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

Overview

The LV88561JA/R, LV88562JA/R, LV88563JA/R and LV88564JA/R are the pre-driver for a single-phase 24 V/48 V BLDC motor, which have the closed loop controller for motor rotation speed. These are 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 with 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
- 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
- Dynamic Lead Angle Adjustment with Respect to Rotational Speed
- Lead-angle Control Parameters can be Configured
- Lineup of Different Closed Loop Gain Selection
- Lineup of Rotation Signal Output Selection
- These are Pb-Free and Halogen-Free Devices

Typical Applications

- PC & Computing Equipment
- Refrigerator
- Games

LV88561, 562, 563, 564 COMPARISON TABLE

| | Loop Gain | Rotation Signal |
|-------------|-----------|-----------------|
| LV88561JA/R | Normal | FG |
| LV88562JA/R | Normal | RD |
| LV88563JA/R | Low | FG |
| LV88564JA/R | Low | RD |

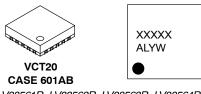


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(LV88561JA, LV88562JA, LV88563JA, LV88564JA)



(LV88561R, LV88562R, LV88563R, LV88564R)

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 [†] |
|--|--|-----------------------|
| LV88561JA-AH LV88562JA-AH LV88563JA-AH LV88564JA-AH | SSOP20J (Pb–Free / Halogen Free) | 2000 / Tape & Reel |
| LV88561RTXG LV88562RTXG LV88563RTXG LV88564RTXG | VCT20 (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

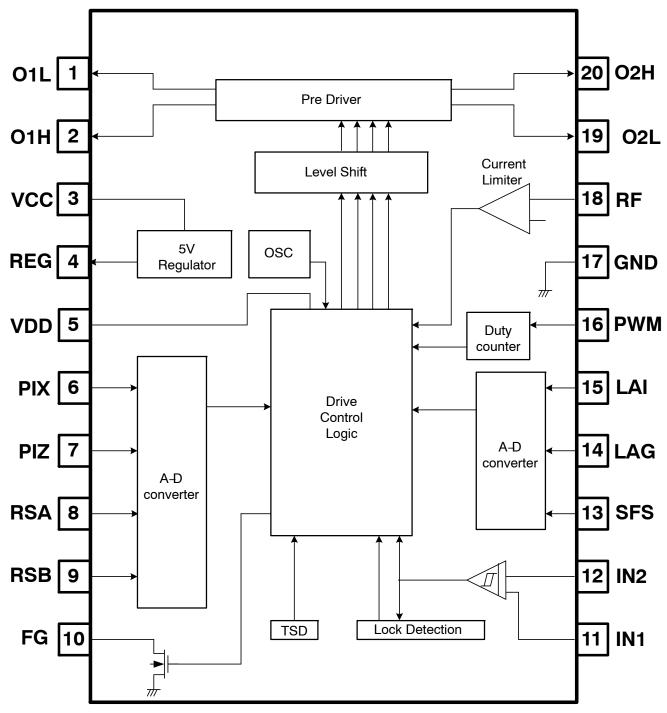


Figure 1. LV88561JA, LV88562JA, LV88563JA, LV88564JA Block Diagram

APPLICATION CIRCUIT DIAGRAM

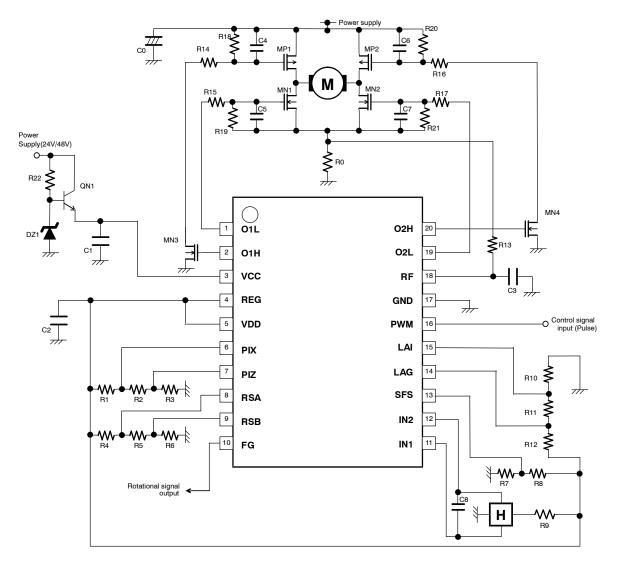


Figure 2. Single-phase BLDC Motor Drive with LV88561JA, LV88562JA, LV88563JA, LV88564JA

| 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 | CO | 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 |

Table 1. EXAMPLE COMPONENT VALUE

*Depend on the user circuit, MP1, MP2, MN1 and MN2. **Depends on the user environment.

Table 2. TRUTH TABLE

| Operating State | IN1 | IN2 | Inner-PWM State* | O1H | 01L | O2H | O2L | FG |
|------------------------------|-----|-----|------------------|-----|-----|-----|-----|-----|
| Rotation – drive mode | L | Н | On | L | Н | н | L | OFF |
| | Н | L | | Н | L | L | Н | L |
| Rotation – regeneration mode | L | Н | Off | L | L | Н | L | OFF |
| | Н | L | | Н | L | L | L | L |
| Lock protector | L | Н | - | L | L | L | L | OFF |
| | Н | L | 1 | L | L | L | L | L |

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

PIN ASSIGNMENT

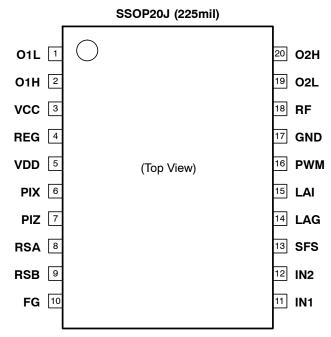


Figure 3. LV88561JA, LV88562JA, LV88563JA, LV88564JA Pin Assignment

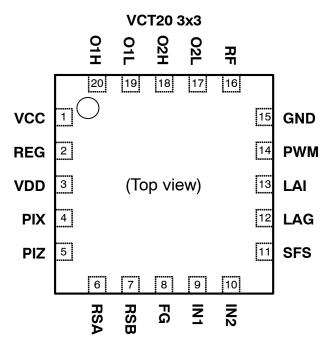


Figure 4. LV88561R, LV88562R, LV88563R, LV88564R Pin Assignment

| Pin No. | Pin name | Function |
|----------|------------|--|
| 1 19 | O1L O2L | Output pins of the low-side gate-drive signal. (See "Truth Table" on page 4 for the polarity) |
| 2 20 | 01H 02H | Output pins of the high-side gate-drive signal. (See "Truth Table" on page 4 for the polarity) |
| 3 | VCC | Power supply pin. The input voltage to this pin must be stabilized without the influence of the noise, ripple, and etc. Therefore, it is necessary to connect the capacitor near VCC pin and GND pin as much as possible. |
| 4 | REG | Output pin of the regulated voltage (5.0 V). 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. This pin should be shorted to REG pin. |
| 6 7 | PIX PIZ | PWM input duty adjust pins at the point of maximum or minimum rotation speed. |
| 8 9 | RSA RSB | Maximum or minimum rotation speed adjust pins. |
| 10 | FG | Output pin of the rotational signal. For LV88561 and LV88563, it functions as FG (Frequency Generator) and for LV88562 and LV88564, it functions as RD (Rotation Detection). This pin should be opened (disconnected) when not in use. |
| 11 12 | IN1 IN2 | Hall signal input pins. |
| 13 | SFS | Soft start adjust pin. |
| 14 | LAG | Lead angle gradient adjust pin. |
| 15 | LAI | Initial lead angle adjust pin in minimum rotation speed. |
| 16 | PWM | PWM input pin of the speed control signal as the rectangular wave. |
| 17 | GND | GND pin. |
| 18 | RF | Output current detect pin. When the voltage level at this pin exceeds the internal set detection level, outputs turn to the regenerating mode. |

Table 3. PIN FUNCTION DESCRIPTION (Pin No. – SSOP20J version)

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 | LV8856xJA | 0.8 | W |
| Allowable power dissipation (Note 3) | Pdmax | LV8856xR | 1.0 | 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 4) | MSL | LV8856xJA | 3 | - |
| Moisture Sensitivity Level (MSL) (Note 4) | MSL | LV8856xR | 1 | - |
| Lead Temperature Soldering Pb-Free Versions (30s or less) (Note 5) | T _{SLD} | | 255 | °C |
| ESD Human body Model : HBM (Note 6) | 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%.

- 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 23.
- 3. Specified circuit board : 50.0 mm x 40.0 mm x 0.8 mm, glass epoxy 4–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 23.

4. Moisture Sensitivity Level (MSL): IPC/JEDEC standard: J-STD-020A

- 5. For information, please refer to our Soldering and Mounting Techniques Reference Manual, SOLDERRM/D http://www.onsemi.com/pub_link/Collateral/SOLDERRM-D.PDF
- 6. 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 7) LV8856xJA | $R_{	hetaJA}$ | 156 | °C/W |
| Thermal Resistance, Junction-to-Ambient (Note 8) LV8856xR | $R_{	hetaJA}$ | 125 | °C/W |

 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 23.

8. Specified circuit board : 50.0 mm x 40.0 mm x 0.8 mm, glass epoxy 4–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 23.

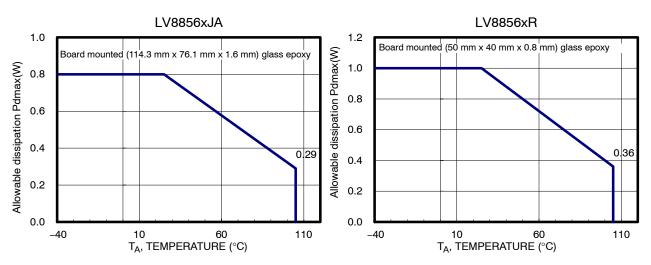


Figure 5. Power Dissipation vs Ambient Temperature Characteristic

| Table 6 | . RECOMMENDED | OPERATING | RANGES | (Note 9) |
|---------|---------------|-----------|--------|----------|
|---------|---------------|-----------|--------|----------|

| 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 10) | 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 |

9. 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.

10. 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 is varied.

| | | | | Ratings | | |
|--|---------|---|------|---------|------|------|
| Parameter | Symbol | Conditions | Min | Тур | Max | Unit |
| Circuit current | ICC | | | 9 | 16 | mA |
| 01H/01L/02H/02L High-side on-resistance | ROHon | IO = 10 mA | | 30 | 80 | Ω |
| 01H/01L/02H/02L 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 | lfglk | VCC = 16 V VFG = 16 V | | | 1 | μΑ |
| REG pin output voltage | VREG | | 4.7 | 5.0 | 5.3 | V |
| Lock-detection time1 (Note 12) | Tld1 | Under rotation | 0.27 | 0.3 | 0.33 | S |
| Lock-detection time2 (Note 13) | Tld2 | Start-up | 0.63 | 0.7 | 0.77 | S |
| Lock-Stop release time1 from 1 st to 4 th 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 14) as from 5 th off time | Tlroff2 | | 12.5 | 14 | 15.5 | S |
| Lock-Restart time ratio2(Note 14) as from 5 th 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 | ∆Vregld | IREG = -10 mA | | 20 | 50 | mV |
| Hall input bias current | lhin | IN1, IN2 = 0 V | | 0 | 1 | μΑ |
| Hall input sensitivity | ΔVhin | | 40 | | | mV |
| Control input bias current | Ictlin | PIX, PIZ, RSA, RSB, SFS, LAG, LAI = 0 V | | 0 | 1 | μΑ |
| PWM input bias current | Ipwmin | VDD = 5.5 V, PWM = 0 V | 14 | 28 | 42 | μΑ |
| 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 |

Table 7. ELECTRICAL CHARACTERISTICS at TA = 25° C, VCC_{OP} = 12 V unless otherwise noted. (Note 11)

11. 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. 12. When the motor rotate state and the motor rotation speed reach to below 50 rpm (phase change period over 0.3s), lock protection function

will activate.

13. At the motor start-up timing, the motor can't rotate until 0.7s, lock protection function work.
14. When the locked rotor state is continued for a long time, lock stop period will change from 5th off time.

TYPICAL CHARACTERISTICS

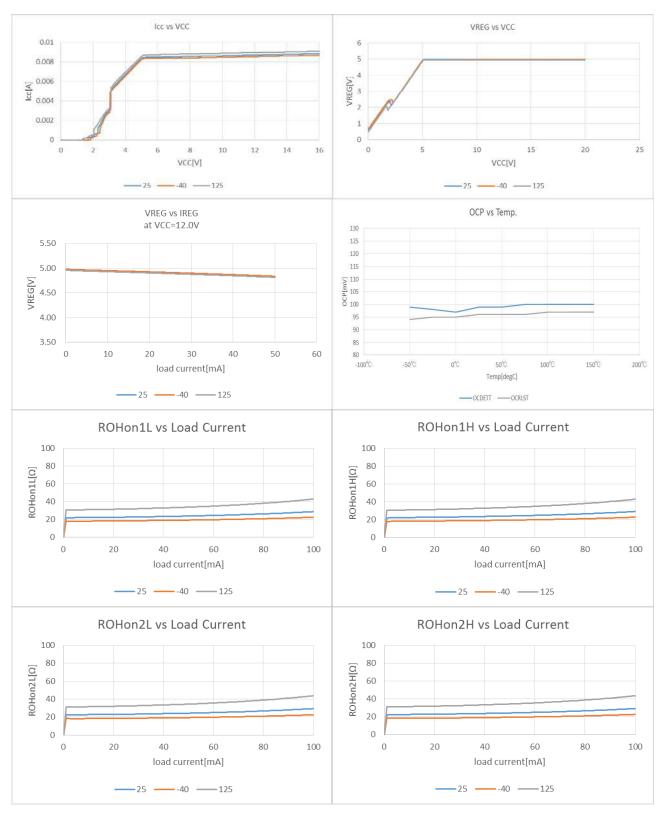
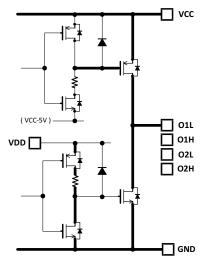
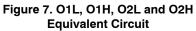


Figure 6. Typical Characteristics

EQUIVALENT CIRCUIT





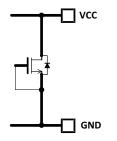


Figure 9. VCC Equivalent Circuit

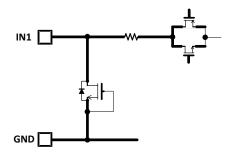


Figure 11. IN1, IN2 Equivalent Circuit

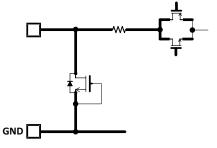


Figure 13. LAI Equivalent Circuit

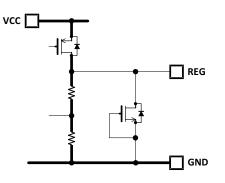


Figure 8. REG Equivalent Circuit

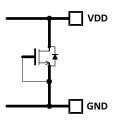


Figure 10. VDD Equivalent Circuit

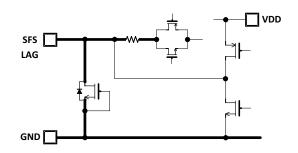


Figure 12. SFS, LAG Equivalent Circuit

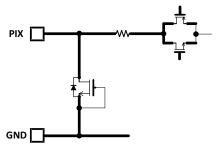
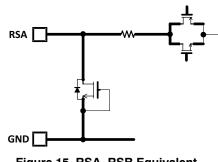


Figure 14. PIX, PIZ Equivalent Circuit





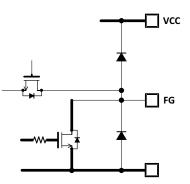


Figure 16. FG Equivalent Circuit

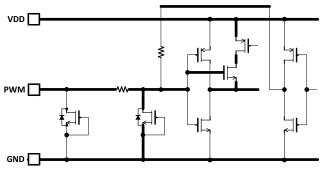


Figure 17. PWM Equivalent Circuit

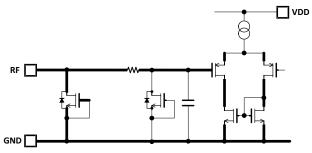
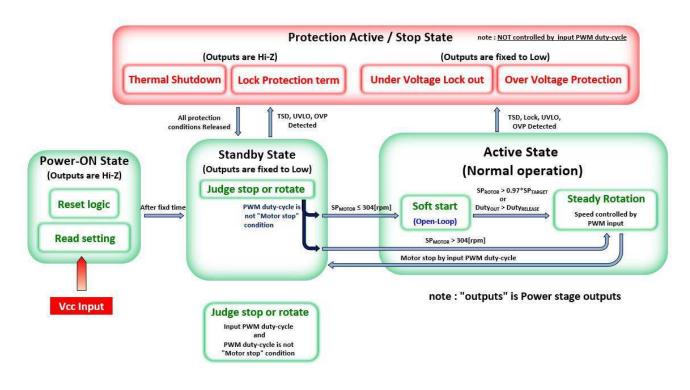


Figure 18. RF Equivalent Circuit

STATE DIAGRAM





FUNCTIONAL DESCRIPTION

Loop Gain

Motor speed loop gain of LV88563 and LV88564 is lower than that of LV88561 and LV88562. If the motor coil current generate large overshoot during motor speed transition, LV88563 and LV88564 can reduce the overshooting current but the motor rotation response speed will decrease. LV88561 and LV88562 are recommended if faster response speed is required.

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. Don't exceed this value. Place capacity from 0.1 μ F to 1.0 μ F in the close this pin.

Rotational Signal Pin (FG)

This is an open drain output pin which outputs the rotational signal. In case of LV88561 and LV88563, FG signal will come out from this pin and its frequency will represent electrical speed of a motor.

In case of LV88562 and LV88564, RD signal will come out from this pin. See page 21 "Lock detection and Lock protection" for more information about the RD signal.

Recommended pull up resistor value is 1 k Ω to 100 k Ω . 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 μ F 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)

LV8856xJA/R provides the dynamic lead angle adjustment. To match the motor characteristics, set two point lead–angel, low speed side (set by LAI pin) and high speed side(set by LAG pin).

At middle range of input duty, the lead-angle iis 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)

LV8856xJA/R 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)

LV8856xJA/R 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 types of 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 LV8856xJA/R can set 2 points speed parameter arbitrarily.

Low speed point (LSP)

High speed point (HSP)

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

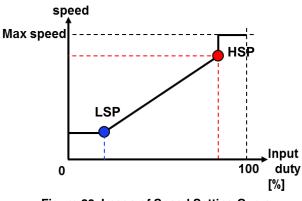


Figure 20. Image of Speed Setting Curve

When the input duty is lower than LSP setting duty, the LV8856xJA/R can select "motor stop" or "keep LSP rotation speed".

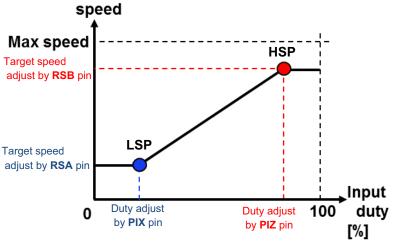
When the input duty is higher than HSP setting duty, the LV8856xJA/R can select "free run" or "keep HSP rotation speed".

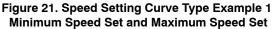
Rotation speed of LSP and HSP is set by RSA and RSB pin. The case of RSA > RSB, "motor stop" mode applied. The case of RSA < RSB, "keep LSP rotation speed" mode applied.

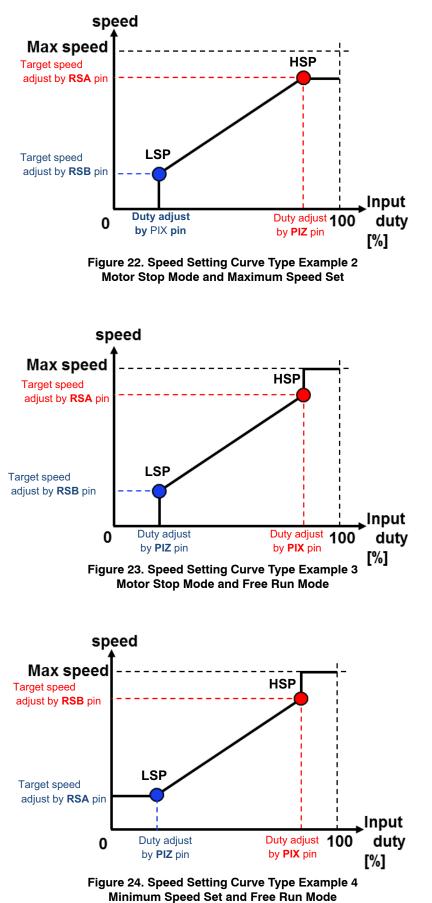
Input duty of LSP and HSP is set by PIX and PIZ pin. The case of PIX > PIZ, "free run" mode applied. The case of PIX < PIZ, "keep HSP rotation speed" mode applied.

So LV8856xJA/R can't set decease speed curve at input duty increase.

Figures 21 – 24 show setting curve example.







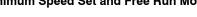
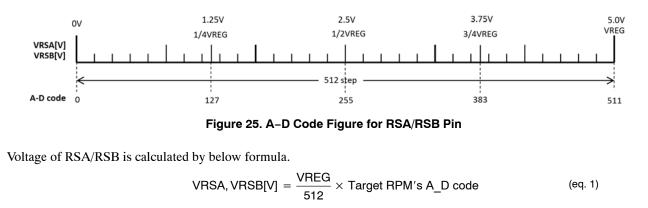


Table 8. ROTATION SPEED SETTING TABLE FOR RSA/RSB PIN

| 0 0 64 960 128 2180 1192 4465 255 10000 321 17500 384 28000 446 300 2 0 66 1000 1130 220 1144 4460 228 11000 322 1144 4460 228 1100 322 1144 4460 228 1100 322 1144 4460 228 1100 322 1144 4460 228 1100 322 1144 4400 228 1100 322 1144 4400 228 1100 328 1100 328 2400 443 330 6 400 70 1140 144 330 1190 331 1100 332 1100 332 2400 445 330 7 410 71 1030 133 2300 249 5600 280 1100 331 1800 342 2400 440 313< | 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 |
|---|----------|-----|----------|------|----------|------|----------|-------|----------|-------|----------|-------|----------|-------|----------|-------|
| 1 0 66 900 120 220 193 4480 227 19000 321 17300 388 23000 4430 332 3 0 67 1010 131 2240 144 4000 228 11100 323 17600 387 23000 451 333 4 0 68 1020 132 2320 186 5000 228 11100 328 17900 388 2400 454 337 7 4100 131 2280 196 5100 282 11100 328 17900 388 2400 456 387 8 420 72 1000 138 2340 2300 1800 388 18000 382 24400 456 340 112 440 74 1100 138 2300 2800 1800 388 18000 382 2400 461 314 | | | | | | | | | | | | | | | | 30000 |
| 2 0 66 1000 130 2220 1144 4400 232 11700 330 72500 337 23800 445 333 4 0 66 1000 132 2260 11600 324 1700 388 24000 452 345 5 0 00 1030 133 2200 116 540 324 1700 388 24000 452 345 8 4400 72 1000 134 2300 120 5400 286 1100 339 12400 359 24400 457 398 9 430 73 1109 137 2380 201 5500 286 11000 331 11800 398 24400 458 310 111 450 75 1120 138 1200 330 1800 307 24600 461 313 112 460 76 < | | - | | | | | | | | | | | | | | 30100 |
| 3 0 67 1010 131 2240 195 4000 232 17500 387 23000 44 5 6 009 1030 133 2280 196 5000 220 11300 325 17700 388 24000 453 355 6 400 70 1040 134 2200 198 5100 222 11400 325 17700 380 24000 453 355 7 410 77 11000 138 2300 148 5100 226 11100 330 18200 244 140 140 140 140 140 140 140 140 140 140 140 140 140 131 140 140 2400 298 12000 331 1800 396 24000 440 131 111 440 76 1140 142 2400 200 1210 331 | | - | | | | | | | | | | | | | | 30200 |
| 4 0 68 1020 132 2280 198 5000 280 11300 324 17700 388 24100 452 333 6 400 70 1040 134 2300 11400 326 17700 380 24100 453 335 7 410 77 1160 134 2300 1400 1510 281 11100 330 12400 453 337 7 410 77 1160 137 2810 2280 2280 2280 2280 2280 2280 2280 2280 2280 2280 2280 2280 2280 233 1800 338 24800 448 331 1131 440 78 110 140 2420 2480 2400 440 341 11 440 77 1160 141 2440 2400 2400 2400 2400 2400 2400 2400 < | | | | | | | | | | | | | | | | 30300 |
| 6 400 70 1040 134 2320 1900 5150 2828 11500 387 117800 380 24200 455 375 8 420 72 1060 138 2340 200 5200 284 11500 382 2450 455 307 10 440 74 1100 138 2840 201 5500 286 11700 380 2450 458 307 11 446 74 1100 138 28400 200 5500 289 1100 381 18500 397 2400 469 311 12 440 79 7110 141 2440 205 5700 289 12100 334 18500 397 2400 462 131 14 490 79 1200 143 2460 207 1200 381 1800 401 2500 463 311 | | | | 1020 | 132 | 2260 | | | 260 | | 324 | | 388 | | 452 | 30400 |
| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | 5 | 0 | 69 | 1030 | 133 | 2280 | 197 | 5050 | 261 | 11300 | 325 | 17700 | 389 | 24100 | 453 | 30500 |
| 8 420 72 1000 138 2340 200 5500 284 11600 382 24400 467 300 10 440 74 1100 138 2380 202 5400 289 11300 330 24600 458 311 13800 334 24600 458 311 13800 334 24600 459 311 12 460 76 1140 140 2440 204 5000 288 12000 333 18600 306 24800 460 311 13600 307 24800 466 311 14 480 78 1160 141 2440 206 5000 270 1220 334 18600 407 2350 465 311 15 400 73 1220 334 18000 407 2350 466 311 16 520 421 1420 5400 27 | 6 | 400 | 70 | 1040 | 134 | 2300 | 198 | 5100 | 262 | 11400 | 326 | 17800 | 390 | 24200 | 454 | 30600 |
| 9 440 73 1068 197 2380 202 5400 286 11700 383 12400 458 130 10 440 74 1100 138 2400 458 310 11 460 75 1140 140 2420 220 5600 281 11900 332 18800 395 24700 468 131 12 460 76 1140 142 24200 200 5600 270 12200 334 18600 397 24000 462 314 14 440 78 1160 142 2460 200 500 270 12200 334 18600 397 2100 462 316 17 070 81 1200 142 2400 270 12200 339 19100 402 25600 468 318 18 530 440 2500 271 1200 | 7 | 410 | 71 | 1050 | 135 | 2320 | 199 | 5150 | 263 | 11500 | 327 | 17900 | 391 | 24300 | 455 | 30700 |
| 10 440 74 1100 139 2400 2400 260 1800 331 18200 395 24700 458 311 12 460 70 1140 144 2440 204 5600 288 12000 333 18400 395 24700 458 311 13 470 77 1180 141 2440 206 5500 289 12100 333 18600 397 24900 461 313 14 480 78 1180 142 2440 206 5600 271 12300 335 18600 400 2500 463 315 16 500 80 1220 144 2500 208 610 276 1290 341 1800 440 2500 467 312 21 550 85 1320 149 2600 271 1200 341 1900 440 2500 <td></td> <td>30800</td> | | | | | | | | | | | | | | | | 30800 |
| 11 450 75 1120 1190 231 18300 386 24700 4590 311 12 460 76 1140 140 2460 260 5600 288 12000 333 18500 396 24800 460 312 13 470 77 1180 142 2460 206 58000 270 12200 333 18500 398 25000 462 314 16 500 60 600 272 12400 483 151 17 510 61 1240 143 2600 274 12600 338 16000 401 25300 465 317 18 520 83 12800 146 2600 277 1200 334 16000 401 25800 467 319 21 540 84 1300 146 2600 277 1200 343 19600 440 </td <td>_</td> <td></td> <td>30900</td> | _ | | | | | | | | | | | | | | | 30900 |
| 12 460 77 1140 1141 2440 204 5600 269 1200 333 16800 397 24900 460 311 14 480 78 1180 1142 2460 206 5500 271 12300 333 16800 397 24900 461 313 16 500 80 1220 143 2500 200 271 12300 333 18800 400 25200 464 311 17 510 81 1220 144 2500 208 6000 272 12400 338 19100 402 2530 466 311 19 530 82 1280 147 2600 271 12600 341 19600 402 2650 467 319 21 550 85 1320 148 2600 271 12600 341 19600 402 2600 477 3 | | | | | | | | 0.00 | | | | | | | | 31000 |
| 13 470 77 1160 141 2440 205 5700 260 12100 333 11800 397 24800 461 311 14 4480 78 11200 134 11800 384 11800 399 25100 443 314 16 500 800 1220 144 2500 208 6000 272 12400 335 11800 401 25800 446 316 17 510 81 1240 144 2560 210 6200 274 12600 338 11800 401 25800 466 318 20 540 81 1320 144 2600 271 6300 277 12800 344 14800 440 25800 470 322 23 560 88 1380 151 6700 281 13900 344 1800 440 25800 471 322 < | | | | | | | | | | | | | | | | 31100 |
| 14 480 78 1180 142 2400 200 5800 270 12200 334 18000 938 22500 442 315 16 500 80 1220 144 2500 208 6000 272 12400 336 1800 400 25300 464 316 17 510 81 1240 144 2500 209 6100 273 12400 338 1900 402 25400 466 317 18 520 82 1280 147 2560 25500 467 319 19100 403 25500 468 381 21 550 85 1320 144 2600 276 12800 341 1800 440 25600 470 322 23 570 87 1360 152 2516 600 281 13400 343 1800 441 320 341 1800< | | | | | | | | | | | | | | | | 31200 |
| 15 400 79 1200 143 2440 207 5900 271 12300 335 18700 999 25100 448 3151 16 500 80 1220 144 2500 208 6000 272 12400 1386 18000 401 25200 466 318 17 550 82 1220 144 25400 466 318 19000 403 25400 466 318 20 540 844 1800 144 2600 271 18000 340 19200 404 25800 470 322 21 560 85 1330 149 2650 211 6000 279 13100 342 19400 406 25800 470 322 22 560 89 1400 153 24600 241 13000 342 19400 406 25200 414 3260 341 | | | | | | | | | | | | | | | | 31300 |
| 16 500 800 1220 144 12600 208 6000 272 12400 336 18000 400 22500 464 317 18 520 82 1260 146 2540 210 6200 274 12600 338 19000 402 25400 466 318 19 530 83 1200 147 25600 420 25400 404 25600 466 318 21 550 85 1320 149 2650 277 12800 341 19000 404 25600 469 321 23 570 86 1340 150 2700 214 6600 278 13000 434 19600 407 23800 471 332 24 580 88 1380 152 2480 211 6300 2810 13200 441 1900 410 2800 713 322 </td <td></td> <td>31400</td> | | | | | | | | | | | | | | | | 31400 |
| 17 510 81 1240 146 2520 200 6100 273 12800 337 19800 401 2530 485 317 18 520 83 1280 147 2560 211 6400 275 12200 339 19100 403 25500 466 131 20 540 84 1300 144 2600 271 12800 341 19300 405 25710 468 322 21 550 85 1340 150 2750 214 6600 278 13100 343 19600 408 28000 471 322 24 580 88 1380 152 2800 211 7000 283 13300 343 19600 448 28000 473 325 24 580 89 1440 155 2805 219 7100 283 13300 344 1400 2 | | | | | | | | | | | | | | | | 31600 |
| 19 530 83 1280 147 2560 211 6300 275 12700 339 19100 403 25500 467 319 20 540 84 1300 1148 2000 211 6400 277 12800 340 19800 404 25600 467 319 22 560 86 1340 151 2770 214 6600 278 13000 343 19800 407 25800 477 322 24 580 88 1830 152 2800 216 67000 281 13200 344 19800 408 28000 477 322 25 590 89 1400 153 2850 217 7000 282 13400 345 11970 409 241 2800 471 322 28 420 92 1440 156 3300 221 7300 288 1 | | | | | | | | | | | | | | | | 31700 |
| 20 540 84 1300 148 2800 212 6400 276 12800 340 118200 404 25600 468 332 22 560 86 1340 150 2700 271 1800 342 19400 406 25700 470 332 23 570 87 1380 151 2750 271 13100 343 19500 408 25800 471 332 24 580 88 1380 152 2880 216 6800 280 13300 344 19600 408 28100 474 322 25 600 90 1440 155 2850 219 7100 282 13500 347 19800 411 28200 474 322 28 620 62 1460 156 3000 222 7700 284 1300 350 2010 413 28600 | | | | | | | | | | | | | | | | 31800 |
| 11 550 85 1320 149 2650 213 6500 277 12000 341 19300 406 25700 449 321 22 560 87 1980 151 2750 215 6700 279 13100 343 19500 407 25800 471 332 24 580 88 1380 152 2800 216 6800 280 344 19800 408 28000 471 332 25 590 89 1400 153 2860 211 6900 281 13400 346 19700 409 26100 471 326 27 610 91 1440 155 2850 219 7100 283 13800 342 2010 411 28600 476 322 28 620 92 1480 157 3050 223 7700 285 13800 350 201 | | | | 1280 | | | | 6300 | | | | | | 25500 | 467 | 31900 |
| $ \begin{array}{c c c c c c c c c c c c c c c c c c c $ | | 540 | 84 | 1300 | 148 | 2600 | 212 | 6400 | 276 | 12800 | 340 | 19200 | 404 | 25600 | 468 | 32000 |
| 23 570 87 1560 151 2750 215 6700 279 13100 343 19800 407 28900 477 323 24 580 89 1400 153 2850 217 6800 281 13300 346 19700 400 2810 3300 346 19600 411 28000 474 322 26 600 90 1440 155 2950 218 7300 282 13400 346 19600 411 28000 473 327 28 620 92 1440 155 2305 221 7300 285 13700 348 20000 411 28600 477 323 30 640 94 1500 158 3100 222 7400 286 13800 351 2000 441 28600 477 333 31 650 96 1520 158 1 | | | | | | | | | | | | | | | | 32100 |
| | | | | | | | | | | | | | | | | 32200 |
| 25 590 99 1400 153 2800 217 6900 281 13300 345 19700 409 24100 473 325 28 600 90 1440 155 2800 218 13400 346 19800 411 28200 474 326 28 630 93 1480 155 2800 220 7200 284 13800 347 19800 411 28400 476 328 30 640 94 1500 158 3100 222 7400 286 13800 360 2414 28600 412 28600 478 333 30 640 94 1540 160 3200 224 7600 288 14000 352 20700 418 333 34 680 98 1580 162 3300 226 7800 290 1420 354 29000 418 2 | | | | | | | | | | | | | | | | 32300 |
| 26 600 90 1420 154 2000 218 7000 282 13400 346 19800 411 28200 474 326 27 610 91 1440 155 2800 220 7200 283 13800 347 19900 411 28500 476 322 29 630 93 1480 157 3060 221 7300 285 13700 349 20100 4113 28600 477 329 30 640 94 1500 158 3100 222 7400 288 13900 351 20300 415 26700 479 331 31 660 96 1540 162 3300 228 7700 288 14000 354 2600 418 333 34 680 98 1580 162 3300 228 7800 291 14200 355 20700 | | | | | | | | | | | | | | | = | 32400 |
| 27 610 91 1440 156 2950 219 7100 283 13800 347 19900 411 26300 475 327 28 620 92 1480 156 3000 220 7200 284 13600 348 20000 411 26400 477 327 30 640 94 1500 158 3100 222 7400 286 13700 348 20000 413 26600 477 323 31 650 95 1520 159 3150 223 7500 289 14100 353 20500 416 26800 480 333 34 680 98 1580 162 3300 227 7800 289 14400 356 20700 418 2700 482 333 34 680 98 1580 164 3460 228 14000 356 20700 | | | | | | | | | | | | | | | | 32500 |
| 28 620 92 1460 156 3000 220 7200 284 13800 348 20000 412 26400 477 328 29 630 93 1480 157 3050 221 7300 285 13700 349 20100 413 26500 477 330 31 650 95 1520 159 3150 222 7700 288 14000 352 20400 416 28600 480 333 32 660 96 1540 160 3200 224 7700 288 14000 353 20500 417 26800 481 333 34 680 98 1580 162 3300 226 7700 291 14300 355 20700 419 27100 483 335 36 700 100 1620 164 3400 228 8100 291 14300 <td< td=""><td></td><td></td><td></td><td>==</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<> | | | | == | | | | | | | | | | | | |
| 29 630 93 1480 157 300 221 7300 286 13700 349 20100 413 26500 477 329 30 640 94 1500 158 3100 222 7500 286 13800 350 20300 414 28600 478 331 32 660 96 1540 160 3200 224 7600 288 14000 352 20400 416 28600 480 333 34 680 98 1580 162 3300 226 77800 290 14400 355 20700 418 27000 482 334 36 690 99 1600 163 3450 227 7900 291 14400 355 20700 481 333 36 700 102 1660 166 3450 221 4400 356 21000 422 27400 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<> | | | | | | | | | | | | | | | | |
| 30 640 94 1500 158 3100 222 7400 286 13800 350 20200 414 26600 478 333 31 650 96 1520 159 3150 223 7500 287 13800 351 20300 415 26700 478 333 32 660 96 1540 160 3200 224 7600 288 14000 352 20400 446 382 33 670 97 1560 161 3200 226 7800 290 14200 354 20600 418 2700 483 335 36 690 99 1600 163 3350 227 7900 291 14300 357 20800 421 2700 485 337 37 710 101 1640 165 350 231 8300 292 14400 356 2000 421 | | | | | | | | | | | | | | | | 32800 |
| $ \begin{array}{ c c c c c c c c c c c c c c c c c c c$ | | | | | | | | | | | | | | | | 33000 |
| 32 660 96 1540 160 3200 224 7600 288 14000 352 20400 416 26800 480 332 33 670 97 1560 161 3250 225 7700 289 14100 353 20500 417 26900 482 334 34 680 98 1560 162 3300 226 7800 291 14300 355 20700 418 27100 483 335 36 700 100 1620 164 3400 228 8000 293 14400 355 20800 422 27400 485 337 38 720 102 1660 166 3500 230 8200 294 14600 360 210 422 27400 488 338 39 730 103 1680 1670 353 8500 296 14700 361 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>33100</td></td<> | | | | | | | | | | | | | | | | 33100 |
| 34 680 98 1580 162 3300 226 7800 290 14200 354 20600 418 27000 482 334 35 680 99 1600 163 3360 227 7900 291 14400 355 20700 419 27100 483 333 36 700 101 1640 185 3450 228 8100 293 14500 357 20800 420 27200 485 333 38 720 102 1660 166 3500 230 8200 294 14600 358 21000 422 27500 487 338 39 730 103 1680 167 3550 231 8300 295 14700 359 21100 424 27500 488 340 41 750 105 1720 169 3650 233 8500 291 1500 < | | | | | | | | | | | | | | | 480 | 33200 |
| $\begin{array}{ c c c c c c c c c c c c c c c c c c c$ | 33 | 670 | 97 | 1560 | 161 | 3250 | 225 | 7700 | 289 | 14100 | 353 | 20500 | 417 | 26900 | 481 | 33300 |
| $\begin{array}{ c c c c c c c c c c c c c c c c c c c$ | 34 | 680 | | 1580 | 162 | 3300 | 226 | 7800 | 290 | 14200 | 354 | 20600 | 418 | 27000 | 482 | 33400 |
| $\begin{array}{ c c c c c c c c c c c c c c c c c c c$ | 35 | | | 1600 | | 3350 | 227 | 7900 | 291 | 14300 | 355 | 20700 | 419 | 27100 | 483 | 33500 |
| $\begin{array}{ c c c c c c c c c c c c c c c c c c c$ | | | | | | | | | | | | | | | | 33600 |
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| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | | | | | | | | | | | | | | | 34100 |
| 44 780 108 1780 172 3800 236 8800 300 15200 364 21600 428 28000 492 344 45 790 109 1800 173 3850 237 8900 301 15300 365 21700 429 28100 493 345 46 800 110 1820 174 3900 238 9000 302 15400 366 21800 430 28200 494 346 47 810 111 1840 175 3950 239 9100 303 15500 367 21900 431 28300 495 347 48 820 112 1860 177 4050 241 9300 305 15700 369 22100 433 28500 497 349 50 840 114 1900 178 4100 243 9600 306 15800 | | | | | | | | 0000 | | | | | | | | 34200 |
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| 46 800 110 1820 174 3900 238 9000 302 15400 366 21800 430 28200 494 346 47 810 111 1840 175 3950 239 9100 303 15500 367 21900 431 28300 495 347 48 820 112 1860 176 4000 240 9200 304 15600 368 22000 432 28400 496 348 49 830 114 1900 178 4100 242 9400 306 15800 370 22200 434 28600 498 350 51 850 115 1920 179 4150 243 9500 307 15900 371 22300 435 28700 499 351 52 860 116 1940 180 4200 244 9600 308 16000 | | | | | | | | | | | | | | | | 34500 |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | | | | | | | | | | | | | | | 34600 |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | 47 | 810 | 111 | 1840 | 175 | 3950 | 239 | 9100 | 303 | | 367 | 21900 | 431 | 28300 | 495 | 34700 |
| 50 840 114 1900 178 4100 242 9400 306 15800 370 22200 434 28600 498 350 51 850 115 1920 179 4150 243 9500 307 15900 371 22200 434 28600 498 350 52 860 116 1940 180 4200 244 9600 308 16000 372 22400 436 28800 500 352 53 870 117 1960 181 4250 245 9700 309 16100 373 22500 437 28900 501 353 54 880 118 1980 182 4300 246 9800 310 16200 374 22600 438 29100 503 355 56 900 120 2020 184 4400 248 10000 312 16400 | | | | | | | | | | | | | | | | 34800 |
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| 54 880 118 1980 182 4300 246 9800 310 16200 374 22600 438 29000 502 354 55 890 119 2000 183 4350 247 9900 311 16300 375 22700 439 29100 503 355 56 900 120 2020 184 4400 248 10000 312 16400 376 22800 440 29200 504 356 57 910 121 2040 185 4450 249 10100 313 16500 377 22900 441 29300 505 357 58 920 122 2060 186 4500 250 10200 314 16600 378 23000 442 29400 506 358 59 930 123 2080 187 4550 251 10300 315 16700 | | | | | | | | | | | | | | | | 35200 |
| 55 890 119 2000 183 4350 247 9900 311 16300 375 22700 439 29100 503 355 56 900 120 2020 184 4400 248 10000 312 16400 376 22800 440 29200 504 356 57 910 121 2040 185 4450 249 10100 313 16500 377 22900 441 29300 505 357 58 920 122 2060 186 4500 250 10200 314 16600 378 23000 442 29400 506 358 59 930 123 2080 187 4550 251 10300 315 16700 379 23100 443 29500 507 359 60 940 124 2100 188 4600 252 10400 316 16800 | | | | | | | | | | | | | | | | 35300 |
| 56 900 120 2020 184 4400 248 10000 312 16400 376 22800 440 29200 504 356 57 910 121 2040 185 4450 249 10100 313 16500 377 22900 441 29300 505 357 58 920 122 2060 186 4500 250 10200 314 16600 378 23000 442 29400 506 358 59 930 123 2080 187 4550 251 10300 315 16700 379 23100 443 29500 507 359 60 940 124 2100 188 4600 252 10400 316 16800 380 23200 444 29500 507 359 61 950 125 2120 189 4650 253 10500 317 16900 | | | | | | | | | | | | | | | | 35400 |
| 57 910 121 2040 185 4450 249 10100 313 16500 377 22900 441 29300 505 357 58 920 122 2060 186 4500 250 10200 314 16600 378 23000 442 29400 506 358 59 930 123 2080 187 4550 251 10300 315 16700 379 23100 443 29500 507 359 60 940 124 2100 188 4600 252 10400 316 16800 380 23200 444 29600 508 360 61 950 125 2120 189 4650 253 10500 317 16900 381 23300 445 29700 509 360 | | | | | | | | | | | | | | | | 35500 |
| 58 920 122 2060 186 4500 250 10200 314 16600 378 23000 442 29400 506 358 59 930 123 2080 187 4550 251 10300 315 16700 379 23100 443 29500 507 359 60 940 124 2100 188 4600 252 10400 316 16800 380 23200 444 29600 508 360 61 950 125 2120 189 4650 253 10500 317 16900 381 23300 445 29700 509 360 | | | | | | | | | | | | | | | | 35700 |
| 59 930 123 2080 187 4550 251 10300 315 16700 379 23100 443 29500 507 359 60 940 124 2100 188 4600 252 10400 316 16800 380 23200 444 29600 508 360 61 950 125 2120 189 4650 253 10500 317 16900 381 23300 445 29700 509 360 | | | | | | | | | | | | | | | | 35800 |
| 60 940 124 2100 188 4600 252 10400 316 16800 380 23200 444 29600 508 360 61 950 125 2120 189 4650 253 10500 317 16900 381 23300 445 29700 509 360 | | | | | | | | | | | | | | | | 35900 |
| 61 950 125 2120 189 4650 253 10500 317 16900 381 23300 445 29700 509 360 | | | | | | | | | | | | | | | | 36000 |
| | 61 | 950 | 125 | 2120 | 189 | 4650 | | 10500 | | | 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 511 360 | 63 | 970 | 127 | 2160 | 191 | 4750 | 255 | 10700 | 319 | 17100 | 383 | 23500 | 447 | 29900 | 511 | 36000 |



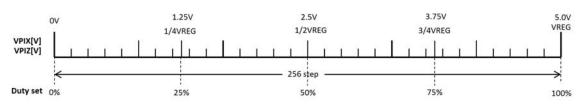


Figure 26. Input Duty Parameter Setting for PIX/PIZ Pin

Voltage of PIX/PIZ is calculated by below formula.

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

Lead-angle Setting Description

LV8856xJA/R provides the dynamic lead angle adjustment. To match the motor characteristics, set two points lead-angel amounts. Settable range is -22.225° to $+22.225^{\circ}$ (0.175° step). LSP's value is set by LAI pin and

HSP's value is set by LAG pin. At middle range of input duty, the lead-angle is applied to calculated value for relative relationship.

LV8856xJA/R can set delay angle setting. Minus value means delay angle.

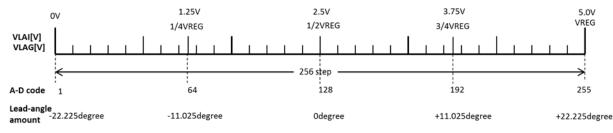
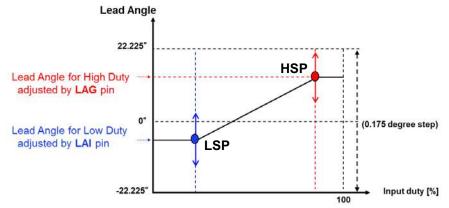


Figure 27. Lead-angle Parameter Setting for LAI/LAG Pin

Voltage of LAI/LAI is calculated by below formula.

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

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





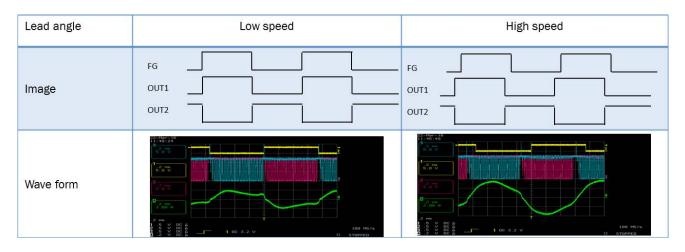


Figure 29. Lead Angle Image Waveform

Soft-Start Setting Description

LV8856xJA/R has soft start function.

To avoid the motor rush current, the output PWM duty rise–up from zero slowly at the starting of motor rotation.

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 reached to the release condition, change to closed–loop speed control mode.

If the motor can't rotation during 0.7s (typ), lock protection function will activate.

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.

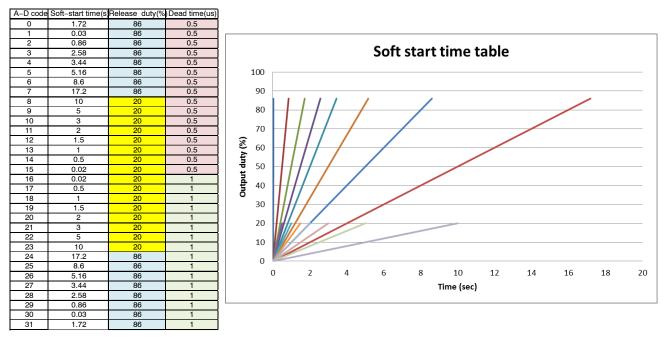
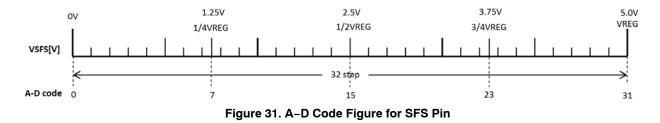


Figure 30. Soft-start and Dead Time Setting Table for SFS Pin



Voltage of SFS is calculated by below formula.

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

Output Waveform

LV8856xJA/R output PWM frequency is fixed by the inner oscillator parameter, 48 kHz (typ) which doesn't depend on input PWM frequency.

Driving method of LV8856xJA/R uses 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%)

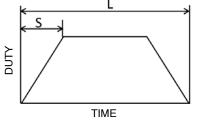


Figure 32. Image of Soft Switching Width

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

Protections

LV8856xJA/R has some protection function.

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

When TSD or Lock protection is working, external FETs are all turned off.

On the other hand, when UVLO or CLM is working, output is turned off and goes into re-circulation state.

Thermal Shutdown Protection (TSD)

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

Next, when IC's junction temperature falls to $140^{\circ}C$ (typ), thermal shutdown function is released and motor starts 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.

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

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

Sense Resistor =
$$\frac{0.10(typ)}{2.0}$$

Res = 0.05 [Ω] (eq. 6)

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.

If IC does not receive the FG edge for 0.3sec (under 50rpm), the IC judges "motor lock" has occurred and the lock protection function will activate. In this mode, the RD signal goes to "High", though it is "Low" at motor starts.

When the motor restarts and IC detects 4 phase changes, the RD signal goes to "Low".

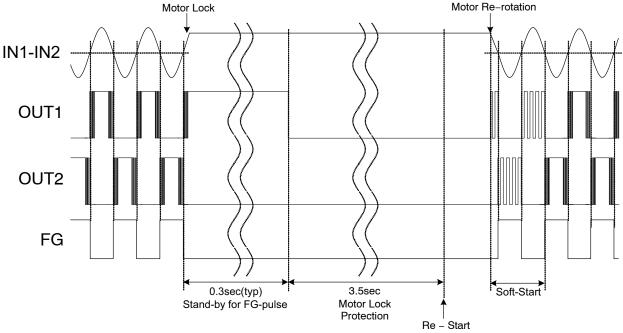


Figure 33. Image of Lock Detection and Lock Protection

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

When the motor rotation is stopped by PWM input signal, the lock detection is reset and the motor starts to rotate smoothly once the IC receives the rotation start instruction.

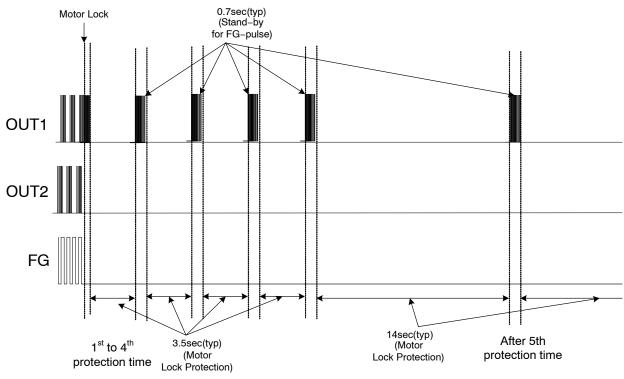


Figure 34. Image of Lock Protection Time

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 $1 \,\mu\text{F}$ (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 μ F 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 flyback do 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 flyback 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 its 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 μ F 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 enough power rating.

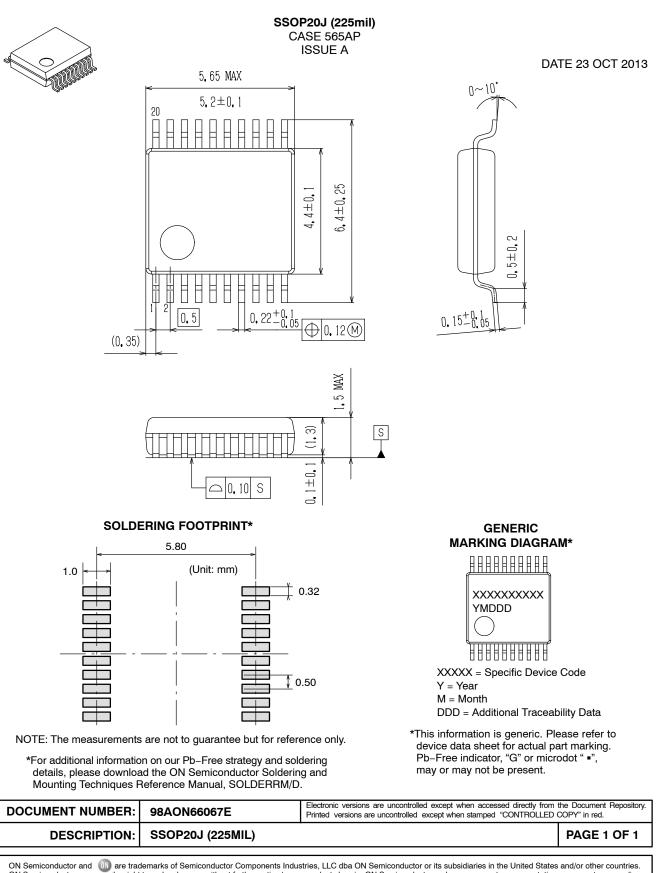
External FET Output Pins

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

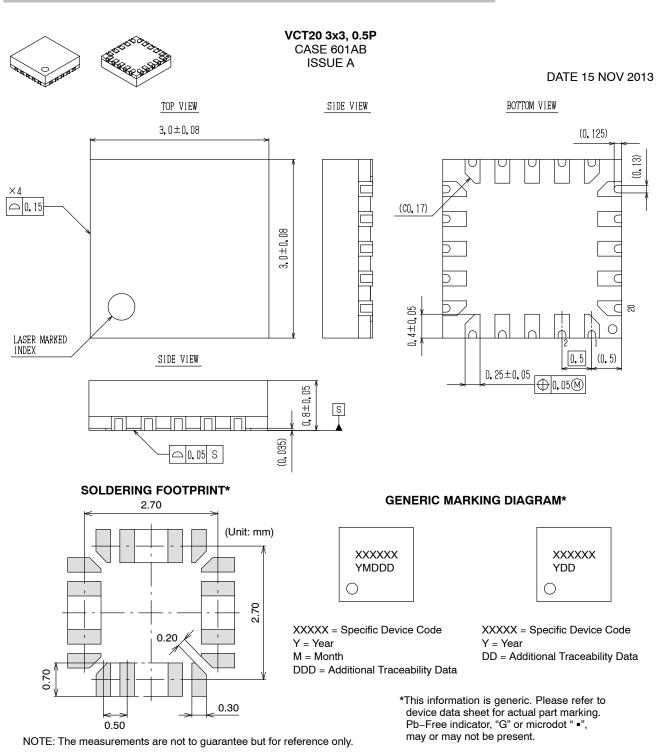
LV8856xJA (x = 1,2,3 or 4) Size: 114.3 mm x 76.1 mm x 1.6 mm Material: Glass epoxy single layer board LV8856xR (x = 1,2,3 or 4) Size: 50.0 mm x 40.0 mm x 0.8 mm Material: Glass epoxy 4–layer board





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