# LV88563

# Motor Driver, Single-Phase, PWM, Full-Wave, 24 V/48 V BLDC Motor

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### Overview

The LV88563JA is the pre−driver for a single−phase 24 V/48 V BLDC motor, which has the closed loop controller for motor rotation speed. This is available to control a motor with low vibration and the low noise. In addition, lead−angle adjustment is possible by external pins. Lead−angle value and lead−angle slant can be adjusted independently. Thus, the device can be driven by high efficiency and low noise with various motors. Motor speed setting curve is adjustable for many variety using external resistor only. As a method of the rotary speed control of the motor, direct−PWM pulse input is adopted.

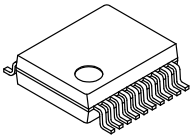
### Features

- Single−phase Full Wave Drive Pre−driver Include Closed Loop Speed Control which is Fitting for High Voltage (24 V/48 V) Application
- Feed Back Gain Slower than LV88561
- Speed Control Function by PWM Duty Input (25 Hz to 100 kHz)
- Soft Start−up Function and PWM Soft Switching Phase Transition
- Soft PWM Duty Cycle Transitions
- Built−in Current Limit Circuit and Thermal Protection Circuit
- Built−in Locked Rotor Protection and Auto Recovery Circuit
- FG Signal Output
- Dynamic Lead Angle Adjustment with Respect to Rotational Speed
- Lead−angle Control Parameters can be Configured

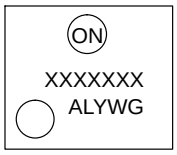
### Typical Applications

- PC & Computing Equipment
- Refrigerator
- Games

### MARKING DIAGRAMS



**SSOP20J**
**CASE 565AP**
*(LV88563JA)*




XX = Specific Device Code
A = Assembly Site (OSPI Tarlac Site Code: MP)
L = Wafer Lot Number
YW = Assembly Start Week
G = Pb−Free Package

### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| LV88563JA−AH | SSOP20J (Pb−Free / Halogen Free) | 2000 / Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

## BLOCK DIAGRAM

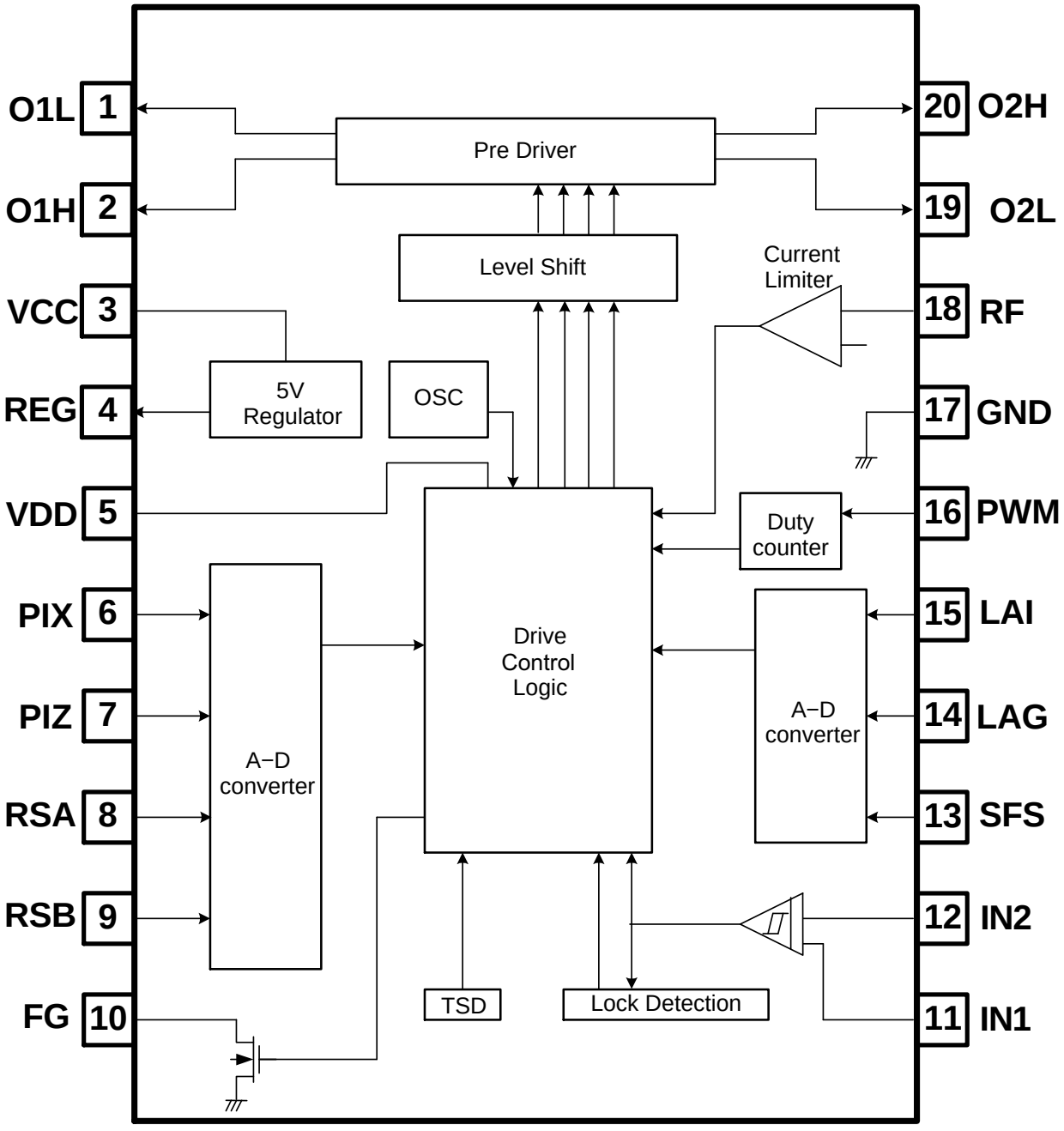



**Figure 1. LV88563JA Block Diagram**

## APPLICATION CIRCUIT DIAGRAM

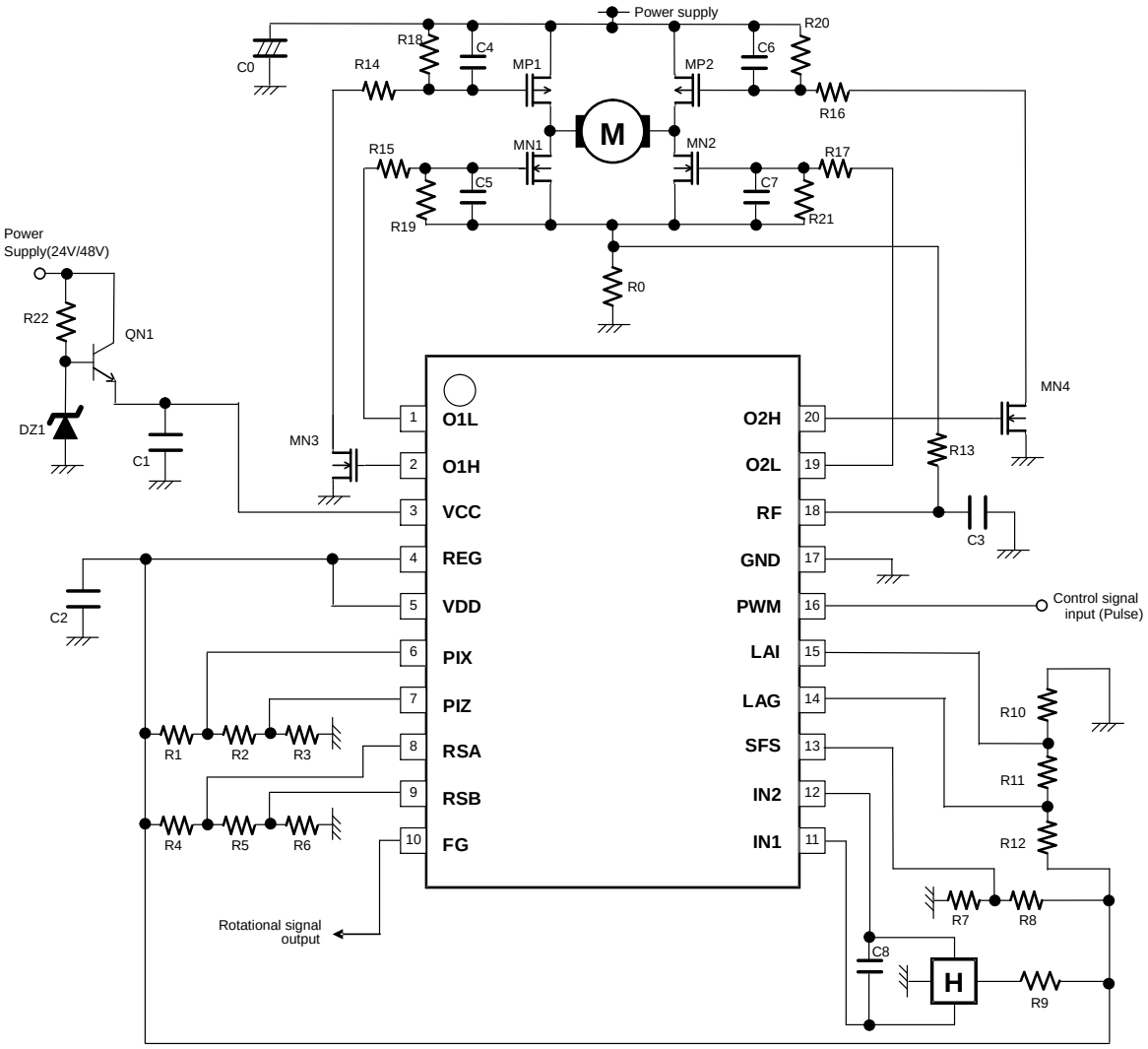



**Figure 2. Single−phase BLDC Motor Drive with LV88563JA**

**Table 1. EXAMPLE COMPONENT VALUE**

| Device | Value | Device | Value |
|---|---|---|---|
| MP1+MN1 | FW389 | R14 | 100 Ω |
| MP2+MN2 | FW389 | R15 | 100 Ω |
| MN3,4 | MCH3486 | R16 | 100 Ω |
| QN1 | NMBTA05LT1G | R17 | 100 Ω |
| DZ1 | MM3Z12VT1G(12V Zener) | R18 | * |
| | | R19 | * |
| R0 | 0.051 Ω // 0.051 Ω | R20 | * |
| R1 | 0 to 50 kΩ | R21 | * |
| R2 | 0 to 50 kΩ | R22 | 5.1 kΩ |
| R3 | 0 to 50 kΩ | | |
| R4 | 0 to 50 kΩ | | |
| R5 | 0 to 50 kΩ | C0 | 4.7 μF −10 uF |
| R6 | 0 to 50 kΩ | C1 | 0.1 μF − 1 μF |
| R7 | 0 to 50 kΩ | C2 | 0.1 μF − 1 μF |
| R8 | 0 to 50 kΩ | C3 | ** |
| R9 | 2.2 kΩ | C4 | 0 to 1500 pF |
| R10 | 0 to 50 kΩ | C5 | 0 to 1500 pF |
| R11 | 0 to 50 kΩ | C6 | 0 to 1500 pF |
| R12 | 0 to 50 kΩ | C7 | 0 to 1500 pF |
| R13 | 0 Ω | C8 | 0 to 0.1 μF |

*It depends on the user's circuit, MP1, MP2, MN1 and MN2.
**It depends on the user's environment.

**Table 2. TRUTH TABLE**

| Operating State | IN1 | IN2 | Inner−PWM State* | O1H | O1L | O2H | O2L | FG |
|---|---|---|---|---|---|---|---|---|
| Rotation − drive mode | L | H | on | L | H | H | L | OFF |
| | H | L | | H | L | L | H | L |
| Rotation – regeneration mode | L | H | off | L | L | H | L | OFF |
| | H | L | | H | L | L | L | L |
| Lock protector | L | H | − | L | L | L | L | OFF |
| | H | L | | L | L | L | L | L |

*Inner PWM state means the OUTPUT active period decided by inner control logic. Don't match PWM−pin input signal.

## PIN ASSIGNMENT

**SSOP20J (225mil)**

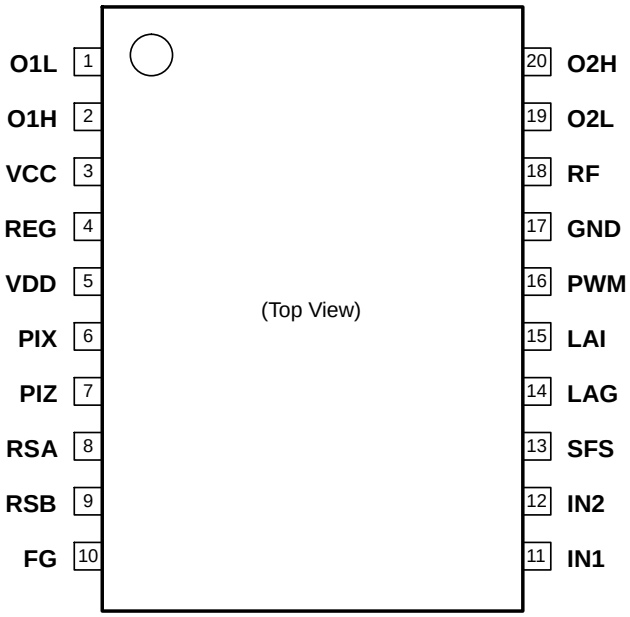



**Figure 3. LV88563JA Pin Assignment**

**Table 3. PIN FUNCTION DESCRIPTION**

| Pin No. | Pin name | Function |
|---|---|---|
| 1<br>19 | O1L<br>O2L | Output pins of the low−side gate−drive signal.<br>(See “Truth Table” on page 4 for the polarity) |
| 2<br>20 | O1H<br>O2H | Output pins of the high−side gate−drive signal.<br>(See “Truth Table” on page 4 for the polarity) |
| 3 | VCC | Power supply pin.<br>The input voltage to this pin must be stabilized without the influence of the noise, ripple, and etc.<br>Therefore, it is necessary to connect the capacitor near VCC pin and GND pin as much as possible. |
| 4 | REG | The output pin of the regulated voltage (5.0 V).<br>It is necessary to connect the capacitor near this pin and GND pin for stabilizing this regulated voltage. |
| 5 | VDD | Logic circuit power supply pin.<br>This pin should be shorted to REG pin. |
| 6<br>7 | PIX<br>PIZ | The pin to adjust the value of PWM input duty for the point of maximum or minimum rotation speed. |
| 8<br>9 | RSA<br>RSB | The pin to adjust the target value of maximum or minimum rotation speed. |
| 10 | FG | The output pin of the rotational signal.<br>When not using it, this pin should be opened [not connected]. |
| 11<br>12 | IN1<br>IN2 | Input pins of hall signals. |
| 13 | SFS | The pin to adjust the soft start state and dead time. |
| 14 | LAG | The pin to adjust the gradient of lead angle for PWM input duty. |
| 15 | LAI | The pin to adjust the initial lead angle in minimum rotation speed. |
| 16 | PWM | The input pin of the speed control signal as the rectangular wave. |
| 17 | GND | GND pin. |
| 18 | RF | The pin to detect the output current.<br>When the voltage level at this pin exceeds the internal set detection level, outputs turn to the regenerating mode. |

**Table 4. MAXIMUM RATINGS**

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| Maximum supply voltage | $VCC_{max}$ | VCC pin | 20 | V |
| Maximum output voltage | VOUTmax | O1H/O1L/ O2H/O2L pin | 20 | V |
| Maximum output current | $IOUT_{max}$ | O1H/O1L/ O2H/O2L pin | 50 | mA |
| Maximum output peak current (Note 1) | IOUTpeak | O1H/O1L/ O2H/O2L pin | 150 | mA |
| REG pin maximum output current | IREGmax | REG pin | 20 | mA |
| RSA/RSB/PIX/PIZ/LAI/LAG/SFS/IN1/IN2/RF pin maximum input voltage | VIN max | RSA/RSB/PIX/ PIZ/LAI/LAG/IN1/ IN2/SFS/RF pin | 5.5 | V |
| PWM pin maximum input voltage | VPWMmax | PWM pin | 5.5 | V |
| FG pin withstanding voltage | VFGmax | FG pin | 20 | V |
| FG pin maximum output current | IFGmax | FG pin | 10 | mA |
| Allowable power dissipation (Note 2) | Pdmax | | 0.8 | W |
| Operating temperature | Topr | | −40 to +105 | °C |
| Storage temperature | Tstg | | −55 to +150 | °C |
| Maximum junction temperature | Tjmax | | 150 | °C |
| Moisture Sensitivity Level (MSL) (Note 3) | MSL | | 3 | − |
| Lead Temperature Soldering Pb−Free Versions (30s or less) (Note 4) | $T_{SLD}$ | | 255 | °C |
| ESD Human body Model : HBM (Note 5) | $ESD_{HBM}$ | | ±2000 | V |

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.

1. $IOUT_{peak}$ is the peak value of the motor supply current with duty_cycle < 5%.
2. Specified circuit board : 114.3 mm x 76.1 mm x 1.6 mm, glass epoxy single layer board. It has 1 oz internal power and ground planes and 1/2 oz copper traces. Please refer to Thermal Test Conditions on page 22.
3. Moisture Sensitivity Level (MSL): IPC/JEDEC standard: J−STD−020A.
4. For information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D http://www.onsemi.com/pub_link/Collateral/SOLDERRM−D.PDF.
5. ESD Human Body Model is based on JEDEC standard: JESD22−A114.

**Table 5. THERMAL CHARACTERISTICS**

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Thermal Resistance, Junction−to−Ambient (Note 6) LV88563JA | $R_{\theta JA}$ | 156 | °C/W |

6. Specified circuit board : 114.3 mm x 76.1 mm x 1.6 mm, glass epoxy single layer board. It has 1 oz internal power and ground planes and 1/2 oz copper traces on top and bottom of the board. Please refer to Thermal Test Conditions on page 22.

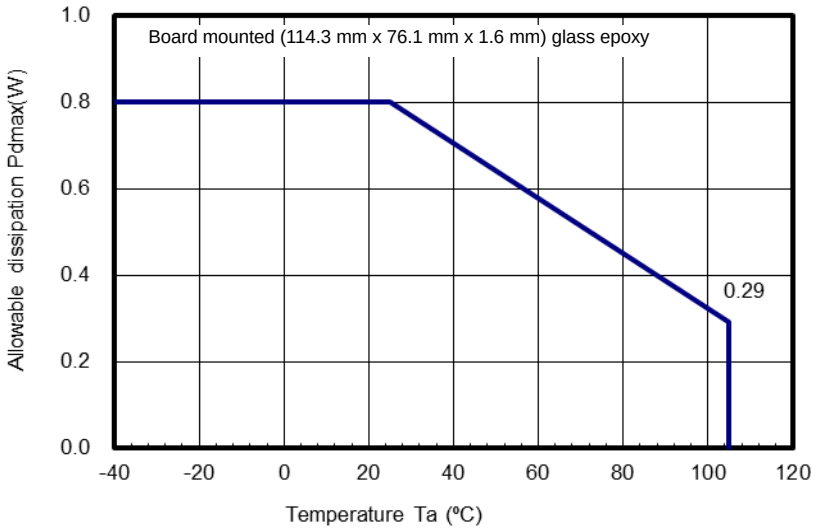



**Figure 4. Power Dissipation vs Ambient Temperature Characteristic**

**Table 6. RECOMMENDED OPERATING RANGES** (Note 7)

| Parameter | Symbol | Conditions | Ratings | Unit |
|---|---|---|---|---|
| VCC supply voltage | VCCtyp | VCC pin | 12 | V |
| VCC operating supply voltage range1 | VCCop1 | VCC pin | 6.0 to 16 | V |
| VCC operating supply voltage range2 (Note 8) | VCCop2 | VCC pin | 3.9 to 6.0 | V |
| PWM input frequency range | Fpwm | PWM pin | 25 to 100k | Hz |
| PWM minimum input low/high pulse width | Twpwm | PWM pin | 100 | ns |
| IN1 input voltage range | Vin1 | IN1 pin | 0 to VREG | V |
| IN2 input voltage range | Vin2 | IN2 pin | 0.3 to 0.55*VREG | V |
| Control input voltage range | Vcnth | RSA/RSB/PIX/ PIZ/LAI/LAG/SFS pin | 0 to VREG | V |

7. 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.
8. When the VCC voltage below 6.0 V, motor rotation function keep to normally until to 3.9 V. But there are possibility that the ELECTRICAL CHARACTERISTICS parameter is varied.

**Table 7. ELECTRICAL CHARACTERISTICS** at $T_A$ = 25°C, $VCC_{OP}$ = 12 V unless otherwise noted. (Note 9)

| Parameter | Symbol | Conditions | Ratings | | | Unit |
|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | |
| Circuit current | ICC | | | 9 | 16 | mA |
| O1H/O1L/O2H/O2L High−side on−resistance | ROHon | IO = 10 mA | | 30 | 80 | Ω |
| O1H/O1L/O2H/O2L Low−side on−resistance | ROLon | IO = 10 mA | | 30 | 80 | Ω |
| O1H/O1L/O2H/O2L PWM output frequency | fpwmo | | 45.6 | 48 | 50.4 | kHz |
| PWM pin low level input voltage | Vpwml | | 0 | | 0.7 | V |
| PWM pin high level input voltage | Vpwmh | | 2.8 | | 5.5 | V |
| PWM input resolution | Δpwm | | | 8 | | Bit |
| FG pin low level output voltage | Vfgl | IFG = 5 mA | | 0.2 | 0.3 | V |
| FG pin leak current | Ifglk | VCC = 16 V<br>VFG = 16 V | | | 1 | μA |
| REG pin output voltage | VREG | | 4.7 | 5.0 | 5.3 | V |
| Lock−detection time1 (Note 10) | Tld1 | Under rotation | 0.27 | 0.3 | 0.33 | S |
| Lock−detection time2 (Note 11) | Tld2 | Start−up | 0.63 | 0.7 | 0.77 | S |
| Lock−Stop release time1 from 1st to 4th off time | Tlroff1 | | 3.1 | 3.5 | 3.9 | S |
| Lock−Restart on time | Tlron | | 0.63 | 0.7 | 0.77 | S |
| Lock−Restart time ratio1 | Rlr1 | Tlroff1/Tlron | | 5 | | − |
| Lock−Stop release time2(Note 12) as from 5th off time | Tlroff2 | | 12.5 | 14 | 15.5 | S |
| Lock−Restart time ratio2(Note 12) as from 5th off time | Rlr2 | Tlroff2/Tlron | | 20 | | − |
| Thermal protection detection temperature | Tthp | (Design target) | 150 | 180 | | °C |
| Thermal protection detection hysteresis | ΔTthp | (Design target) | | 40 | | °C |
| Current limit detection voltage | VTHCLM | RF−GND | 0.09 | 0.10 | 0.11 | V |
| REG pin output voltage load regulation | ΔVregld | IREG = −10 mA | | 20 | 50 | mV |
| Hall input bias current | Ihin | IN1, IN2 = 0 V | | 0 | 1 | μA |
| Hall input sensitivity | ΔVhin | | 40 | | | mV |
| Control input bias current | Ictlin | PIX, PIZ, RSA, RSB, SFS, LAG, LAI = 0 V | | 0 | 1 | μA |
| PWM input bias current | Ipwmin | VDD = 5.5 V,<br>PWM = 0 V | 14 | 28 | 42 | μA |
| UVLO detection voltage | Vuvdet | VCC voltage | 3.1 | 3.4 | 3.6 | V |
| UVLO release voltage | Vuvrls | VCC voltage | 3.3 | 3.6 | 3.9 | V |
| UVLO hysteresis voltage | ΔVuv | | 0.1 | 0.2 | 0.4 | V |

9. 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.
10. When the motor rotate state, and the motor rotation speed reach to below 50 rpm (phase change period over 0.3s), lock protection function work.
11. When the motor start−up timing, the motor can't rotate until 0.7s, lock protection function work.
12. When the locked rotor state is continued to long time, lock stop period change as from 5th off time.

## TYPICAL CHARACTERISTICS

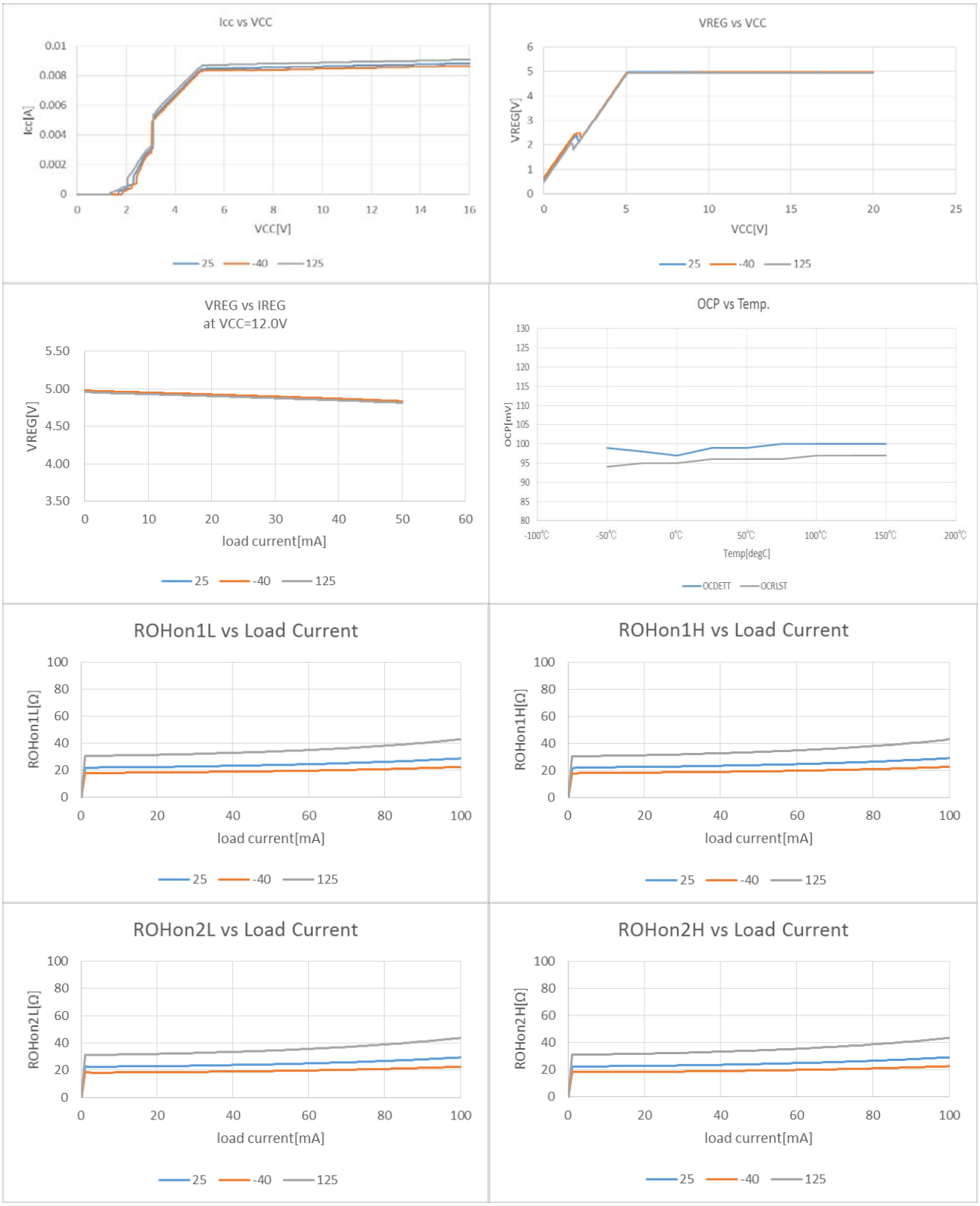



**Figure 5.**

## EQUIVALENT CIRCUIT

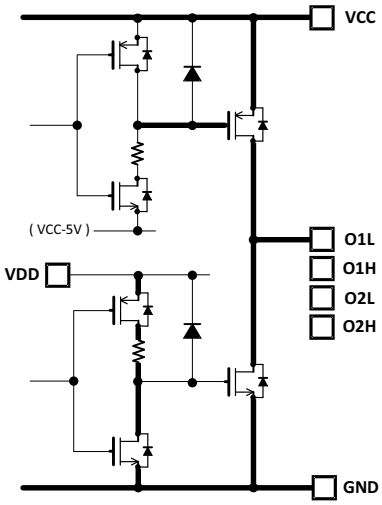



**Figure 6. O1L, O1H, O2L and O2H Equivalent Circuit**

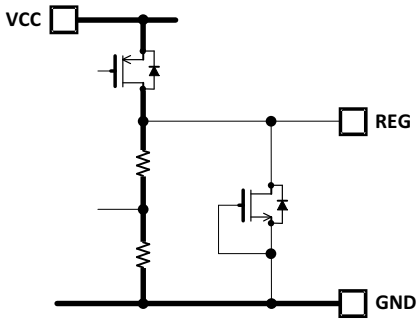



**Figure 7. REG Equivalent Circuit**

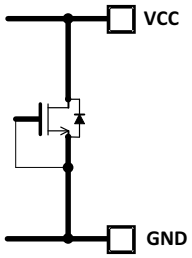



**Figure 8. VCC Equivalent Circuit**

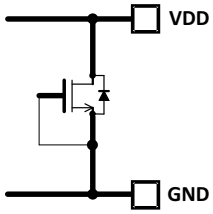



**Figure 9. VDD Equivalent Circuit**

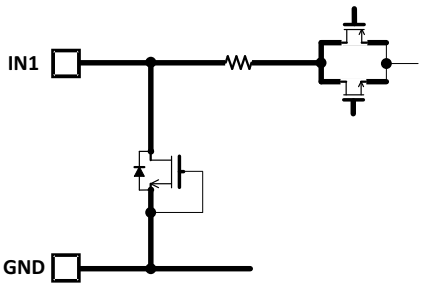



**Figure 10. IN1, IN2 Equivalent Circuit**

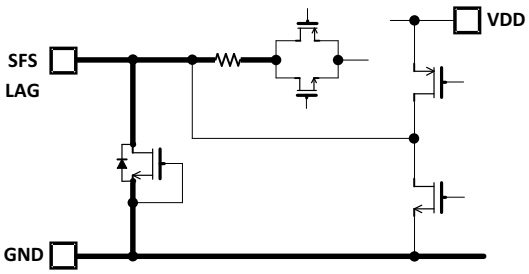



**Figure 11. SFS, LAG Equivalent Circuit**

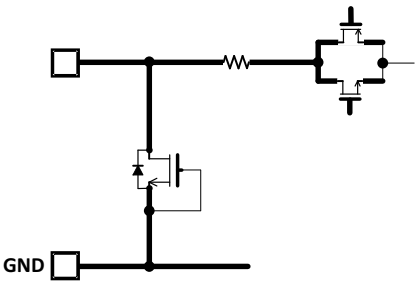



**Figure 12. LAI Equivalent Circuit**

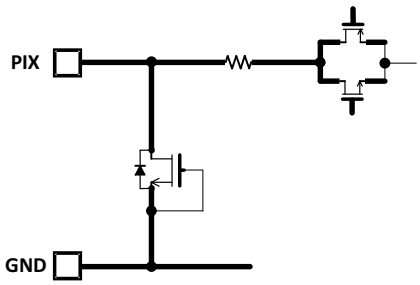



**Figure 13. PIX, PIZ Equivalent Circuit**

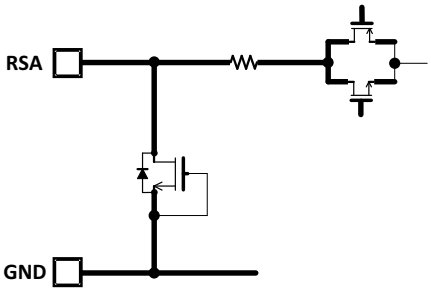



Figure 14. RSA, RSB Equivalent Circuit

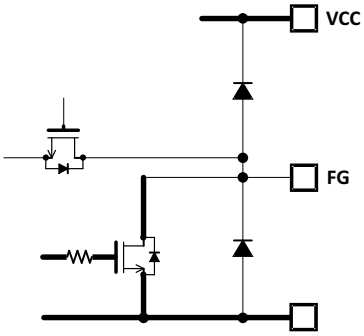



Figure 15. FG Equivalent Circuit

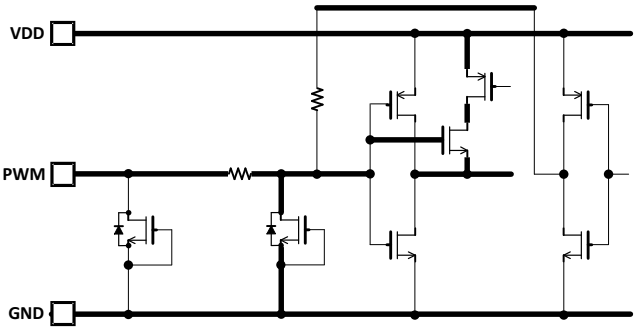



Figure 16. PWM Equivalent Circuit

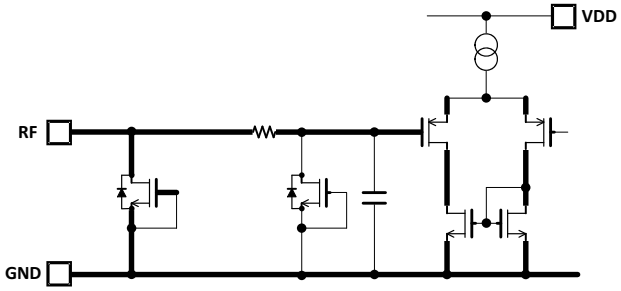



Figure 17. RF Equivalent Circuit

## STATE DIAGRAM

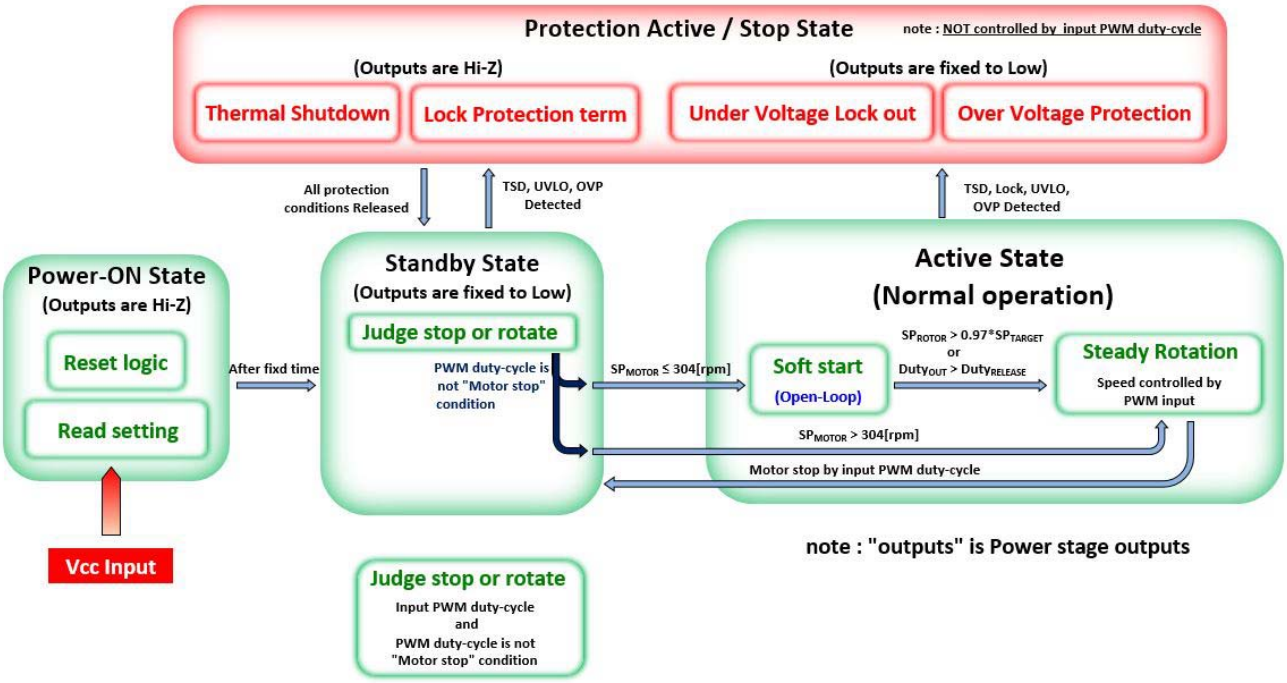



**Figure 18. State Diagram**

## FUNCTIONAL DESCRIPTION

### Current Sense Resistor Pin (RF)

RF is current sense input terminal.

Voltage across the sense resistor represents the motor current and is compared against the internal $VTH_{OVC}$ (0.10 Vtyp.) for setting the over−current limiter (CLM).

### VCC and GND Pin (VCC,GND)

Since Power FET side ground line has to tolerate surge of current, separate it from the GND pin as far away as possible and connect it point−to−point to the ground side of the capacitor (C0) between VCC and GND.

### Internal 5.0 V Voltage Regulator Pin (REG, VDD)

REG is internal 5.0 V voltage regulator.

VDD is power supply for internal logic, oscillator, and protection circuits. Please connect REG and VDD.

When PIX, PIZ, RSA, RSB, LAI, LAG and SFS are used, it is recommended that application circuits are made using this output. The maximum load current of REG is 20 mA. Warn not to exceed this. Place capacity from 0.1 μF to 1.0 μF in the close this pin.

### Rotational Signal Pin (FG)

Frequency of the FG output represents the motor's electrical rotational speed. It is an open drain output. Recommended pull up resistor value is 1 kΩ to 100 kΩ. Leave the pin open when not in use.

### Output Pins for External FET Control (O1H, O1L, O2H, O2L)

These pins are output for external MOSFET. O1H and O2H connect to upper side P−ch FET's gate−line. O1L and O2L connect to lower side N−ch FET's gate line.

### Hall−Sensor Input Pins (IN1, IN2)

Differential output signals of the hall sensor are to be interfaced at IN1 and IN2. It is recommended that 0.01 μF capacitor is connected between both pins to filter system noise.

When a Hall IC is used, the output of the Hall IC must be connected to the pin IN1. And, the pin IN2 must be kept in the middle level of the Hall IC power supply voltage.

### Command Input (PWM)

This pin reads the duty cycle of the PWM pulse and controls rotational speed. The PWM input signal level is supported from 2.5 V to 5 V. The combination with the rotational speed control by DC voltage, is impossible.

When the pin is not used, it must be connected to ground. The minimum pulse width is 100 ns.

### Lead−angle Setting Pin (LAI, LAG)

LV88563JA provides the dynamic lead angle adjustment. To match the motor characteristics, set two point lead−angel amounts, low speed side (set by LAI pin) and high speed side(set by LAG pin).

At middle range of input duty, the lead−angle amounts applied to calculated value for relative relationship.

The DC voltage levels applied to these pins are converted to the lead angle parameter. The voltages are fetched right after the power−on−reset. Because the internal conversion circuit works inside REG power rail, it is recommended that the LAI and LAG voltages are made from $V_{REG}$.

### Rotation Speed Setting Pin (RSA, RSB)

LV88563JA provides the feedback speed control, so this device can set the rotation speed value (RPM) directly.

To make the motor speed setting curve, set two point rotation speed value, high speed side and low speed side.

The DC voltage levels applied to these pins are converted to the rotation speed parameter. The voltages are fetched right after the power−on−reset. Because the internal conversion circuit works inside REG power rail, it is recommended that the RSA and RSB voltages are made from $V_{REG}$.

### Rotation Speed Curve Duty Setting Pin (PIX, PIZ)

To make the motor speed setting curve, set two point input duty parameter, high speed side and low speed side.

The DC voltage levels applied to these pins are converted to the input duty parameter. The voltages are fetched right after the power−on−reset. Because the internal conversion circuit works inside REG power rail, it is recommended that the PIX and PIZ voltages are made from $V_{REG}$.

### Soft−Start and Dead Time Setting Pin (SFS)

LV88563JA provides synchronous rectification drive for high efficiency drive. External FET size is variable caused by the motor application. So this driver IC is able to choose 2 type dead time.

Soft start function pattern is able to choose from 16 types.

The DC voltage levels applied to these pins are converted to the soft−start setting and dead time parameter. The voltage is fetched right after the power−on−reset. Because the internal conversion circuit works inside REG power rail, it is recommended that the SFS voltage is made from $V_{REG}$.

## DETAILED DESCRIPTION

As for all numerical value used in this description, the design value or the typical value is used.

### Rotation Speed Curve Setting Description

The LV88563JA can set 2 points speed parameter arbitrarily.

Low speed point (LSP)

High speed point (HSP)

And at middle range of input duty, the rotation speed applied to calculated value for relative relationship.

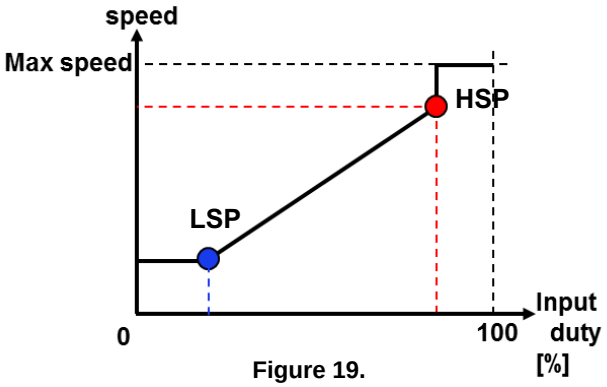



Figure 19.

When the input duty is lower than LSP setting duty, the LV88563JA can select “motor stop” or “keep LSP rotation speed”.

When the input duty is higher than HSP setting duty, the LV88563JA can select “free run” or “keep HSP rotation speed”.

Rotation speed of LSP and HSP is set by RSA and RSB pin. The case of RSA > RSB, “motor stop” mode applied. The case of RSA < RSB, “keep LSP rotation speed” mode applied.

Input duty of LSP and HSP is set by PIX and PIZ pin. The case of PIX > PIZ, “free run” mode applied. The case of PIX < PIZ, “keep HSP rotation speed” mode applied.

So LV88563JA can’t set decease speed curve at input duty increase.

Figures 20 − 23 show setting curve example.

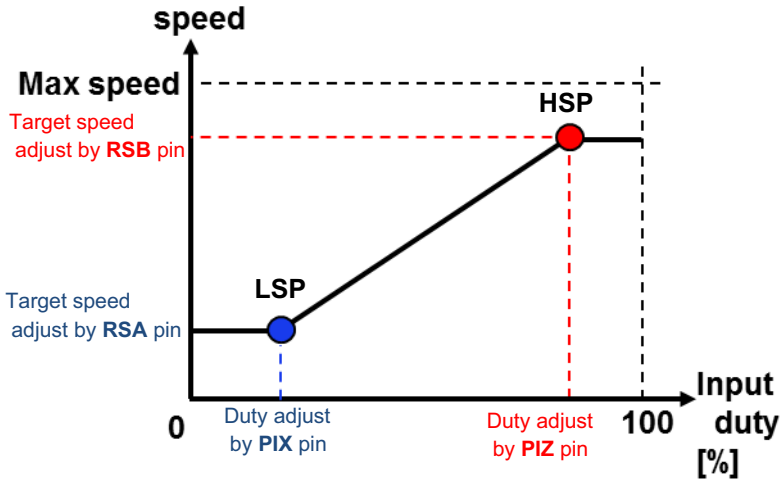



**Figure 20. Speed Setting Curve Type Example 1 Minimum Speed Set and Maximum Speed Set**

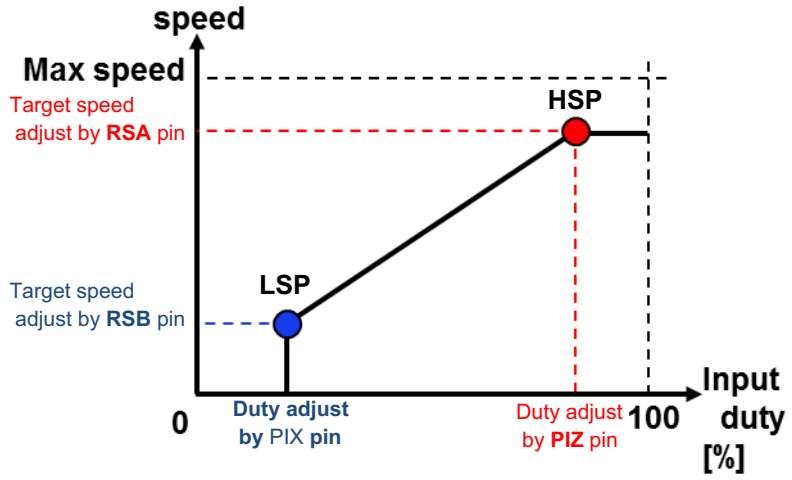



**Figure 21. Speed Setting Curve Type Example 2**
**Motor Stop Mode and Maximum Speed Set**

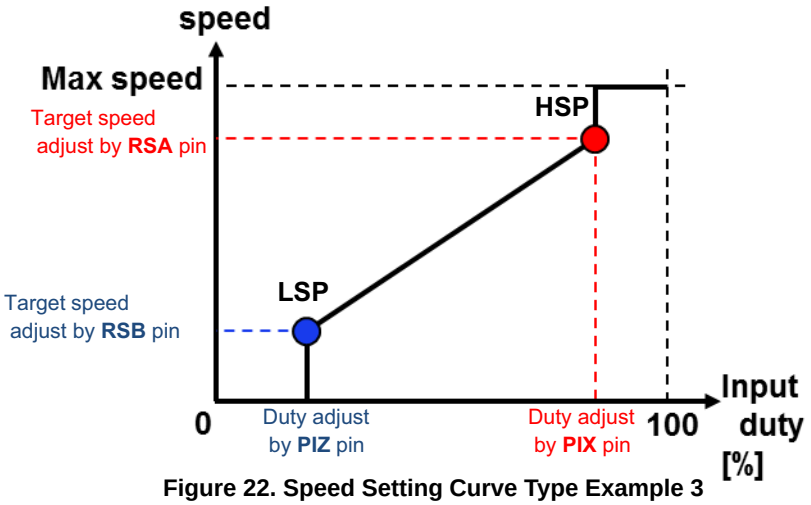



**Figure 22. Speed Setting Curve Type Example 3**
**Motor Stop Mode and Free Run Mode**

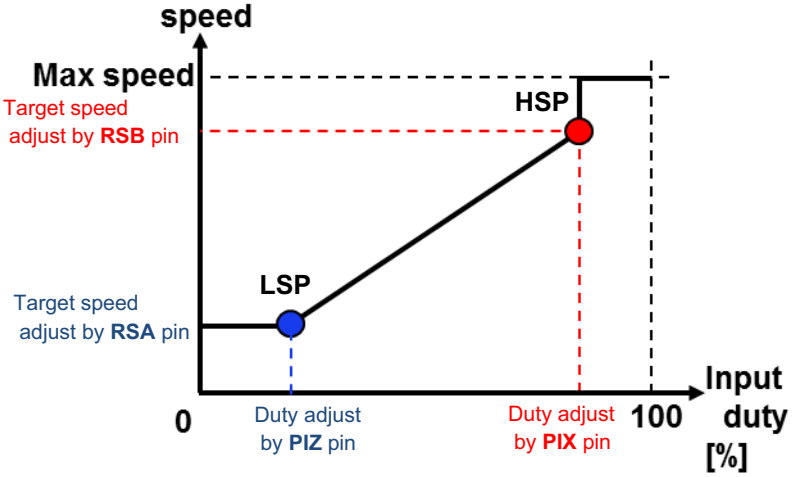



**Figure 23. Speed Setting Curve Type Example 4**
**Minimum Speed Set and Free Run Mode**

**Table 8. ROTATION SPEED SETTING TABLE FOR RSA/RSB PIN**

| A−D code | RPM | A−D code | RPM | A−D code | RPM | A−D code | RPM | A−D code | RPM | A−D code | RPM | A−D code | RPM | A−D code | RPM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 64 | 980 | 128 | 2180 | 192 | 4800 | 256 | 10800 | 320 | 17200 | 384 | 23600 | 448 | 30000 |
| 1 | 0 | 65 | 990 | 129 | 2200 | 193 | 4850 | 257 | 10900 | 321 | 17300 | 385 | 23700 | 449 | 30100 |
| 2 | 0 | 66 | 1000 | 130 | 2220 | 194 | 4900 | 258 | 11000 | 322 | 17400 | 386 | 23800 | 450 | 30200 |
| 3 | 0 | 67 | 1010 | 131 | 2240 | 195 | 4950 | 259 | 11100 | 323 | 17500 | 387 | 23900 | 451 | 30300 |
| 4 | 0 | 68 | 1020 | 132 | 2260 | 196 | 5000 | 260 | 11200 | 324 | 17600 | 388 | 24000 | 452 | 30400 |
| 5 | 0 | 69 | 1030 | 133 | 2280 | 197 | 5050 | 261 | 11300 | 325 | 17700 | 389 | 24100 | 453 | 30500 |
| 6 | 400 | 70 | 1040 | 134 | 2300 | 198 | 5100 | 262 | 11400 | 326 | 17800 | 390 | 24200 | 454 | 30600 |
| 7 | 410 | 71 | 1050 | 135 | 2320 | 199 | 5150 | 263 | 11500 | 327 | 17900 | 391 | 24300 | 455 | 30700 |
| 8 | 420 | 72 | 1060 | 136 | 2340 | 200 | 5200 | 264 | 11600 | 328 | 18000 | 392 | 24400 | 456 | 30800 |
| 9 | 430 | 73 | 1080 | 137 | 2360 | 201 | 5300 | 265 | 11700 | 329 | 18100 | 393 | 24500 | 457 | 30900 |
| 10 | 440 | 74 | 1100 | 138 | 2380 | 202 | 5400 | 266 | 11800 | 330 | 18200 | 394 | 24600 | 458 | 31000 |
| 11 | 450 | 75 | 1120 | 139 | 2400 | 203 | 5500 | 267 | 11900 | 331 | 18300 | 395 | 24700 | 459 | 31100 |
| 12 | 460 | 76 | 1140 | 140 | 2420 | 204 | 5600 | 268 | 12000 | 332 | 18400 | 396 | 24800 | 460 | 31200 |
| 13 | 470 | 77 | 1160 | 141 | 2440 | 205 | 5700 | 269 | 12100 | 333 | 18500 | 397 | 24900 | 461 | 31300 |
| 14 | 480 | 78 | 1180 | 142 | 2460 | 206 | 5800 | 270 | 12200 | 334 | 18600 | 398 | 25000 | 462 | 31400 |
| 15 | 490 | 79 | 1200 | 143 | 2480 | 207 | 5900 | 271 | 12300 | 335 | 18700 | 399 | 25100 | 463 | 31500 |
| 16 | 500 | 80 | 1220 | 144 | 2500 | 208 | 6000 | 272 | 12400 | 336 | 18800 | 400 | 25200 | 464 | 31600 |
| 17 | 510 | 81 | 1240 | 145 | 2520 | 209 | 6100 | 273 | 12500 | 337 | 18900 | 401 | 25300 | 465 | 31700 |
| 18 | 520 | 82 | 1260 | 146 | 2540 | 210 | 6200 | 274 | 12600 | 338 | 19000 | 402 | 25400 | 466 | 31800 |
| 19 | 530 | 83 | 1280 | 147 | 2560 | 211 | 6300 | 275 | 12700 | 339 | 19100 | 403 | 25500 | 467 | 31900 |
| 20 | 540 | 84 | 1300 | 148 | 2600 | 212 | 6400 | 276 | 12800 | 340 | 19200 | 404 | 25600 | 468 | 32000 |
| 21 | 550 | 85 | 1320 | 149 | 2650 | 213 | 6500 | 277 | 12900 | 341 | 19300 | 405 | 25700 | 469 | 32100 |
| 22 | 560 | 86 | 1340 | 150 | 2700 | 214 | 6600 | 278 | 13000 | 342 | 19400 | 406 | 25800 | 470 | 32200 |
| 23 | 570 | 87 | 1360 | 151 | 2750 | 215 | 6700 | 279 | 13100 | 343 | 19500 | 407 | 25900 | 471 | 32300 |
| 24 | 580 | 88 | 1380 | 152 | 2800 | 216 | 6800 | 280 | 13200 | 344 | 19600 | 408 | 26000 | 472 | 32400 |
| 25 | 590 | 89 | 1400 | 153 | 2850 | 217 | 6900 | 281 | 13300 | 345 | 19700 | 409 | 26100 | 473 | 32500 |
| 26 | 600 | 90 | 1420 | 154 | 2900 | 218 | 7000 | 282 | 13400 | 346 | 19800 | 410 | 26200 | 474 | 32600 |
| 27 | 610 | 91 | 1440 | 155 | 2950 | 219 | 7100 | 283 | 13500 | 347 | 19900 | 411 | 26300 | 475 | 32700 |
| 28 | 620 | 92 | 1460 | 156 | 3000 | 220 | 7200 | 284 | 13600 | 348 | 20000 | 412 | 26400 | 476 | 32800 |
| 29 | 630 | 93 | 1480 | 157 | 3050 | 221 | 7300 | 285 | 13700 | 349 | 20100 | 413 | 26500 | 477 | 32900 |
| 30 | 640 | 94 | 1500 | 158 | 3100 | 222 | 7400 | 286 | 13800 | 350 | 20200 | 414 | 26600 | 478 | 33000 |
| 31 | 650 | 95 | 1520 | 159 | 3150 | 223 | 7500 | 287 | 13900 | 351 | 20300 | 415 | 26700 | 479 | 33100 |
| 32 | 660 | 96 | 1540 | 160 | 3200 | 224 | 7600 | 288 | 14000 | 352 | 20400 | 416 | 26800 | 480 | 33200 |
| 33 | 670 | 97 | 1560 | 161 | 3250 | 225 | 7700 | 289 | 14100 | 353 | 20500 | 417 | 26900 | 481 | 33300 |
| 34 | 680 | 98 | 1580 | 162 | 3300 | 226 | 7800 | 290 | 14200 | 354 | 20600 | 418 | 27000 | 482 | 33400 |
| 35 | 690 | 99 | 1600 | 163 | 3350 | 227 | 7900 | 291 | 14300 | 355 | 20700 | 419 | 27100 | 483 | 33500 |
| 36 | 700 | 100 | 1620 | 164 | 3400 | 228 | 8000 | 292 | 14400 | 356 | 20800 | 420 | 27200 | 484 | 33600 |
| 37 | 710 | 101 | 1640 | 165 | 3450 | 229 | 8100 | 293 | 14500 | 357 | 20900 | 421 | 27300 | 485 | 33700 |
| 38 | 720 | 102 | 1660 | 166 | 3500 | 230 | 8200 | 294 | 14600 | 358 | 21000 | 422 | 27400 | 486 | 33800 |
| 39 | 730 | 103 | 1680 | 167 | 3550 | 231 | 8300 | 295 | 14700 | 359 | 21100 | 423 | 27500 | 487 | 33900 |
| 40 | 740 | 104 | 1700 | 168 | 3600 | 232 | 8400 | 296 | 14800 | 360 | 21200 | 424 | 27600 | 488 | 34000 |
| 41 | 750 | 105 | 1720 | 169 | 3650 | 233 | 8500 | 297 | 14900 | 361 | 21300 | 425 | 27700 | 489 | 34100 |
| 42 | 760 | 106 | 1740 | 170 | 3700 | 234 | 8600 | 298 | 15000 | 362 | 21400 | 426 | 27800 | 490 | 34200 |
| 43 | 770 | 107 | 1760 | 171 | 3750 | 235 | 8700 | 299 | 15100 | 363 | 21500 | 427 | 27900 | 491 | 34300 |
| 44 | 780 | 108 | 1780 | 172 | 3800 | 236 | 8800 | 300 | 15200 | 364 | 21600 | 428 | 28000 | 492 | 34400 |
| 45 | 790 | 109 | 1800 | 173 | 3850 | 237 | 8900 | 301 | 15300 | 365 | 21700 | 429 | 28100 | 493 | 34500 |
| 46 | 800 | 110 | 1820 | 174 | 3900 | 238 | 9000 | 302 | 15400 | 366 | 21800 | 430 | 28200 | 494 | 34600 |
| 47 | 810 | 111 | 1840 | 175 | 3950 | 239 | 9100 | 303 | 15500 | 367 | 21900 | 431 | 28300 | 495 | 34700 |
| 48 | 820 | 112 | 1860 | 176 | 4000 | 240 | 9200 | 304 | 15600 | 368 | 22000 | 432 | 28400 | 496 | 34800 |
| 49 | 830 | 113 | 1880 | 177 | 4050 | 241 | 9300 | 305 | 15700 | 369 | 22100 | 433 | 28500 | 497 | 34900 |
| 50 | 840 | 114 | 1900 | 178 | 4100 | 242 | 9400 | 306 | 15800 | 370 | 22200 | 434 | 28600 | 498 | 35000 |
| 51 | 850 | 115 | 1920 | 179 | 4150 | 243 | 9500 | 307 | 15900 | 371 | 22300 | 435 | 28700 | 499 | 35100 |
| 52 | 860 | 116 | 1940 | 180 | 4200 | 244 | 9600 | 308 | 16000 | 372 | 22400 | 436 | 28800 | 500 | 35200 |
| 53 | 870 | 117 | 1960 | 181 | 4250 | 245 | 9700 | 309 | 16100 | 373 | 22500 | 437 | 28900 | 501 | 35300 |
| 54 | 880 | 118 | 1980 | 182 | 4300 | 246 | 9800 | 310 | 16200 | 374 | 22600 | 438 | 29000 | 502 | 35400 |
| 55 | 890 | 119 | 2000 | 183 | 4350 | 247 | 9900 | 311 | 16300 | 375 | 22700 | 439 | 29100 | 503 | 35500 |
| 56 | 900 | 120 | 2020 | 184 | 4400 | 248 | 10000 | 312 | 16400 | 376 | 22800 | 440 | 29200 | 504 | 35600 |
| 57 | 910 | 121 | 2040 | 185 | 4450 | 249 | 10100 | 313 | 16500 | 377 | 22900 | 441 | 29300 | 505 | 35700 |
| 58 | 920 | 122 | 2060 | 186 | 4500 | 250 | 10200 | 314 | 16600 | 378 | 23000 | 442 | 29400 | 506 | 35800 |
| 59 | 930 | 123 | 2080 | 187 | 4550 | 251 | 10300 | 315 | 16700 | 379 | 23100 | 443 | 29500 | 507 | 35900 |
| 60 | 940 | 124 | 2100 | 188 | 4600 | 252 | 10400 | 316 | 16800 | 380 | 23200 | 444 | 29600 | 508 | 36000 |
| 61 | 950 | 125 | 2120 | 189 | 4650 | 253 | 10500 | 317 | 16900 | 381 | 23300 | 445 | 29700 | 509 | 36000 |
| 62 | 960 | 126 | 2140 | 190 | 4700 | 254 | 10600 | 318 | 17000 | 382 | 23400 | 446 | 29800 | 510 | 36000 |
| 63 | 970 | 127 | 2160 | 191 | 4750 | 255 | 10700 | 319 | 17100 | 383 | 23500 | 447 | 29900 | 511 | 36000 |

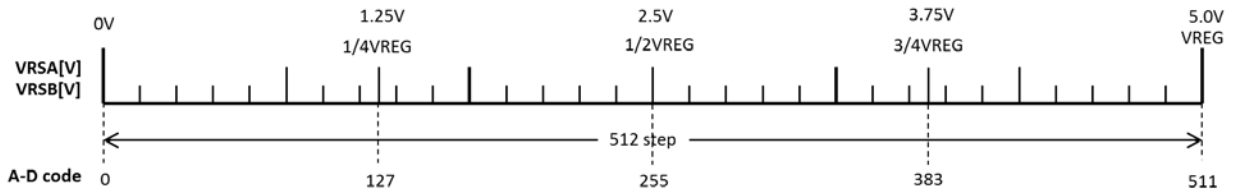



**Figure 24. A−D Code Figure for RSA/RSB Pin**

Voltage of RSA/RSB is calculated by below formula.

$$\mathrm{VRSA, VRSB[V]} = \frac{\mathrm{VREG}}{512} \times \mathrm{Target\ RPM's\ A\_D\ code} \qquad \text{(eq. 1)}$$

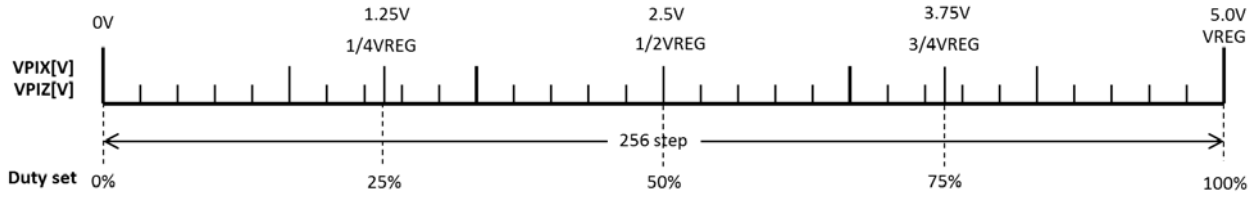



**Figure 25. Input Duty Parameter Setting for PIX/PIZ Pin**

Voltage of PIX/PIZ is calculated by below formula.

$$\mathrm{VPIX, VPIZ[V]} = \mathrm{VREG} \times \frac{\mathrm{Target\ Duty[\%]}}{100} \qquad \text{(eq. 2)}$$

**Lead−angle Setting Description**

LV88563JA provides the dynamic lead angle adjustment. To match the motor characteristics, set two points lead−angel amounts. Settable range is −22.225° to +22.225° (0.175° step).

LV88563JA can set delay angle setting. Minus value means delay angle.

LSP's value set by LAI pin

HSP's value set by LAG pin.

At middle range of input duty, the lead−angle amounts applied to calculated value for relative relationship.

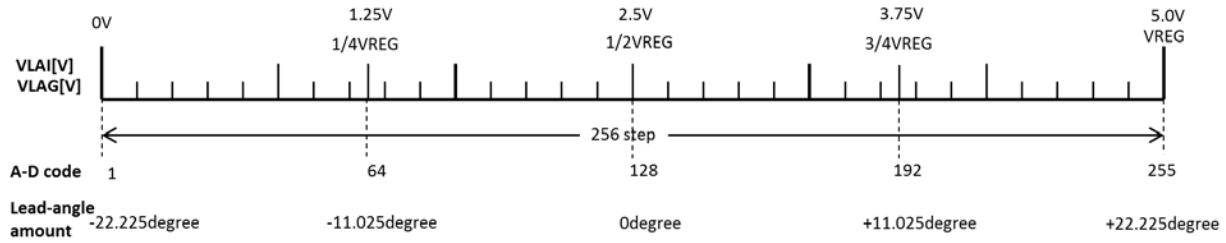



**Figure 26. Lead−angle Parameter Setting for LAI/LAG Pin**

Voltage of LAI/LAI is calculated by below formula.

$$\mathrm{VLAI, VLAG[V]} = \frac{\mathrm{VREG}}{2} + \mathrm{VREG} \times \frac{\mathrm{Target\ Lead\ Angle\ Value\ [°]}}{44.45} \qquad \text{(eq. 3)}$$

Lead angle amounts of LSP and HSP doesn't care each relationship of large/small.

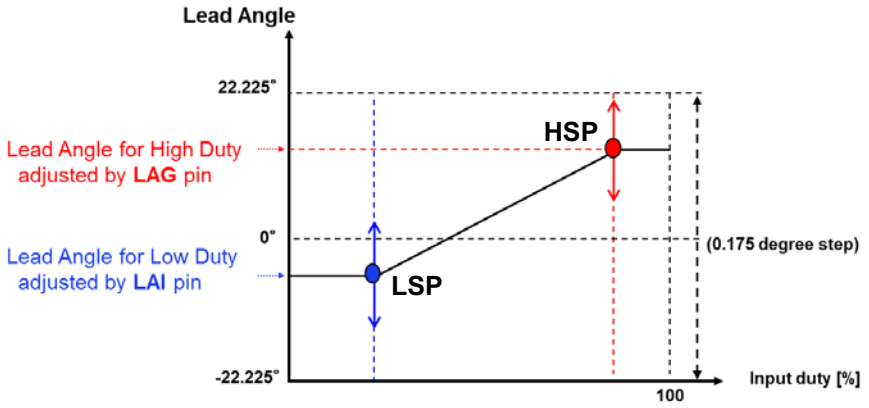



**Figure 27.**

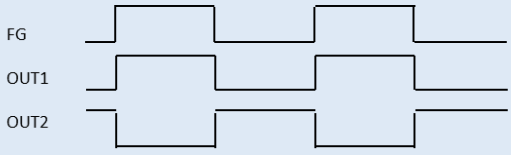
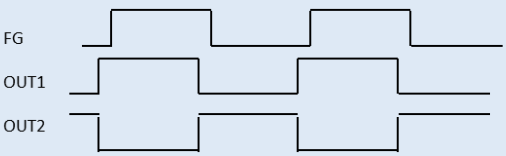
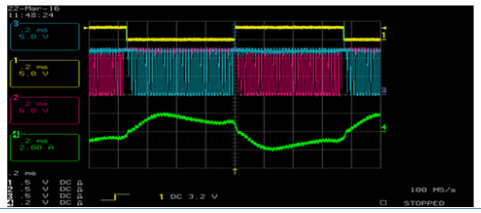
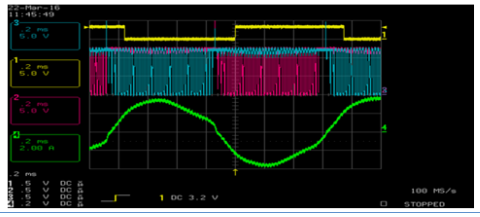
| Lead angle | Low speed | High speed |
|---|---|---|
| Image |   |   |
| Wave form |  |  |

**Figure 28. Lead−angel Image Waveform**

### Soft−start Setting Description

LV88563JA has soft start function.

To avoid the motor rush current, when the motor booting timing output PWM duty rise−up from zero slowly.

The soft start action release conditions are below

- Rotation speed reach to target speed decided by PWM input.
- Output duty reach to “Release duty”.

When reach to release condition, change to closed− loop speed control mode.

If the motor can’t rotation during 0.7s (typ), lock protection function works.

The recommendation of soft−start time is 1.72 s. Hence, it can be set by A−D code “0” and “31” for easy implementation by pin pull−down or pull−up.

| A−D code | Soft−start time(s) | Release duty(%) | Dead time(us) |
|---|---|---|---|
| 0 | 1.72 | 86 | 0.5 |
| 1 | 0.03 | 86 | 0.5 |
| 2 | 0.86 | 86 | 0.5 |
| 3 | 2.58 | 86 | 0.5 |
| 4 | 3.44 | 86 | 0.5 |
| 5 | 5.16 | 86 | 0.5 |
| 6 | 8.6 | 86 | 0.5 |
| 7 | 17.2 | 86 | 0.5 |
| 8 | 10 | 20 | 0.5 |
| 9 | 5 | 20 | 0.5 |
| 10 | 3 | 20 | 0.5 |
| 11 | 2 | 20 | 0.5 |
| 12 | 1.5 | 20 | 0.5 |
| 13 | 1 | 20 | 0.5 |
| 14 | 0.5 | 20 | 0.5 |
| 15 | 0.02 | 20 | 0.5 |
| 16 | 0.02 | 20 | 1 |
| 17 | 0.5 | 20 | 1 |
| 18 | 1 | 20 | 1 |
| 19 | 1.5 | 20 | 1 |
| 20 | 2 | 20 | 1 |
| 21 | 3 | 20 | 1 |
| 22 | 5 | 20 | 1 |
| 23 | 10 | 20 | 1 |
| 24 | 17.2 | 86 | 1 |
| 25 | 8.6 | 86 | 1 |
| 26 | 5.16 | 86 | 1 |
| 27 | 3.44 | 86 | 1 |
| 28 | 2.58 | 86 | 1 |
| 29 | 0.86 | 86 | 1 |
| 30 | 0.03 | 86 | 1 |
| 31 | 1.72 | 86 | 1 |

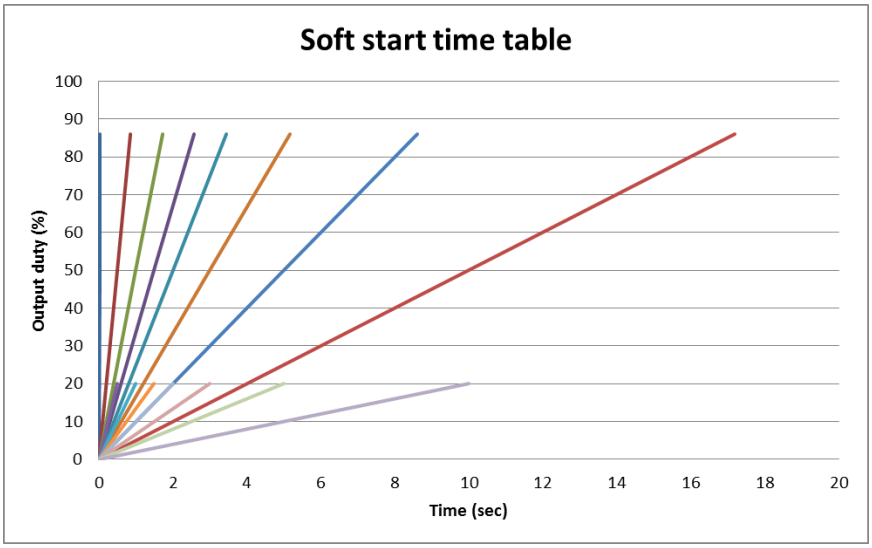



**Figure 29. Soft−start and Dead Time Setting Table for SFS Pin**

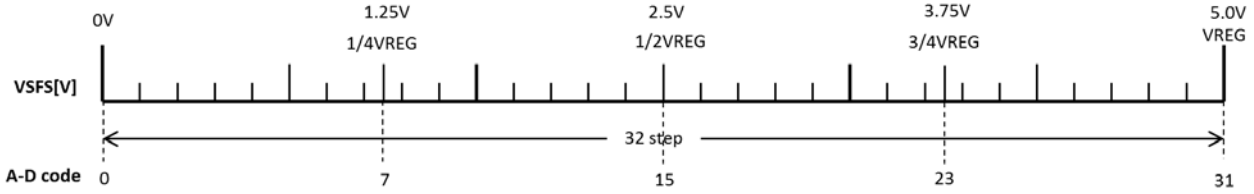



**Figure 30. A−D Code Figure for SFS Pin**

Voltage of SFS is calculated by below formula.

$$VSFS[V] = \frac{VREG}{32} \times \text{Target Setting's A\_D Code} \quad \text{(eq. 4)}$$

**Output Waveform**

LV88563JA output PWM frequency is fixed by inner oscillator parameter, 48 kHz (typ)

Not concern with input PWM frequency.

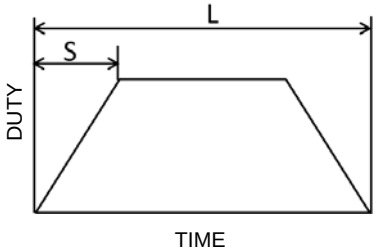



**Figure 31.**

Driving method of LV88563JA using PWM soft switching drive.

Soft switching width is changed by input PWM duty.

When the input duty is HSP setting duty, soft switching width is narrow (S/L = 20.5%)

On the other hand when the input duty is LSP setting duty, soft switching width becomes wide (S/L = 46.9%)

In this part, the rise/fall time of soft switching waveform is equal. Therefore, the "S" in the figure can be also applied to fall time.

At the middle range input duty, the soft switching width is applied to calculated value for relative relationship.

**Protections**

LV88563JA has some protection function.

− Thermal shutdown protection (TSD)
− Under voltage lock out (UVLO)
− Current limiter (CLM)
− Lock protection

When the TSD or Lock protection worked, external FETs are all turn off.

The other hand, when UVLO or CLM worked, output is PWM off and becomes re−circulation state.

### Thermal Shutdown Protection (TSD)

When this IC's junction temperature rise to 180°C (typ), O1H/O2H output turn to high, and O1L/O2L output turn to low. External FETs are all turn off and coil current shut off.

Next, IC's junction temperature fall to 150°C (typ), thermal shutdown function is released and motor start to rotate.

### Under Voltage Lock Out (UVLO)

UVLO work voltage: VCC 3.4 V (typ)
UVLO release voltage: VCC 3.6 V (typ)

### Current Limiter (CLM)

When the coil current increases and the voltage of the RF pin rises to 0.1 V (typ), the CLM operates and shut the coil current.

CLM current is adjustable by resistor value between RF−GND.

The sense resistor value is calculated as follows.

$$\text{Sense Resistor}[\Omega] = \frac{VTH_{CLM}[V]}{I_{CLM}[A]} \quad \text{(eq. 5)}$$

For example, to set the CLM current threshold at 2 A, the sense resistor value is

$$\text{Sense Resistor} = \frac{0.10(\text{typ})}{2.0}$$
$$\text{Res} = 0.05\ [\Omega] \quad \text{(eq. 6)}$$

### Feed Back Gain Setting

LV88563JA is set lower feed back gain than LV88561. When the motor speed changes by control signal, the pace of speed change becomes slow.

### Lock Detection and Lock Protection

When the motor lock is happened, heat is generated because IC continues to supply electricity to the motor. And IC detects this radiated heat and turns off the electricity to the motor.

Under motor rotation state, if this IC does not receive the FG edge for 0.3sec (under 50 rpm),This IC judges " motor lock" and operates lock protection function.

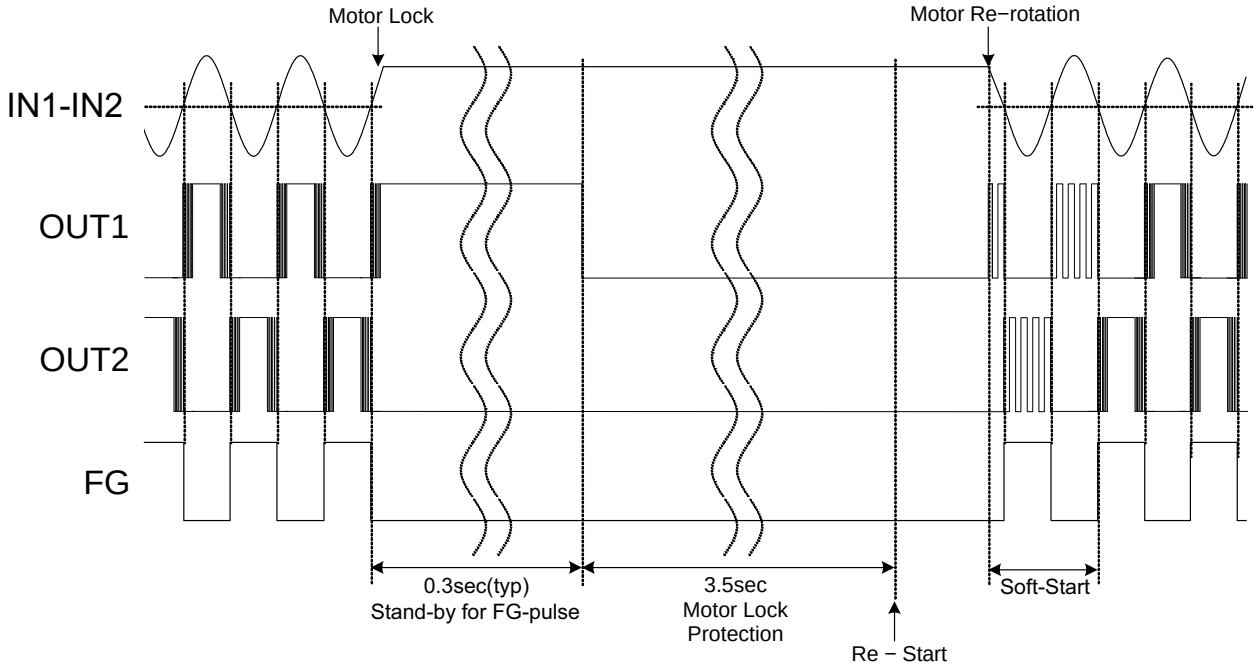



**Figure 32.**

It takes 3.5s for Lock protection time(1st to 4th protection time). This equals to the total of lock detection time and lock protection time. The lock detection time – the lock protection time ratio is approx. 1:5 (from 1st to 4th protection time).

After 5th protection time, the lock protection time becomes 14s and protection−start time ratio is approx.. 1:20 (after 5th protection time)

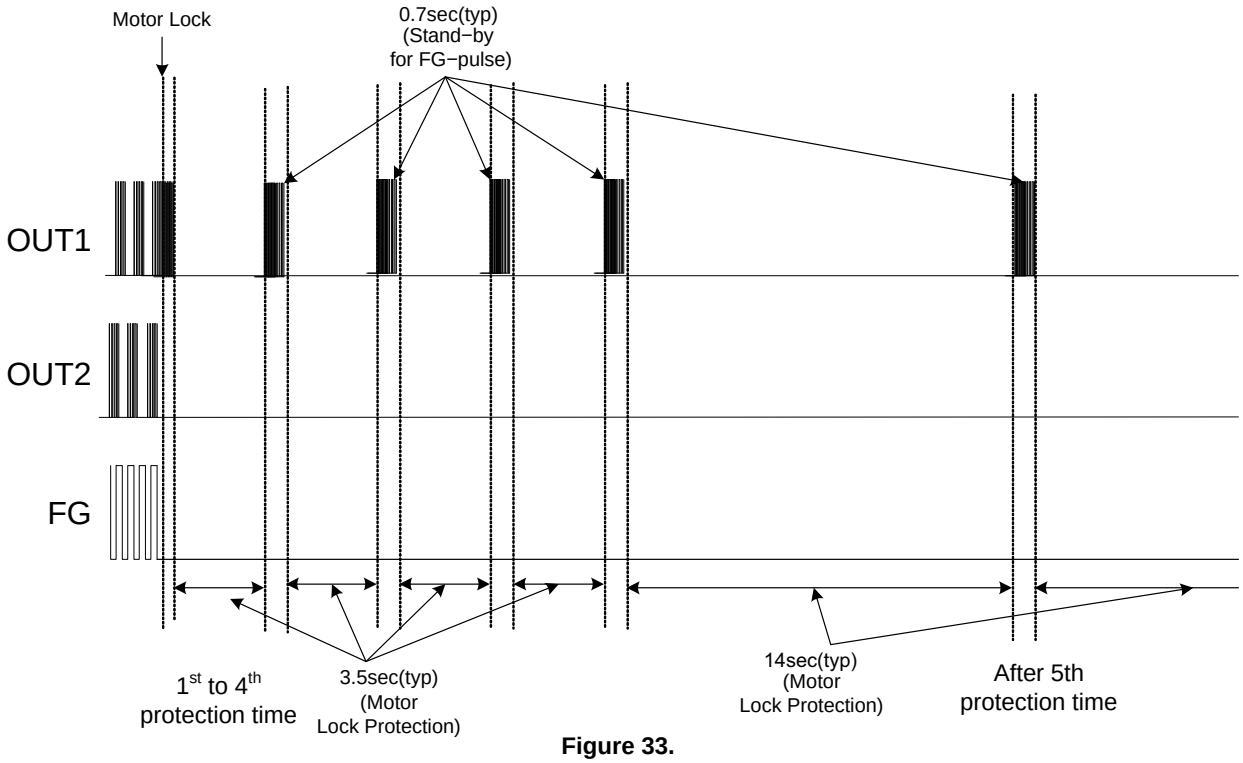

Motor Lock
0.7sec(typ)
(Stand−by
for FG−pulse)
OUT1
OUT2
FG
1st to 4th
protection time
3.5sec(typ)
(Motor
Lock Protection)
14sec(typ)
(Motor
Lock Protection)
After 5th
protection time

**Figure 33.**

## PCB GUIDELINES

### VCC and Ground Routing

Make sure to short−circuit power line externally by a low impedance route on one side of PCB. As high current flows into external FET to GND, connect it to GND through a low impedance route.

The capacitance connected between the VCC pin and the opposite ground is to stabilize the battery. Make sure to connect an electrolytic capacitor with capacitance value of about 1 μF (0.1 μF or greater) to eliminate low frequency noise. Also, to eliminate high frequency noise, connect a capacitor of superior frequency characteristics, with capacitance value of about 0.1 μF and make sure that the capacitor is connected as close to the pin as possible. Allow enough room in the design so the impact of PWM drive and kick−back does not affect other components. Especially, when the coil inductance is large and/or the coil resistance is small, current ripple will rise so it is necessary to use a high−capacity capacitor with superior frequency characteristics. Please note that if the battery voltage rises due to the impact of the coil kick−back as a result of the use of diode for preventing the break down caused by reverse connection, it is necessary to either increase the capacitance value or place Zener diode between the battery and the ground so that the voltage does not exceed absolute maximum voltage.

When the electrolytic capacitor cannot be used, add the resistor with the value of about 1 Ω and a ceramic capacitor with the capacitor value of about 10 μF in series for the alternative use. When the battery line is extended, (20−30 cm to 2−3 m), the battery voltage may overshoot when the power is supplied due to the impact of the routing of the inductance. Make sure that the voltage does not exceed the absolute maximum standard voltage when the power supply turns on.

These capacitance values are just for reference, so the confirmation with the actual application is essential to determine the values appropriately

### RF Routing

Power current (output current) flows through the RF line. Make sure to short−circuit the line from RF through GND as well as GND. The RF resistance must choose the enough power rating

### External FET Output Pins

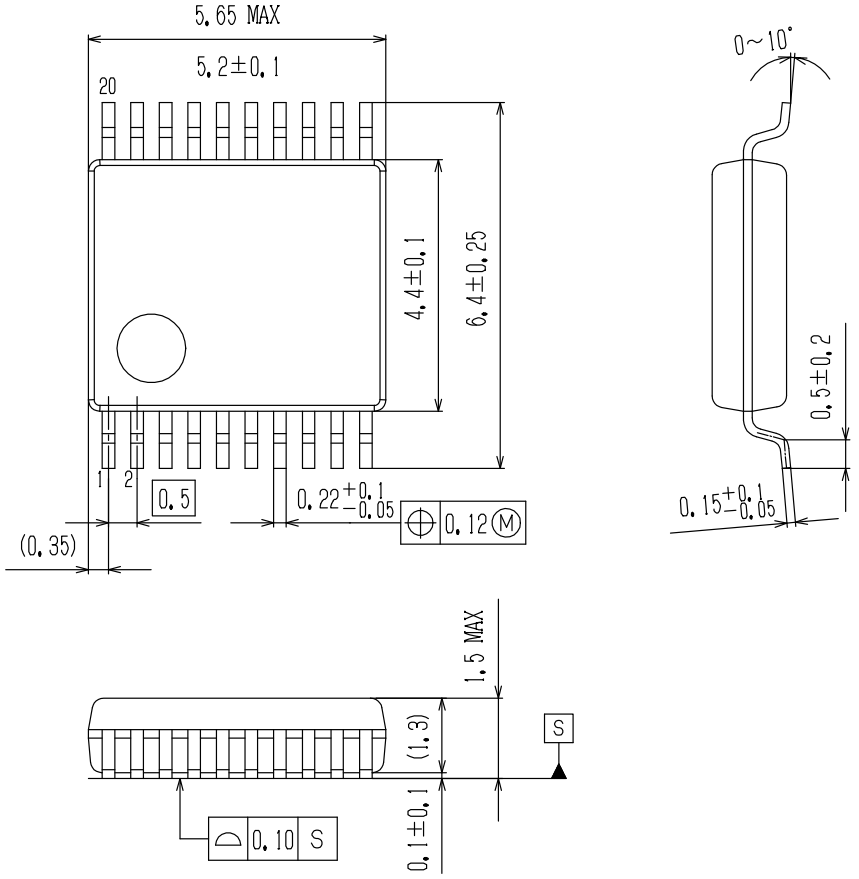
Since the pins have to tolerate surge of current, make sure that the wires are thick and short enough when designing the PCB board.

### Thermal Test Conditions

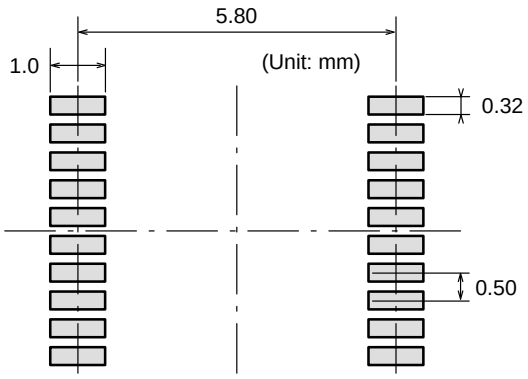
Size: 114.3 mm x 76.1 mm x 1.6 mm
Material: Glass epoxy single layer board

## PACKAGE DIMENSIONS

**SSOP20J (225mil)**
CASE 565AP
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.

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