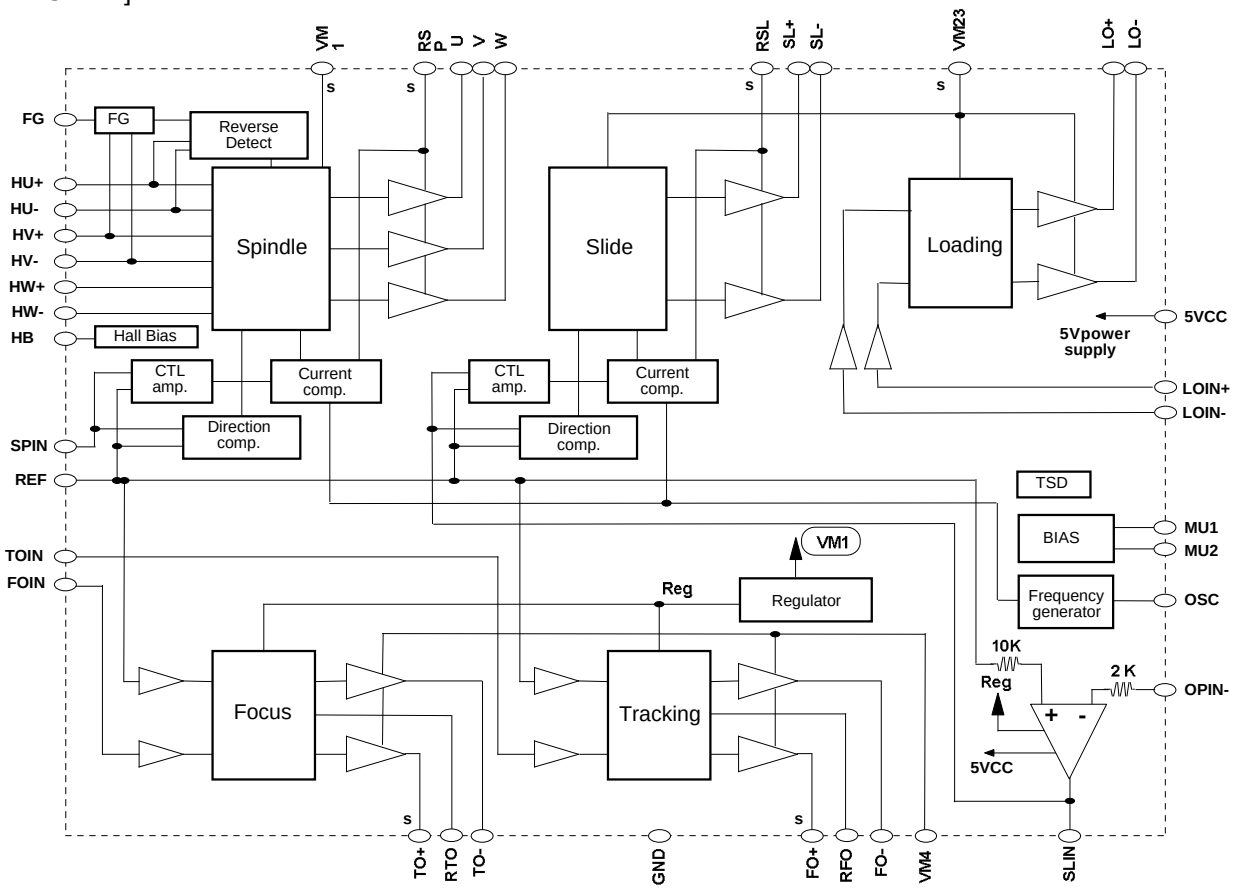


Package outline : 42 PIN POWER SSOP (42P9R-B)

[APPLICATION]

CD-ROM, DVD, DVD-ROM, DVD-RAM ,Optical disc related system,etc

[BLOCK DIAGRAM]



[PIN FUNCTION]

TERMINAL	SYMBOL	TERMINAL FUNCTION	TERMINAL	SYMBOL	TERMINAL FUNCTION
1	LOIN+	Loading control input(+)	**42**	LOIN-	Loading control input(-)
2	MU1	mute 1	**41**	RFO	Current feedback terminal for Focus
3	MU2	mute 2	**40**	RTO	Current feedback terminal for Tracking
4	VM23	Motor Power Suppry 3(for Slide/Loading)	**39**	5VCC	5V Power Suppry
5	LO+	Loading non-inverted output	**38**	VM4	Motor Power Suppry 4(for FS and TS)
6	LO-	Loading inverted output	**37**	TO-	Tracking inverted output
7	GND	GND	**36**	TO+	Tracking non-inverted output
8	RSL	Slide current sense	**35**	FO+	Focus non-inverted output
9	SL+	Slide non-inverted output	**34**	FO-	Focus inverted output
10	SL-	Slide inverted output	**33**	GND	GND
11	GND	GND	**32**	SLIN	Slide control input
12	W	Motor drive output W	**31**	OPIN-	Operational amplifier imverted input
13	V	Motor drive output V	**30**	OSC	PWM carrier oscilation set
14	U	Motor drive output U	**29**	GND	GND
15	RSP	Spindle current sensie	**28**	FOIN	Focus control voltage input
16	HW-	HW- sensor amp. input	**27**	TOIN	Tracking control voltage input
17	HW+	HW+ sensor amp. input	**26**	SPIN	Spindle control voltage input
18	HV-	HV- sensor amp. input	**25**	REF	Reference voltage input
19	HV+	HV+ sensor amp. input	**24**	FG	Frequency generator output
20	HU-	HU- sensor amp. input	**23**	HB	Bias for Hall Sensor
21	HU+	HU+ sensor amp. input	**22**	VM1	Motor Power Suppry 1(for Spindle)

[ABSOLUTE MAXIMUM RATING] (Ta=25ºC)

SYMBOL	PARAMETER	CONDITIONS	RATING	Unit
5VCC	5V power supply		7	V
VM1	Motor power supply 1	Spindle power supply	15	V
VM23	Motor power supply 23	Slide and Loading power supply	15	V
VM4	Motor power supply 4	Focus and Tracking power supply	15	V
IoA	Motor Output Current A	Spindle and Slide output current with external shottky diode ***note 1**	1.2	A
IoB	Motor Output Current B	Focus,Tracking and Loading output current ***note 1**	1.0	A
Vin	Maximum input voltage of terminals	MU1,MU2,Hw-,Hw+,Hv-,Hv+,Hu-,Hu+,REF, SPIN,TOIN,FOIN,OSC,OPIN-,LOIN-,LOIN+	0 to 5VCC	V
Pt	Power dissipation	Free Air and on the grass epoxy board	2.6	W
Kθ	Thermal derating	Free Air and on the grass epoxy board	20.8	mW / ºC
Tj	Junction temperature		150	ºC
Topr	Operating temperature		-20 to +75	ºC
Tstg	Storage temperature		-40 to +150	ºC

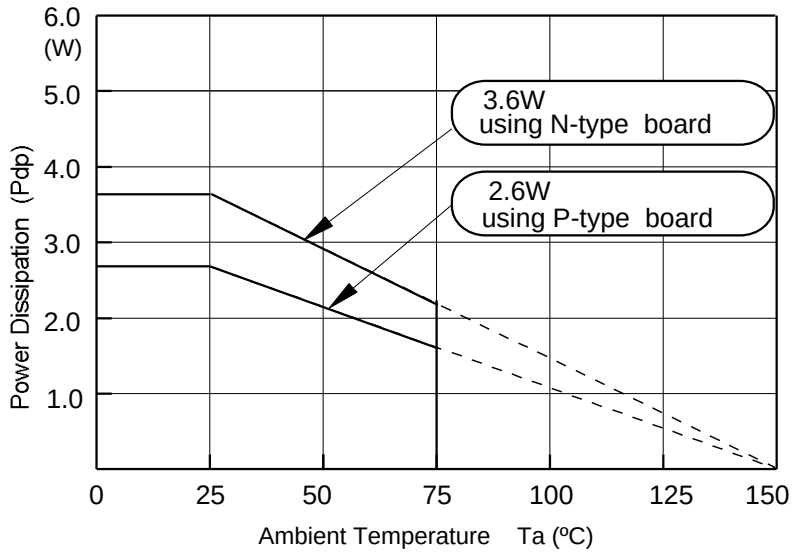
***note1 ; The ICs must be operated within the Pt (power dissipation) or the area of safety operation**
The spindle and slide output terminal is needed external shottky diode between each output and GND when it is used above 0.6A. Discription(IoA) is case of with external shottky diode.

[RECOMMENDED OPERATING CONDITIONS] (Ta=25ºC)

SYMBOL	PARAMETER	LIMITS			Unit
		minimum	typical	maximum	
VM1	VM1 power supply(for Spindle)	6	12	13.2	V
VM23	VM23 power supply(for Slide and Loading)	4.5	12	13.2	V
VM4	VM4 power supply(for Focus and Tracking)	4.5	5	13.2	V
IoA	**Spindle and Slide Output Current** ***note2**	—	0.5	1.0	A
IoB	Focus, Tracking and Loading Output Current	—	0.5	0.8	A
Fosc	Motor power supply 2	30	—	120	KHz

***note2**
The spindle and slide output terminal is needed external shottky diode between each output and GND when it is used above 0.6A. Discription(IoA) is case of with external shottky diode.

[THERMAL DERATING]



This IC's package is POWER-SSOP, so improving the board on which the IC is mounted enables a large power dissipation without a heat sink.

For example, using an 1 layer glass epoxy resin board, the IC's power dissipation is 2.6W at least. And it comes to 3.6W by using an improved 2 layer board.

The information of the N, P type board is shown in attached.

[ELECTRICAL CHARACTERISTICS]

Common

(Ta=25ºC, 5VCC=VM4=5V,VM1=VM23=12V unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	LIMITS			Unit
			MIN	TYP	MAX	
Icc1	Supply current	5VCC,VM1, VM23, VM4 current	—	60	78	mA
Icc2	Sleep current	5VCC,VM1, VM23, VM4 current under Sleep (MU1 = MU2 =0V)	—	—	30	µA
Fosc	PWM carrier frequency	OSC : with 180pF	—	110	—	KHz
VinOP	OPamp input voltage range	OPIN-	0	—	5	V
IinOP	OPamp input current	OPIN-=1.65V	-1.0	-0.15	0	µA
VofOP	OPamp input offset voltage	REF=1.65V(OPIN-=OPOUT ;buffer)	-10	—	+10	mV
VoutOP	OPamp output voltage range	Io=-2.0 to +2.0mA	0.5	—	4.5	V
VinREF	REF input voltage range		1.0	—	3.3	V
IinREF	REF input voltage range	VREF=1.65V	-10	—	+10	µA
VMULO	MUTE terminal low voltage	MU1,MU2	—	—	0.8	V
VMUHI	MUTE terminal high voltage	MU1,MU2	3.0	—	—	V
IMU	Mute terminal input current	MU1,MU2 at 5V input voltage	—	—	500	µA

[ELECTRICAL CHARACTERISTICS]

Spindle

(Ta=25ºC, 5VCC=VM4=5V,VM1=VM23=12V unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS	LIMITS MIN	LIMITS TYP	LIMITS MAX	Unit
Vdyc1	Dynamic range of output	Io=0.5 [A]	10.3	10.8	—	V
Vdead1-	**Control voltage dead zone 1**	SPIN<REF [REVERSE]	-80	-40	0	mV
Vdead1+		REF<SPIN [FORWARD]	0	+40	+80	mV
Vin1	**Control voltage input range 1**	SPIN	0	—	5	V
Gvo1	Control gain 1	Gio1=Gvo1/ Rs [A/V]	0.85	1.0	1.15	V/V
Vlim1F	Control limit 1F	Ilim1F=Vlim1F/ Rs [A] [FORWARD]	0.4	0.5	0.6	V
Vlim1R	Control limit 1R	Ilim1R=Vlim1R/ Rs [A] [REVERSE]	0.27	0.34	0.41	V
VHcom	Hall sensor amp. common mode input range	Hu+,Hu-,Hv+,Hv-,Hw+ ,Hw-	1.3	—	3.7	V
VHmin	Hall sensor amp input signal level	Hu+,Hu-,Hv+,Hv-,Hw+ ,Hw-	60	—	—	mVp-p
VHB	HB output voltage	at Load current (IHB)=10mA	0.6	0.85	1.2	V
IHB	HB terminal sink current	MU1=MU2=0V or MU1=MU2=5V or MU1=5V/MU2=0V	—	—	30	mA

Slide

(Ta=25ºC, 5VCC=VM4=5V,VM1=VM23=12V unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS		LIMITS MIN	LIMITS TYP	LIMITS MAX	Unit
Vdyc2	Dynamic range of output	Io=0.5 [A]	at VM23=5[V]	3.3	3.8	—	V
			at VM23=12[V]	10.3	10.8	—	
Vdead2-	Control voltage dead zone 2	SLIN < REF		-80	-40	0	mV
Vdead2+		REF < SLIN		0	+40	+80	mV
Vin2	Control voltage input range 2	SLIN		0	—	5	V
Gvo2	Control gain 2	Gio2=Gvo2/ Rs [A/V]		0.85	1.0	1.15	V/V
Vlim2	Control limit 2	Ilim2=Vlim2/ Rs [A]		0.43	0.5	0.58	V
Tdon	Output turn-on delay			—	1.0	2.0	µsec
Tdoff	Output turn-off delay			—	3.5	7.0	µsec
Tdsw	Output switching delay			—	5.0	10.0	µsec
Ileak	Output leak current	MU1=MU2=5v,MU1=MU2=0v		-100	—	100	µA

[ELECTRICAL CHARACTERISTICS]

Loading

(Ta=25ºC 5VCC=VM4=5V,VM1=VM23=12V unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS		LIMITS MIN	LIMITS TYP	LIMITS MAX	Unit
Vdyc3	Dynamic range of output	Io=0.5[A]	VM23=5[V]	3.3	3.8	—	V
			VM23=12[V]	10.3	10.8	—	
Vin3	**Control voltage input range3**	LOIN+,LOIN-		0	—	5	V
Gvo3	Control gain 3	$\frac{(LO+) - (LO-)}{(LOIN+) - (LOIN-)}$		16.6	18	19.3	dB
Voff1	Output offset voltage	(LO+) - (LO-)	LOIN+=LOIN-=5V	-100	0	+100	mV
			LOIN+=LOIN-=1.65V	-50	0	+50	mV

Focus / Tracking

(Ta=25ºC, 5VCC=VM4=5V,VM1=VM23=12V unless otherwise noted.)

SYMBOL	PARAMETER	CONDITIONS		LIMITS MIN	LIMITS TYP	LIMITS MAX	Unit
Vdyc4	Dynamic range of output	Io=0.5[A] VM1=12[V]	VM4=5[V]	3.8	4.2	—	V
			VM4=12[V]	6.8	7.6	—	
Vin4	**Control voltage input range 4**	FOIN,TOIN		0	—	5	V
Gvo4	Control gain 4	$\frac{RFO\ (RTO)-FO-(TO-)}{FOIN(TOIN)-REF}$		-6.7	-8.0	-9.4	dB
Voff2	Output offset voltage	RFO (RTO)-FO-(TO-) at REF=FOIN(TOIN)=1.65V		-5	0	+5	mV

[THERMAL CHARACTERISTICS]

SYMBOL	PARAMETER	FUNCTION START TEMPERATURE OF IC MIN	FUNCTION START TEMPERATURE OF IC TYP	FUNCTION START TEMPERATURE OF IC MAX	FUNCTION STOP TEMPERATURE OF IC MIN	FUNCTION STOP TEMPERATURE OF IC TYP	FUNCTION STOP TEMPERATURE OF IC MAX	Unit
TSD	Thermal Shut Down	—	160	—	—	130	—	ºC

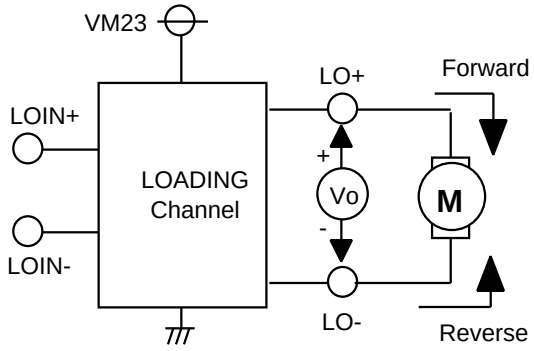
Channel select function

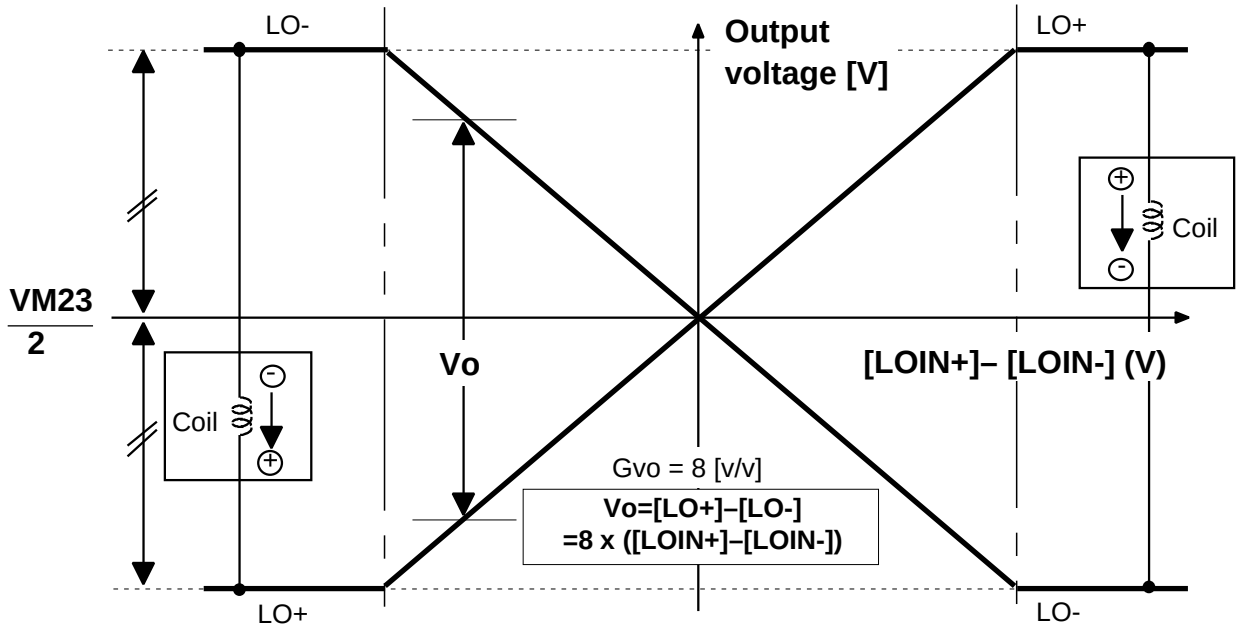
Logic control			Drive channel						Brake select
	MU1	MU2	Loading	Slide	Focus	Tracking	Spindle	Opamp	(SPIN<REF)
SELECT4	H	H	On	On	On	On	On	On	Short
SELECT3	L	H	On	Off	On	On	On	On	Short
SELECT2	H	L	On	On	On	On	On	On	PWM
SELECT1	L	L	Off	Off	Off	Off	Off	Off	--

This IC has two MUTE terminal (MU1 and MU2).
It is possible to control ON / OFF of each channel by external logic inputs.
It has four kinds of function for select.In case of SELECT1, the bias of all circuit becomes OFF.
Therefore, this mode is available in order to reduce the power dissipation when the waiting mode.
In case of SELECT2,it is possible to select the PWM reverse braking to take the brake of Spindle motor.
Also,in case of SELECT4,it is possible to select the short braking when in the same.
In case of SELECT3,it is possible to do OFF the slide channel.
Regard with making OFF the loading channel in case of SELECT2,SELECT3 and SELECT4,please refer to [Loading channel].

Loading channel

The loading channel is the circuit of BTL voltage drive. This circuit has the referential input. Output swing is determined with DVin X 8. Also,it is possible for this channel to use for the slide motor , the focus coil and the tracking coil.
The input terminal is high impedance. It is possible to do variable a gain by external resistor.
The output becomes high impedance in case of both input voltage becomes under 0.5 volts. It is possible for the input terminal to operate from 0 volts.The following table and diagram show an application in case of two MCU port and one MCU port for the loading motor.In case of one MCU port, if use three state port, it is possible for this channel to have the stop function.



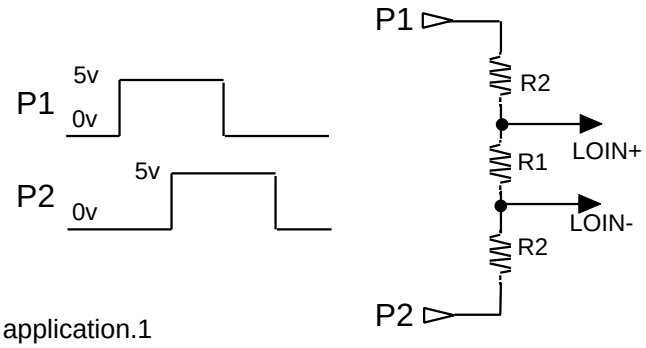


application.1 (MCU :Two port H/L control)

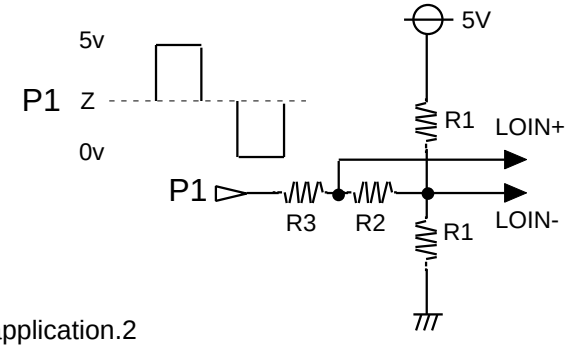
Logic control P1	Logic control P2	Situation of loading channel	Output voltage swing
5V	5V	Short brake --> Stop	Vo= 0 [V]
0	5V	Reverse rotation	Vo= - 8x5xR1/(R1+2xR2)
5V	0	Forward rotation	Vo= 8x5xR1/(R1+2xR2)
0	0	Off [High impedance output]	Off

application.2 (MCU :One port H/Z/L control)

Logic control P1	Situation of loading channel	Output voltage swing
5V	Forward rotation	Vo= - 2.5[V] x8x R2 / (R1/2)+R2+R3
Z (Hi impedance)	Short brake --> Stop	Vo= 0 [V]
0V	Reverse rotation	Vo= - 2.5[V] x8x R2 / (R1/2)+R2+R3



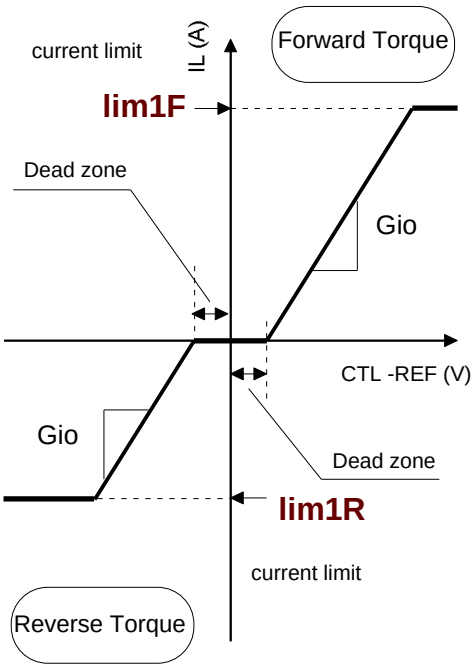
application.1
(Two port H/L control)



application.2
(One port H/Z/L control)

SPINDLE channel

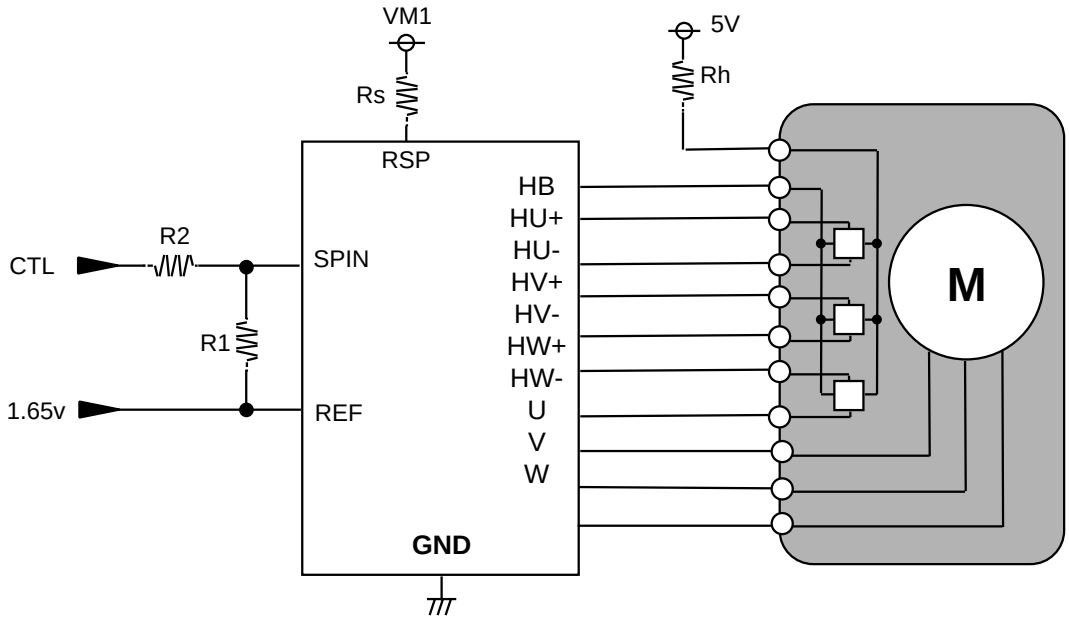
The relationship between the differential voltage between SPIN and REF and the torque is shown in right Figure. The voltage gain[Gvo] is 1.0 [V/V].
The current gain[Gio] is 2.0A/V (at sensing resistor : 0.5 ohm,and R1=∞,R2=0ohm) in forward torque directions, and the dead zone is from 0mV to 80mV (at R1=∞,R2=0ohm) .
The coil current gain under the reverse torque is the same with in forward torque directions.And the limitation function gets on when the differential voltage of VM1(12V) to RSP is 0.5V at forward and 0.3V at reverse.
Therefore current-gain-control and current-limit of this IC is determined with sensing resister value, and more detail control can be determined with setting a gain-resister outer this IC as below.



The example of current-gain and current-limit of SPINDLE.

Rs [W]	Ilim1F [A]	Ilim1R [A]	Gio* [A/V]		
			R1=∞ R2=0 ohm	R1=R2	R1=2•R2
0.50	1.00	0.68	2.00	1.00	0.66
0.75	0.66	0.45	1.33	0.66	0.44
1.00	0.50	0.34	1.00	0.50	0.33

Gio*= R1 / [(R1+R2)•Rs] [A/V]

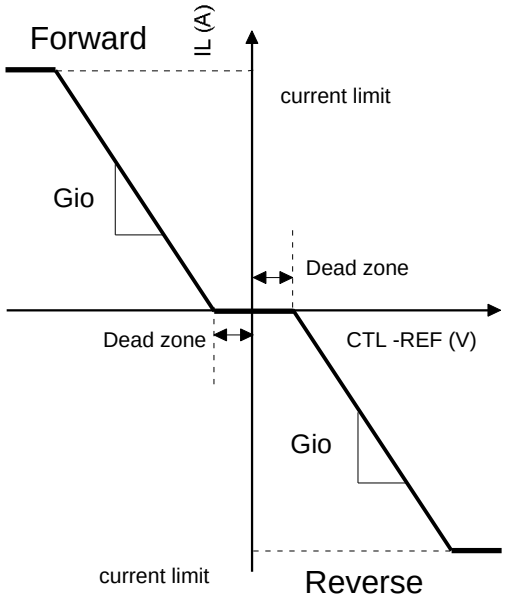


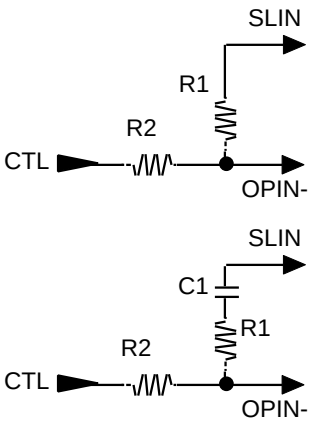
SLIDE channel

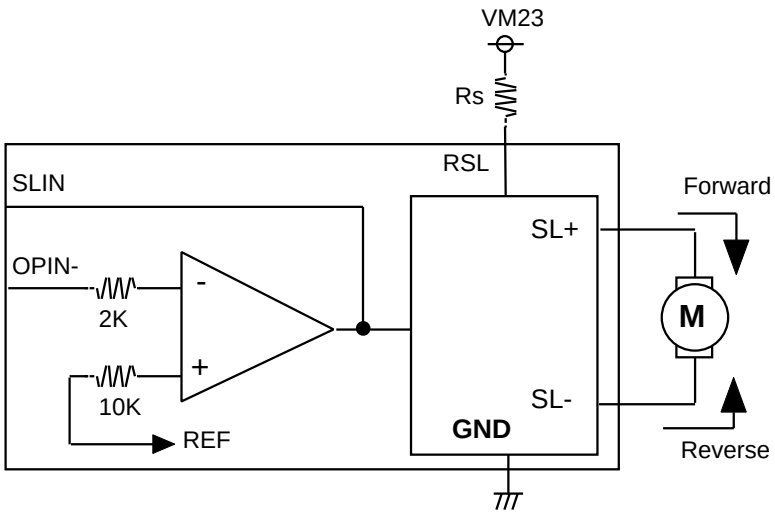
The relationship between the differential voltage between SLIN and REF and the torque is shown in right Figure. The voltage gain[Gvo] is 1.0 [V/V]. The current gain is 2.0A/V (at sensing resistor : 0.5 ohm and R1=R2) in forward torque directions, and the dead zone is from 0mV to 60mV (at R1=R2=16kohm).

The coil current gain under the reverse torque is the same with in forward torque directions.And the limitation function gets on when the differential voltage of VM23(12V) to RSL is 0.5V.

Therefore current-gain-control and current-limit of this IC is determined with sensing resister value.In the input part,built-in an inverted amplifier. It is possible to control more detail by setting external circuit.







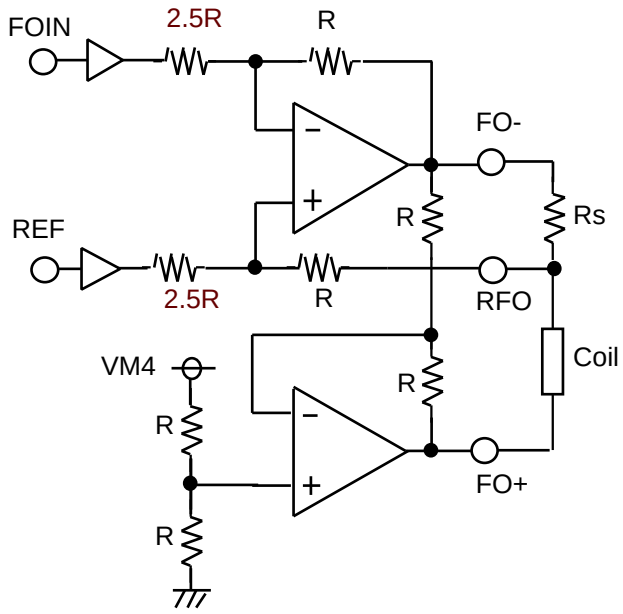
The example of current-gain and current-limit of SLIDE.

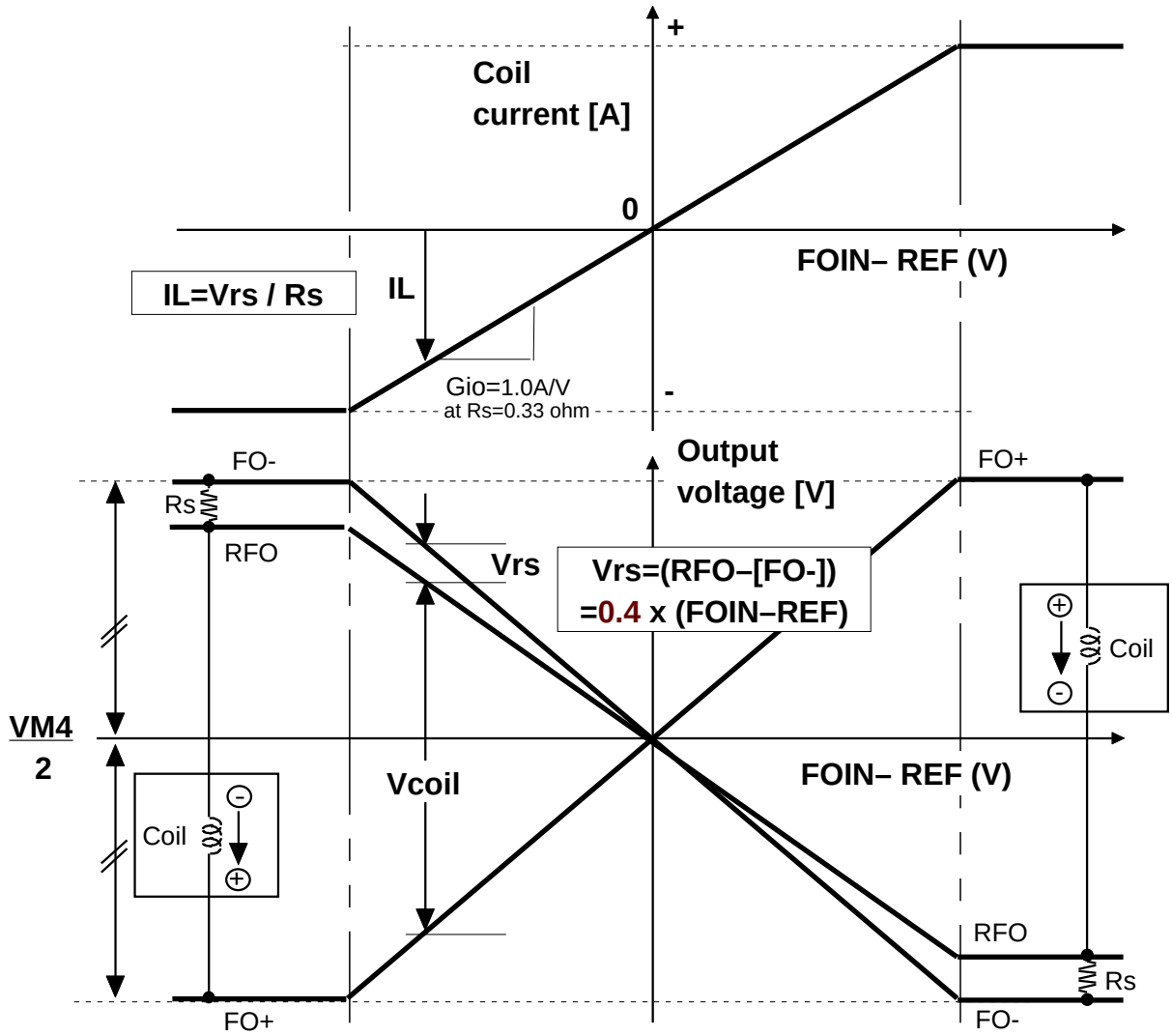
Rs [Ω]	Ilim [A]	Gio* [A/V]	
		R1=R2	2•R1=R2
0.50	1.00	2.00	1.00
0.75	0.66	1.33	0.66
1.00	0.50	1.00	0.50

Gio*= R1 / R2•Rs [A/V]

FOCUS / TRACKING channel

The focus and tracking channel is the current feedback control drive of MITSUBISHI original.The focus and tracking is the same composition.
The relationship between the differential voltage between FOIN and REF and the output current is shown in right Figure.
The voltage gain is 0.4 [V/V].Therefore, the current gain is 0.8[A/V] in case of the sensing resistor is 0.5 ohm.
The maximum range of output swing is limited around 7.5 volts,in case of VM4 is above 10 volts.

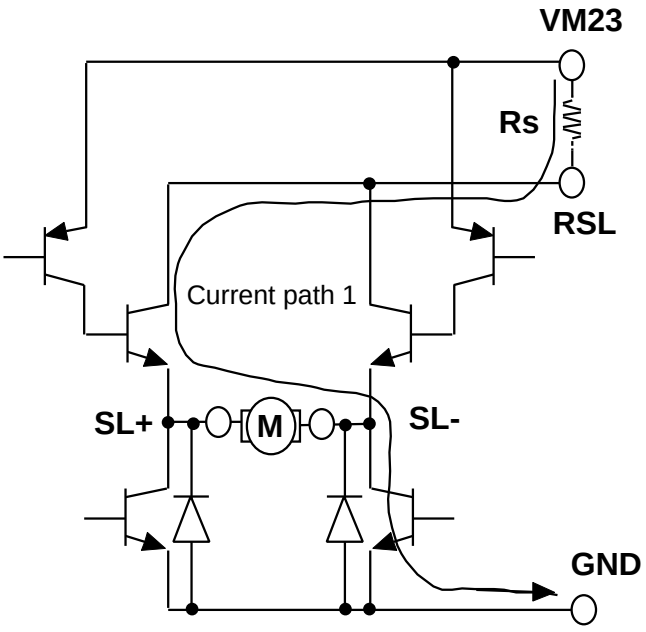




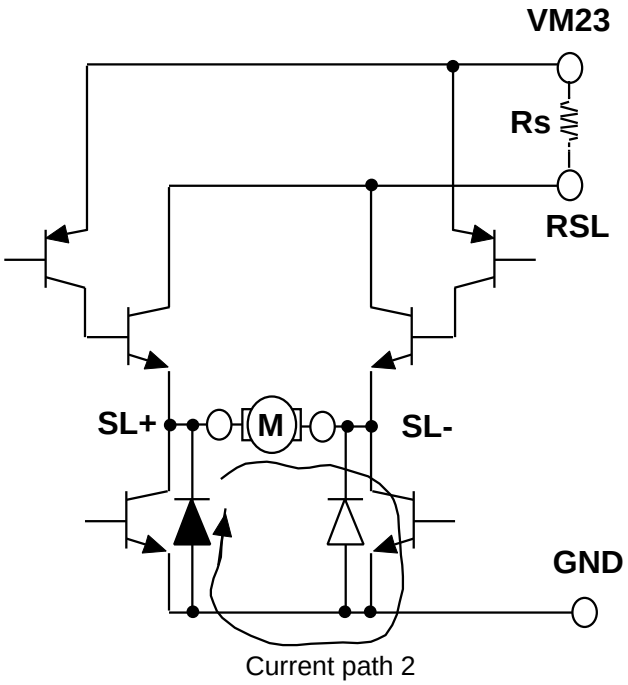
Direct PWM operation

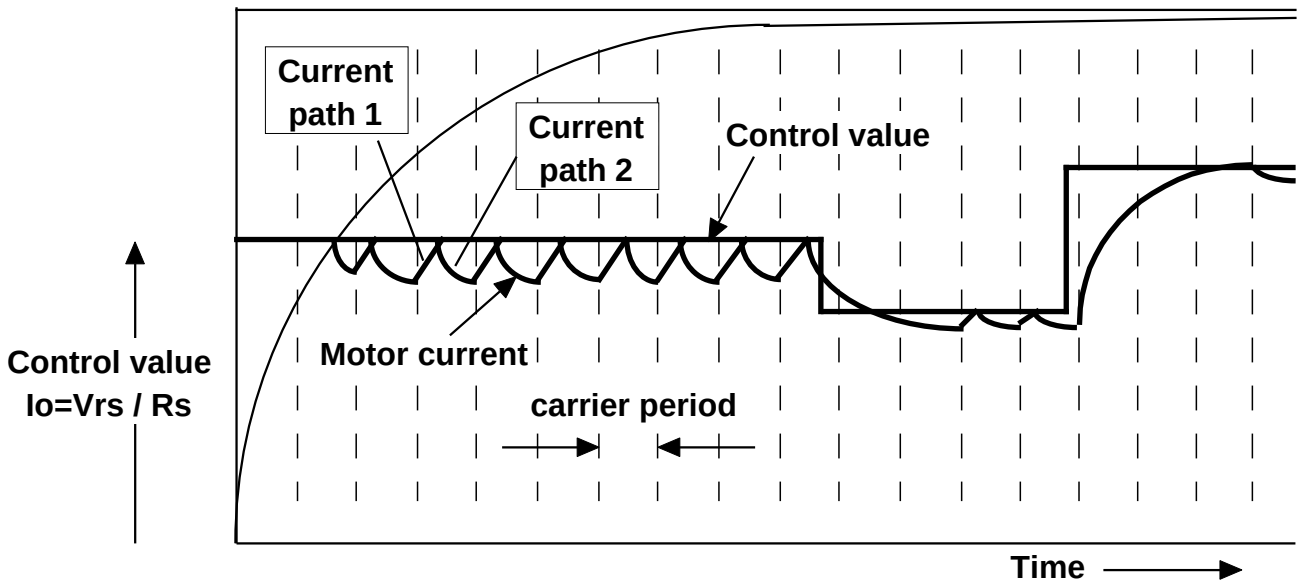
The spindle and the slide channel is controlled by the direct PWM control.
Also,built-in the current limit circuit. This IC controls the motor current directly.

FORWARD Current path timing 1.



FORWARD Current path timing 2.





PWM carrier frequency setting

PWM carrier frequency is decided by charging and discharging the capacitor that is connected to OSC terminal outer IC. Examination of the relationship the capacitor connected to OSC terminal and PWM carrier frequency is given in following table.

Capacitor [pF]	330	220	180	130	110
Carrier Frequency [KHz]	**65**	**90**	**110**	**140**	**160**

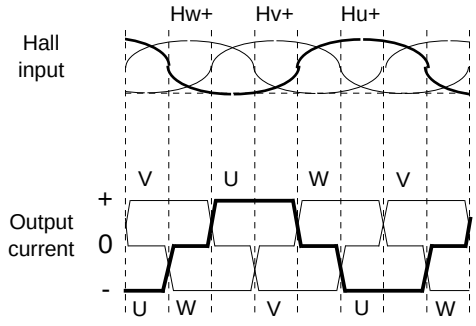
*note) This PWM carrier frequency is TYP value.

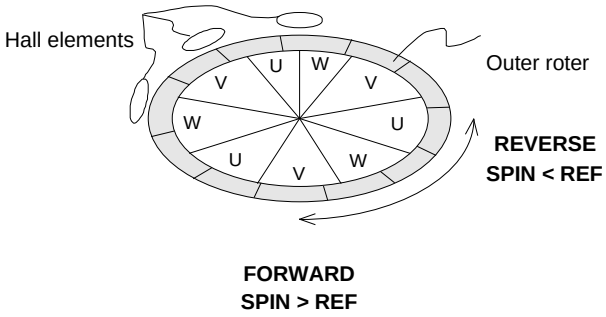
Recommendation of SHORT BRAKE MODE at SPINDLE DRIVE

This IC has two brake mode, PWM-BRAKE-MODE and SHORT-BRAKE-MODE. In this IC recommendation, SHORT-BRAKE-MODE is superior to PWM-BRAKE-MODE to reducing the power dissipation and to avoid braking down of this IC. (By excessive reverse torque current in braking a motor with PWM-BRAKE from high-speed-rotation with being excessive Back-EMF, this IC could be broken.)

The relationship between hall-amplifier-input and output-current-commutation at SPINDLE DRIVE

The relationship between the hall elements and the motor output current is shown in bellow Figure.





FG function at SPINDLE DRIVE

The FG terminal outputs the square pulse signal synchronizing with the Hall inputs [Hv+, Hv-] timing.
And, the FG terminal is open-collector output.

Phase delay circuit at SLIDE

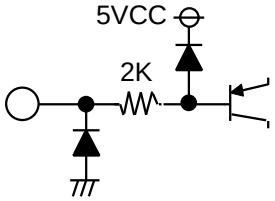
Phase delay circuit is built in the IC to detect an output spike current, when the motor current direction is switching.
In switching the motor current direction, Phase delay circuit switch-off all output trangister of H-bridge for 3µsec.

Output current setting at SLIDE

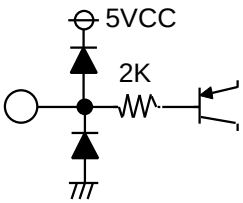
In this IC, since output tranjister is NPN-type tranjister, motor coil current (Io) is larger than sensing resistance current about 20mA (TYP.) according to base current of output tranjister.
Therefore please design output current with consisting these base current.

I/O circuit

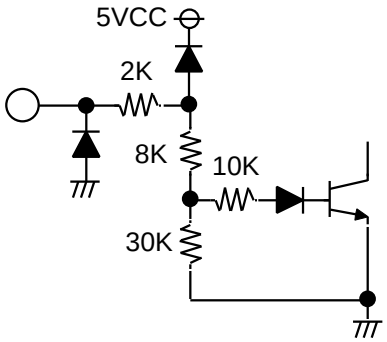
• FOIN, TOIN, SPIN
LOIN+, LOIN-
OPIN-, REF



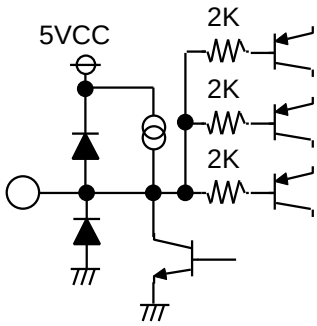
• Hu+, Hu-
Hv+, Hv-
Hw+, Hw-



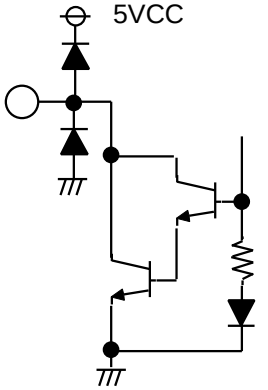
• MU1, MU2



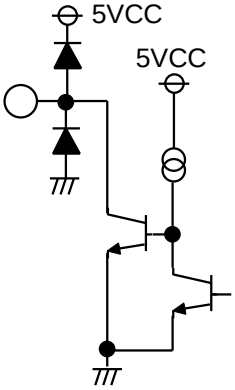
• OSC



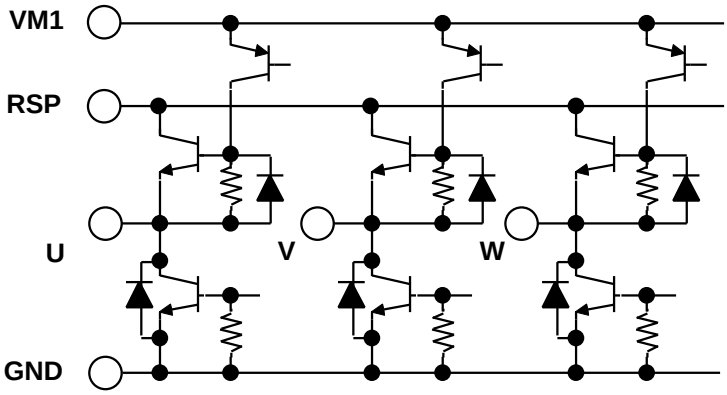
• HB



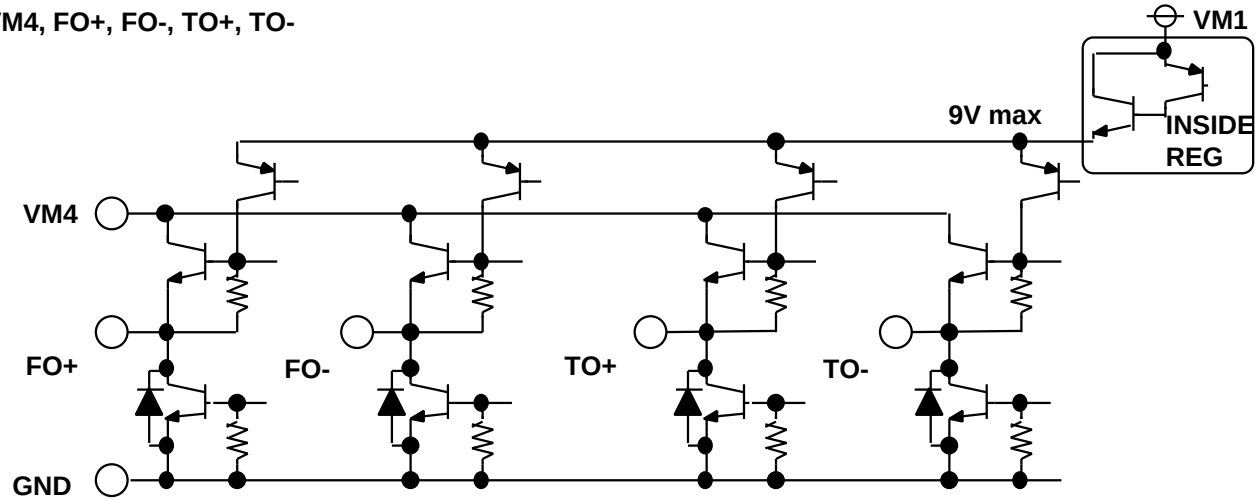
• FG



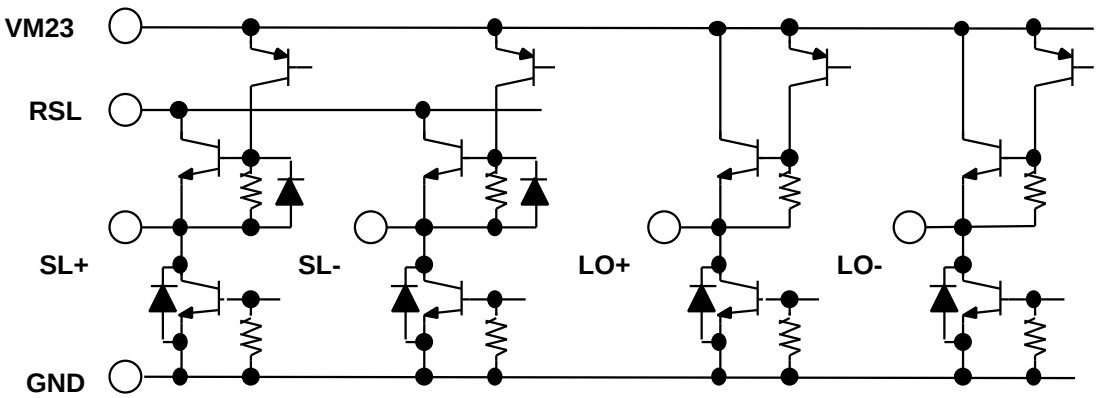
• VM1, RSP, U, V, W



• VM4, FO+, FO-, TO+, TO-



• VM23, RSL, SL+, SL-, LO+, LO-



<The boards for thermal derating evaluation>

Board material

Glass-epoxy FR-4

Size

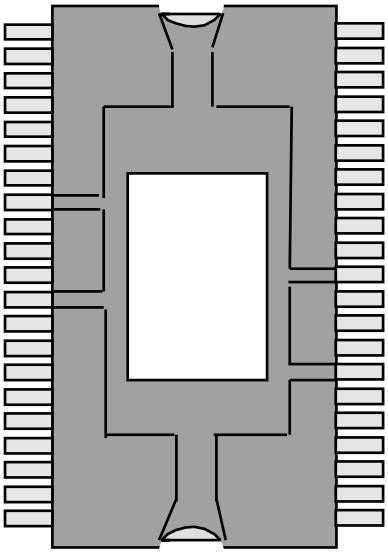
70 x 70mm

thickness

t = 1.6mm

1 and 2 layers

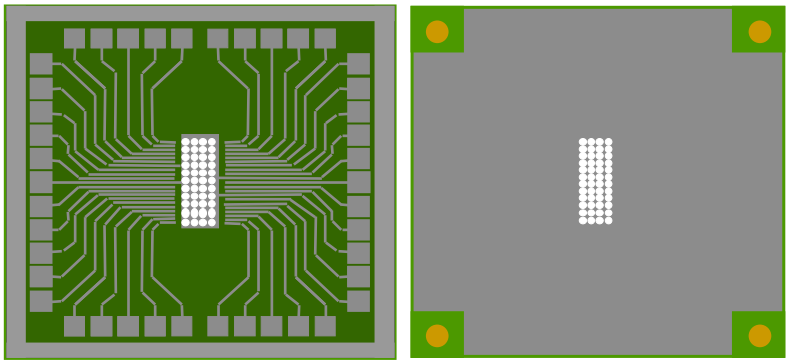
material : copper



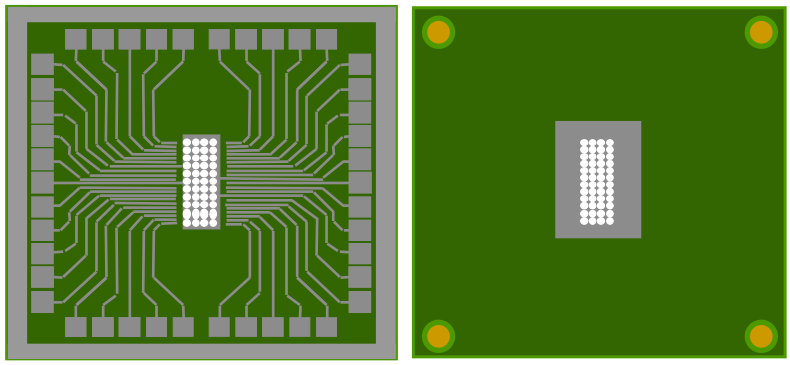
POWER-SSOP 42P9R-B

1st layer [TOP view] 2nd layer [BACK view]

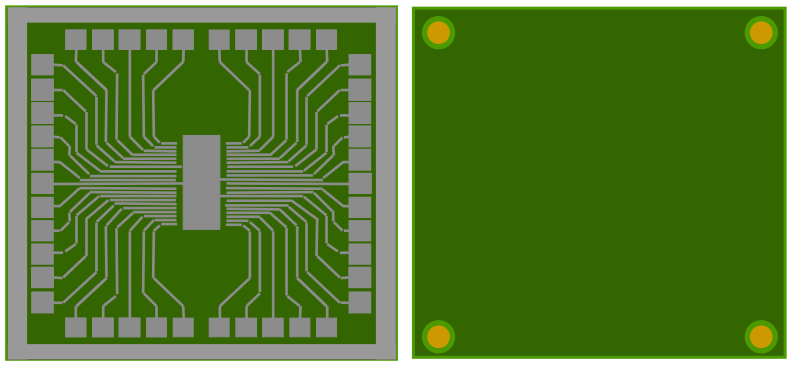
N-type board [2 layer]

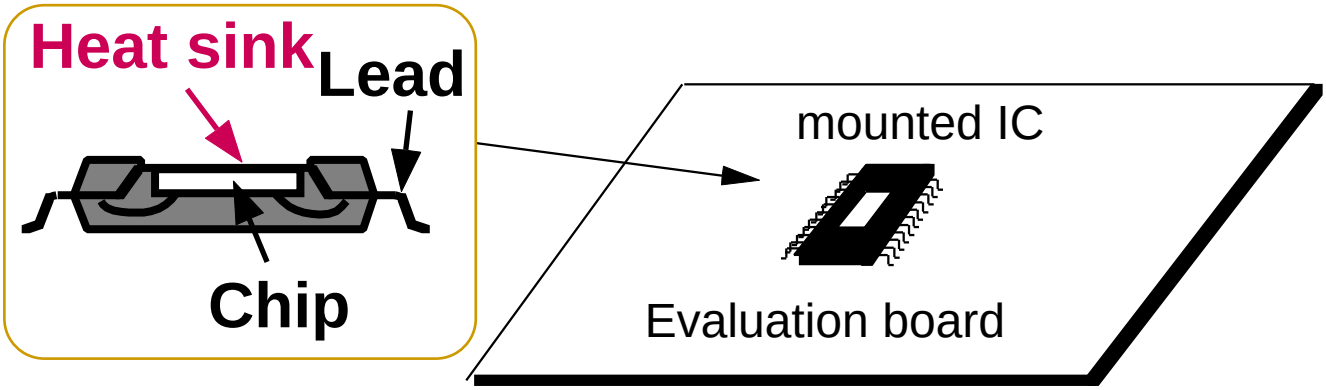


O-type board [2 layer]



P-type board [1 layer]





<APPLICATION CIRCUIT no.1>