

LB1860, LB1860M, LB1861, LB1861M

Monolithic Digital IC

Two-Phase Half-Wave Variable Speed Fan Motor Driver



ON Semiconductor®

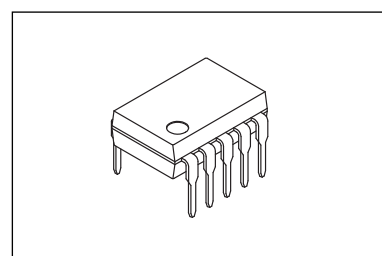
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Overview

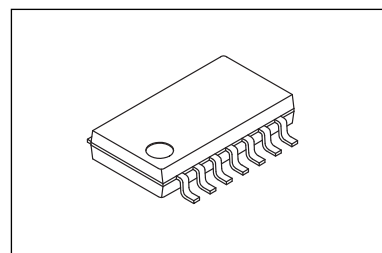
The LB1860 series ICs are drivers for two-phase unipolar drive DC brushless fan motors. They have functions such as driving, lock protection, restart and speed control.

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 $T_a = 25^\circ\text{C}$, (): LB1860M, LB1861M

Parameter	Symbol	Conditions	Ratings	Unit
Maximum input current	I_{CC} max	$t \leq 20$ 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	P_{d1} max		1.1	W
	P_{d2} max	Mounted on $20 \times 15 \times 1.5$ mm glass epoxy board	(0.8)	W
Operating temperature	T_{opr}		-30 to $+80$	$^\circ\text{C}$
Storage temperature	T_{stg}		-55 to $+125$	$^\circ\text{C}$

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 $T_a = 25^\circ\text{C}$

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

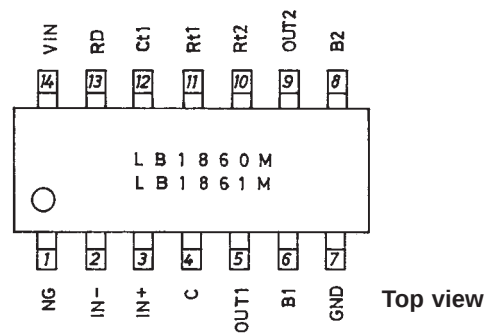
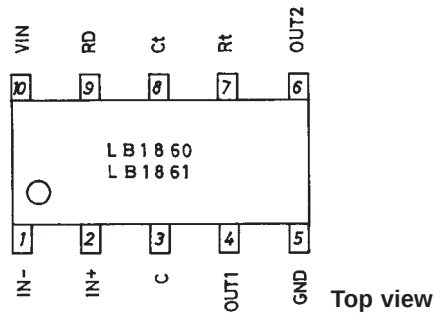
Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

Electrical Characteristics at $T_a = 25^\circ\text{C}$, $I_{CC} = 10$ 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	$V_{RD}(\text{sat})$	$I_{RD} = 5$ mA		0.15	0.3	V
C flow-out current	I_{C1}	$C = \text{GND}$	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}	$V_{RT} = \text{GND}$	-440	-350	-240	μA
Rt comparator voltage	V_{RT}	$R_T = \text{OPEN}$	0.59	$0.62 V_{IN}$	0.65	V
Thermal protection circuit operating voltage	TSD	Design target		180		$^\circ\text{C}$
Thermal protection circuit hysteresis	ΔTSD	Design target		40		$^\circ\text{C}$

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

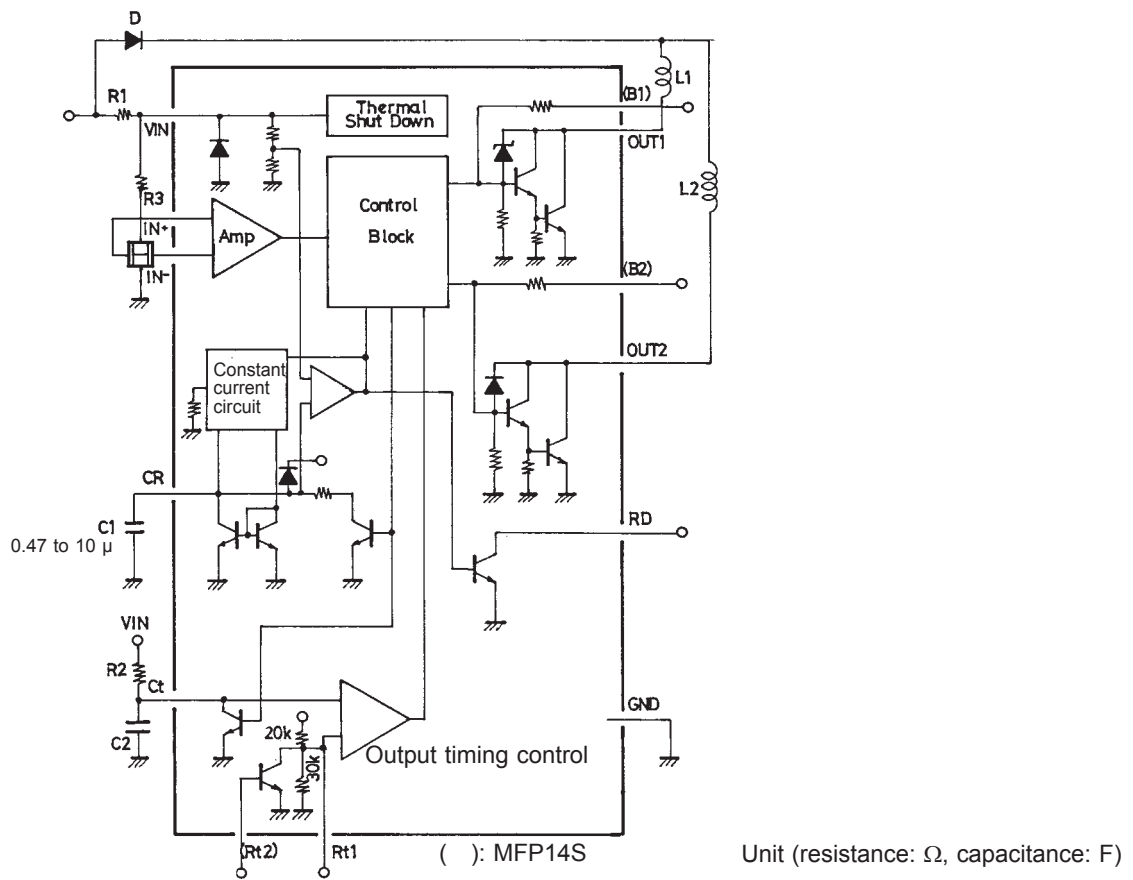


Figure 1

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 (V_{ct}) 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:

$$t_o = \underset{\substack{\uparrow \\ \text{Fixed} \\ \text{constant}}}{t_{\text{off}}} + \underset{\substack{\uparrow \\ \text{Rotation speed} \\ \text{proportional constant}}}{t_{\text{on}}}$$

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

- 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.

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

- 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:

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

(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)

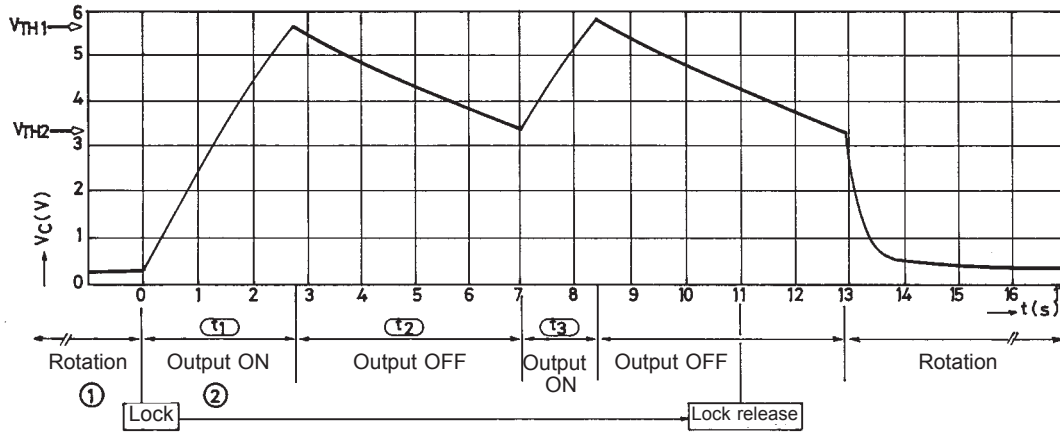
- Output current I_O = 1.5 A max
- Output saturation voltage V_{O sat} = 1.15 V/1.0 A typ
- Output limiting voltage V_{OLM} = 57 V typ (LB1860, 1860M)
V_{OLM} = 32 V typ (LB1861, 1861M)
- Since the LB1860 series have a protect zener diode between collector and base, the kickback voltage induced by the 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

- 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.
- When a fan is locked, no discharge occurs through the C and the C voltage rises, turning OFF the output at $0.8 \times V_{IN}$.
- 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.
- 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")

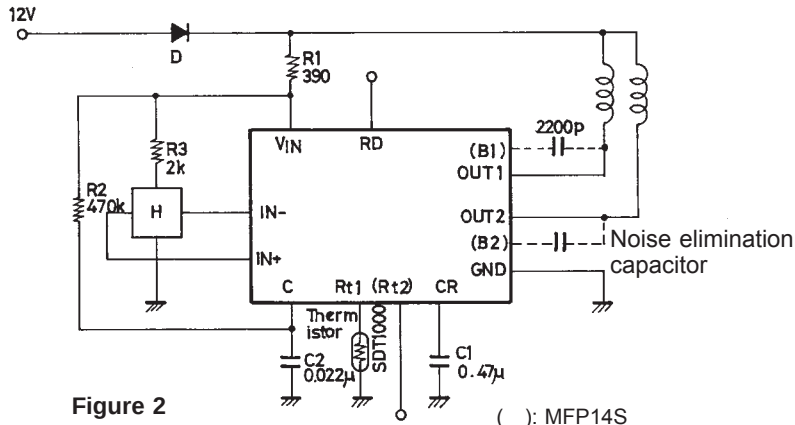
(7) Radio noise reducing (Pins B1, B2)

- Base pin of Darlington connection output transistor
- If radio noises need to be processed properly, the following actions should be taken:
 - Connect a capacitor of 0.01 μ to 0.1 μ F between B1 and B2.
 - 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

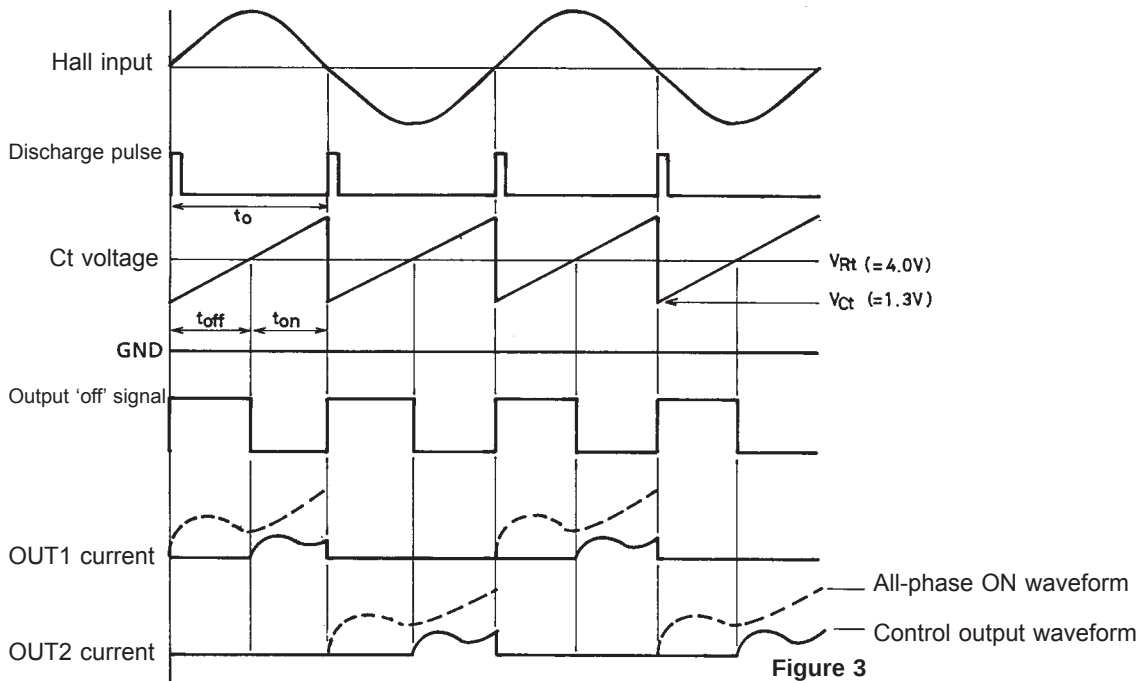


Use of a thermistor enables motor speed to be sensitive to the operating ambient temperature.

The Rt pin voltage at Ta = 20 °C has 1.42 ms of 't_{off}' 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 V_{ct} (= 1.3 V) level, which results in a 0 of 't_{off}'. 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



Package Dimensions

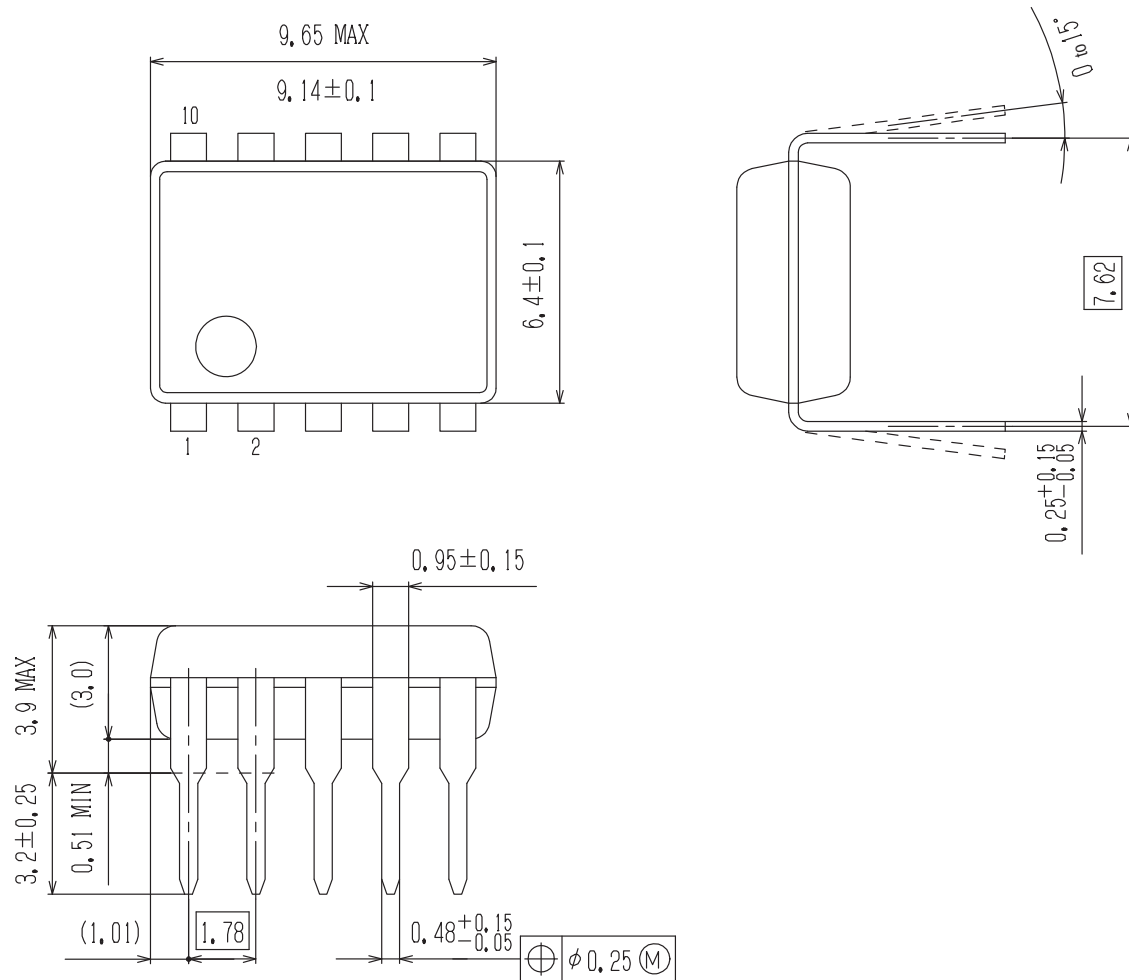
unit : mm

[LB1860, LB1861]

PDIP10 / DIP10S (300 mil)

CASE 646AK

ISSUE O



Package Dimensions

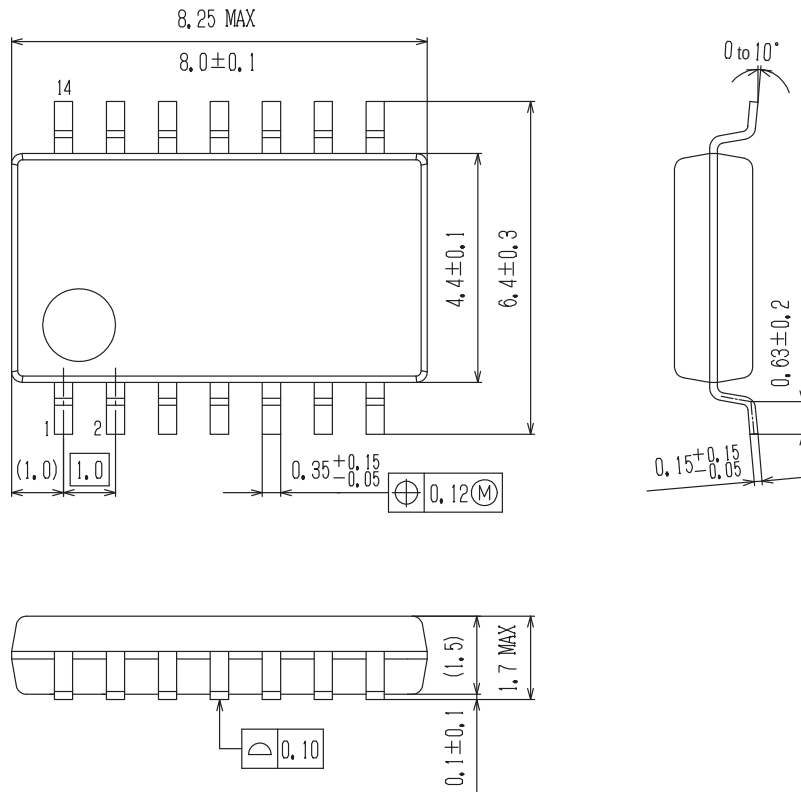
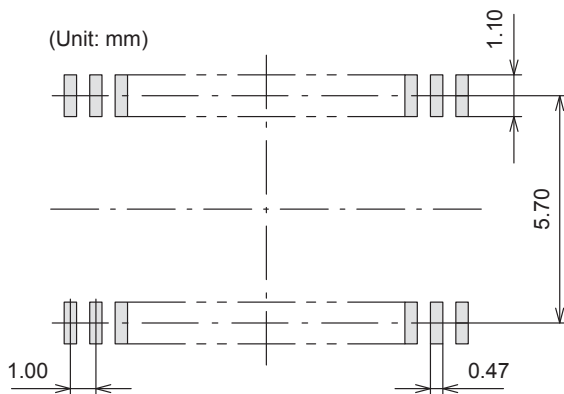
unit : mm

[LB1860M, LB1861M]

SOIC14 W / MFP14S (225 mil)

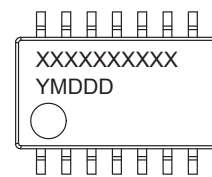
CASE 751CB

ISSUE A

**SOLDERING FOOTPRINT***

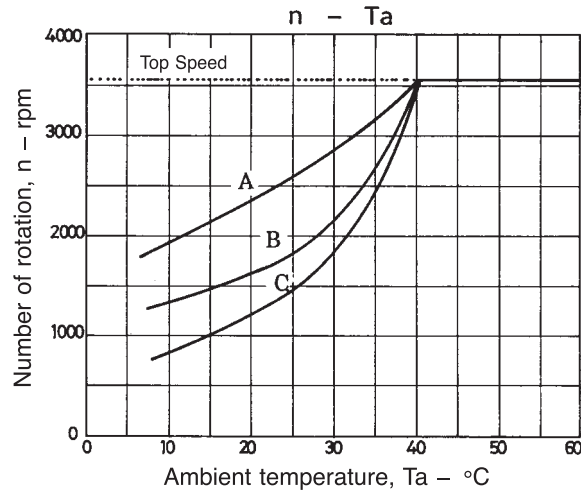
NOTE: The measurements are not to guarantee but for reference only.

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

GENERIC MARKING DIAGRAM*

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

*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

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