ON Semiconductor

Is Now

To learn more about onsemi™, please visit our website at www.onsemi.com

LV8402GP

ON Semiconductor®

http://onsemi.com

Bi-CMOS IC

2ch Forward/Reverse Motor Driver Application Note

Overview

LV8402GP is a 2ch forward/reverse motor driver IC using D-MOS FET for output stage. As MOS circuit is used, it supports the PWM input. Its features are that the on resistance (0.75Ω typ) and current dissipation are low.

It also provides protection functions such as heat protection circuit and reduced voltage detection and is optimal for the motors that need high-current.

Function

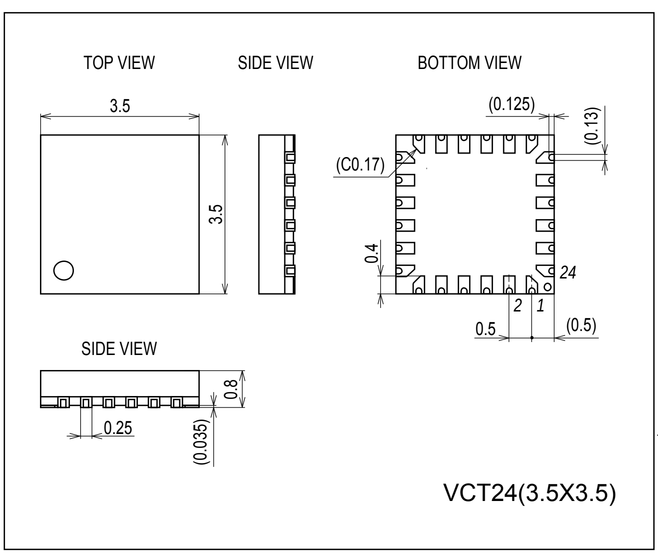
- 2ch forward/reverse motor driver.
- Low power consumption
- Low-ON resistance 0.75Ω.
- Built-in EXTRA mode for PWM port reduction when a motor drives by two phase excitation.
- Built-in low voltage reset and thermal shutdown circuit.
- 4 mode function forward/reverse, brake and standby
- Built-in charge pump.

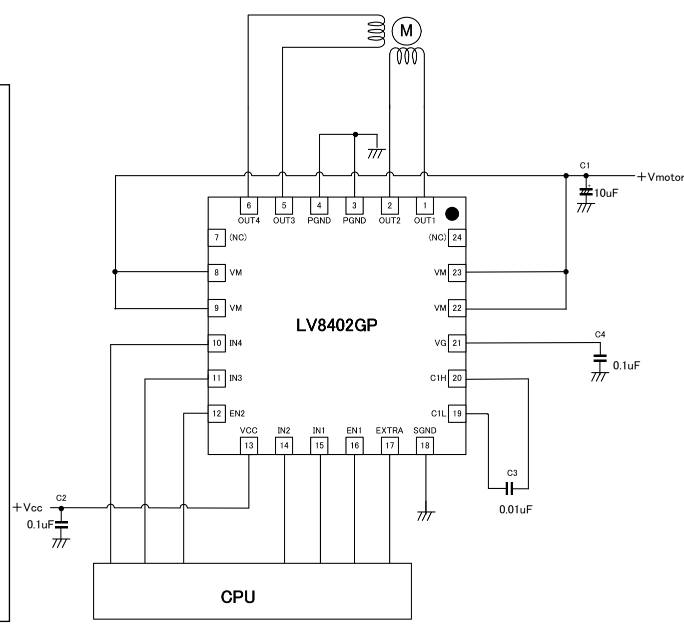
Typical Applications

- SLR-Camera lens anti-shake/Iris /auto focus control
- LCD projector lens focus /pan-tilt drive
- Battery powered toys and games
- Portable printers/scanners
- Robotic actuators and pumps

Package Dimensions

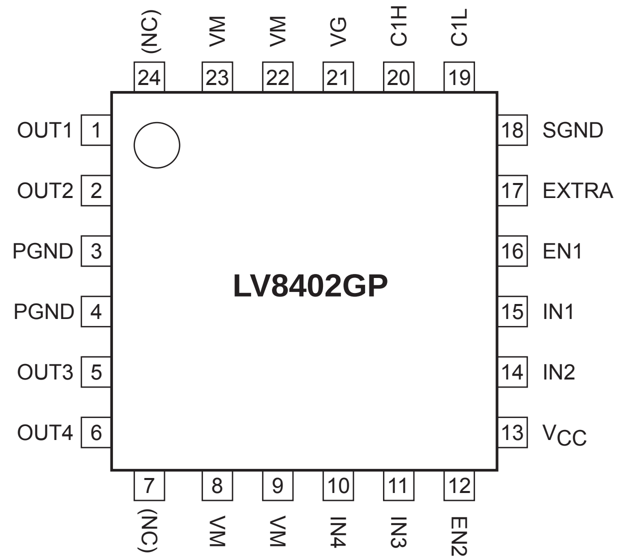
unit : mm (typ)





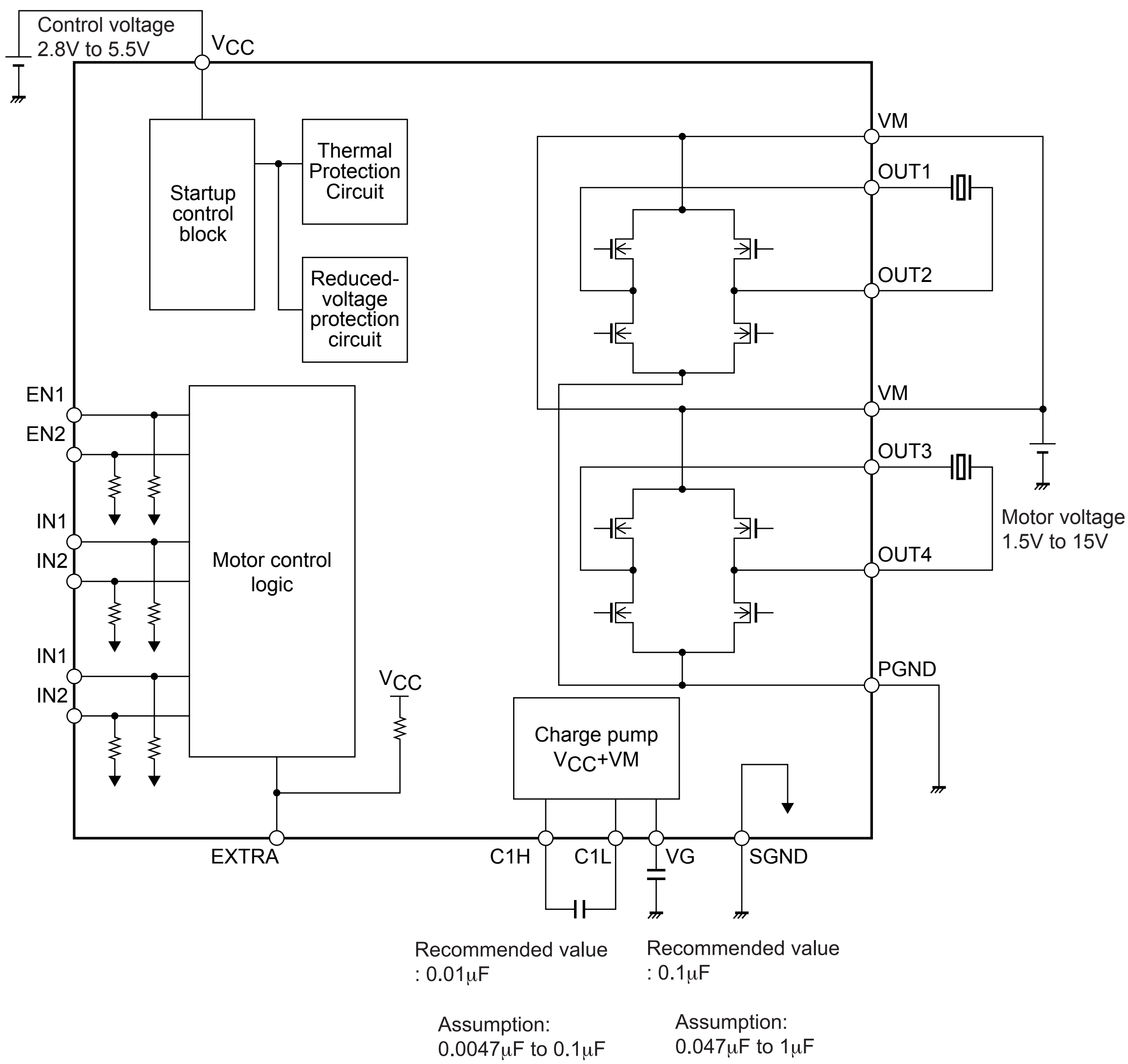
December, 2013

Pin Assignment

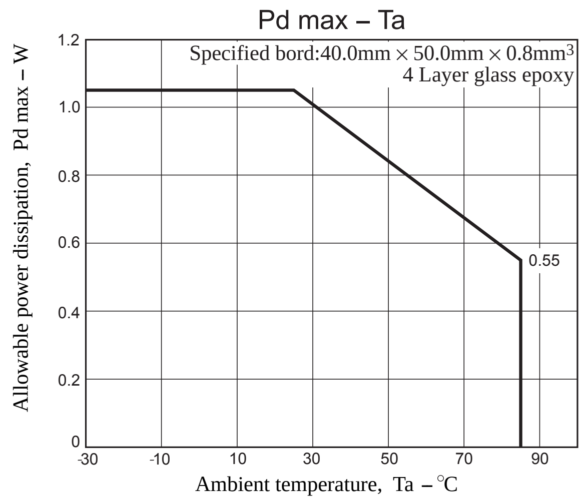


Top view

Block Diagram



* Connect a kickback absorption capacitor as near as possible to the IC. Coil kickback may cause increase in VM line voltage, and a voltage exceeding the maximum rating may be applied momentarily to the IC, which results in deterioration or damage of the IC



Specifications

Maximum Ratings at Ta = 25°C, SGND = PGND = 0V

Parameter	Symbol	Conditions	Ratings	Unit
Power supply voltage (for load)	VM max		-0.5 to 16.0	V
Power supply voltage (for control)	V_{CC} max		-0.5 to 6.0	V
Output current	I_O max		1.4	A
Output peak current	I_O peak	t ≤ 10ms	2.5	A
Input voltage	V_{IN} max		-0.5 to V_{CC}+0.5	V
Allowable power dissipation	Pd max	Mounted on a specified board*	1050	mW
Operating temperature	Topr		-30 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

* Specified board : 40.0mm × 50.0mm × 0.8mm, 4 Layer glass epoxy board.

Caution 1) Absolute maximum ratings represent the value which cannot be exceeded for any length of time.
Caution 2) Even when the device is used within the range of absolute maximum ratings, as a result of continuous usage under high temperature, high current, high voltage, or drastic temperature change, the reliability of the IC may be degraded. Please contact us for the further details.

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Power supply voltage (VM pin)	VM		1.5		15,0	V
Power supply voltage (V_{CC} pin)	V_{CC}		2.8		5.5	V
Input signal voltage	V_{IN}		0		V_{CC}	V
Input signal frequency	f max			200		kHz

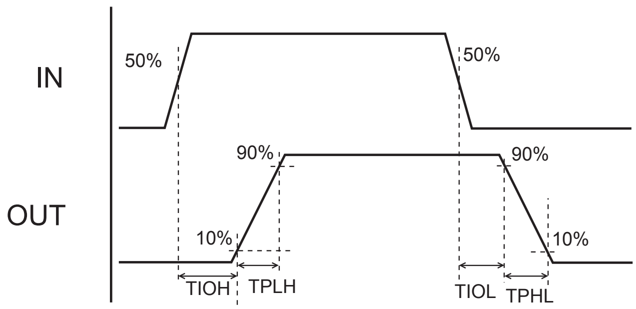
Electrical Characteristics at Ta = 25°C, V_{CC} = 3.0V, VM = 6.0V, SGND = PGND = 0V, unless otherwise specified.

Parameter		Symbol	Conditions	Remarks	Ratings min	Ratings typ	Ratings max	Unit
Standby load current drain		IMO	EN1=EN2=0V, EXTRA=3V	1			1.0	µA
Standby control current drain		ICO	EN1=EN2=IN1=IN2=IN3=IN4=0V	2			1.0	µA
Operating control current drain		IC1	EN=3V, with no load	3		0.85	1.2	mA
High-level input voltage		V_{IH}	2.7 ≤ V_{CC} ≤ 5.5V		0.6×V_{CC}		V_{CC}	V
Low-level input voltage		V_{IL}	2.7 ≤ V_{CC} ≤ 5.5V		0		0.2×V_{CC}	V
High-level input current (IN1, IN2 , IN3 , IN4 , EN1, EN2)		I_{IH}	V_{IN} = 3V	4		15	25	µA
Low-level input current (IN1, IN2, IN3 , IN4 , EN1, EN2)		I_{IL}	V_{IN} = 0V	4	-1.0			µA
Pull-down resistance value		RDN	IN1, IN2, IN3 , IN4 , EN1, EN2	4	100	200	400	kΩ
High-level input current 2 (IN1, IN2 , IN3 , IN4 , EN1, EN2)		$I_{IH}2$	V_{IN} = 3V	5			1.0	µA
Low-level input current 2 (IN1, IN2, IN3 , IN4 , EN1, EN2)		$I_{IL}2$	V_{IN} = 0V	5	-25	-15		µA
Pull-up resistance value		RUP	EXTRA	5	100	200	400	kΩ
Charge pump voltage		VG	V_{CC} + VM		8.5	9.0	9.5	V
Output ON resistance 1		RON1	Sum of top and bottom sides ON resistance.	6		0.75	1.2	Ω
Output ON resistance 2		RON2	Sum of top and bottom sides ON resistance. V_{CC} = 2.8V	6		1.0	1.5	Ω
Low-voltage detection voltage		VCS	V_{CC} pin voltage is monitored	7	2.15	2.30	2.45	V
Thermal shutdown temperature		Tth	Design guarantee value *	8	150	180	210	°C
Output block	Turn-on time	TPLH	When no load. Design guarantee value *	9		0.3	0.5	µS
			When no load.	10		100	200	nS
	Turn-off time	TPHL	When no load. Design guarantee value *	9		0.35	0.6	µS
			When no load.	10		100	200	nS

* : Design guarantee value and no measurement is preformed.

Remarks

1. Current consumption when output at the VM pin is off.
2. Current consumption at the V_{CC} for standby mode.
3. EN1=3V (IC starts) shows the current consumption of the V_{CC} pin.
4. Pins IN 1, 2, 3, 4, EN1, and EN2 are all pulled down according to resistance.
5. EXTRA pin is pulled up according to resistance.
6. Sum of upper and lower saturation voltages of OUT pin divided by the current.
7. All power transistors are turned off if a low V_{CC} condition is detected.
8. All output transistors are turned off if the thermal protection circuit is activated. They are turned on again as the temperature goes down.
9. Rising time from 10 to 90% and falling time from 90 to 10% are specified.
10. The change of the voltage of the input pin provides for time until the voltage of the terminal OUT changes by 10% at the time of 50% of V_{CC}.



Truth Table

EXTRA	EN1 (EN2)	IN1 (IN3)	IN2 (IN4)	OUT1 (OUT3)	OUT2 (OUT4)	Charge pump	Mode
H	H	H	H	Z	Z	ON	Stand-by
		H	L	L	H		Reverse
		L	H	H	L		Forward
		L	L	L	L		Brake
	L	-	-	L	L	OFF	Stand-by
L	H	H	-	L	H	ON	Reverse
		L	-	H	L		Forward
	L	-	-	L	L		Brake

- : denotes a don't care value. Z: High-Impedance

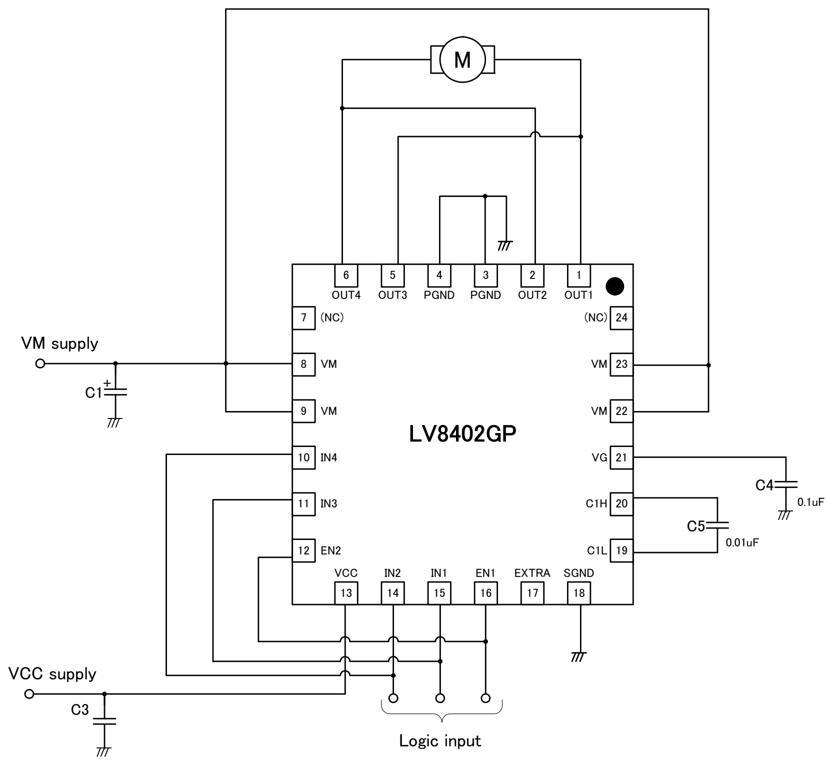
• In the standby mode, current consumption vanishes.

* All power transistors turn off and the motor stops driving when the IC is detected in low voltage or thermal protection mode.

Usage Notes

- 2ch parallel connection

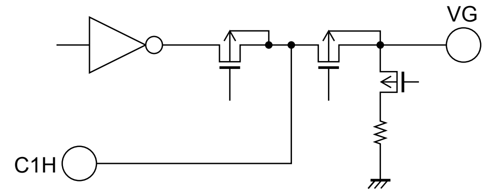
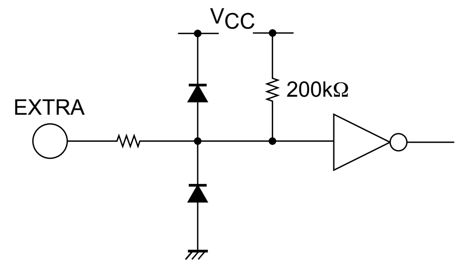
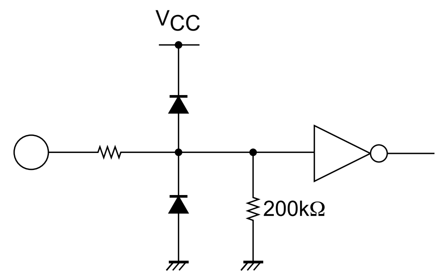
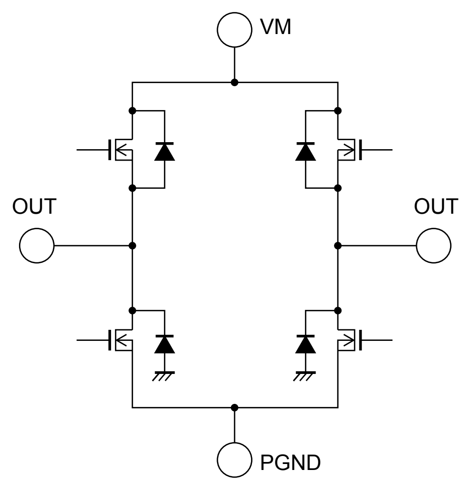
  If use of high current is required, you can connect 2 H Bridges in parallel to drive 1 DC motor.
  By connecting IN1-IN3, IN2-IN4, EN1-EN2, OUT1-OUT3, and OUT2-OUT4 respectively, ON resistance is reduced by half and current capacity doubles.



- Charge pump circuit is integrated.

  VG voltage (VM+VCC) drives the gate of the upper power transistor.
  VCC voltage drives the gate of the lower power transistor.
  The characteristics of the on resistance of output power transistor is independent of VM voltage, but dependent on VCC voltage.

Pin Functions

Pin No.	Pin name	Description	Equivalent circuit
20 21	C1H VG	Step-up capacitor connection pin.	
17	EXTRA	Extra logic pin. (Logic switch for PWM)	
16 12 15 14 11 10	EN1 EN2 IN1 IN2 IN3 IN4	Driver output switching. Logic enable pin. (Pull-down resistor incorporated)	
1 2 5 6	OUT1 OUT2 OUT3 OUT4	Driver output.	
8, 9, 22, 23	VM	Motor block power supply.	
13	V_{CC}	Logic block power supply.	
18	SGND	Control block ground.	
3, 4	PGND	Driver block ground.	

Reference data

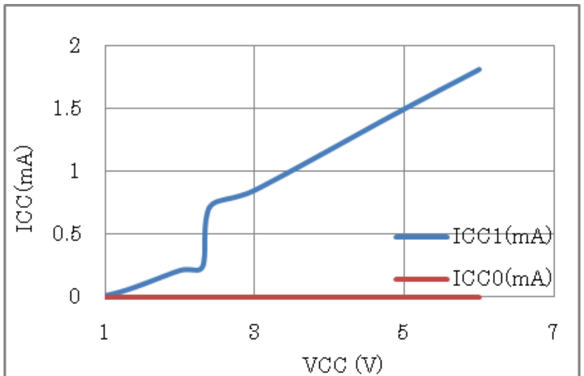


Figure 1 VCC Current Drain vs VCC Voltage at VM=6V

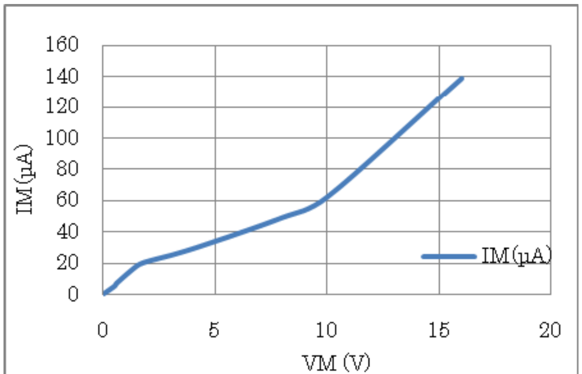


Figure 2 VM Current Drain vs VM Voltage at VCC=3V

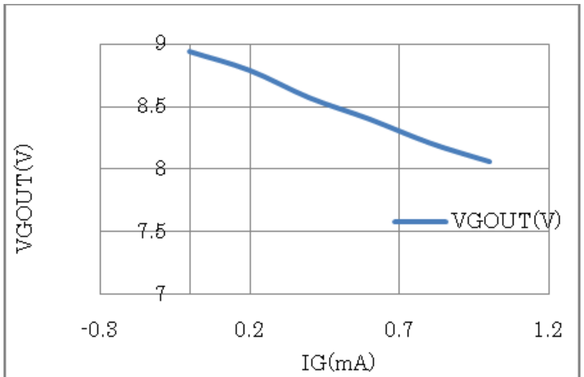


Figure 3 Chargepump output voltage vs IG at VCC=3V/VM=6.0V

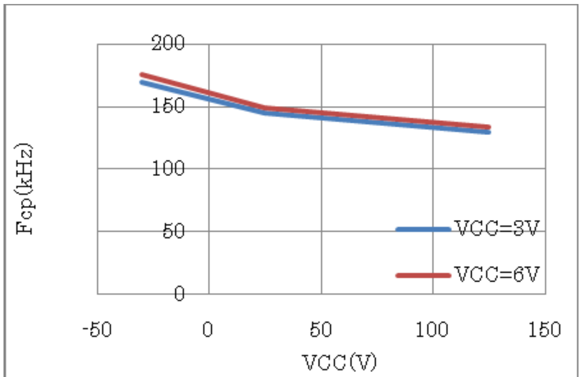


Figure 4 Chargepump frequency vs temp at VM=6V

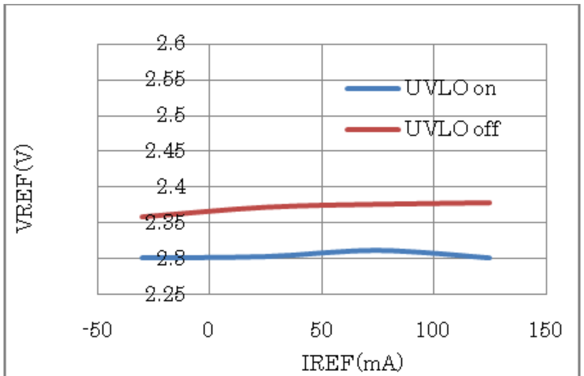


Figure 5 UVLO threshold voltage vs temperture

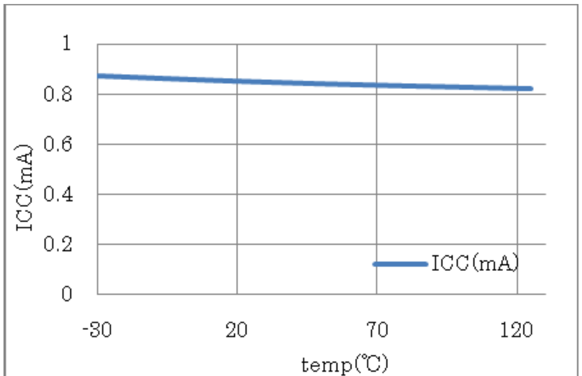


Figure 6 Current drain vs temperture at VCC=3V/VM=6V

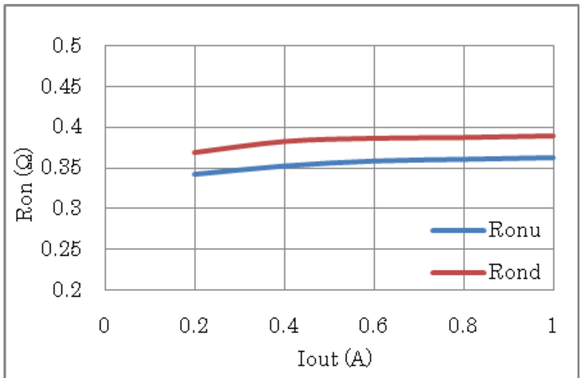


Figure 7 Output on Resistance vs Output Current at VCC=2.8V

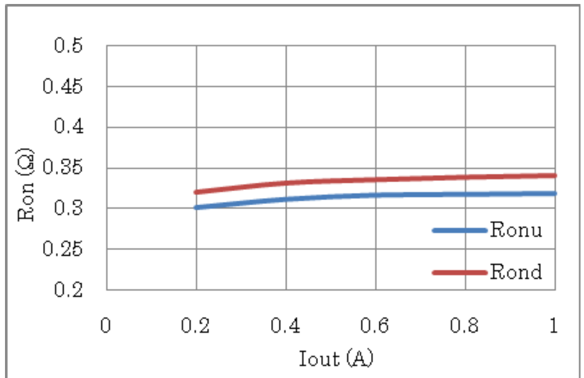


Figure 8 Output on Resistance vs Output Current at VCC=5V

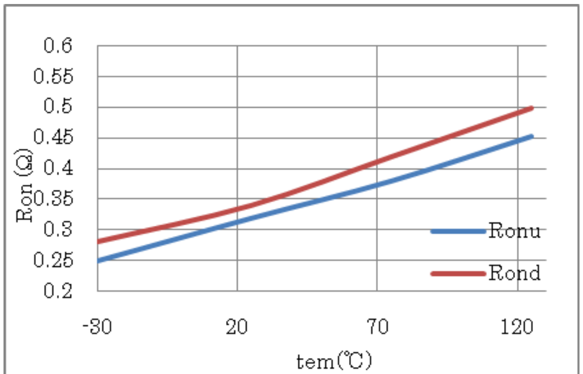


Figure 9 Output on Resistance vs temperture at VCC=5V/Io=1.0A

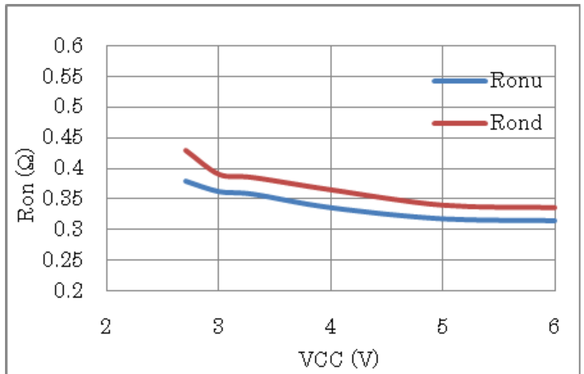


Figure 10 Output on Resistance vs VCC at Io=1.0A

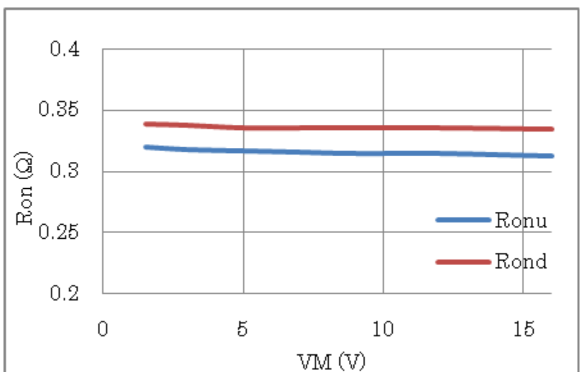


Figure 11 Output on Resistance vs VM at VCC=5V/Io=1.0A

APPLICATION INFORMATION

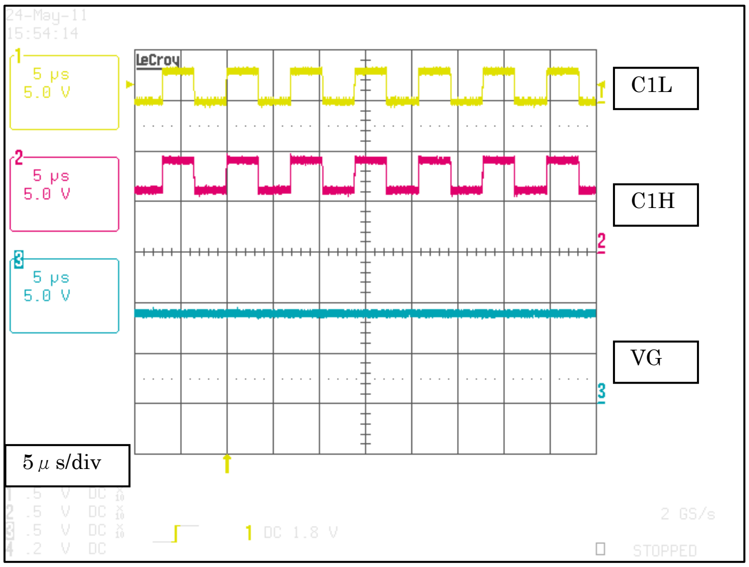
1.Charge pump circuit

In LV8402GP, Nch-MOSFET is used in the upper and lower output transistor. And to drive the gate of the upper Nch-MOSFET, charge pump circuit is integrated.

By connecting capacitor between C1L and C1H and another capacitor between VG and SGND, the voltage of VM+VCC is generated in VG.

The recommended capacitor between C1L and C1H: 0.01μF/25V The assumed value: 0.0047μF to 0.1μF.
The recommended capacitor between VG and SGND: 0.1μF/25V The assumed value: 0.047μF to 1μF.
The capacitance influences the capability of load current of VG voltage.

Charge pump waveform example



condition
VM=6V VCC=3V

C1L pin 0V to VCC pulse
C1H pin VM to (VM+VCC) pulse
VG pin VM+VCC voltage

2. Thermal Shutdown

The LV8402GP will disable the outputs if the junction temperature reaches 180°C.

When temperature falls 30 °C, the IC outputs a set output mode.

TSD = 180°C (typ)
ΔTSD = 30°C (typ)

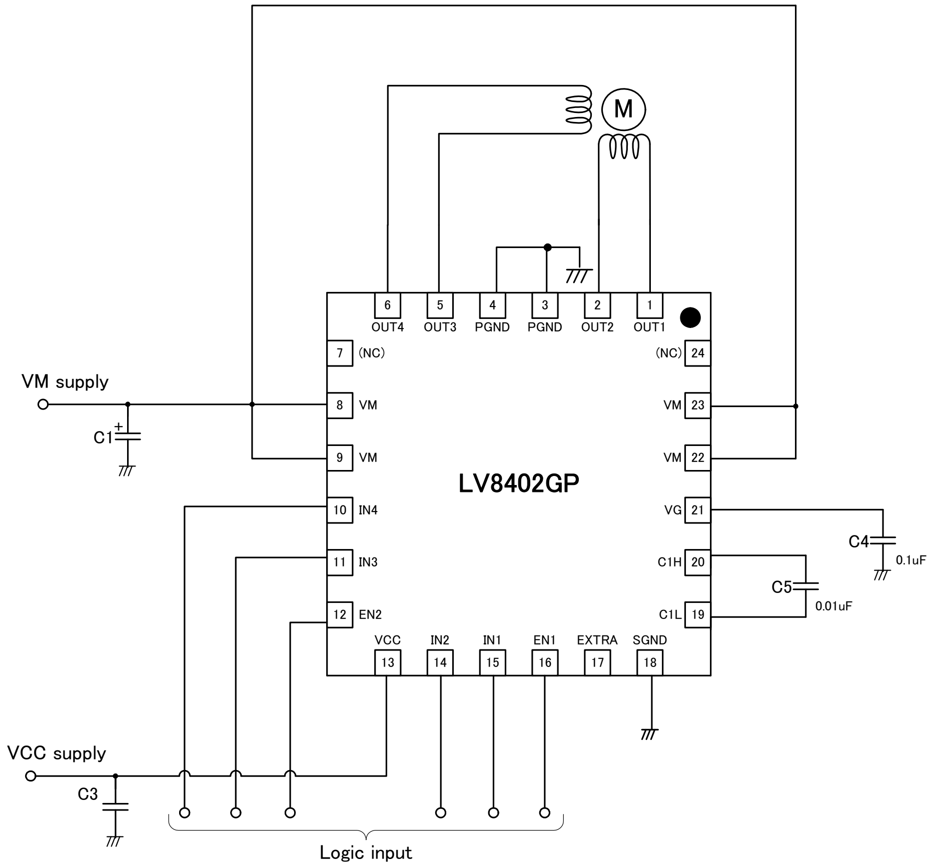
3. Low voltage protection function

When the power supply voltage is as follows 2.3V in LV8402GP, OFF does the output.

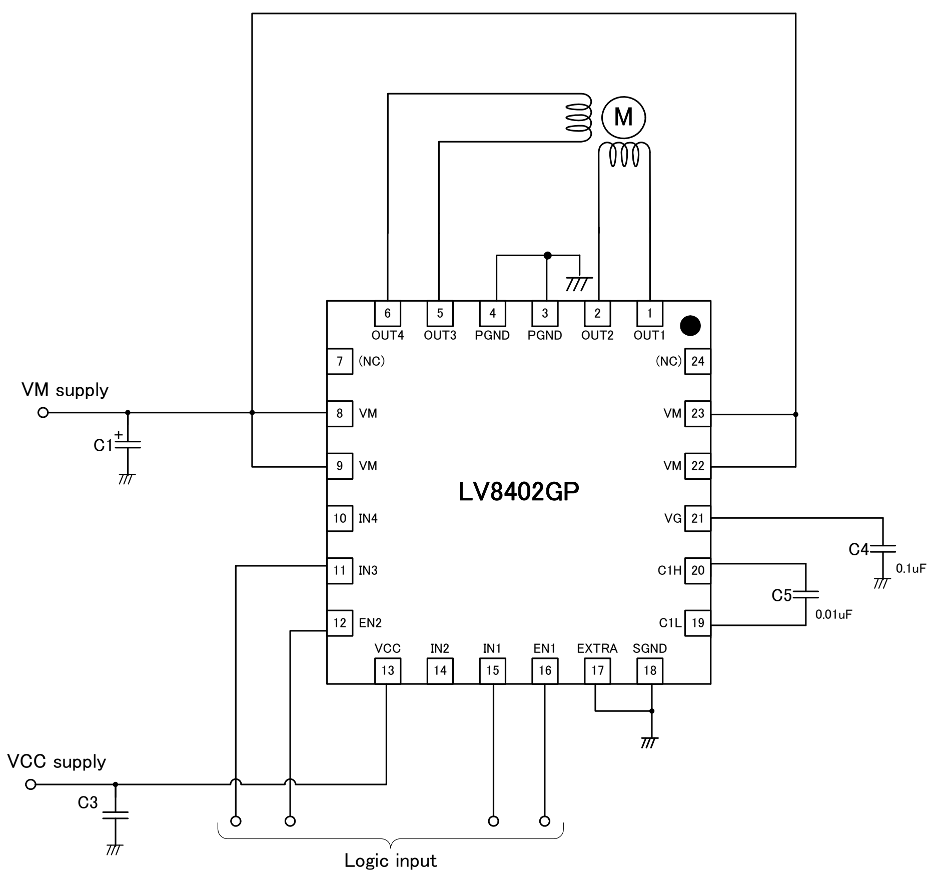
When the power supply voltage is as above typical 2.38V, the IC outputs a set state.

Motor connecting figure

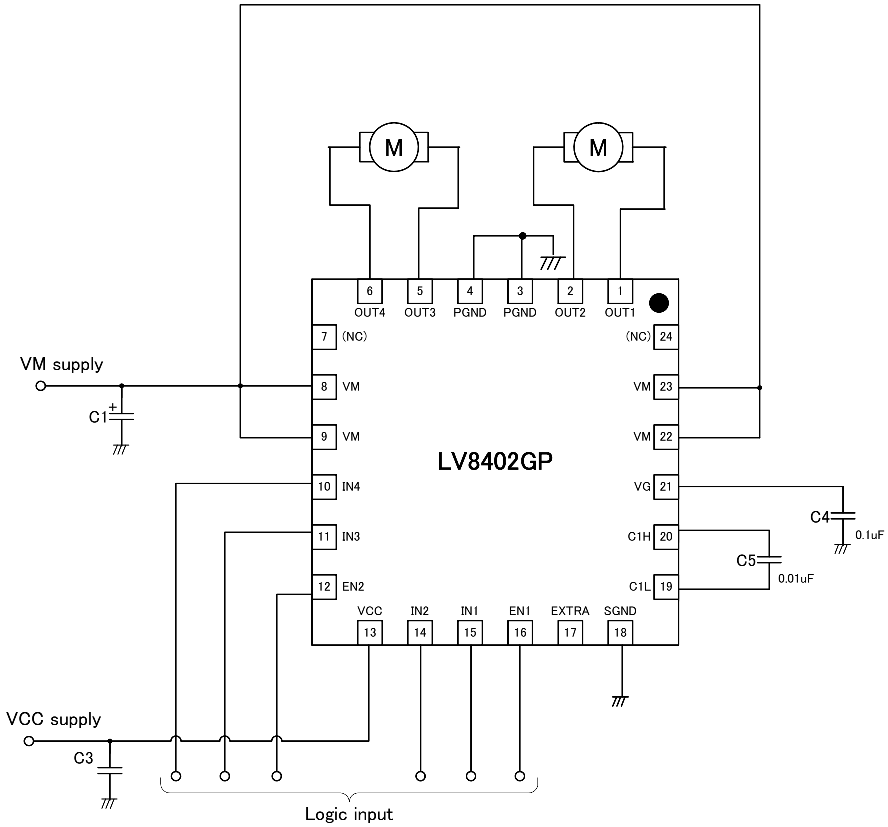
- stepping motor connect (1-2phase excitation , 2phase excitation nomal mode)



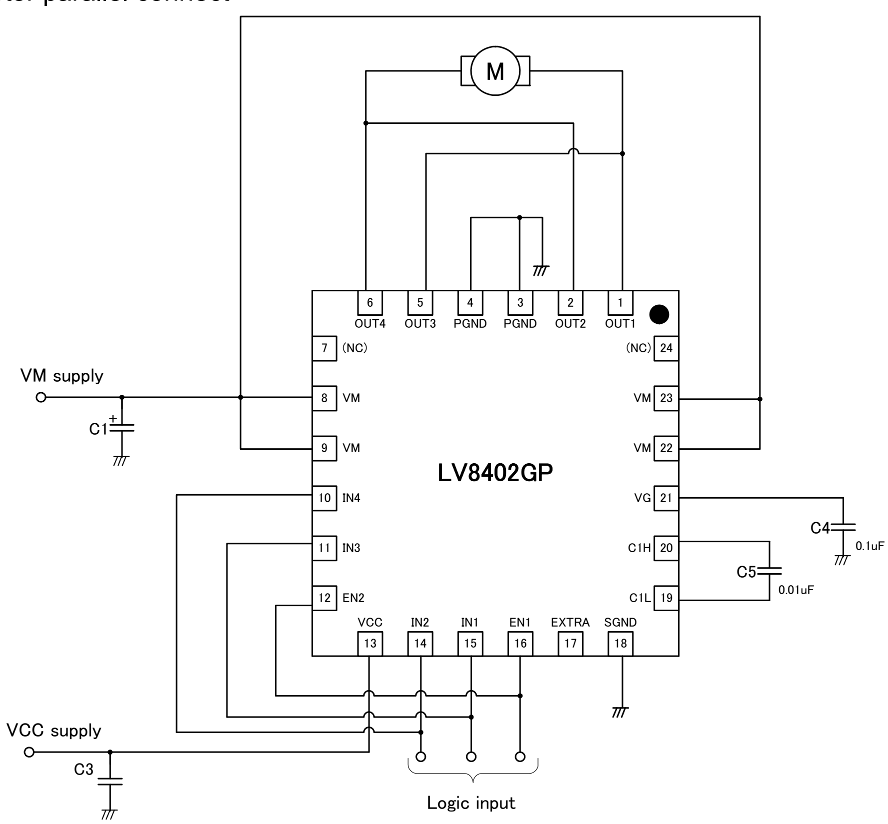
- stepping motor connect (2-phase excitation extra mode)



- 2 DC motors connect



- DC motor parallel connect



The capacitor C1 and C3 are used to stabilize power supply. And capacitance is variable depends on board layout, capability of motor or power supply.

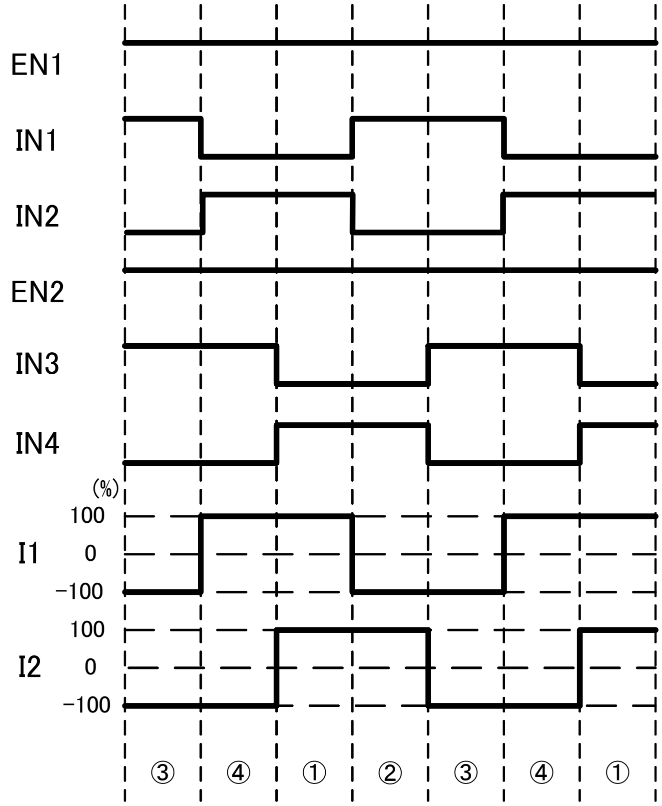
Recommendation range for C1: approx. 0.1μF to 10μF

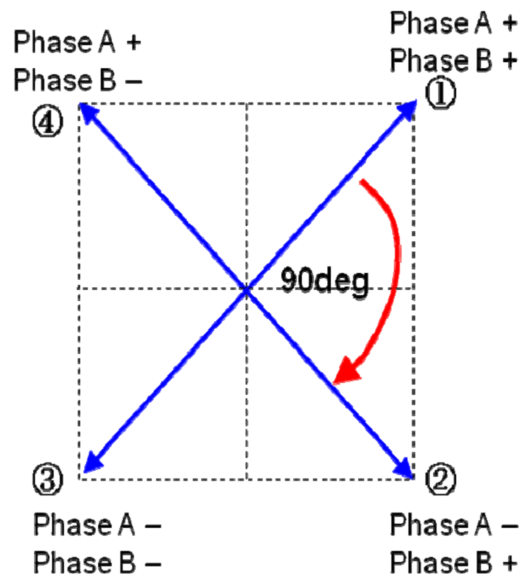
Recommendation range for C2: approx. 0.01μF to 1μF

In order to set an optimum capacitance for stable power supply, make sure to confirm the waveform of the supply voltage of a motor under operation

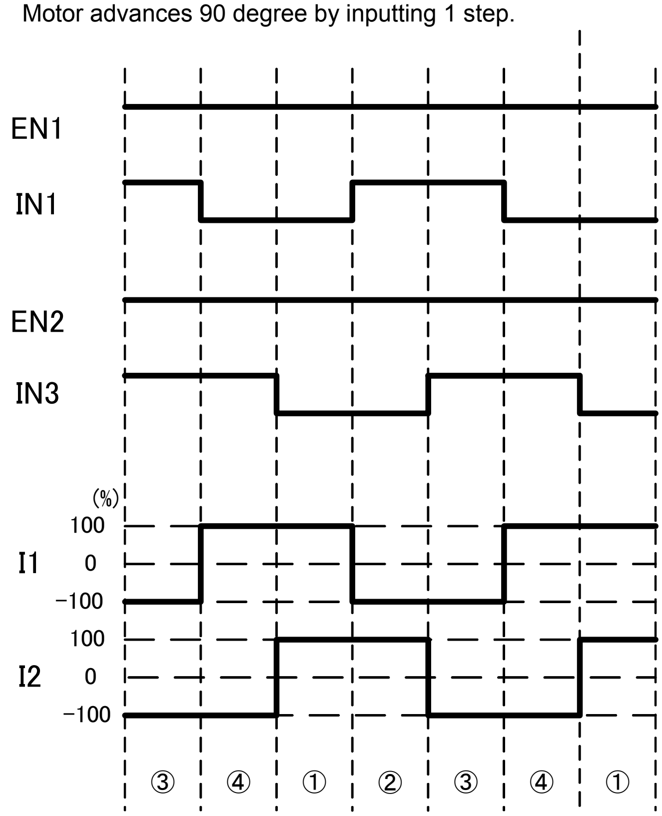
Operation principal

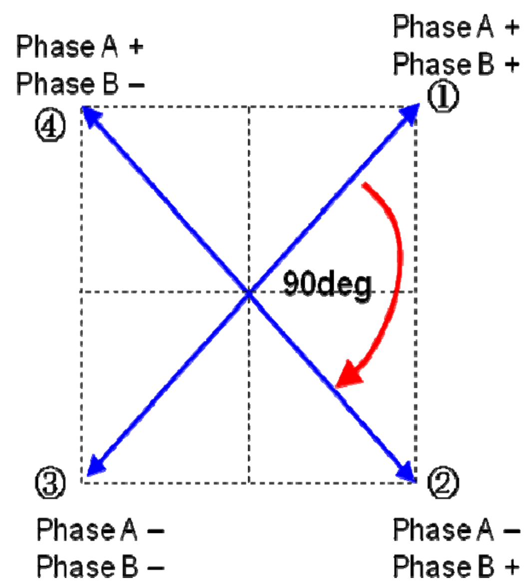
- Full-Step Drive (2 phase excitation drive) normal mode **EXTRA pin = Open**
  Motor advances 90 degree by inputting 1 step.



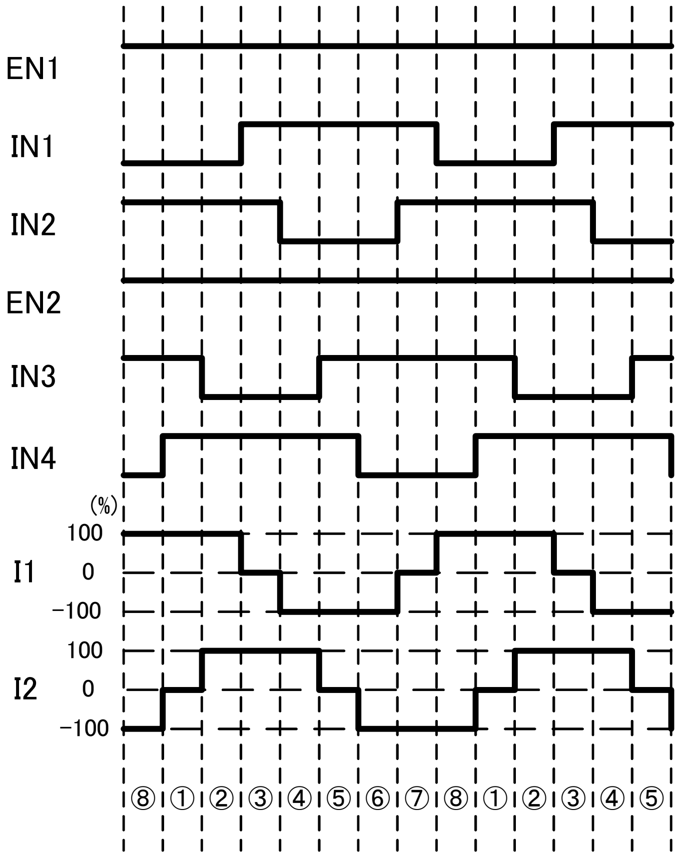


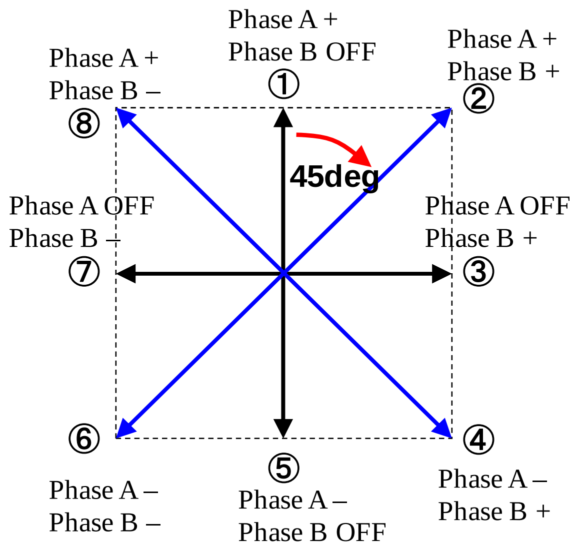
- Full-Step Drive (2 phase excitation drive) EXTRA mode **EXTRA pin = Low**
  Motor advances 90 degree by inputting 1 step.





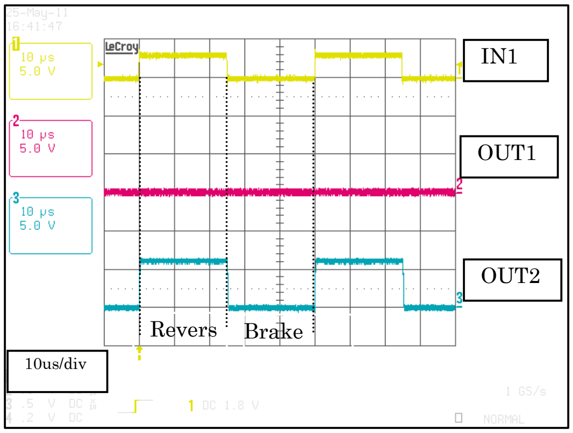
- Half-Step Drive (1-2 phase excitation drive)
  Motor advances 45 degree by inputting 1 step.



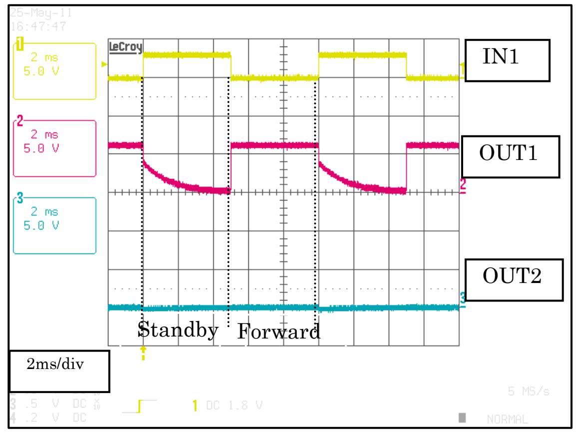


Waveform example

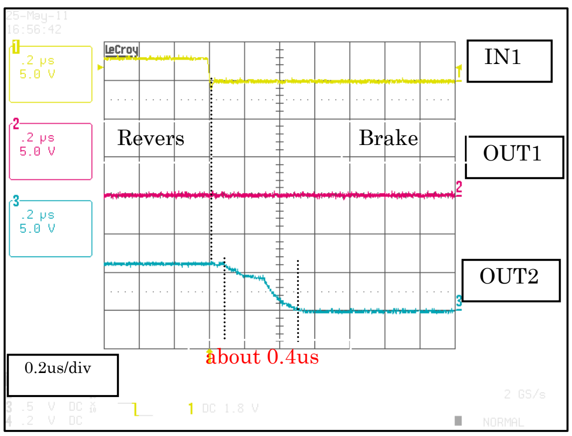
No load VCC=3V VM=6V EN1=”H”, IN2=”L”



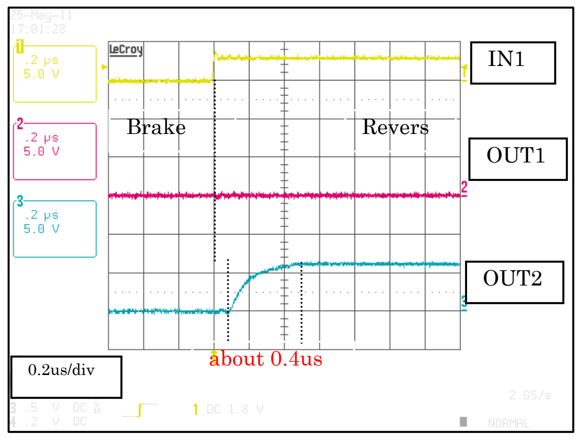
No load VCC=3V VM=6V EN=”H”, IN2=”H”



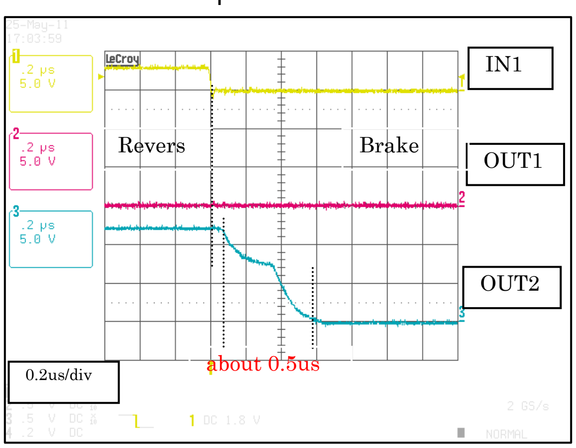
No load VCC=3V VM=6V EN1=”H” IN2=”L”
Time scale expansion “fall time”



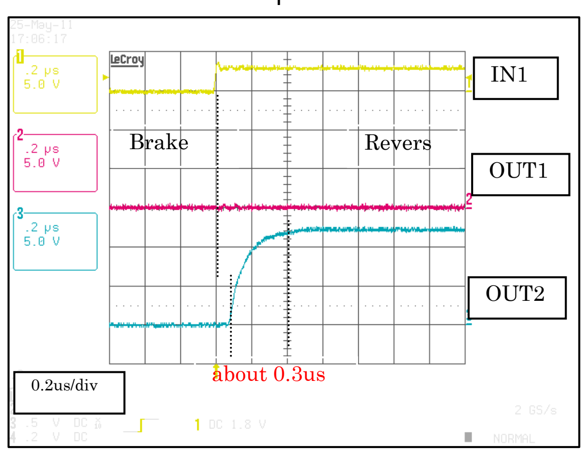
No load VCC=3V VM=6V EN1=”H” IN2=”L”
Time scale expansion “rise time”



No load VCC=3V VM=12V EN1=”H” IN2=”L”
Time scale expansion “fall time”

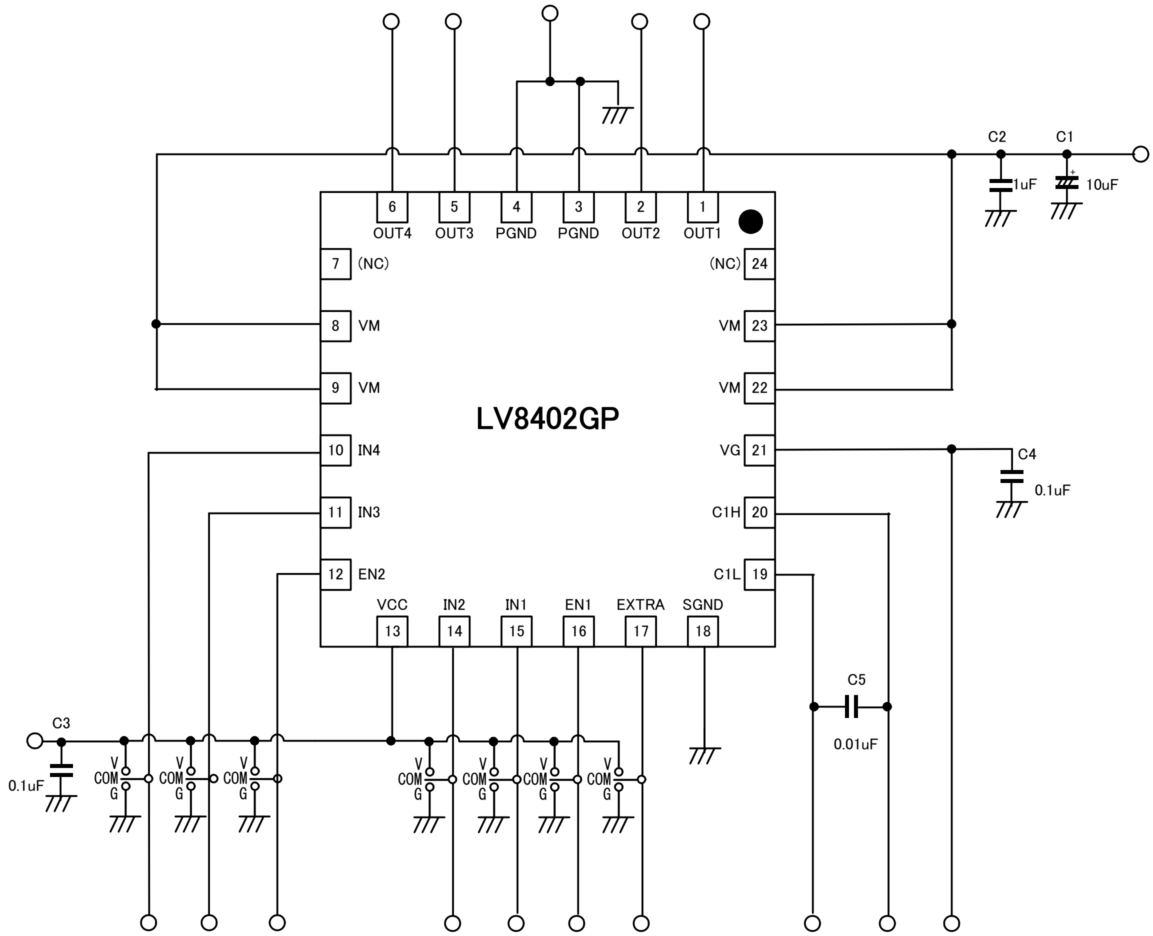


No load VCC=3V VM=12V EN1=”H” IN2=”L”
Time scale expansion “rise time”

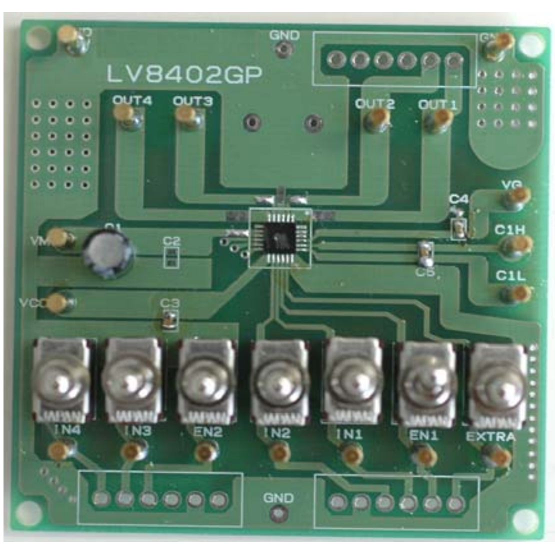


Evaluation board description

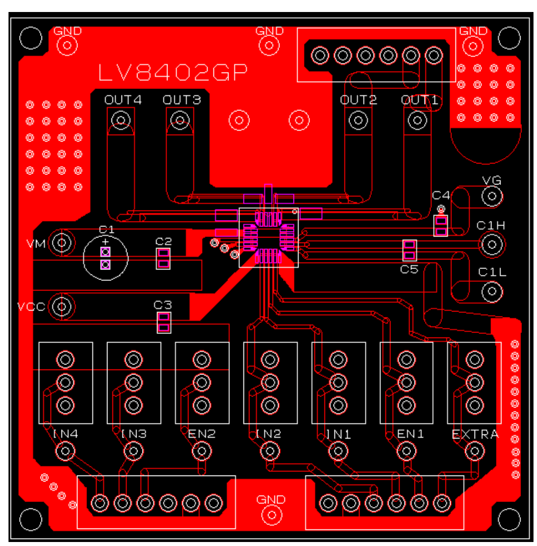
1.Evaluation board circuit diagram



Board view



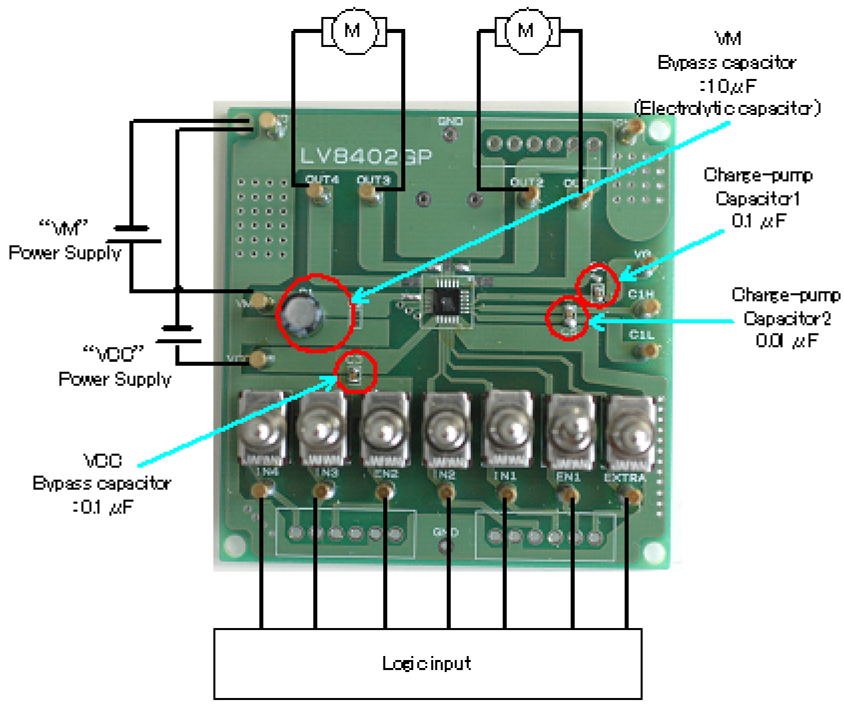
Board layout



Bill of Materials for LV8402GP Evaluation Board

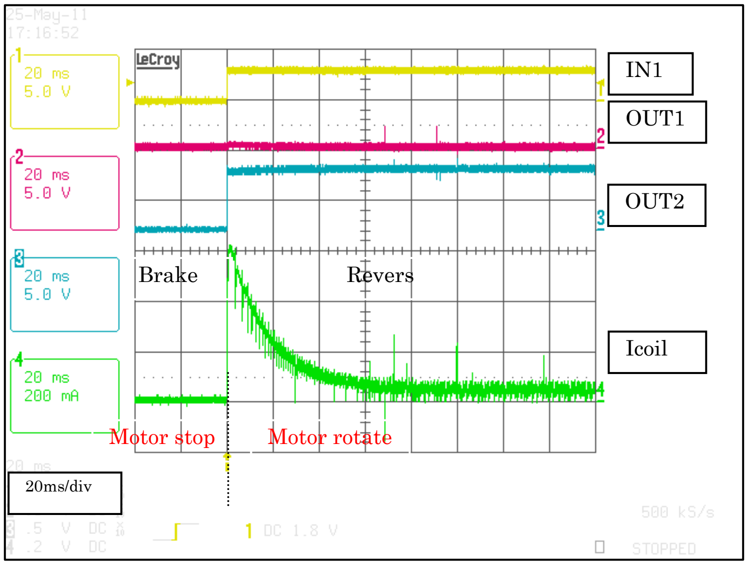
Designator	Qty	Description	Value	Tol	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
IC1	1	Motor Driver			VCT24	ON Semiconductor	LV8402GP	No	Yes
C1	1	VM Bypass capacitor	10μF 50V			SUN Electronic Industries	50ME10HC	Yes	Yes
C3	1	VCC Bypass capacitor	0.1μF 100V			murata	GRM188R72A 104KA35D	Yes	Yes
C4	1	Charge pump capacitor1	0.1μF 100V			murata	GRM188R72A 104KA35D	Yes	Yes
C5	1	Charge pump capacitor2	0.1μF 100V			murata	GRM188B11H 103K	Yes	Yes
SW1-SW7	7	Switch				MIYAMA	MS-621-A01	Yes	Yes
TP1-TP14	14	Test points				MAC8	ST-1-3	Yes	Yes

2. Two DC motor drive



- Connect OUT1 and OUT2, OUT3 and OUT4 to a DC motor each.
- Connect the motor power supply with the terminal VM, the control power supply with the terminal VCC. Connect the GND line with the terminal GND.
- DC motor becomes the predetermined output state corresponding to the input state by inputting a signal such as the following truth value table into EN1, EN2, IN1~IN4.
- See the table in p.5 for further information on input logic.

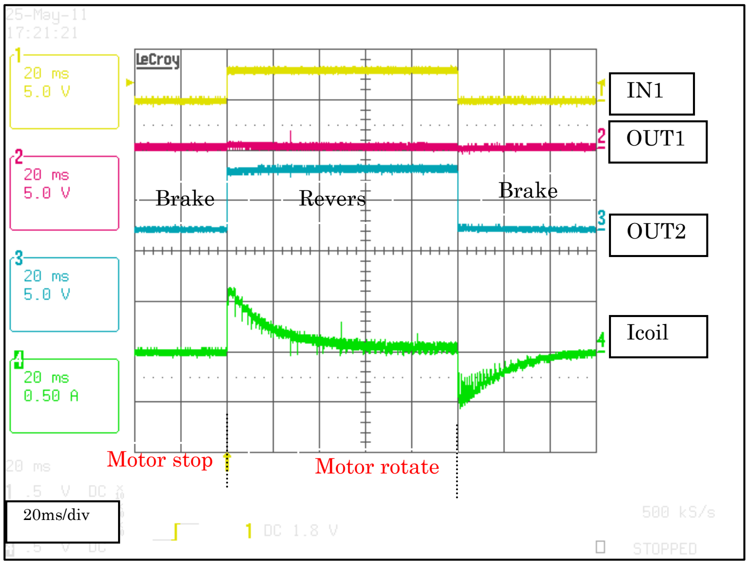
DC motor load VCC=3V VM=6V EN1="H", IN2="L"
Current waveform example "motor start"



High current flows when the DC motor starts to rotate. After a while, induced voltage "Ea" is generated from motor and current value gradually decreases in the course of motor rotation.
Given that the coil resistor is Rcoil, motor supply voltage is Vm, the motor current Im is obtained as follows: Im=(Vm-Ea) /Rcoil

DC motor load　VCC=3V VM=6V EN1=”H”, IN2=”L”

Current waveform example　　“brake current”

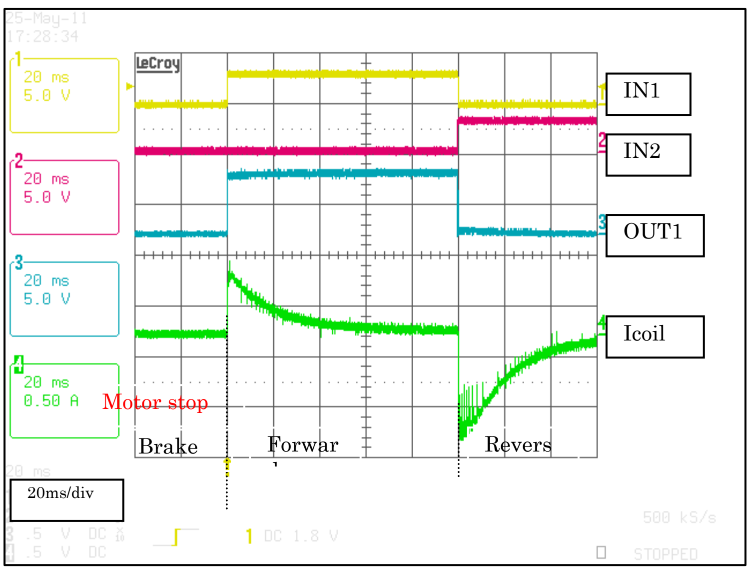


By setting brake mode while the DC motor is under rotation, DC motor becomes short-brake state and thereby decreases rotation count rapidly.

In this case, the current of Im=Ea/Rcoil flows reversely due to the induced voltage Ea generated while the motor was under rotation. And by stopping the rotation of DC motor, Ea becomes 0. Therefore, the current also becomes 0.

DC motor load　VCC=3V VM=6V EN1=”H”

Current waveform example　　“active reverse brake current”

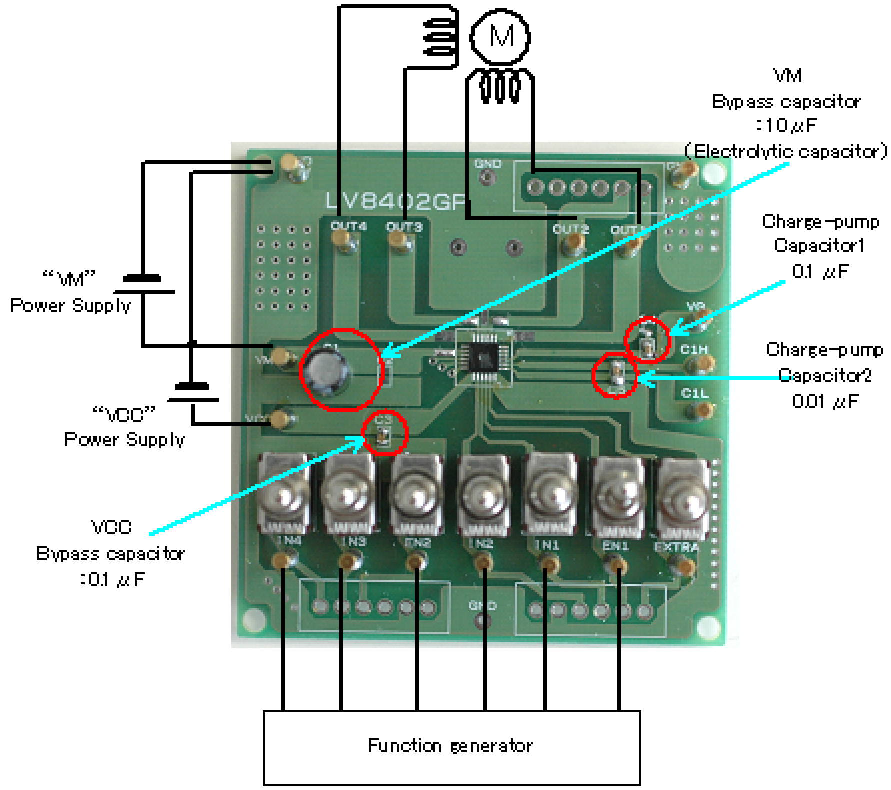


If a direction of rotation is switched while the DC motor is under rotation, torque for reverse rotation is generated. Therefore, the change of rotation takes place more abruptly.

In this case, since the voltage of VM is added as well as the induced voltage Ea that occurred during the motor rotation, the following current flows: Im= (VM+Ea) /Rcoil

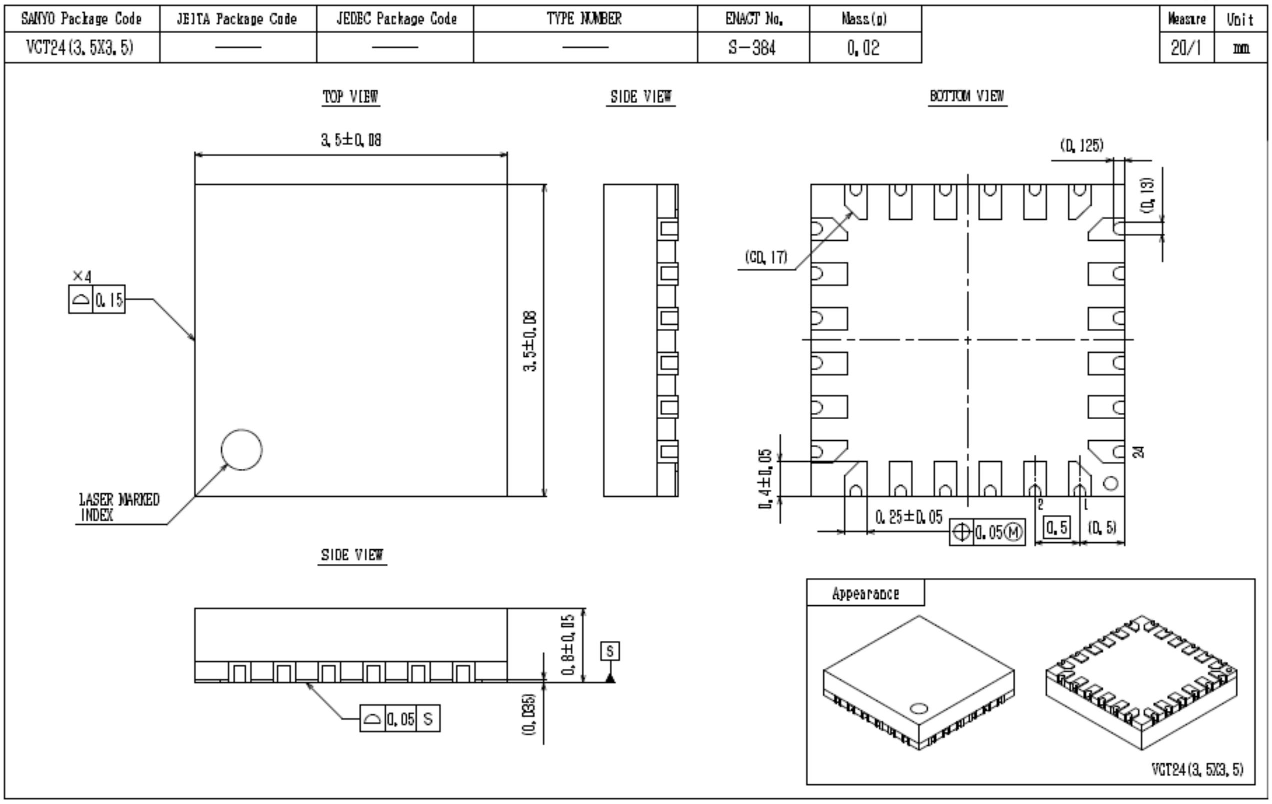
Since this driving method generates the highest current at the startup of DC motor, if the current value exceeds the Iomax, it is recommended to set brake mode between forward and reverse to reduce induced voltage.

3. One stepping motor drive

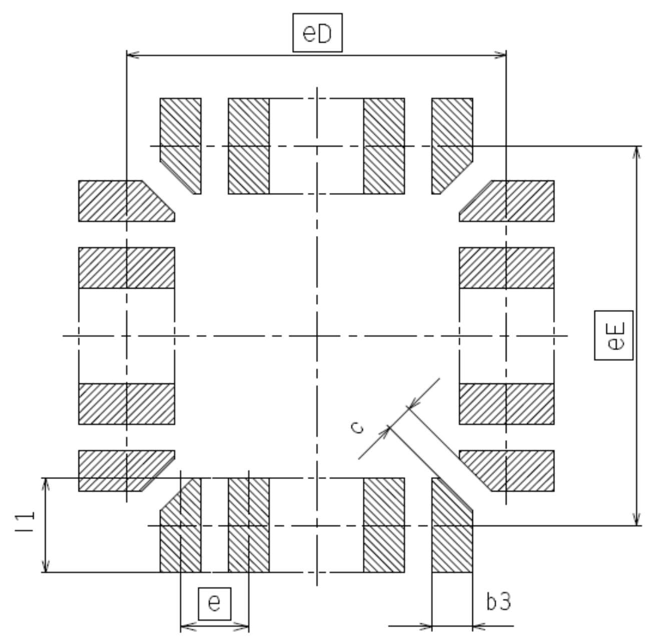


- Connect a stepping motor with OUT1, OUT2, OUT3 and OUT4.
- Connect the motor power supply with the terminal VM, the control power supply with the terminal VCC. Connect the GND line with the terminal GND.
- STP motor drives it in an Full-Step, Half-Step by inputting a signal such as follows into EN1,EN2,IN1~IN4.
- For input signal to function generator, refer to p.12 and p.13.
  To reverse motor rotation, make sure to input signal to outward direction.

OUTLINE DRAWING



Recommended Soldering Footprint



(Unit:mm)

Reference symbol	Packages name				
	VCT/UCT16(2,6X2,6)	VCT/UCT20(2,6X2,6)	VCT/UCT20(3,0X3,0)	VCT/UCT24(3,0X3,0)	VCT/UCT24(3,5X3,5)
eD	2,30	2,30	2,70	2,70	3,20
eE	2,30	2,30	2,70	2,70	3,20
e	0,50	0,40	0,50	0,40	0,50
b_3	0,30	0,19	0,30	0,19	0,30
l_1	0,70	0,70	0,70	0,70	0,70
c	0,20	0,20	0,20	0,20	0,20