LB1939T

Bip integrated circuit

Constant Voltage Drive

Stepper Motor Driver Application Note

ON Semiconductor®

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Overview

The LB1939T is a constant voltage drive for single stepper motor. It is optimal for motor drive in portable system products (Battery drive available).

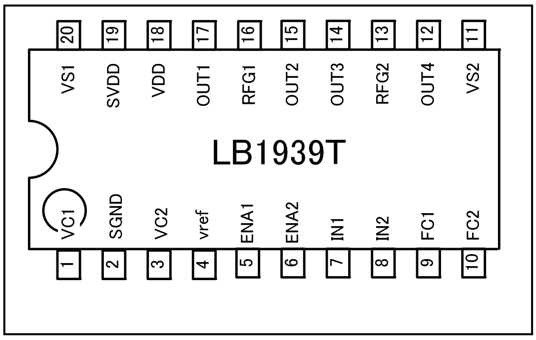
Function

- Low voltage drive
  Dual power supply operation Vs=1.6V to 7.5V VDD=1.9V to 6.5V.
  Single power supply operation Vs=VDD=1.9V to 7.5V.
- Low saturation voltage Vosat=0.3V at Io=200mA.
- Supports constant voltage and constant current drive
- Built-in reference voltage circuit
- Small and thickness Package TSSOP20
- Current consumption 0 uA by standby mode

Typical Applications

- POS terminal
- Document scanner
- Security Camera
- Gas table

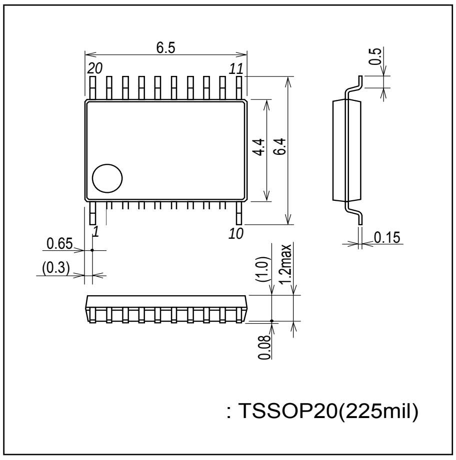
Pin Assignment



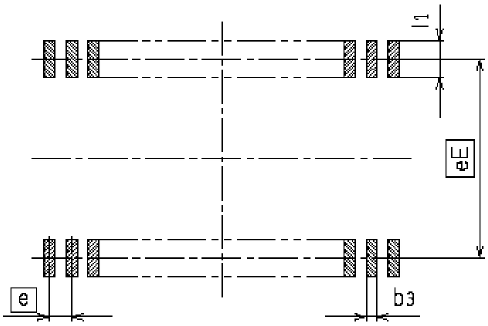
Package Diagram

unit : mm(typ)

3246



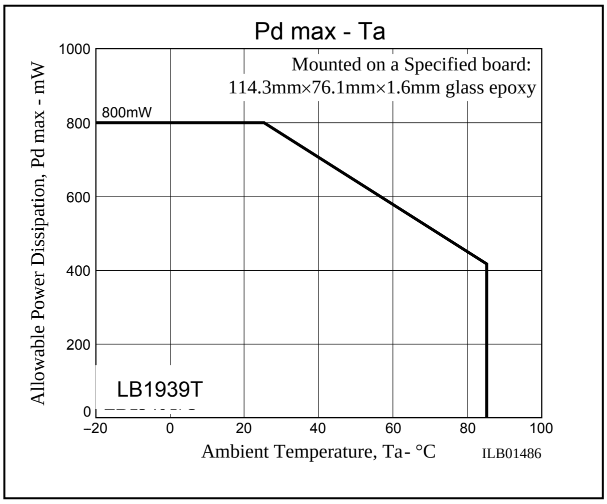
Recommended Soldering Footprint



(Unit:mm)

Reference Symbol	TSSOP20(225mil)
eE	**5.80**
e	**0.65**
b3	**0.32**
l1	**1.00**

Pd max-Ta



Block Diagram

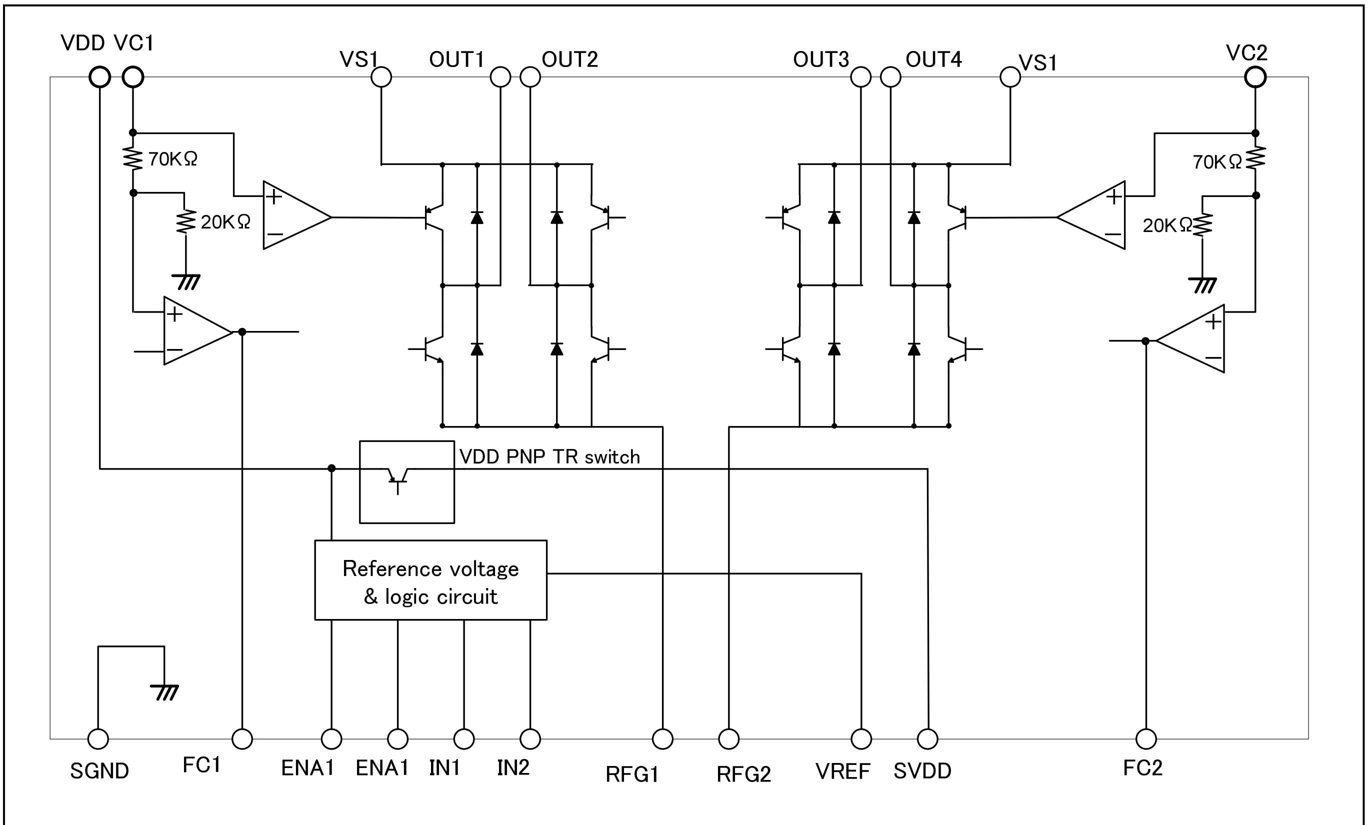


Figure1 One stepping motor drive

Specifications

Absolute Maximum Ratings at Ta = 25□C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	VB max	VS1, VS2, V_{DD}	-0.3 to +10.5	V
Output applied voltage	V_{OUT} max	OUT1, OUT2, OUT3, OUT4	-0.3 to +10.5	V
Output Current	I_O max	t ≦10msec	400	mA
Input applied voltage	V_{IN} max	ENA1, ENA2, IN1, IN2, VC	-0.3 to +10.5	V
Allowable power dissipation	Pd max	Mounted on a specified board *	800	mW
Operating temperature	Topr		-20 to +85	□C
Storage temperature	Tstg		-55 to +150	□C

* Mounted on a Specified board: 114.3mm×76.1mm×1.6mm, glass epoxy

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

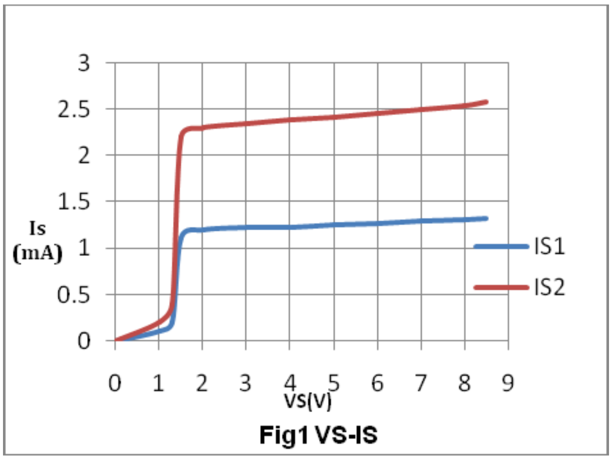
Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = 25°C

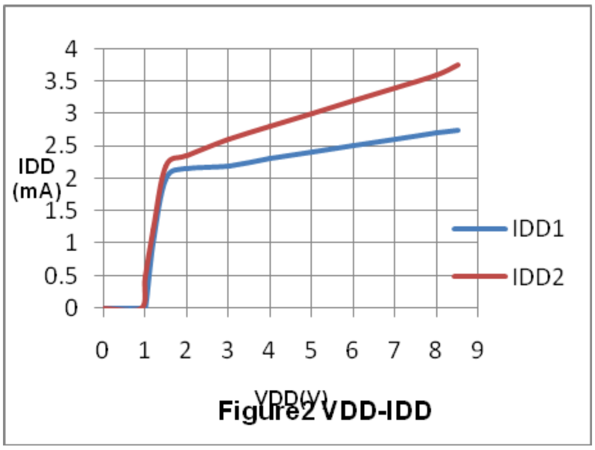
Parameter	Symbol	Conditions	Ratings			unit
			min	typ	max	
Function-guaranteed voltage range	VOPR1	V_{DD} system, VS = 2.0V	1.9		6.5	V
	VOPR2	VS system, V_{DD} = 5.0V	1.6		7.5	
Low level input threshold voltage	V_{IL}	ENA1, ENA2, IN1, IN2	-0.3		1.0	V
High level input threshold voltage	V_{IH}	ENA1, ENA2, IN1, IN2	2.0		6.0	V

Electrical Characteristics at Ta = 25°C, VS = 3V, V_{DD} = 5V

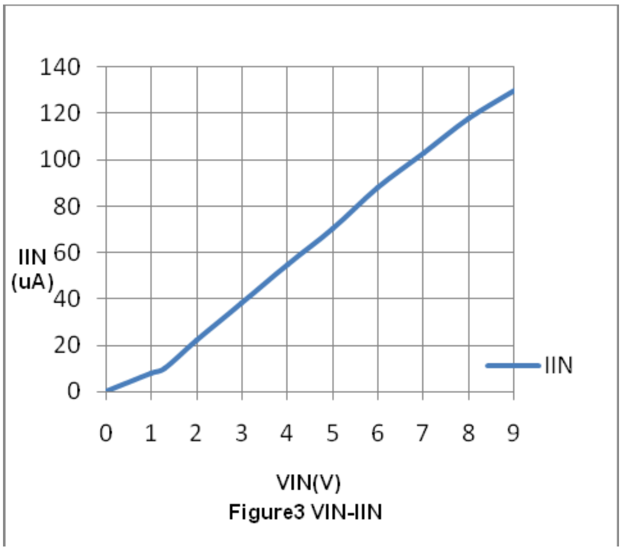
Parameter	Symbol	Conditions	Ratings			unit
			min	typ	max	
Standby current dissipation	ISTB	VS = V_{DD} = 6.5V		0.1	1.0	µA
Regulator output circuit						
VREF output voltage	VREF	I_{OL} = 0 to 1mA	0.85	0.9	0.95	V
SVDD output voltage	VSVDD	I_{OL} = 10mA	4.70	4.8		V
H bridge output circuit						
OUT output saturation voltage (at saturation control)	V_O(sat)1	V_{DD} = 5.0V, VS = 2.0V I_O = 200mA (PNP side)		0.20	0.30	V
	V_O(sat)2	V_{DD} = 5.0V, VS = 2.0V I_O = 200mA (NPN side)		0.10	0.15	V
OUT output voltage (at constant voltage control)	VOUT1	V_{DD} = 6.0V, VC = 1.5V, VS = 3.5V Io=200mA （PNP Transistor side）	2.8	2.9	3.0	V
	VOUT2	V_{DD} = 6.0V, VC = VREF, VS = 3.5V Io=200mA （PNP Transistor side）	1.65	1.75	1.85	V
OUT output current (at constant current control)	$I_{OUT}1$	V_{DD} = 6.0V, VC = 0.9V, VS = 3.5V Io=200mA （PNP Transistor side） R_L = 5Ω (between OUT-OUT), RFB = 1Ω	197	210	223	mA
	$I_{OUT}2$	V_{DD} = 6.0V, VC = VREF, VS = 3.5V Io=200mA （PNP Transistor side） R_L = 5Ω (between OUT-OUT), RFB = 1Ω	189	210	231	mA
VS system operating current drain1	IS1	VC =SVDD		4	7	mA
VS system operating current drain2	IS2	VC =VREF		1.5	3	mA
V_{DD} system operating current rain1	$I_{DD}1$	VC =SVDD ENA1 = 2V		4	7	mA
V_{DD} system operating current rain2	I_{DD2}	VC =VREF ENA1 = 2V		4	7	mA
VC input voltage range	VC		0.1		7	V
VC input current	IVC	V_{DD} = 6.0V, VS = 2.0V, VC = 5V	0	50	100	µA
Control input circuit						
Control pin maximum input current	I_{IH}	V_{IH} = 5.5V		70	100	µA
	I_{IL}	V_{IL} = GND	-1		0	



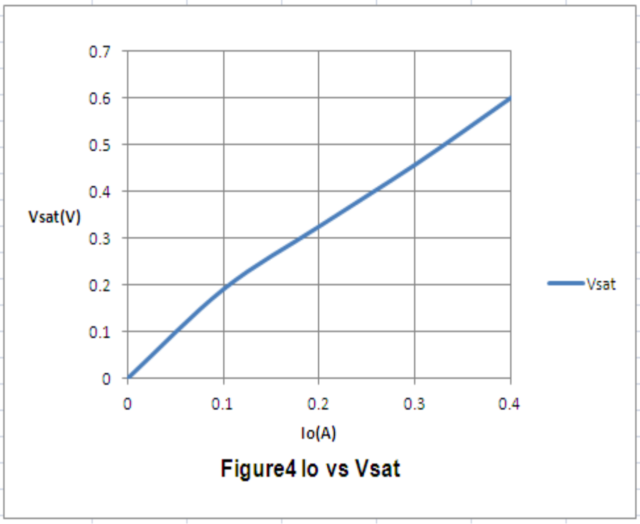
Is (mA)
VS(V)
IS1
IS2
Fig1 VS-IS



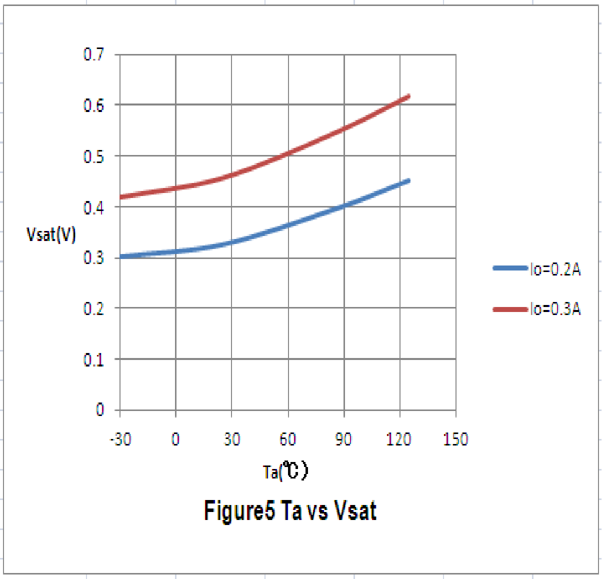
IDD (mA)
VDD(V)
IDD1
IDD2
Figure2 VDD-IDD



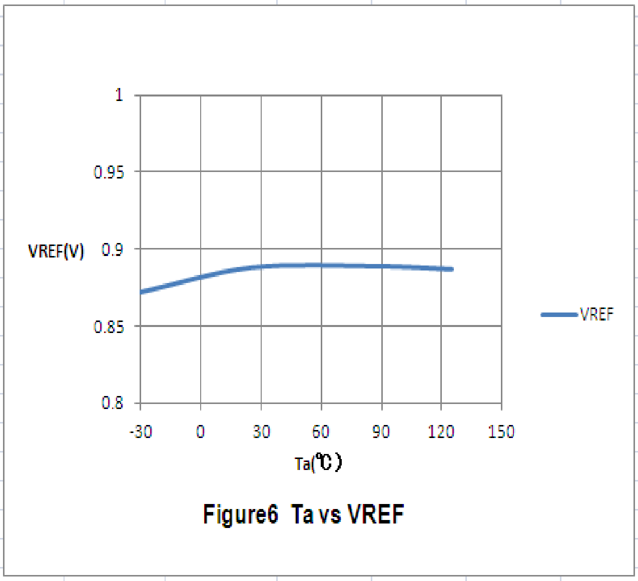
IIN (uA)
VIN(V)
IIN
Figure3 VIN-IIN



Vsat(V)
Io(A)
Vsat
Figure4 Io vs Vsat



Vsat(V)
Ta(℃)
Io=0.2A
Io=0.3A
Figure5 Ta vs Vsat



VREF(V)
Ta(℃)
VREF
Figure6 Ta vs VREF

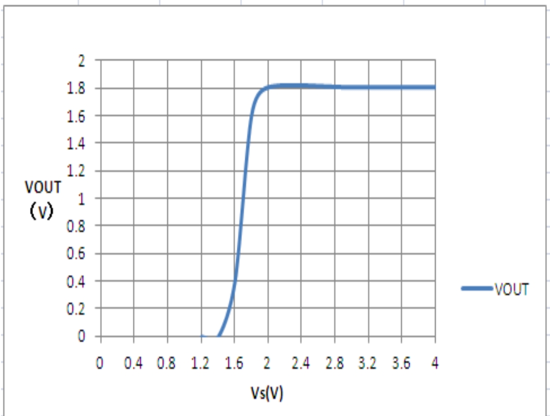


Figure7 Vs vs VOUT (RL=7.5Ω)

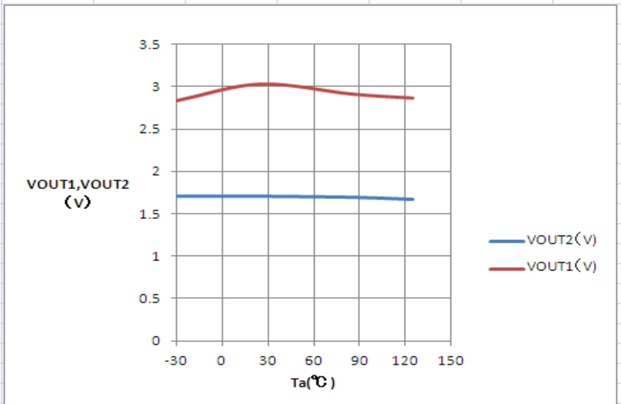


Figure8 Ta vs VOUT1, 2

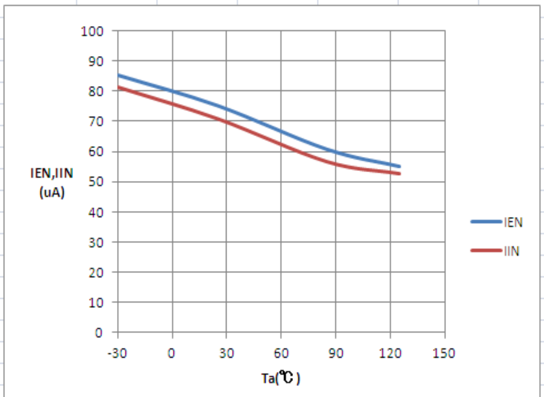


Figure9 Ta vs IEN IIN

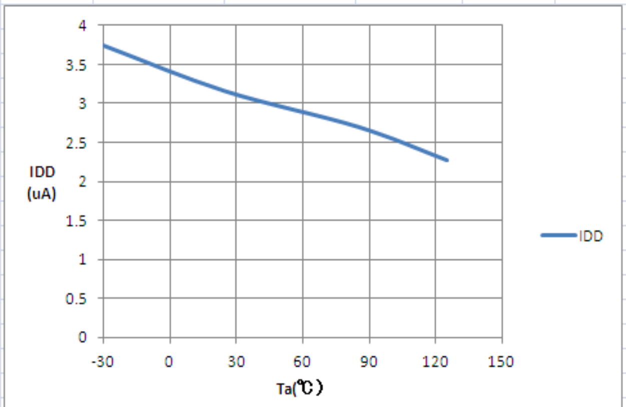
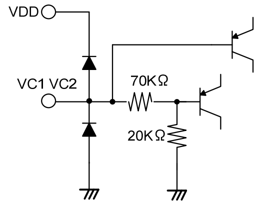
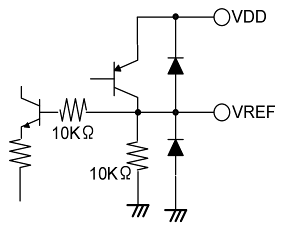
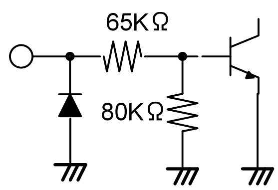
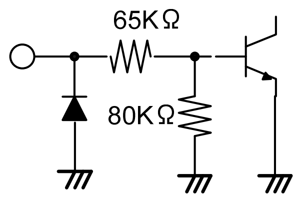
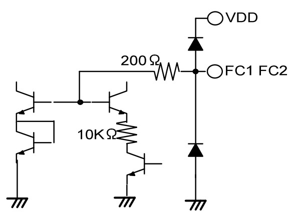
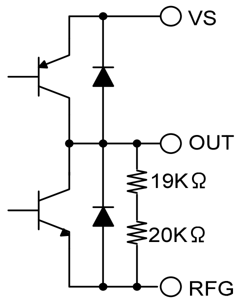
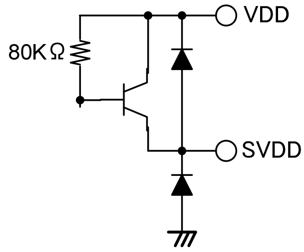


Figure10 Ta vs IDD

Pin function

Pin No.	Pin name	Pin function	Equivalent Circuit
11,20	VS1,VS2	Power-supply voltage pin. VS voltage is impressed. The permissible operation voltage is from 1.6 to 7.5(V). The capacitor is connected for stabilization for GND .	
1,3	VC1,VC2	Output voltage set up terminal (1pin 3pin) Output voltage is 1.95 times of VC1, VC2 voltages.	
2	SGND	Signal GND	
4	VREF	Reference voltage output terminal (4pin)	
5 6	ENA1 ENA2	Motor drive control input pin.(5pin,6pin) It shifts from the stand-by state to a prescribed output operation corresponding to the state of the input when the ENA pin becomes a standby mode by L, the circuit current can be adjusted to 0, and it makes it to H. It is a digital input, and the range of L level input is 0 to 1.0(V) and the range of H level input are 2.0 to 6.0(V). Pull-down resistance 80(kΩ) is built into in the terminal. ENA1 is start up for OUT1-OUT2. ENA2 is start up for OUT3-OUT4.	
7	IN1	Motor drive control input pin. Driving control input pin of OUT1 (17pin) and OUT2 (15pin). With built-in pull-down resistance.	
8	IN2	Motor drive control input pin. Driving control input pin of OUT3 (14pin) and OUT4 (12pin). With built-in pull-down resistance.	
9 10	FC1 FC2	OUTPUT phase compensation for current drive. FC1 is phase compensation pin for OUT1-OUT2. FC2 is phase compensation pin for OUT3-OUT4. It connected capacitor (example:0.001uF-0.01uF)	
7	OUT4	Driving output pin. The motor coil is connected between terminal OUT3 (8pin).	
8	OUT3	Driving output pin. The motor coil is connected between terminal OUT4 (7pin).	
9	OUT2	Driving output pin. The motor coil is connected between terminal OUT1 (10pin).	
10	OUT1	Driving output pin. The motor coil is connected between terminal OUT2 (9pin).	

Pin No.	Pin name	Pin function	Equivalent Circuit
19	SVDD	SVDD is bias terminal when VC1 and VC2 set up voltage. Please confirm application circuit for current drive at page	
18	VDD	Signal power-supply terminal. VDD voltage is impressed. The permissible operation voltage is from 1.9 to 6.5(V). The capacitor is connected for stabilization for GND.	
16 13	RFG1 RFG2	Power GND or current detect terminal. RFG1, RFG2 is Power GND when IC is constant voltage drive. RFG1, RFG2 connected current detect resistor to GND when IC is constant current drive.	

Operation explanation

1. Truth table

Input				Output					Mode
ENA		IN		OUT				SVDD	
1	2	1	2	1	2	3	4		
L	L								Standby (current dissipation zero)
H		H		L	H			on	Reverse rotation
		L		H	L			on	Forward rotation
	H		H			L	H	on	Reverse rotation
			L			H	L	on	Forward rotation
A blank means “don’t care”.				A blank means “off”.					

2. Thermal shutdown function

The thermal shutdown circuit is incorporated and the output is turned off when junction temperature Tj exceeds 175°C.

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.

TSD = 175°C (typ)

(1)Thermal shutdown temperature

The thermal shutdown temperature Ttsd is 175±20°C with fluctuations.

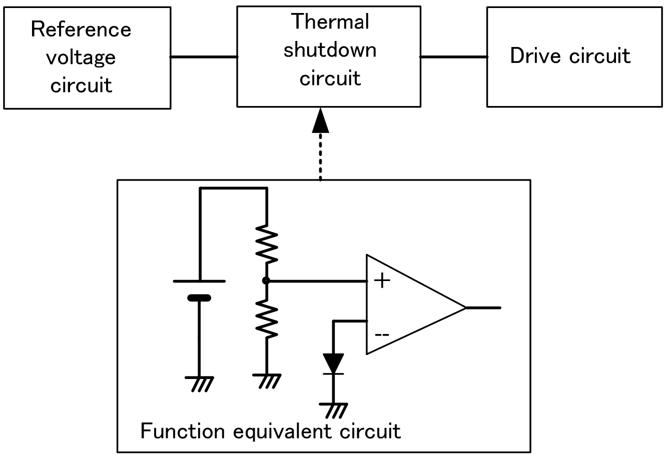
(2)Thermal shutdown operation

The operation of the thermal shutdown circuit is below sentennce.

When the chip temperature Tj is in the direction of increasing ,it protect IC by output drive reduce at approximately 175°C.

(Thermal shutdown circuit block diagram)

The thermal shutdown circuit compares the voltage of the heat sensitive element (diode) with the reference voltage and shuts off the drive circuit at a certain temperature to protect the IC chip from overheating.



Note: The above is an example of thermal shutdown circuits although ther are same differences from the actual internal circuit.

Design Documentation

(1)Voltage magnitude relationship

There are no restrictions on the magnitude relationships between the voltage applied to Vcc and ENA1,ENA2,IN1,IN2.

(2)Observe the following points when designing the printed circuit board pattern layout.

- Make the VS and ground (RFG pin) lines as wide and as short as possible to lower the wiring inductance.
- Insert bypass capacitors between VDD and ground mounted as close as possible to the IC.
- Insert bypass capacitors between VS and ground mounted as close as possible to the IC.

Timing Chart and Operation principal

Full-Step (2phase excitation) drive

Motor advances 90 degree by inputting 1 step.

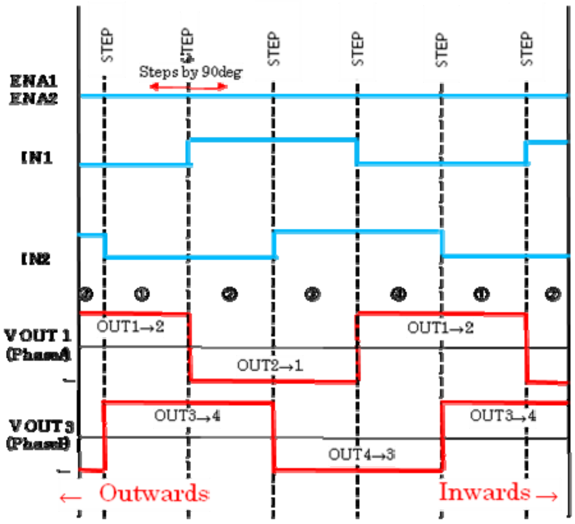


Figure 1. Full-Step Timing

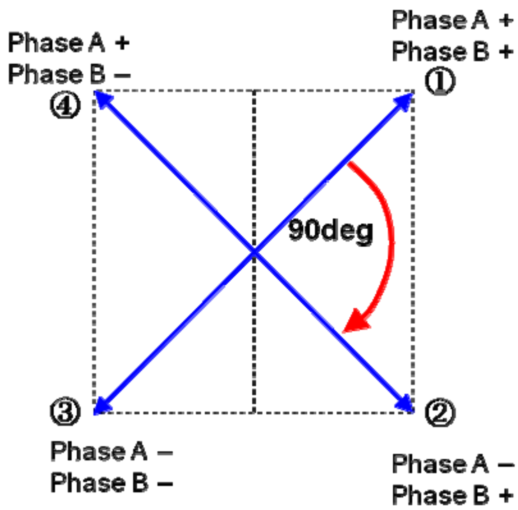


Figure 2 Motor electric angle (Full Step Drive)

Half-Step (1-2phase excitation) drive

Motor advances 45 degree by inputting 1 step.

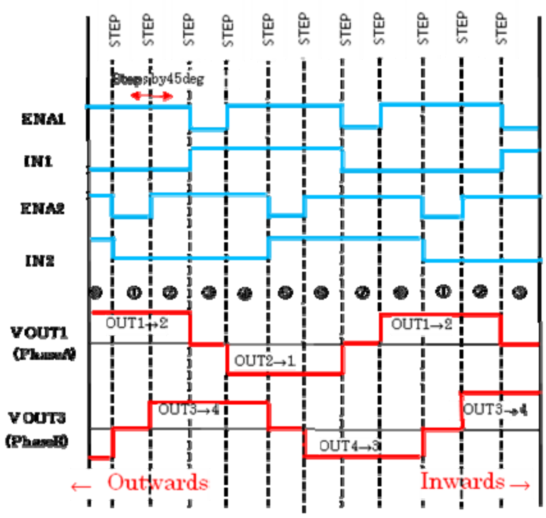


Figure 12 Half-Step Timing

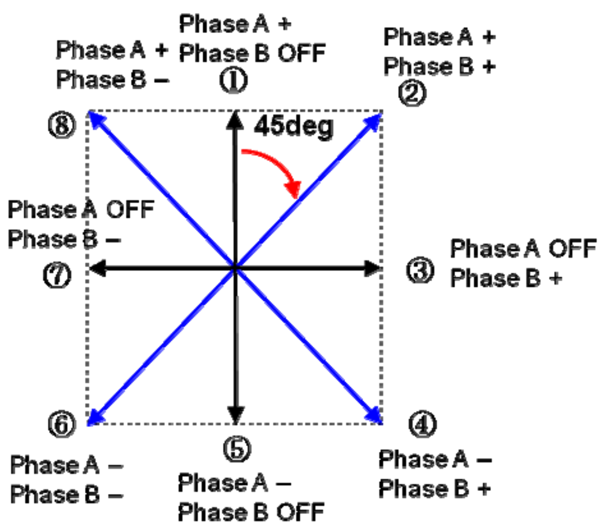
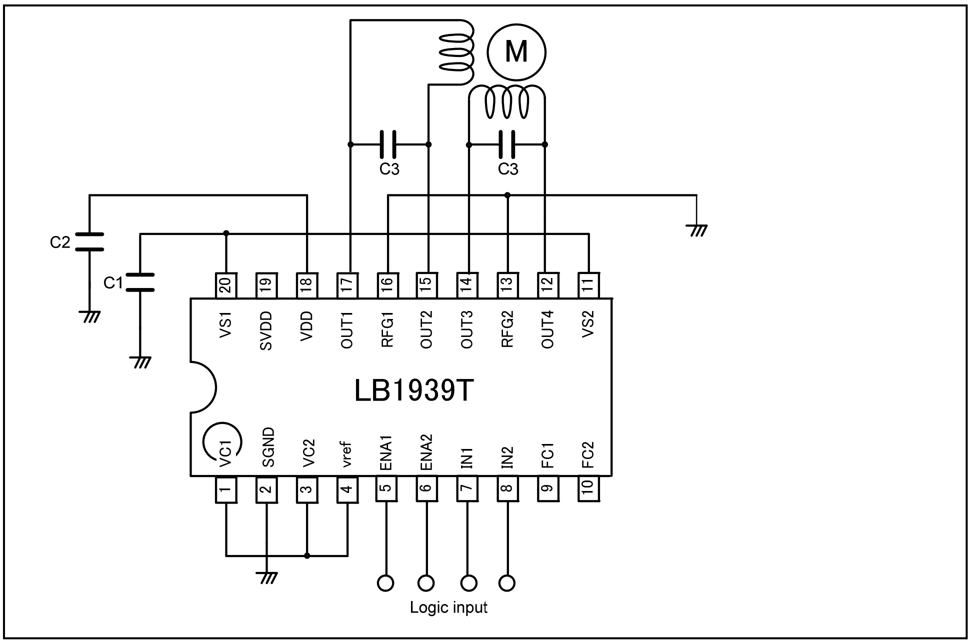


Figure 22 Motor electric angle (Half-Step Drive)

Application Circuit Example

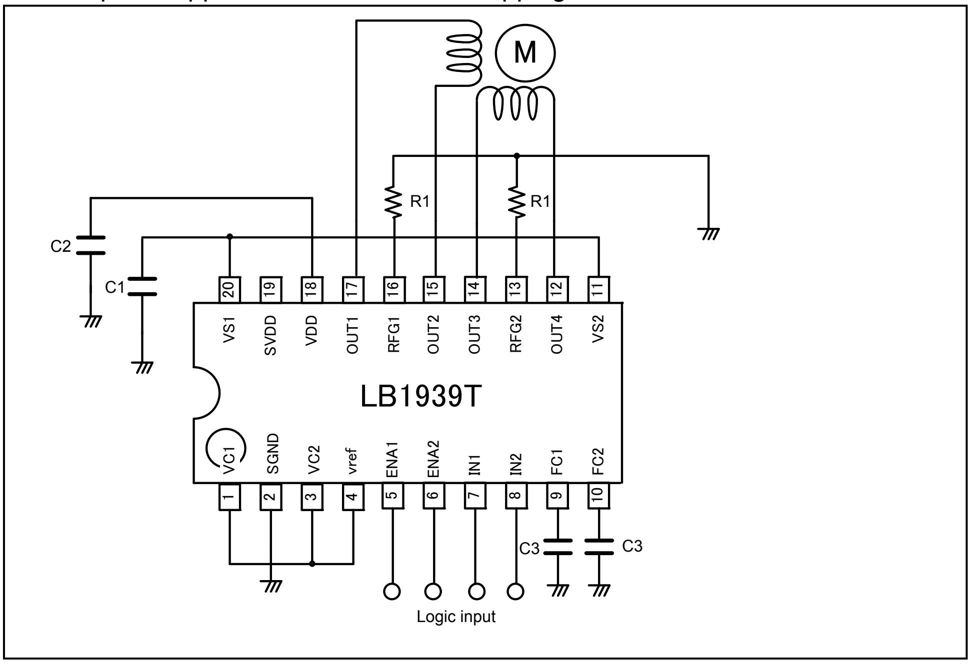
1. Example of applied circuit when one stepping motor with constant voltage drive



* Bypass capacitor (C1) connected between VS-GND of all examples of applied circuit recommends the electric field capacitor of 0.1µA to 10µA.
Confirm there is no problem in operation in the state of the motor load including the temperature property about the value of the capacitor.
Bypass capacitor (C2) connected between VDD-GND of all examples of applied circuit recommends the electric field capacitor of 0.1µA to 1µA.
Mount the position where the capacitor is mounted on nearest IC.
Phase compensation capacitor (C3) connected between OUT-OUT for constant voltage control.
Capacitor value of C3 depends on stepping motor. Please confirm stepping motor operation and Set up capacitor value.

Output voltage with constant voltage drive is below in this schematic.
Vout=VC ×1.95=0.9×1.95=1.75V
(VC=VREF=0.9V)

2. Example of applied circuit when one stepping motor with constant current drive.



* Bypass capacitor (C1) connected between VS-GND of all examples of applied circuit recommends the electric field capacitor of 0.1µA to 10µA.
Confirm there is no problem in operation in the state of the motor load including the temperature property about the value of the capacitor.

Bypass capacitor (C2) connected between VDD-GND of all examples of applied circuit recommends the electric field capacitor of 0.1μA to 1μA.
Mount the position where the capacitor is mounted on nearest IC.
Phase compensation capacitor (C3) connected between FC-GND for constant current control.
Capacitor value of C3 depends on stepping motor. Please confirm stepping motor operation and Set up capacitor value.

Output current with constant current drive is below in this schematic.

The voltage input to the VC pin is resistor divided internally (by 70kohm and 20kohm resistor) to 1/4.5 and +input of constant current control amplifier as reference.

- Input of this constant current control amplifiers is connected , through the wire bond resistor Rb =0.1Ω to the RFG pin .

The constant current control circuit operates by comparing voltage of external current detection resistor connected to the RFG pin and reference voltage (VC).

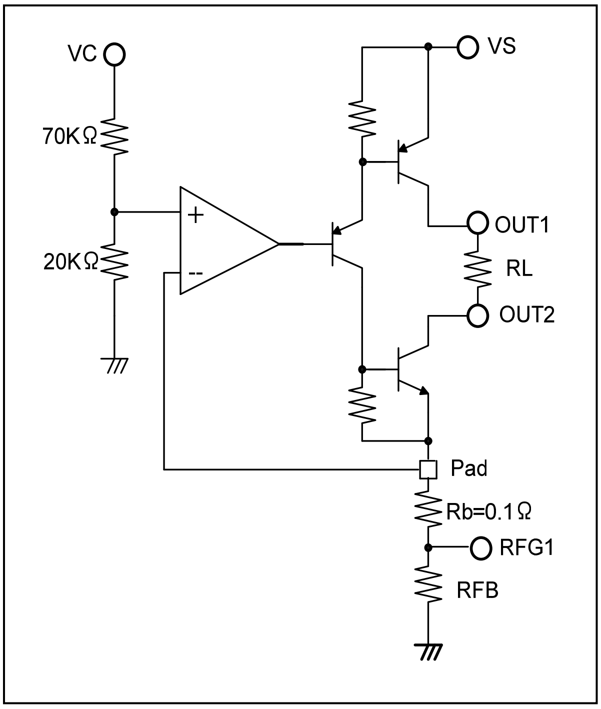
Note that the voltage at VA is following formula blow.

VA=VC/4.5+Ib×20kΩ
= VC/4.5+0.03

Ib: bias current of amplifier=1.5uA.

Therefore OUTPUT current Io is following expression below.

Io=VA/(RFB+Rb)
＝(VC/4.5+0.03)/(RFB+Rb)



For example, if constant current is used with application circuit with
Fig 2 VC=Vref =0.9V, if R1 is 1Ω then output current can be calculated as following below expression.
Io=(0.9/4.5+0.03)/（1+0.1）
＝(0.23/1.1)
＝0.209A
If the value driven load resistance RL is r, RFG pin voltage is 0.23V and npn transistor output saturation voltage is 0.1V (typ), pnp transistor output voltage can be calculated as follows.

Vout=(RFGpin voltage)+(npn transistor output saturation voltage)+(voltage of motor terminal)
=0.23+0.1+0.209×r
=0.33+0.209×r
At the same time, however this IC`s internal constant voltage controls the output voltage as follows.
Vout`=VC×1.95

Therefore, it will not be possible to use the constant current mode if the value of r is sp that Vout is greater than Vout'.
That is, the condition.

0.33+0.209×r>1.75

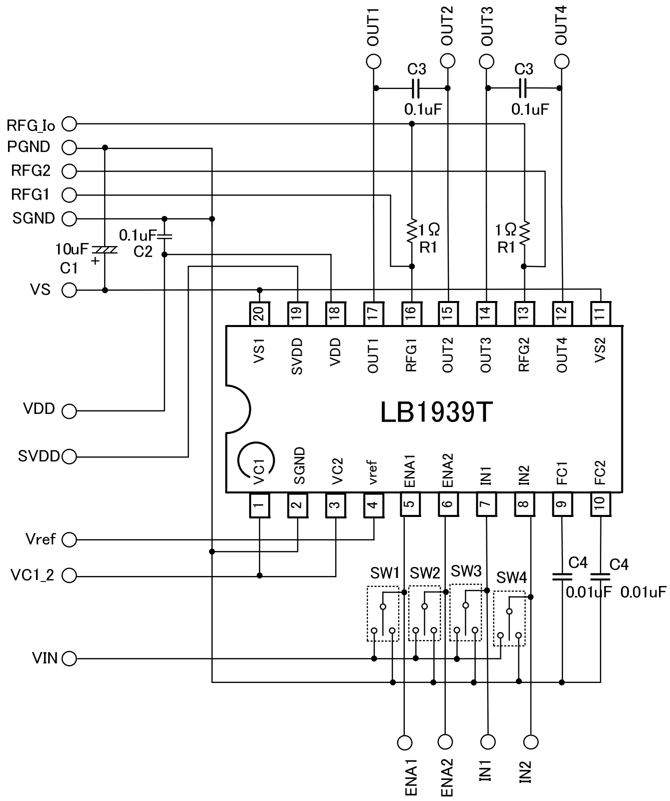
Implies that

r>6.79

This means that constant current control can be used when the value of the load resistance used is strictly less than 6.79ohm.

Evaluation Board Manual

1. Evaluation Board circuit diagram

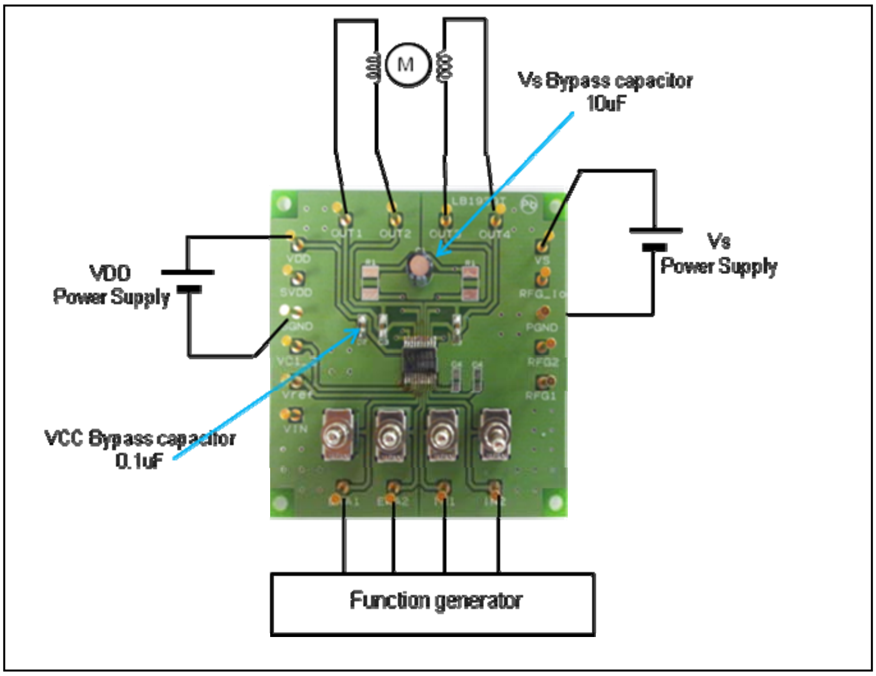


Our provided Eva board is constant voltage mode.
Please contact RFG1-terminal and RFG2-terminal and PGND-terminal.
Therefore R1 resistor and C4 capacitor is not mount evaluation board.
If Eva board use constant current driving, Please Eva board changing below
It remove C3 capacitor and mount R1 and C4 parts.
Finally contact RFG-Io and PGND.

Bill of Materials for LB1939T Evaluation Board

Designator	Quantity	Description	Value	Tolerance	Footprint	Manufacturer	Manufacturer Part Number	Substitution Allowed	Lead Free
C1	1	VS Bypass Capacitor	10μF, 50V			SUN Electronic Industries	50ME10HC	Yes	
C2	1	VCC Bypass Capacitor	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C3	2	output voltage stabilization Capacitor	0.1μF, 100V	±10%		Murata	GRM188R72A104KA35*	Yes	Yes
C4	2	frequency control for current drivr	10000pF, 50V	±5%		Murata	GRM188B11H103KA01D	Yes	Yes
R1	2	Output current Sensing resistor	1.0Ω 1/4W	±1%		ROHM	MCR10EZHFL1R00	Yes	Yes
IC1	1	Motor Driver				ON Semiconductor	LB1939T	No	Yes
SW1-SW7	4	Switch				MIYAMA	MS-621C-A01		
TP1-TP18	16	Test Point				MAC8	ST-1-3		

2. One stepping motor drive



- Connect a stepping motor with OUT1, OUT2, OUT3 and OUT4.
- Connect the motor power supply with the terminal VCC, the control power supply with the terminal VIN. Connect the GND line with the terminal GND.
- STP motor drives it in a Full-Step, Half-Step by inputting a signal such as follows into IN1~IN4.
- For input signal to function generator, refer to p.8.
  To reverse motor rotation, make sure to input signal to outward direction.

Waveform of LB1939T evaluation board when driving stepping motor

- Full-Step Drive

LB1939T Full-Step (VCC=3.3V, 200pps)