

LB1860, LB1860M, LB1861, LB1861M



ON Semiconductor®

www.onsemi.com

Monolithic Digital IC

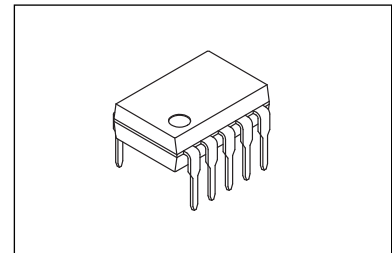
Two-Phase Half-Wave Variable Speed Fan Motor Driver

Overview

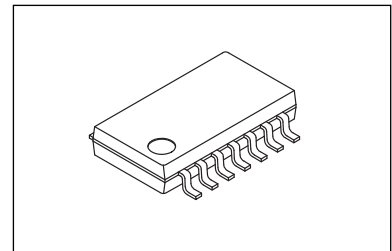
The LB1860 series ICs are drivers for two-phase unipolar drive DC brushless fan motors. They have functions such as driving, lock protection, restart and speed control.

Features

- Two-speed mode select function requiring less external component additions : Full speed and Low speed. Or, thermistor-controlled continuous variable-speed function according to ambient operation temperatures.
→ Motor starts rotating at a low speed.
- Motor lock protection and automatic return circuit built in
- Output transistors: Output current $I_O = 1.5\text{ A}$, output circuit protection Zener diodes
(LB1860 : $M-V_Z = 57\text{ V}$ / LB1861: $M-V_Z = 32\text{ V}$)
→ Enables low-level noise protection with chip capacitor.
- Built-in thermal shutdown circuit Built-in rotation detect function
(Drive mode: “L”, Stop mode: “H”)
- The LB1860 series can be operated from either 12 V or 24 V power supply by changing an external resistor.
(Strong protection against power supply surge)
- Connectable direct to a Hall element



PDIP10 / DIP10S (300 mil)
[LB1860, LB1861]



SOIC14 W / MFP14S (225 mil)
[LB1860M, LB1861M]

ORDERING INFORMATION

See detailed ordering and shipping information on page 9 of this data sheet.

Specifications

Absolute Maximum Ratings at Ta = 25 °C, (): LB1860M, LB1861M

Parameter	Symbol	Conditions	Ratings	Unit
Maximum input current	I _{CC} max	t % 20 ms	200	mA
Output supply voltage	V _{OUT}		Internal	V
Output current	I _{OUT}		1.5	A
RD flow-in current	I _{RD}		10	mA
RD supply voltage	V _{RD}		50	V
Allowable power dissipation	Pd1 max		1.1	W
	Pd2 max	Mounted on 20 × 15 × 1.5 mm glass epoxy board	(0.8)	W
Operating temperature	Topr		-30 to +80	°C
Storage temperature	Tstg		-55 to +125	°C

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

Allowable Operating Ranges at Ta = 25 °C

Parameter	Symbol	Conditions	Ratings	Unit
Input current range	I _{CC}		6.0 to 50	mA
Common-mode input voltage range	V _{ICM}		0 to V _{IN} -1.5	V

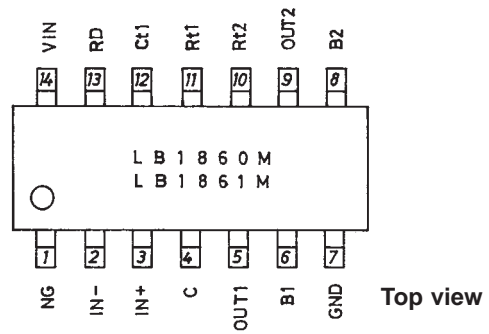
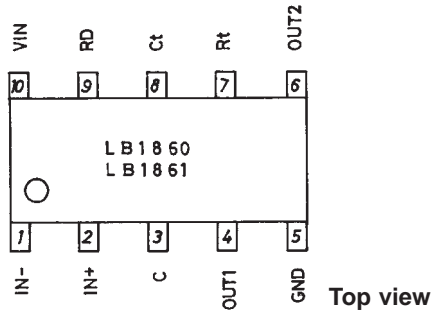
Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Electrical Characteristics at Ta = 25 °C, I_{CC} = 10 mA

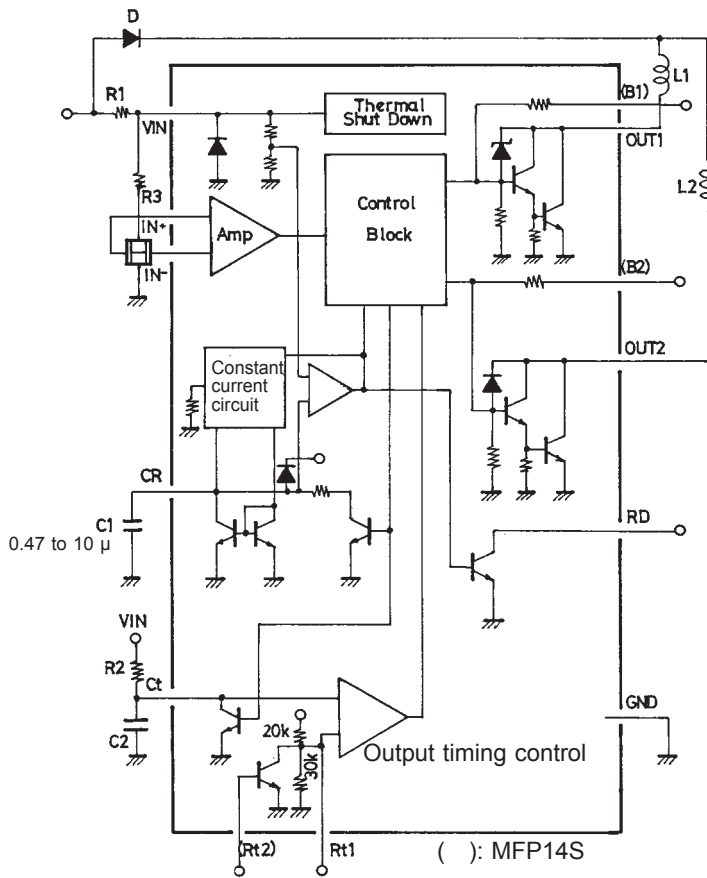
Parameter	Symbol	Conditions	min	typ	max	Unit
Output limiting voltage	V _{OLM1}	LB1860, 1860M: I _O = 0.1 A	54	57	60	V
		LB1861, 1861M: I _O = 0.1 A	30	32	34	V
Output saturation voltage	V _{O sat1}	I _O = 0.5 A		0.95	1.2	V
	V _{O sat2}	I _O = 1.0 A		1.15	1.5	V
	V _{O sat3}	I _O = 1.5 A		1.4	2.0	V
Input voltage	V _{IN}	I _{CC} = 7.0 mA	6.4	6.7	7.0	V
Amp input offset voltage	V _{OFF}		-7.0	0	7.0	mV
Amp input bias current	I _{BA}		-250			nA
RD output saturation voltage	V _{RD} (sat)	I _{RD} = 5 mA		0.15	0.3	V
C flow-out current	I _{C1}	C = GND	2.7	3.9	5.0	μA
C discharge current	I _{C2}	C = V _{IN}	0.35	0.50	0.65	μA
Comparator input threshold voltage	V _{TH1}		0.77	0.8 V _{IN}	0.83	V
	V _{TH2}		0.44	0.47 V _{IN}	0.50	V
Ct discharge voltage	V _{ct}		0.18	0.2 V _{IN}	0.22	V
Rt input current	I _{RT}	V _{RT} = GND	-440	-350	-240	μA
Rt comparator voltage	V _{RT}	R _T = OPEN	0.59	0.62 V _{IN}	0.65	V
Thermal protection circuit operating voltage	TSD	Design target		180		°C
Thermal protection circuit hysteresis	ΔTSD	Design target		40		°C

Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

Pin Assignments



Block Diagram and Application Circuit



Unit (resistance: Ω, capacitance: F)

Figure 1

Truth Table

(): LB1860M, 1861M

IN ⁺	IN ⁻	Ct	Rt1	Rt2	CR	OUT1	OUT2	RD	Mode
H	L	H	L	—	L	H	L	L	Full speed
L	H	H	L	—	L	L	H	L	Full speed
(H)	(L)	—	—	(H)	(L)	(H)	(L)	(L)	(Full speed)
(L)	(H)	—	—	(H)	(L)	(L)	(H)	(L)	(Full speed)
—	—	L	H	L	L	H	H	L	Low speed
—	—	—	—	—	H	H	H	H	Lock protection

Designer’s Notes

(1) Variable-speed circuit (Rt and Ct pins) — Refer to the application circuit diagram

- The time constant gained by external components C2 and R2 is used to set the length of an ‘off’ operation time period after phase switching. This means that the variable-speed operations can be performed by changing the ‘on’ operation time of each phase through the duty control.
- The sawtooth waveform signals are generated by the C2-R2 time constant. The voltage of this signal (Ct pin voltage) increases from 1.3 V to 4.0 V (Vct) at each phase switching. That is, during this period, the driver becomes inactive (t_{off}), in which output circuit is turned off.
- If V_{CC} ≥ 4.0 V, the driver IC remains active (t_{on}) until the next phase switching. During this period, output circuit is turned on.
- If the active drive time of each phase is assumed to ‘t_o’, the following relation can be established:

$$t_o = \begin{matrix} t_{off} & + & t_{on} \\ \uparrow & & \uparrow \\ \text{Fixed} & & \text{Rotation speed} \\ \text{constant} & & \text{proportional constant} \end{matrix}$$

$$t_{off} = 0.69 \times C2 \times R2 \dots\dots\dots 1$$

- From this relation, it can be observed that the ‘t_o’ and ‘t_{on}’ are in proportional relation with each other, and that the ‘t_{on}/t_o’ equals the ‘on’ time duty. As a result, a certain rotation speed can be fixed despite the fact that rotation speed exclusively depends on each motor.
- At the start, the ‘t_{on}’ value becomes longer while the ‘t_{off}’ value remains unchanged. This means that the ‘t_{off}/t_o’ duty becomes small enough compared to normal rotation mode. Therefore, the same start torque as that of the full speed rotation can be obtained because the ‘on’ operation time duty increases. This enables the motor to start at a very low speed.

(2) Supply voltage (V_{IN} pin)

- The LB1860 has the internal parallel regulator which supplies power to the Hall amplifier circuit and the control block. Therefore, the driver ICs are not affected by power source fluctuations and kickbacks from the motor. They maintain the stable operations even if noise signals such as surge are generated.
- Set the resistance R1 between V_{CC} and V_{IN} so that the I_{CC} current of 6 mA to 50 mA can flow onto the V_{IN} pin within the supply voltage range of a fan motor.
- V_{IN} is 6.7 V typ at I_{CC} = 7 mA.
- The current flowing into V_{IN} is calculated using the equation shown below.

$$I_{CC} = \frac{V_{CC} - V_{IN}}{R1} \dots\dots\dots 2$$

- Consideration given to surge voltage
- The maximum allowable current at V_{IN} pin is 200 mA. Therefore, the pin is designed to withstand abnormal positive voltage of:

$$V_{surge} = V_{IN} + R1 \times 200 \text{ mA} \dots\dots\dots 3$$

(3) Hall input pin voltage (Pins IN⁻, IN⁺)

- Set the voltage levels of the input pin for the Hall element output and the Hall element output voltage to within the range of 0 V to V_{IN} - 1.5 V.
- The gain between the hall input pin and the output pin is 100 dB or greater. The offset voltage of the hall input amp is ±7 mV, therefore, the hall element output must be set with the offset voltage (±7 mV) considered.

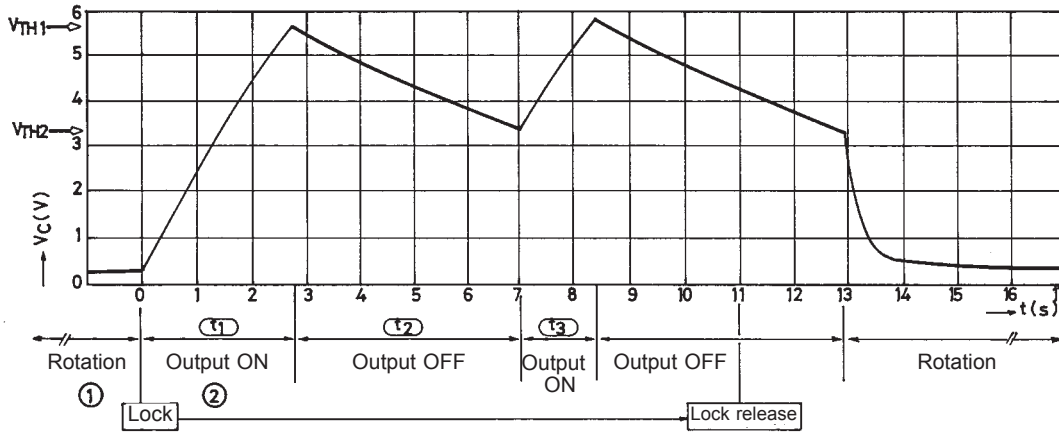
(4) Output transistor (Pins OUT1, OUT2)

- Output current I_O = 1.5 A max
- Output saturation voltage V_{O sat} = 1.15 V/1.0 A typ
- Output limiting voltage V_{OLM} = 57 V typ (LB1860, 1860M)
V_{OLM} = 32 V typ (LB1861,1861M)
- Since the LB1860 series have a protect zener diode between collector and base, the kickback voltage induced by the coil is cut at V_{OLM} = 57 V (32 V). When external capacitors are connected between OUT and GND, the capacitance should not exceed 10 μF.

(5) Output protection function (C pin)

- Capacitor pin used in forming an automatic return circuit.
- If rotation is stopped due to overload, the pin voltage level increases and then forces the output to become inactive. In this case, after proper load adjustment, the output returns to the 'drive' mode from the 'stop' mode automatically. By changing the capacitor value, the lock detect time period can be set.

For C marked with 1 μ F	Lock detect time	Approximately 2 sec.
	Lock protect time (output ON)	Approximately 1 sec.
	(output OFF)	Approximately 6 sec.



Automatic Return Circuit C Pin Voltage

- 1 When a fan is rotating, the capacitor is charged at 4 μ A (typ) and discharged through the C with pulses according to the rotational speed.
- 2 When a fan is locked, no discharge occurs through the C and the C voltage rises, turning OFF the output at $0.8 \times V_{IN}$.
- 3 When the output is turned OFF, discharge occurs through the C at 0.5 μ A (typ). If the lock is not released when the C voltage drops to V_{TH2} , the capacitor is charged to V_{TH1} again. (At this moment, the output is turned ON.) These operations 2 and 3 repeated at a cycle of approximately $t_{on} : t_{off} = 1:6$ protect a motor.
- 4 If the lock is released when the C voltage drops to V_{TH2} , the output is turned ON, starting rotation.

(6) Rotation detect signal (RD pin)

- Open collector output (Drive mode: "L", Stop mode: "H")

(7) Radio noise reducing (Pins B1, B2)

- Base pin of Darlington connection output transistor
- If radio noises need to be processed properly, the following actions should be taken:
 - 1 Connect a capacitor of 0.01 μ to 0.1 μ F between B1 and B2.
 - 2 Connect a capacitor of 0.001 μ to 0.01 μ F between OUT and B.
 If output causes oscillation, add a resistor of 200 Ω to 1 k Ω in series with a capacitor.

(8) Thermal shutdown function

- Shutdown the driver output in case of coil short-circuiting and abnormal IC heating.

Thermistor-controlled Application Circuit Example

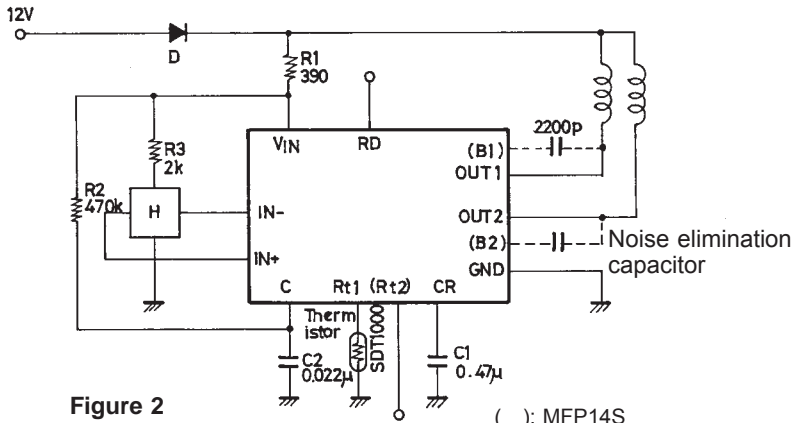


Figure 2

() : MFP14S
Unit (resistance: Ω, capacitance: F)

Use of a thermistor enables motor speed to be sensitive to the operating ambient temperature.

The Rt pin voltage at Ta = 20 °C has 1.42 ms of 'toff' as calculated in expression 4 with the application constant of Figure 2. However, the Rt pin voltage at Ta = 40 °C is reduced into less than the Vct (= 1.3 V) level, which results in a 0 of 'toff'. This means the 100% duty.

$$t = -C2 \times R2 \times \ln \frac{(V_{IN} - V_{Rt})}{V_{IN} - V_{Ct}} \dots\dots\dots 4$$

Output Timing Chart

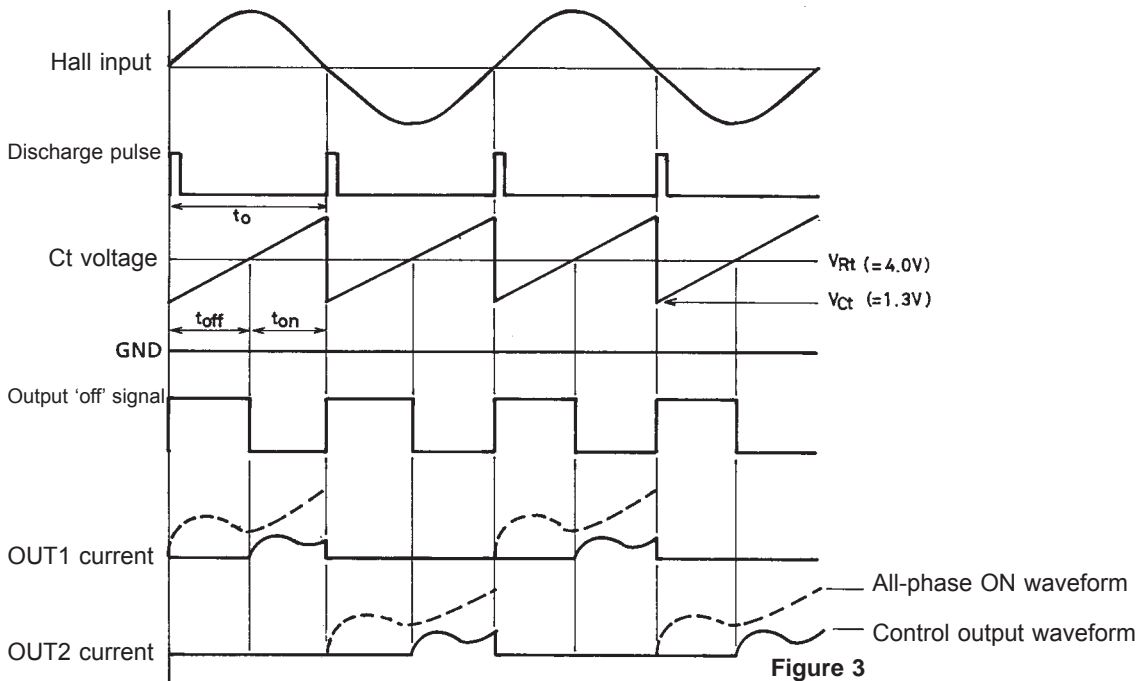


Figure 3

Package Dimensions

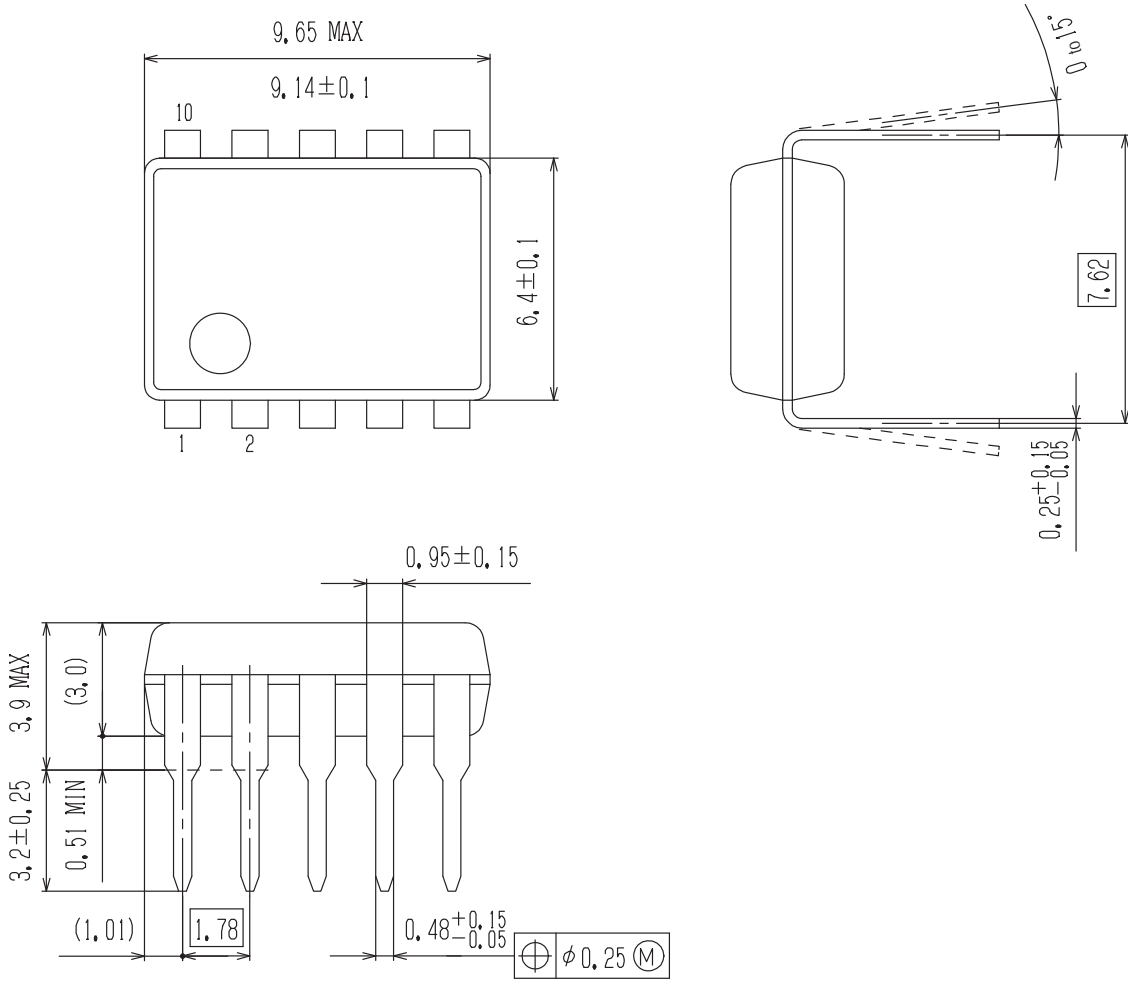
unit : mm

[LB1860, LB1861]

PDIP10 / DIP10S (300 mil)

CASE 646AK

ISSUE O



Package Dimensions

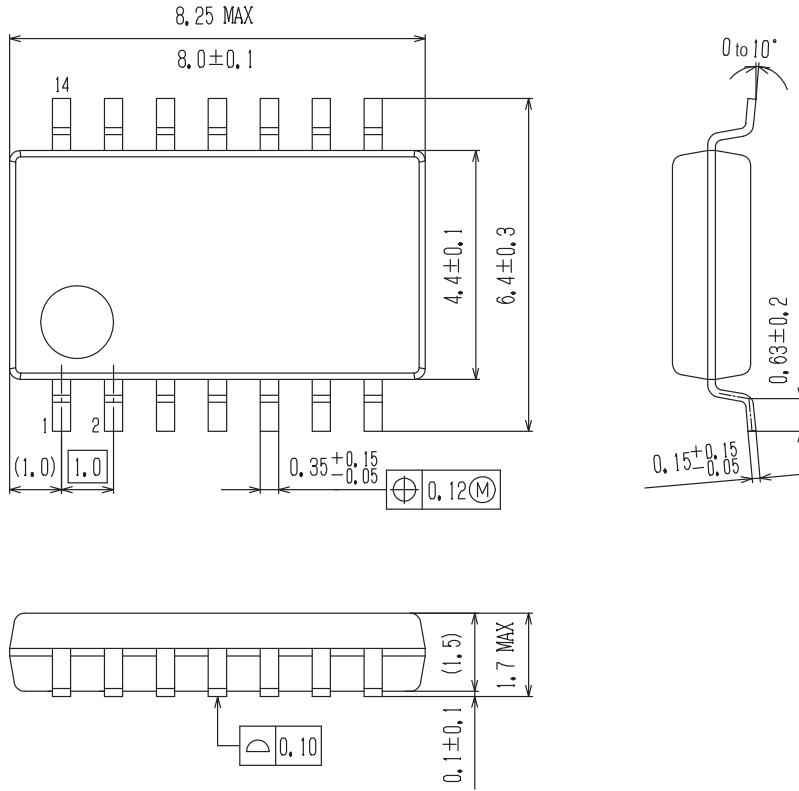
unit : mm

[LB1860M, LB1861M]

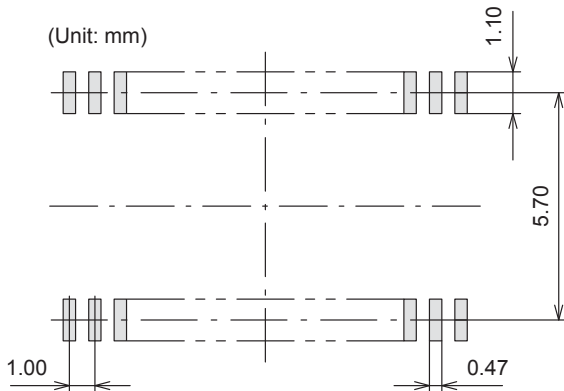
SOIC14 W / MFP14S (225 mil)

CASE 751CB

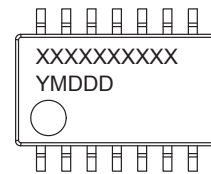
ISSUE A



SOLDERING FOOTPRINT*



GENERIC MARKING DIAGRAM*

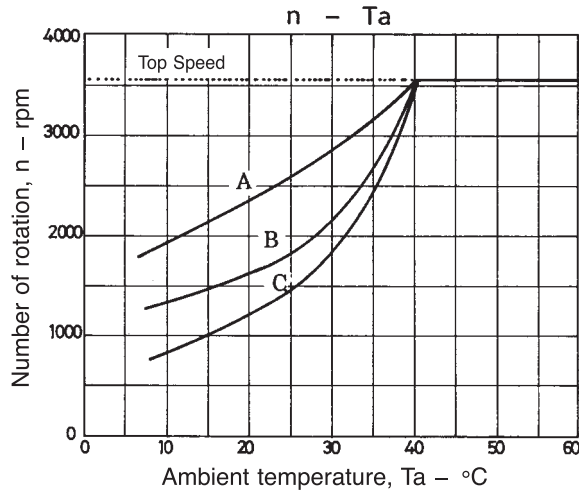


XXXXX = Specific Device Code
 Y = Year
 M = Month
 DDD = Additional Traceability Data

NOTE: The measurements are not to guarantee but for reference only.

*For additional information on our Pb-Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

*This information is generic. Please refer to device data sheet for actual part marking. Pb-Free indicator, "G" or microdot "•", may or may not be present.



ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
LB1860M-TLM-E	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel
LB1860M-TLM-H	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel
LB1860M-W-AH	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel
LB1861M-TLM-E	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel
LB1861M-TLM-H	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel
LB1861M-W-AH	SOIC14 W / MFP14S (225 mil) (Pb-Free / Halogen Free)	1000 / Tape & Reel

† For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D. http://www.onsemi.com/pub_link/Collateral/BRD8011-D.PDF

ON Semiconductor and the ON Semiconductor logo are trademarks of Semiconductor Components Industries, LLC dba ON Semiconductor or its subsidiaries in the United States and/or other countries. ON Semiconductor owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of ON Semiconductor's product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. ON Semiconductor reserves the right to make changes without further notice to any products herein. ON Semiconductor makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does ON Semiconductor assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation special, consequential or incidental damages. Buyer is responsible for its products and applications using ON Semiconductor products, including compliance with all laws, regulations and safety requirements or standards, regardless of any support or applications information provided by ON Semiconductor. "Typical" parameters which may be provided in ON Semiconductor data sheets and/or specifications can and do vary in different applications and actual performance may vary over time. All operating parameters, including "Typicals" must be validated for each customer application by customer's technical experts. ON Semiconductor does not convey any license under its patent rights nor the rights of others. ON Semiconductor products are not designed, intended, or authorized for use as a critical component in life support systems or any FDA Class 3 medical devices or medical devices with a same or similar classification in a foreign jurisdiction or any devices intended for implantation in the human body. Should Buyer purchase or use ON Semiconductor products for any such unintended or unauthorized application, Buyer shall indemnify and hold ON Semiconductor and its officers, employees, subsidiaries, affiliates, and distributors harmless against all claims, costs, damages, and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if such claim alleges that ON Semiconductor was negligent regarding the design or manufacture of the part. ON Semiconductor is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.