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LV8411GR

Bi-CMOS LSI

For DSC, and Cell Phone Camera Modules
4-channel Single-chip Motor Driver IC Application Note

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Overview

The LV8411GR is an H- bridge motor driver IC and is able to control 4 modes of forward, reverse, brake, and standby.
This IC housed in a miniature package is optimum for use in a stepping motor driving system for DSC or a camera module of cell phones.

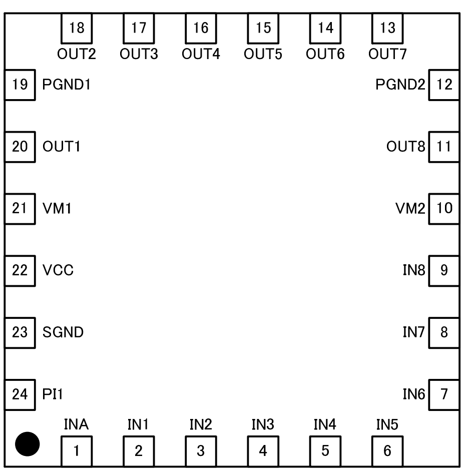
Function

- Saturation drive H bridge: 4 channels
- Built-in thermal protection circuit
- Built-in low voltage malfunction prevention circuit
- Incorporates a transistor for driving photosensors

Typical Applications

- Digital still camera (DSC)
- Camera module of cell phones

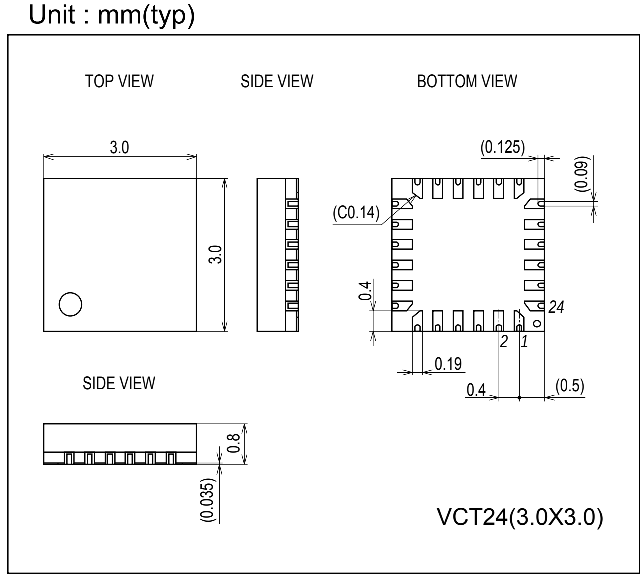
Pin Assignment



(Top view)

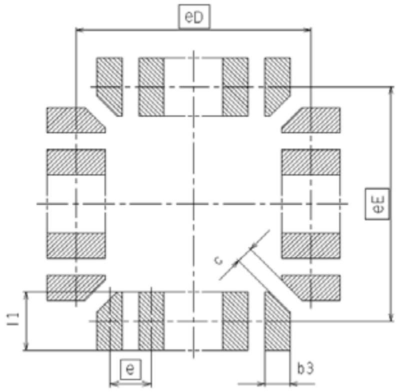
Package Dimensions

Unit : mm(typ)



Caution: The package dimension is a reference value, which is not a guaranteed value.

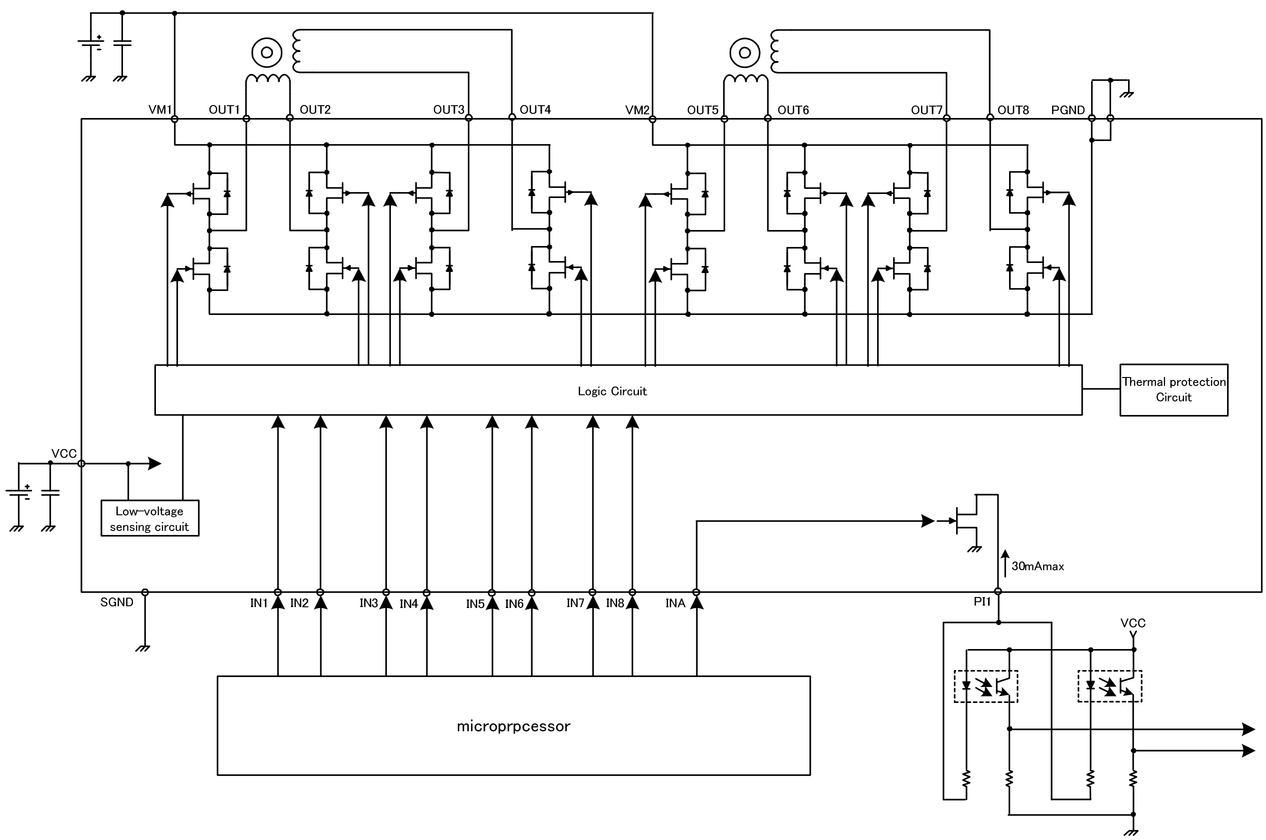
Recommended Soldering Footprint



Unit : mm

Reference Symbol	VCT24(3.0×3.0)
eD	2.70
eE	2.70
e	0.40
b3	0.19
l1	0.70
c	0.20

Block Diagram



Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Power supply voltage 1	V_M max		6.0	V
Power supply voltage 2	V_{CC} max		6.0	V
Output peak current	I_O peak	Channels 1 to 4, t ≤ 10msec, ON-duty ≤ 20%	600	mA
Output continuous current 1	I_O max1	Channels 1 to 4	400	mA
Output continuous current 2	I_O max2	PI1	30	mA
Allowable power dissipation	Pd max	Mounted on a circuit board*	1.05	W
Operating temperature	Topr		-30 to +85	°C
Storage temperature	Tstg		-55 to +150	°C

* Specified circuit board : 40mm×50mm×0.8mm : glass epoxy four-layer 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 range 1	V_M		2.5		5.5	V
Power supply voltage range 2	V_{CC}		2.5		5.5	V
Logic input voltage range	V_{IN}		0		V_{CC}+0.3	V
Input frequency	f_{IN}	IN1 to 8, INA			100	kHz

Electrical Characteristics at Ta=25°C, V_M=5.0V, V_{CC}=3.3V, unless otherwise specified.

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Standby mode current drain	Istn	IN1 to 8 = "L"			1.0	μA
VM current drain	IM	IN1 = "H", IM1 + IM2, with no load	50	100	200	μA
V_{CC} current drain	I_{CC}	IN1 = "H"	0.3	0.6	1.2	mA
V_{CC} low-voltage cutoff voltage	$VthV_{CC}$		2.0	2.25	2.5	V
Low-voltage hysteresis voltage	VthHIS		100	150	200	mV
Thermal shutdown temperature	TSD	Design guarantee value *	160	180	200	°C
Thermal hysteresis width	ΔTSD	Design guarantee value *	10	30	50	°C
OUT1 to 8						
Logic pin internal pull-down resistance	Rin	IN1 to 8	50	100	200	kΩ
Logic pin input current	IinL	V_{IN} = 0V, IN1 to 8			1.0	μA
	IinH	V_{IN} = 3.3V, IN1 to 8	16.5	33	60	μA
Logic input high-level voltage	Vinh	IN1 to 8	2.5			V
Logic input low-level voltage	Vinl	IN1 to 8			1.0	V
Output on-resistance	Ronu	I_O = 400mA, upper ON resistance		0.75	0.9	Ω
	Rond	I_O = 400mA, lower ON resistance		0.45	0.6	Ω
Output leakage current	$I_O$leak				1.0	μA
Diode forward voltage	VD	ID = -400mA	0.7	0.9	1.2	V
PI1						
Logic pin internal pull-down resistance	Rin	INA	50	100	200	kΩ
Logic pin input current	IinL	V_{IN} = 0V, INA			1.0	μA
	IinH	V_{IN} = 3.3V, INA	16.5	33	60	μA
Logic input high-level voltage	Vinh	INA	2.5			V
Logic input low-level voltage	Vinl	INA			1.0	V
Output on-resistance	Ron	I_O = 10mA		3.0	6.0	Ω
Output leakage current	$I_O$leak				1.0	μA

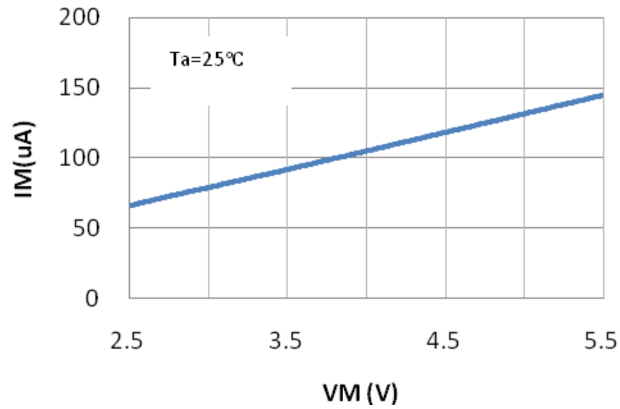


Figure 2. VM current drain vs. VM supply voltage

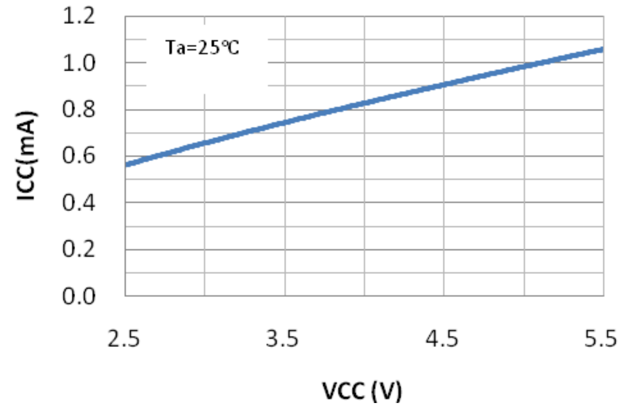


Figure 3. VCC current drain vs. VCC supply voltage

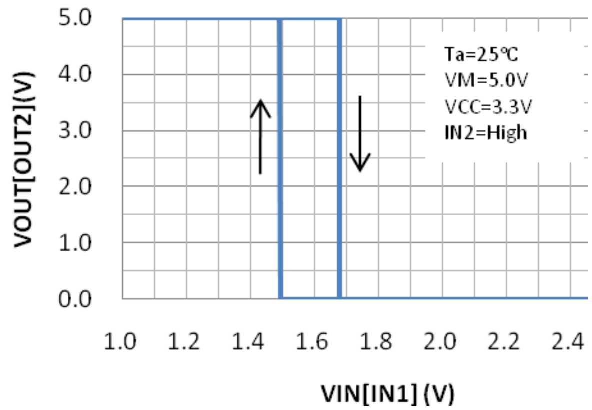


Figure 4. Output voltage vs. Input voltage

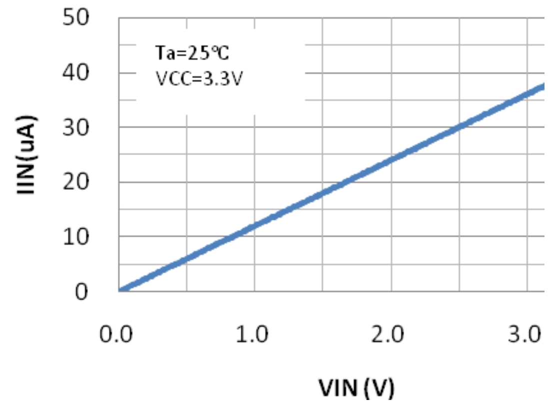


Figure 5. Input current vs. Input voltage

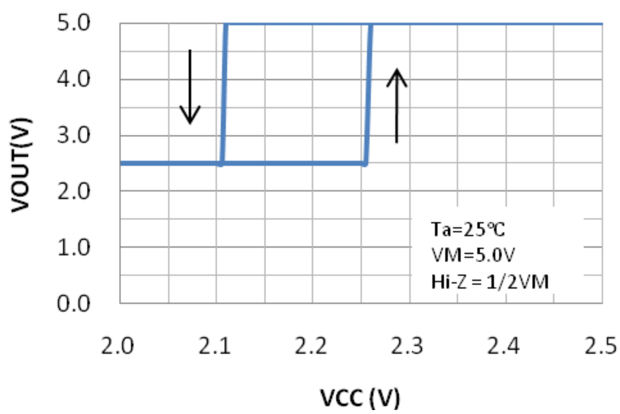


Figure 6. VCC low voltage protection characteristic

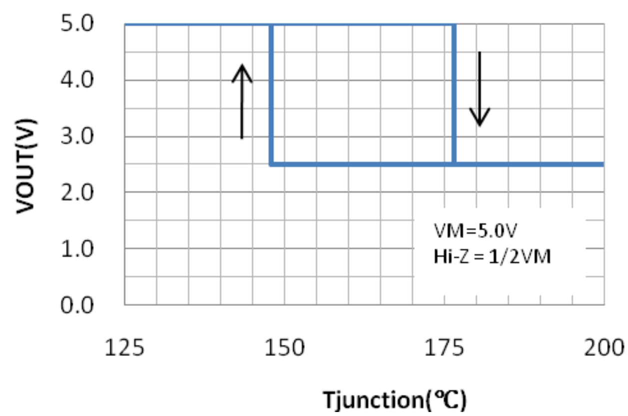


Figure 7. Thermal protection characteristic

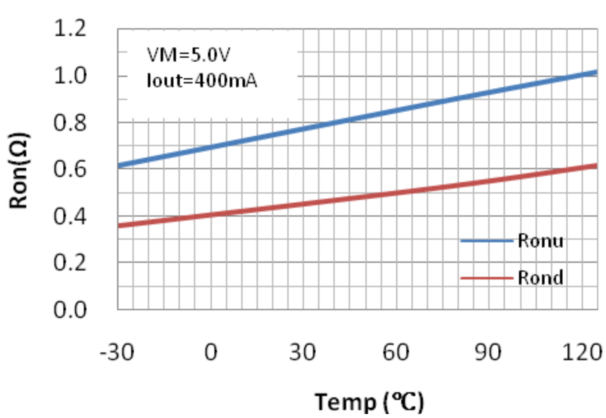


Figure 8. Output on-resistance vs. Temperature

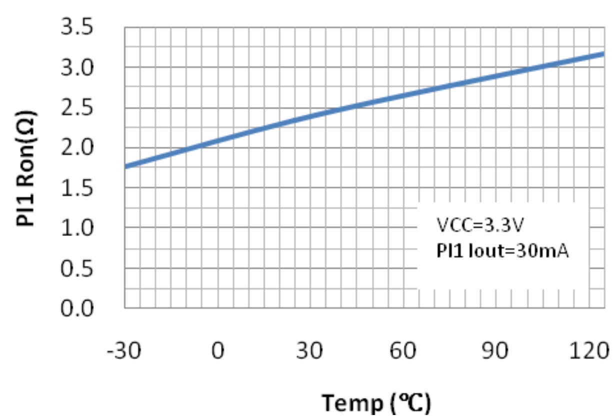
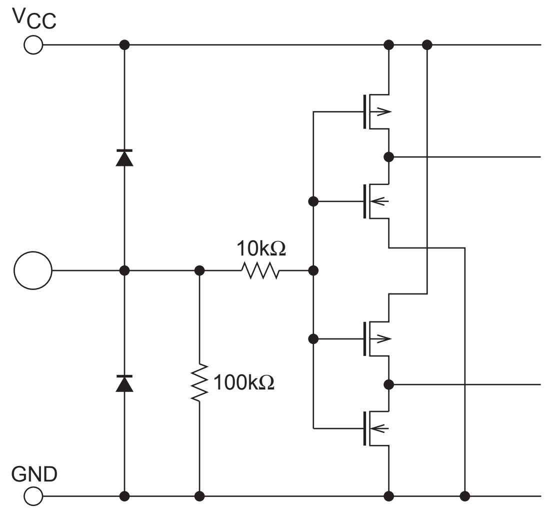
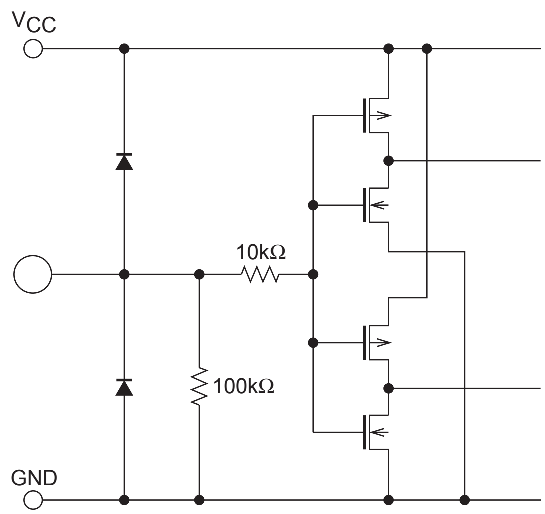
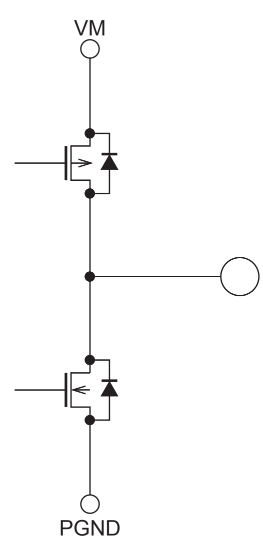
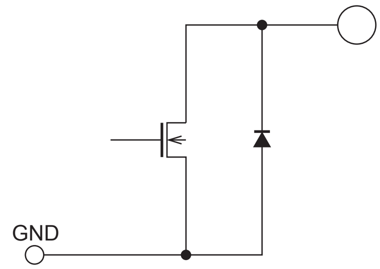


Figure 9. PI1 on-resistance vs. Temperature

Pin Functions

Pin No.	Pin name	Pin Function	Equivalent Circuit
1	INA	Control signal input pin (Photo sensor driving transistor) When High, PI1 operates. With 100KΩ of pulldown resistor, when OPEN, the operation is equivalent to that of Low control signal. PWM control is feasible when input frequency is 100KHz or lower.	
2 3 4 5 6 7 8 9	IN1 IN2 IN3 IN4 IN5 IN6 IN7 IN8	Control signal input pin When the voltage level is High, all the outputs that correspond to inputs are activated. Since 100KΩ of pull-down resistor is inserted, when OPEN the operation is equivalent to that of Low control signal. PWM control is feasible when the input frequency is 100KHz or lower.	
11 13 14 15 16 17 18 20	OUT8 OUT7 OUT6 OUT5 OUT4 OUT3 OUT2 OUT1	Output pin This pin is connected to the motor. Operation mode is determined according to the state of control signal input pins.	

Pin No.	Pin name	Pin Function	Equivalent Circuit
24	PI1	Photo sensor driving transistor output pin ON/OFF of the internal Nch MOS is determined according to the state of INA	
22	V_{CC}	Logic system power supply connection pin Supply voltage range is between 2.5V and 5.5V. To stabilize VCC power line, connect a bypass capacitor between this pin and SGND(pin 23).	
10 21	VM2 VM1	Motor power supply connection pin Supply voltage range is between 2.5V and 5.5V. To stabilize VM power line, connect a bypass capacitor between these pins and PGND(12,19pin) respectively.	
23	SGND	Signal ground	
12 19	PGND2 PGND1	Power ground	

Operation explanation

Saturation drive H bridge

4-channels H bridge drivers are integrated independently which enable controlling 4 modes: forward, reverse, brake, and standby.

Logic input specifications

• Common channels 1 to 4

ch1 : IN1 to IN2, OUT1 to OUT2
ch2 : IN3 to IN4, OUT3 to OUT4
ch3 : IN5 to IN6, OUT5 to OUT6
ch4 : IN7 to IN8, OUT7 to OUT8

Input		Output		Operation mode
IN1	IN2	OUT1	OUT2	
L	L	OFF	OFF	Standby
H	L	H	L	CW (forward)
L	H	L	H	CCW (reverse)
H	H	L	L	Brake

When IN1 to IN8 are “Low”, the operation of H bridge output stage is in standby mode.
When “high” is applied to an input pin that corresponds to each channel, the output transistor of the H- bridge output stage operates and the operation shifts as follows: forward, reverse, and brake.

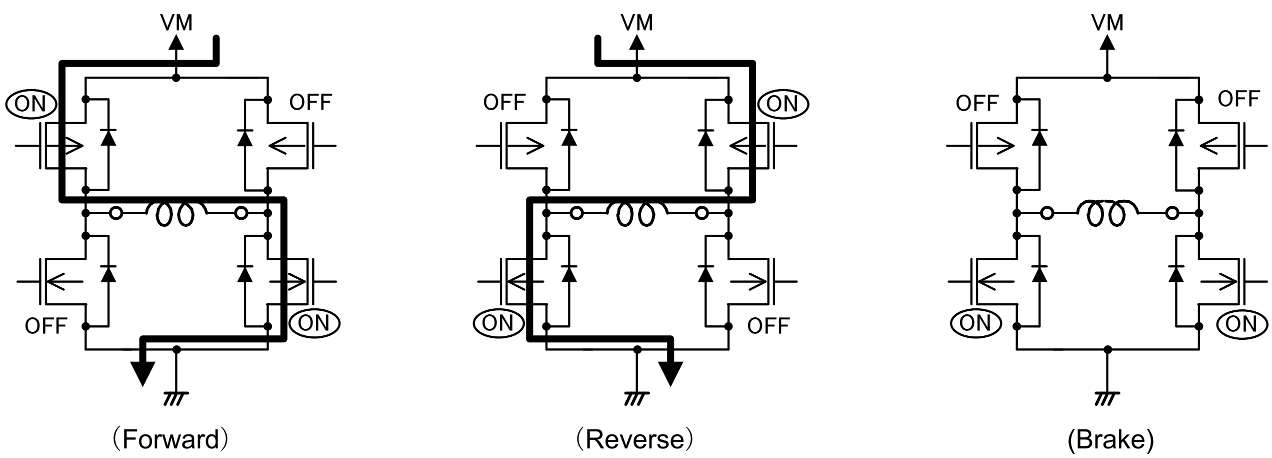


Figure 10. Output stage transistor function

• Photo sensor driving transistor

By setting INA to High, Nch transistor for driving photo sensor operates.
Since you can sink constant current of 30mA at a maximum, this motor driver can be used for LED.

When thermal shutdown and V_{CC} low-voltage cut circuits are activated, OUT1 through OUT8 are turned OFF under control of the internal circuit. But the output (PI1) of photo sensor driving transistor continues operation.

Input	Photo sensor driving
INA	PI1
L	OFF
H	ON

Thermal protection

This IC includes thermal shutdown circuit.
The thermal shutdown circuit in is corporated and the output is turned off when junction temperature Tj exceeds 180°C. As the temperature falls by hysteresis, the output turned on again (automatic restoration).
The thermal shutdown circuit does not guarantee the protection of the final product because it operates when the temperature exceed the junction temperature of Tjmax=150°C.
Thermal hysteresis width is the difference of temperature between the start of thermal shutdown and auto recovery.

Thermal shutdown temperature = 180°C (typ)
Thermal hysteresis width = 30°C(typ)

VCC Low voltage malfunction prevention

This IC includes the function of VCC Low voltage malfunction prevention.
When the supply voltage of VCC lowers down to approximately 2.25V (typ), H bridge output stage shifts from operation mode to standby mode. On the other hand, when the supply voltage of VCC increases to approximately 2.4V, H bridge output stage shifts to operation mode.
Low-voltage hysteresis voltage is the difference of VCC electric potential between VCC increase and decrease where switch of H bridge output stage occurs.

VCC low-voltage cutoff voltage = 2.25V(typ)
Low-voltage hysteresis voltage = 150mV(typ)

Application Circuit Example

•2phase excitation mode setting of stepping motor

A stepping motor can be driven through 2-phase excitation mode by switching input signal as follows.

INPUT				OUTPUT				Position No.
IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	
H	L	L	H	H	L	L	H	(1)
H	L	H	L	H	L	H	L	(2)
L	H	H	L	L	H	H	L	(3)
L	H	L	H	L	H	L	H	(4)

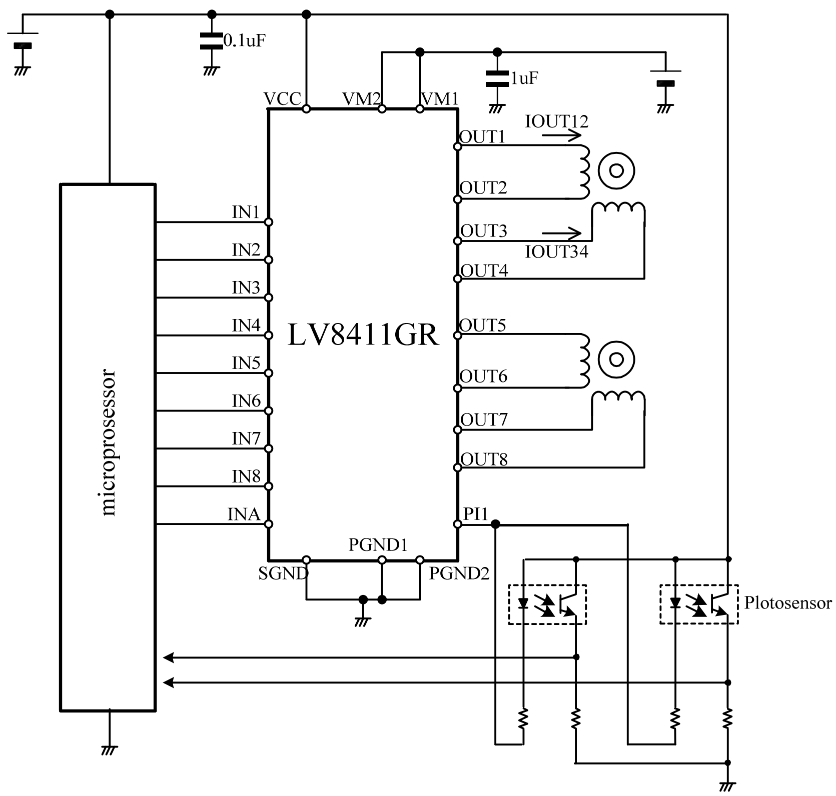


Figure 11. Sample Application Circuit
(Stepping motor drive circuit)

Bypass capacitor has no specific regulation on electrolytic capacitor or ceramic capacitor. However, it is recommended that the capacitor with large capacitance is connected adjacent to supply pin and GND to ensure that it can control voltage fluctuation of the supply line sufficiently. When capacitor with high capacitance is used, charge current to capacitor increases. Hence, caution is required for the battery's capability of current supply.

Recommendation value
Between VM and PGND: 1.0uF or higher
Between VCC and SGND: 0.1uF or higher

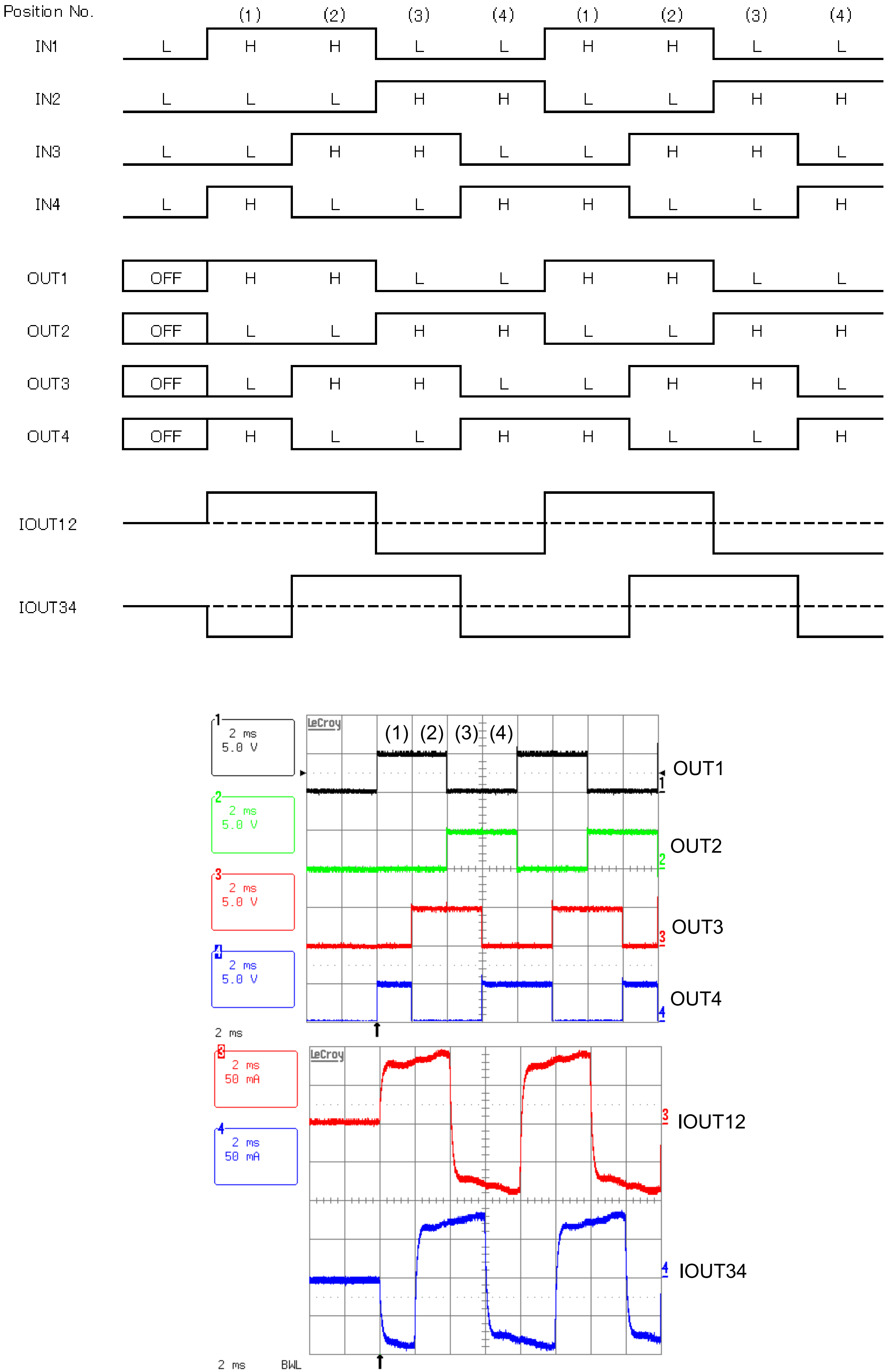


Figure 12. Timing chart for stepping motor 2phase excitation

•1-2phase excitation mode setting of stepping motor

A stepping motor can be driven through 1-2-phase excitation mode by switching input signal as follows.

INPUT				OUTPUT				Position No.
IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	
H	L	L	H	H	L	L	H	(1)
H	L	L	L	H	L	OFF	OFF	(2)
H	L	H	L	H	L	H	L	(3)
L	L	H	L	OFF	OFF	H	L	(4)
L	H	H	L	L	H	H	L	(5)
L	H	L	L	L	H	OFF	OFF	(6)
L	H	L	H	L	H	L	H	(7)
L	L	L	H	OFF	OFF	L	H	(8)

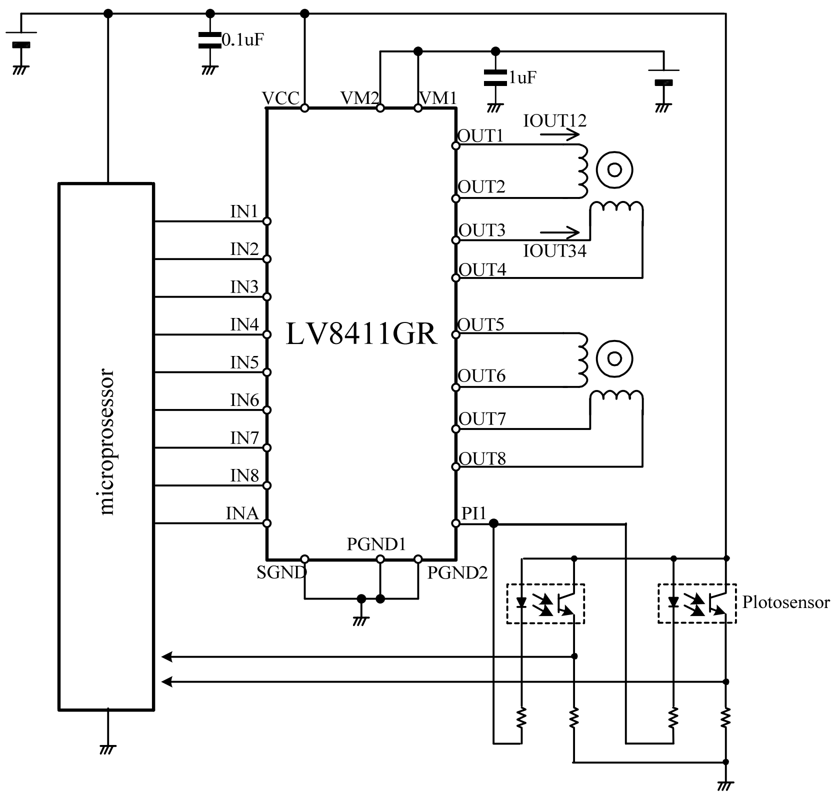


Figure 13. Stepping motor drive circuit

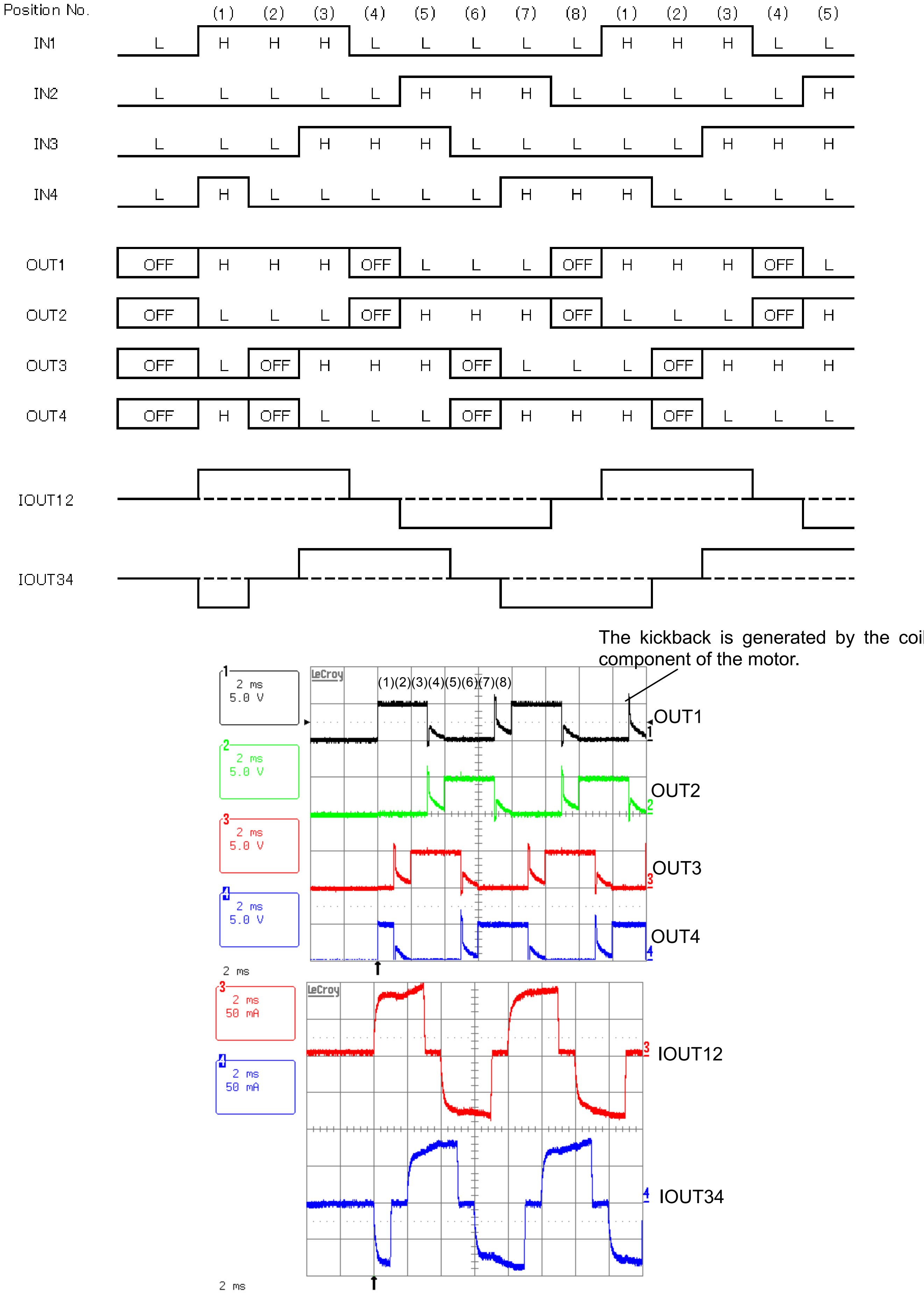


Figure 14.Timing chart for stepping motor 1-2phase excitation

•Operation setting of DC motor

CW (forward)

INPUT		OUTPUT		Condition.
IN1	IN2	OUT1	OUT2	
H	L	H	L	CW(forward)
H	H	L	L	Brake

CCW (reverse)

INPUT		OUTPUT		Condition.
IN1	IN2	OUT1	OUT2	
L	H	L	H	CCW (reverse)
H	H	L	L	Brake

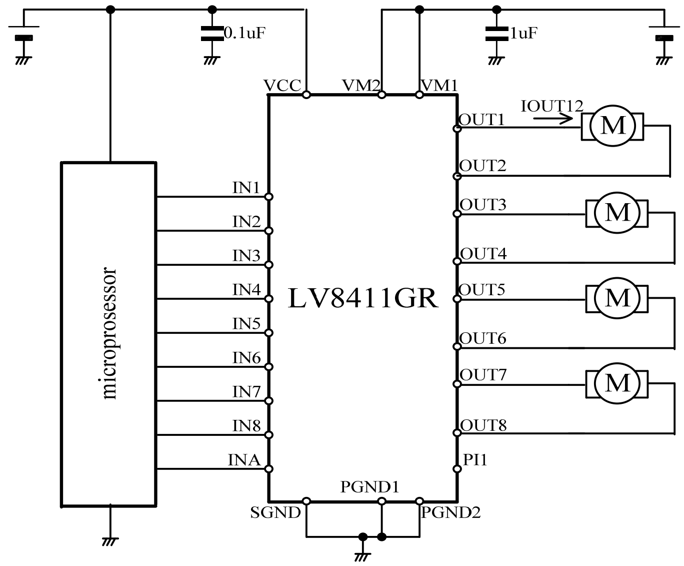


Figure 15. DC motor drive circuit

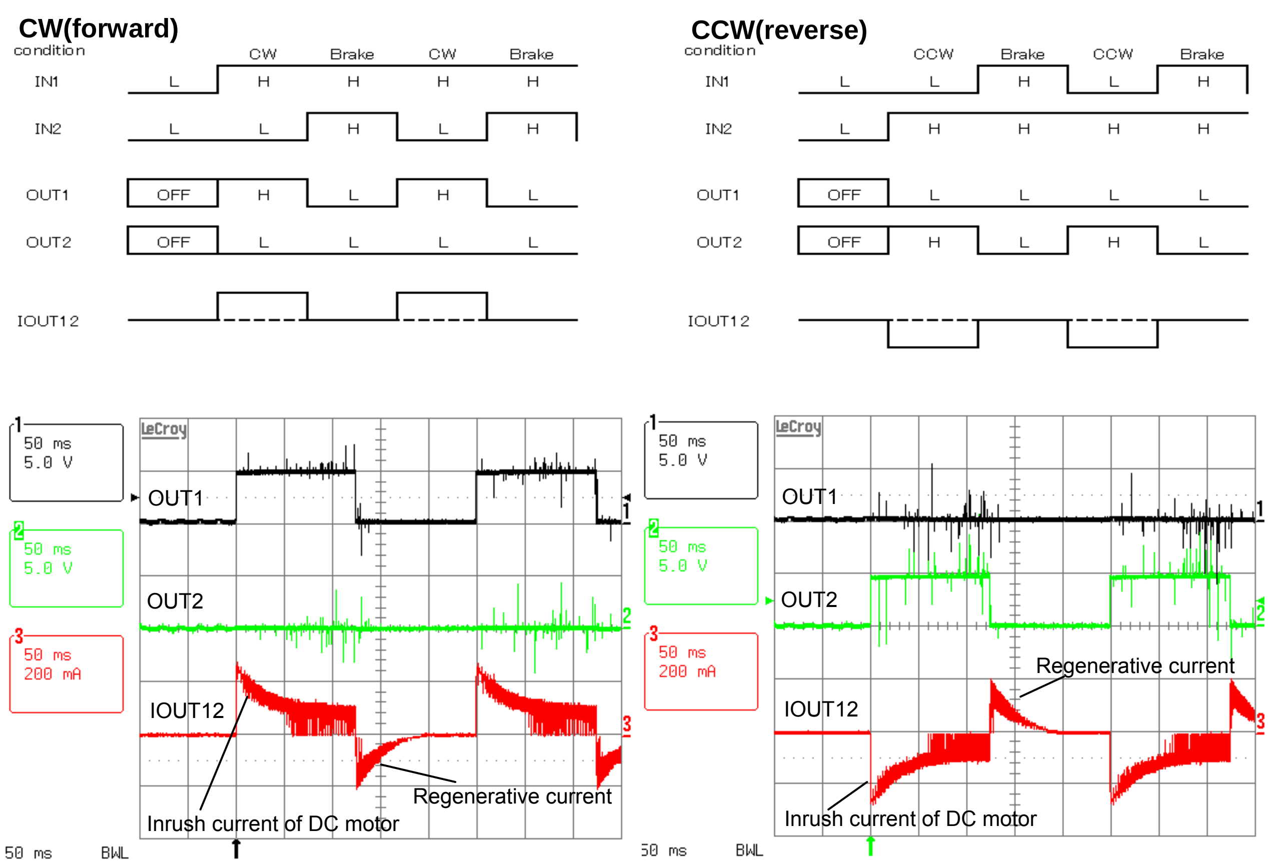


Figure 16. Driving waveform of DC motor

Input and output characteristics of H-Bridge

LV8411GR can be driven by direct PWM control of H-Bridge by inputting PWM signal to IN.
However output response of H-Bridge worsens around On-duty 0%, which generates dead zone. As a result, IC control loses linearity.
If you intend to drive motor in such control range, make sure to check the operation of your motor.

Input-Output Characteristics of H-Bridge (reference data)
Forward/Reverse⇔Brake
VM=5.0V

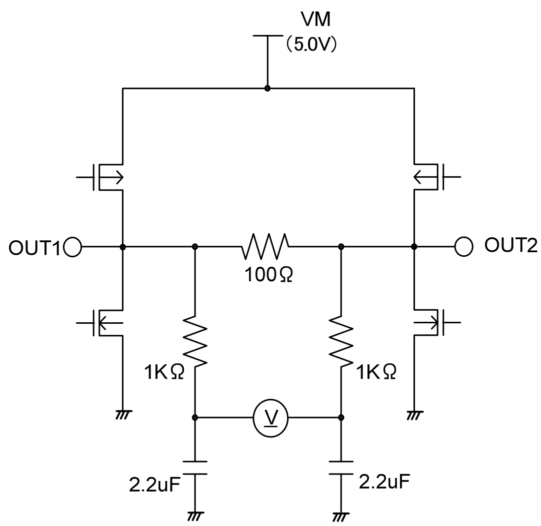


Figure 17.Measurement connection diagram

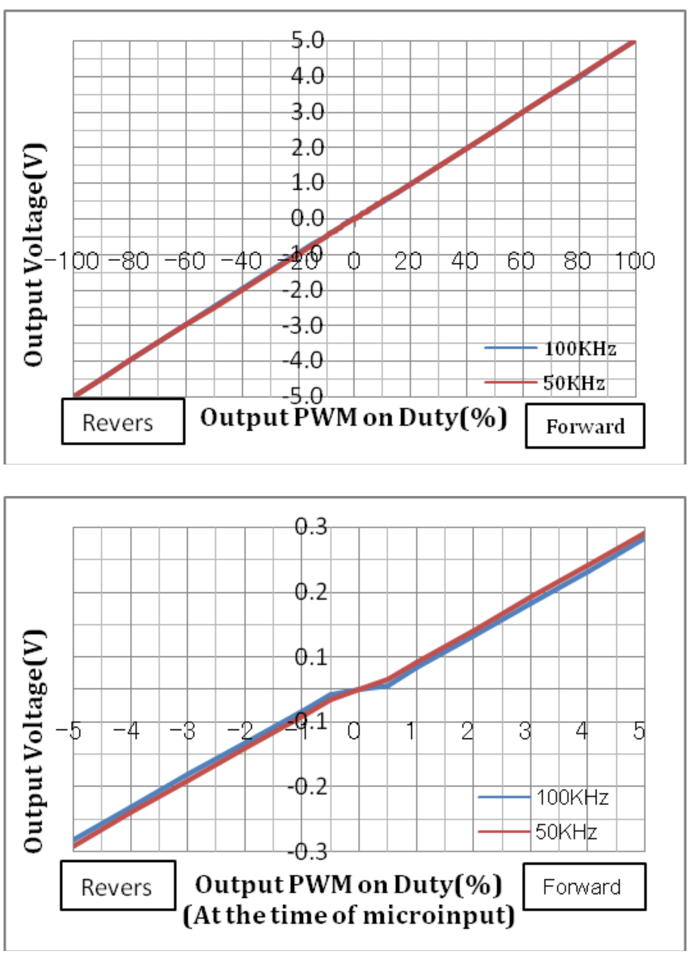
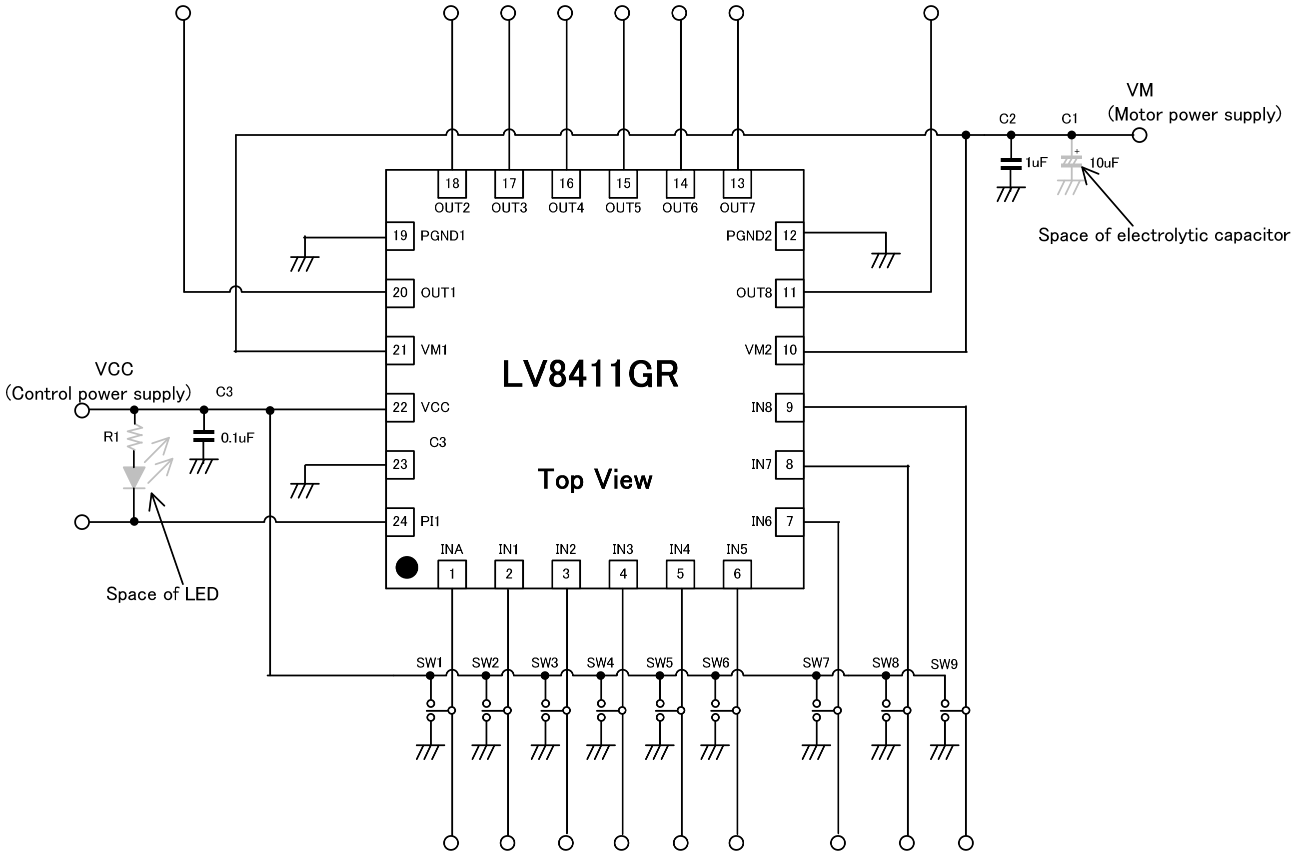


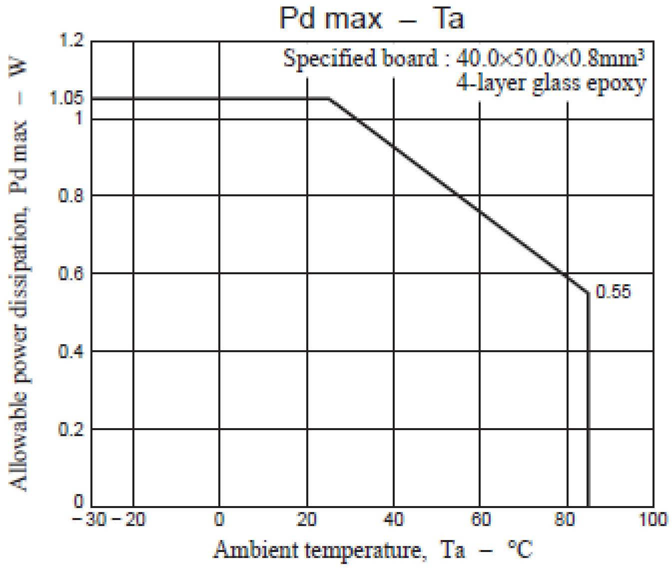
Figure 18. Input and Output Characteristics of H-Bridge

1. Evaluation Board circuit diagram



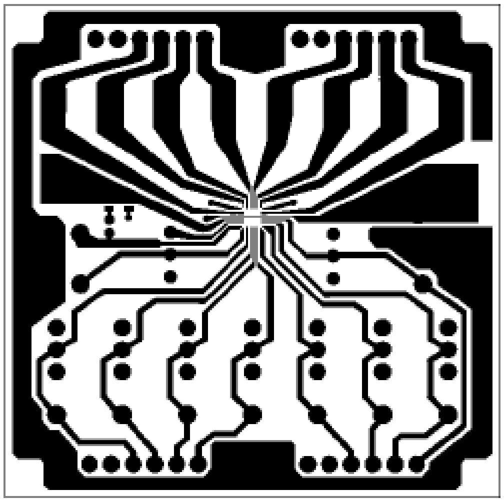
Bill of Materials for LV8411GR Evaluation Board

Designator	Qty	Description	Value	Tol	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
IC1	1	Motor Driver			VCT24 (3.0×3.0)	ON Semiconductor	LV8411GR	No	Yes
C1	1	VM Bypass capacitor	10μF					Yes	
C2	1	VM Bypass capacitor	1.0μF 10V	10%	1608	Murata	GRM188B11A 105K	Yes	Yes
C3	1	VCC Bypass capacitor	0.1μF 100V	10%	1608	Murata	GRM188R72A 104KA35D	Yes	Yes
R1	1	LED current limitation resistance						Yes	
LED	1	Substitution of photo sensor						Yes	
SW1-SW9	9	Switch				MIYAMA	MS-621-A01	Yes	Yes
TP1-TP20	20	Test points				MAC8	ST-1-3	Yes	Yes



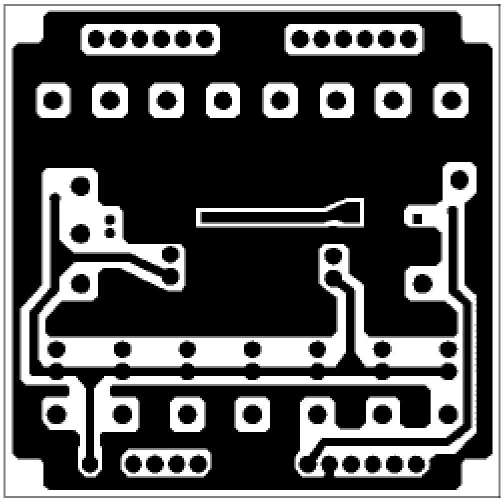
Evaluation Board PCB Design

57mm



(Top side)

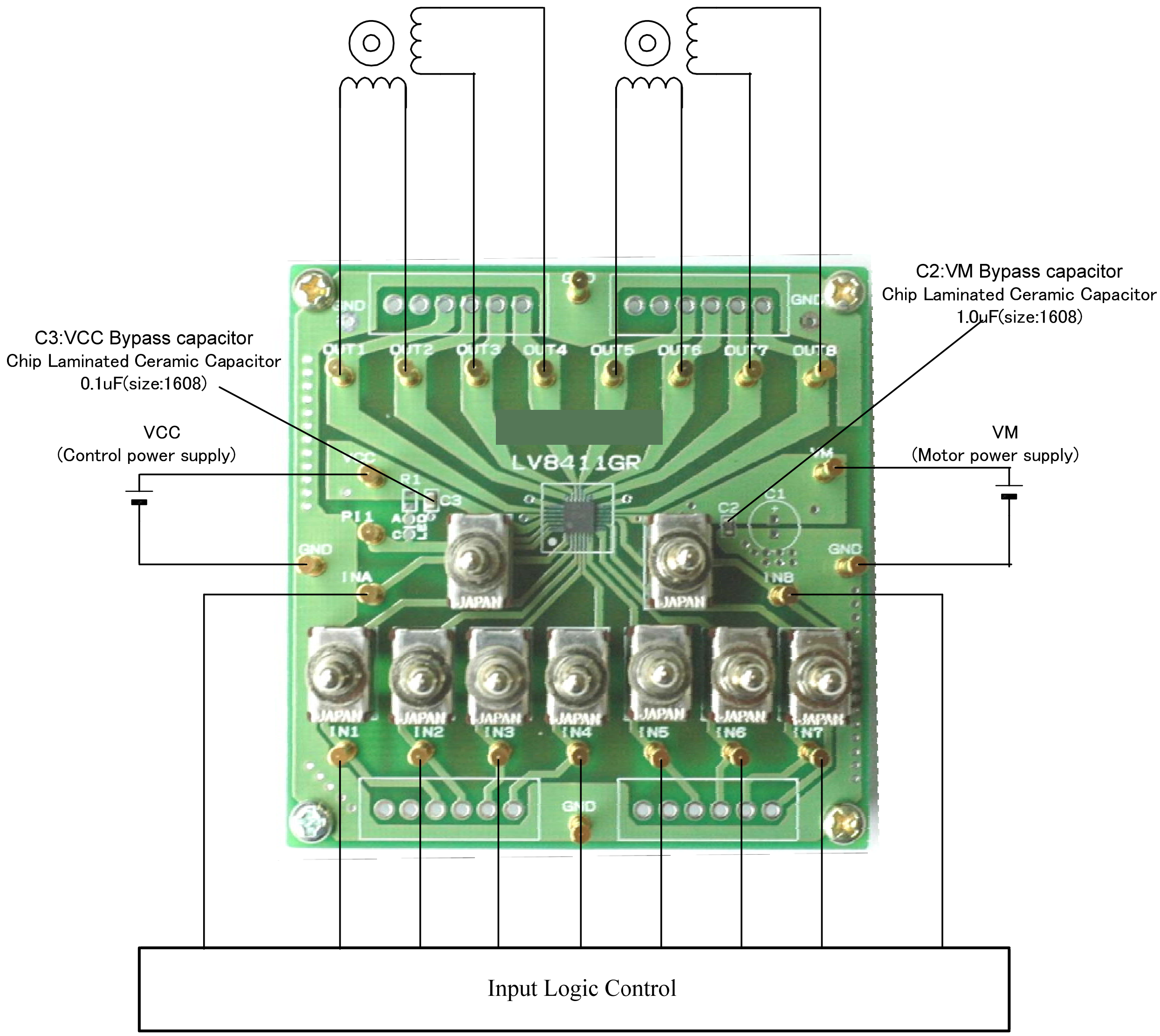
57mm



57mm

(Back side)

2. Two stepping motor drive



- Connect a stepping motor 1 with OUT1, OUT2, OUT3 and OUT4.
- Connect a stepping motor 2 with OUT5, OUT6, OUT7 and OUT8.
- 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.
- You can drive stepping motor through 2-phase excitation mode by switching input signal as follows. In the case of stepping motor 2, switch IN5 to IN8 in the same way.

INPUT				OUTPUT				Position No.
IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	
H	L	L	H	H	L	L	H	(1)
H	L	H	L	H	L	H	L	(2)
L	H	H	L	L	H	H	L	(3)
L	H	L	H	L	H	L	H	(4)

For 1-2-phase excitation mode, switch input signal as follows.

INPUT				OUTPUT				Position No.
IN1	IN2	IN3	IN4	OUT1	OUT2	OUT3	OUT4	
H	L	L	H	H	L	L	H	(1)
H	L	L	L	H	L	OFF	OFF	(2)
H	L	H	L	H	L	H	L	(3)
L	L	H	L	OFF	OFF	H	L	(4)
L	H	H	L	L	H	H	L	(5)
L	H	L	L	L	H	OFF	OFF	(6)
L	H	L	H	L	H	L	H	(7)
L	L	L	H	OFF	OFF	L	H	(8)

*The descriptions in p.8 to p.11are the same as the description in this section.

•By setting INA to High, Nch transistor for photo sensor operates.
Since you can sink constant current of 30mA at a maximum, this motor driver can be used for LED.

If necessary, please use LED to confirm the operation of the IC.