

Features and Benefits

- ❑ Soft switching for low noise fans
- ❑ Low supply voltage
- ❑ Full bridge single coil driver
- ❑ High sensitivity Hall sensor
- ❑ Low power consumption
- ❑ Reverse voltage protection
- ❑ Locked rotor protection and auto-restart
- ❑ Thermal protection and auto-restart
- ❑ No external components needed
- ❑ Integrated tachometer (US168) or rotation detection output (US169)

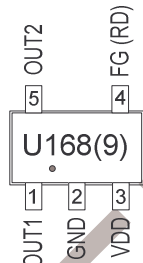
Ordering Information

Part No.	Temperature Suffix	Package Code
US168	E (-40°C to 85°C)	SE (SOT23 5L)
US169	E (-40°C to 85°C)	SE (SOT23 5L)

Applications

- ❑ 3.3V / 5V low noise cooling fans
- ❑ Low voltage/ low power brushless DC motors
- ❑ Micro-motors, vibration motors (cell phones), etc.

SOT23 5L package:



Pin Description:

- OUT 1 - Coil pin 1 FG(RD) - Frequency Generation (US168) or Rotation Detection (US169) open drain output
- OUT 2 - Coil pin 2
- VDD - Power supply GND - Ground

2 Description

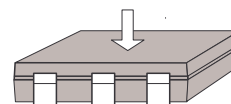
US168/169 is a single chip solution for driving of single coil brushless DC motors. It is based on advanced Melexis CMOS process.

US168 has an open-drain tachometer output FG that follows the Hall sensor latching output. In US169 the open-drain rotation detection output RD is active low when the motor is spinning and goes high when blocked.

When the magnetic flux does not switch its direction for period longer than 0.4s the built-in locked-rotor protection (LRP) shuts off the coil current for about 2.4s (typical values).

The used bridge drivers provide soft switching of bidirectional current through the single phase motor winding.

Magnetic Flux Direction



1 Functional Diagram

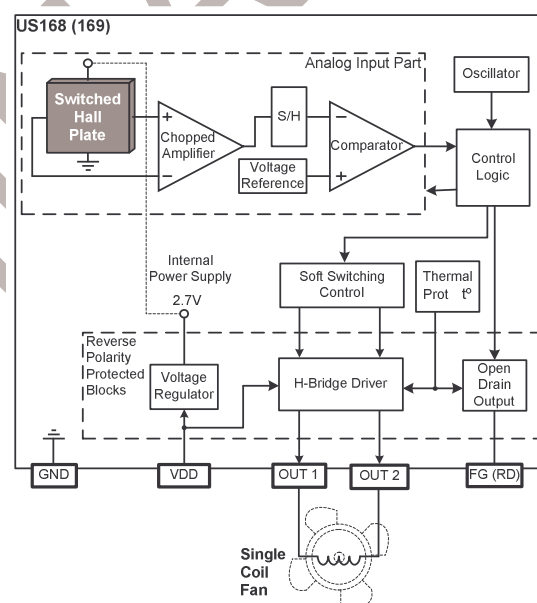


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3 Glossary of Terms

Full Bridge (H-Bridge): Two push-pull output drivers that can source or sink current. When a load is connected between the drivers, the load current can flow in both directions.

MilliTesla (mT), Gauss: Units of magnetic flux density; $1 \text{ milliTesla} = 10 \text{ Gauss}$

Single Coil Motor: A DC motor with only one coil winding. It requires a bidirectional or full bridge driver. Single coil motors achieve better winding usage compared to the two coil motors. This is the basis for smaller and more efficient stator design.

4 Absolute Maximum Ratings

Parameter		Symbol	Value	Units
Supply Voltage (overvoltage)		V _{DD}	-7 to 7	V
Voltage on FG (RD) pin (overvoltage)		V _{FG} (V _{RD})	-6 to 7	V
Continuous Output Current	Single layer JEDEC test board	I _{OUT}	250	mA
	Multi layer JEDEC test board	I _{OUT}	300	mA
Peak Output Current		I _{OUTp}	400	mA
Magnetic Flux Density		B	Unlimited	mT
Operating Temperature Range		T _A	-40 to 85	°C
Storage Temperature		T _S	-65 to 150	°C
Junction Temperature		T _J	125	°C
ESD Sensitivity Level			2	kV

Exceeding the absolute maximum ratings may cause permanent damage. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

5 US168/169 Electrical Characteristics

Operating conditions: $T_A = 25^\circ\text{C}$ and $V_{DD} = 5\text{V}$ (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Voltage	V_{DD}	Operating	1.8	5	6.5	V
Static Supply Current	I_{DD}	No load on OUT1/OUT2		2	3	mA
Output ON Resistance	R_{ON}	$T_A = 25^\circ\text{C}$, Full Bridge		2.5	4	Ω
		$T_A = 85^\circ\text{C}$, Full Bridge		3	5	Ω
FG/RD Output Low Voltage	V_{OL}	$I_{OL} = 4\text{mA}$			0.5	V
FG/RD Output Voltage Clamp	V_{CLMP}	$I_{OUT} = 20\text{mA}$	7.5			V
FG/RD Output Leakage Current	I_{LEAK}	$V_{FG} (V_{RD}) = 5\text{V}$			10	μA
FG/RD Output Current Limit	I_{FGLIM}	$V_{FG} = 5\text{V}$		20		mA
Soft Switching Threshold Voltage	V_{DDSW}			2	2.6	V
Output Switching Slope Duration	T_{SW}	50 Ω load on OUT1/OUT2		160		μs
Locked-Rotor ON Period	T_{ON}			0.4		s
Locked-Rotor OFF Period	T_{OFF}			2.4		s
Package Thermal Resistance	R_{TH}	1-layer JEDEC test board		301.2		°C/W
		Multi-layer JEDEC test board		195.8		°C/W
Thermal Protection Temperature	T_{PROT}			160		°C
Thermal Protection Release Temperature	T_{REL}			130		°C
Thermal Protection Hysteresis	T_{HYST}			30		°C
Maximum Rotation Speed		2 pole-pairs motor, Total Efficiency > 75%	20 000			RPM

6 US168/169 Magnetic Characteristics

$T_a = 25^\circ\text{C}$ and $V_{DD} = 5\text{V}$ (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operate Point	B_{OP}	50 Ω load on OUT1/OUT2		2.5	5	mT
Release Point	B_{RP}	50 Ω load on OUT1/OUT2	-5	-2.5		mT
Hysteresis	B_{HYS}	50 Ω load on OUT1/OUT2		5		mT

Note: 1 mT = 10 Gauss

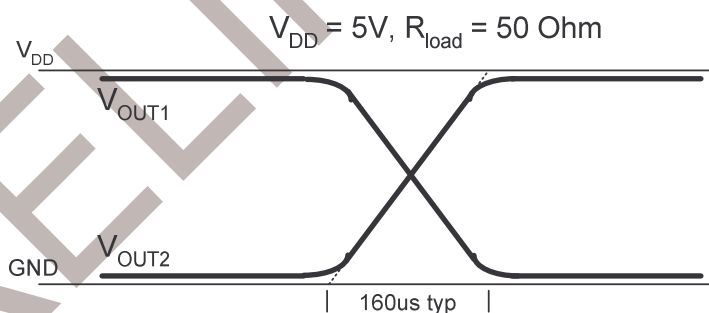
7 Driver outputs vs. magnetic field polarity

Parameter	OUT1	OUT2
North Pole	Low	High
South Pole	High	Low

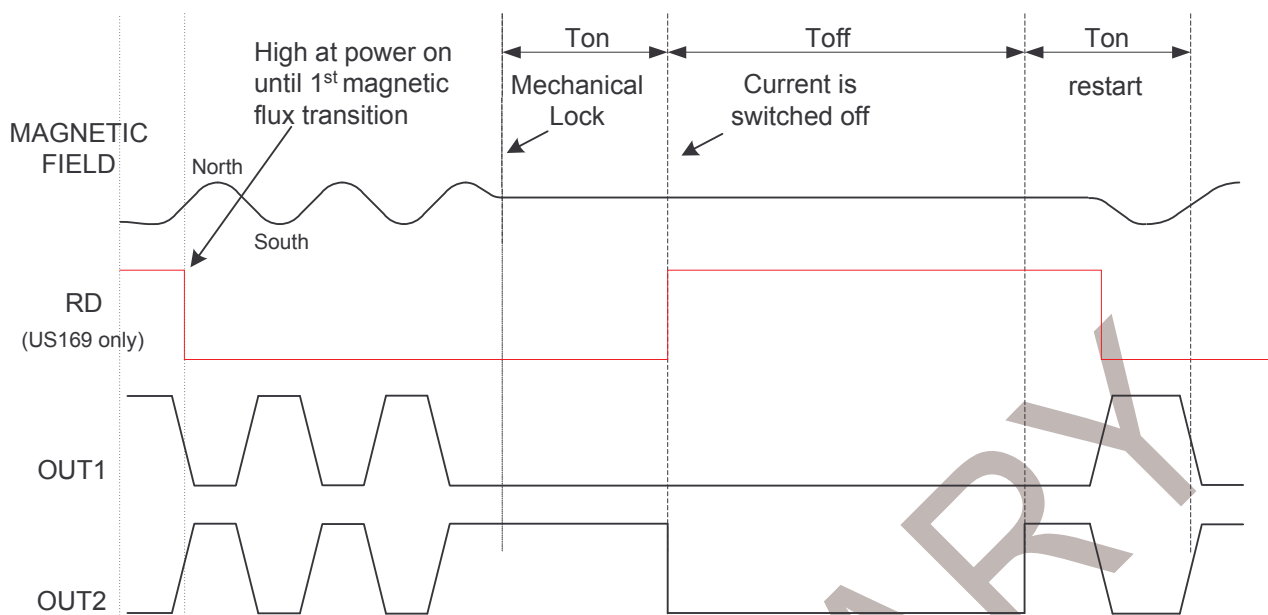
Note: The magnetic field is applied on the branded (top) side of the package

8 Functional Description

US168/169 includes a sensitive magnetic Hall sensor with chopping amplifier for offset cancellation. Used soft switching (for $V_{DD} > 2\text{V}$) of the bidirectional current through the single motor coil is important for low noise applications. Built-in voltage regulator allows stable chip operation in wide supply voltage range.



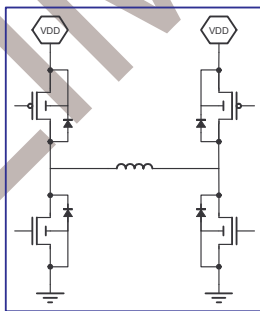
The on-chip Locked-Rotor Protection (LRP) automatically shuts off the coil current when the rotor is mechanically blocked for period longer than 0.4s, or the rotation speed drops below 38 RPM (typical values). The fan tries to restart every 2.8 seconds until the rotor is released. The on/off cycling reduces the average stall current to 1/7 of the normal; this is enough to prevent overheating or damage of most fans.



If for some reason the junction temperature T_J exceeds 160°C, the thermal protection of the chip sets the outputs Out1, Out2 low and also sets the output FG (RD) high.

The built-in features reverse voltage protection, LRP and thermal protection make US168/169 robust in severe operation conditions and eliminate the need of external components.

9 Full Bridge Single Coil Driver

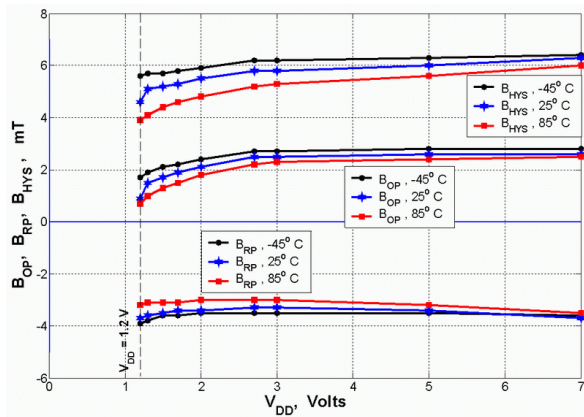


10 Unique Features

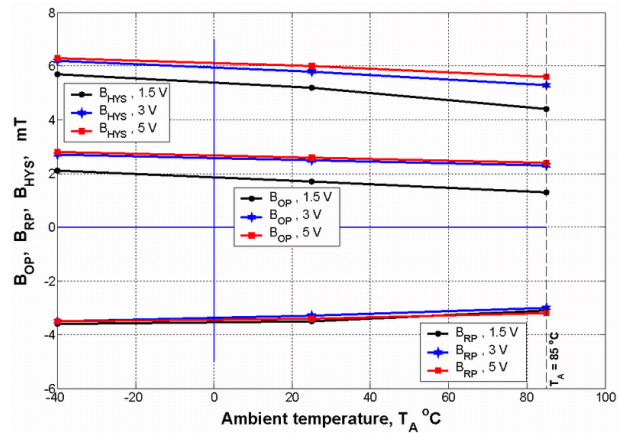
- Soft coil switching for very low audio noise.
- Operating at very low voltage, beginning from 1.2 - 1.8V.
- Compared to the two coil fan construction, the single-coil approach with full bridge driving improves motor winding usage and makes possible smaller and more efficient stator design.
- Built-in diodes avoid the need of external diodes for output protection.
- Built-in reverse voltage protection avoids the need of external serial diode which reduces the supply voltage.
- On-chip thermal protection prevents chip overheating.

11 Performance Graphs

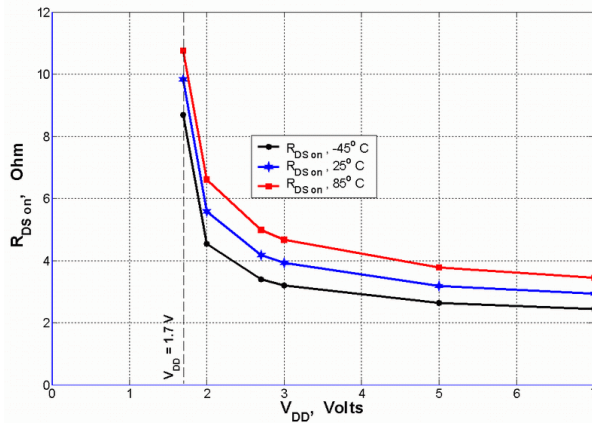
11.1 Magnetic Thresholds vs V_{DD}



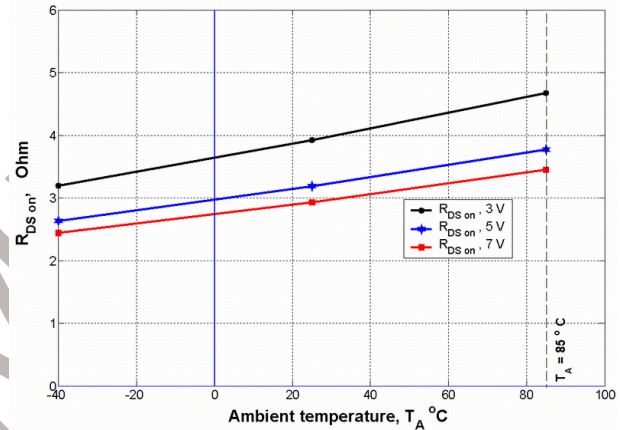
11.2 Magnetic Thresholds vs Temperature



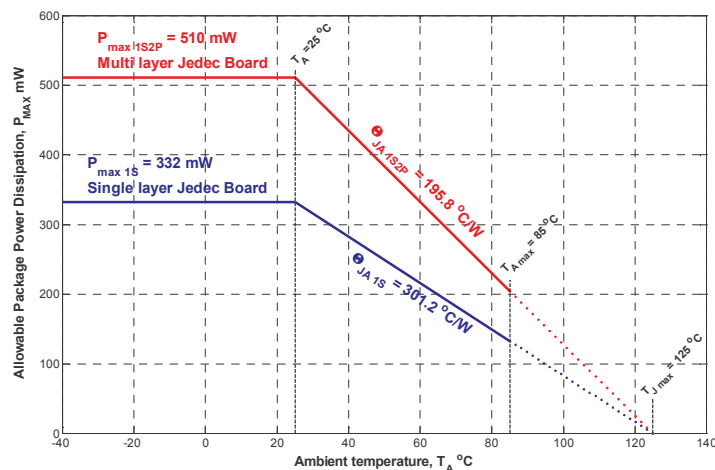
11.3 $R_{DS\ ON}$ vs V_{DD}



11.4 $R_{DS\ ON}$ vs Temperature



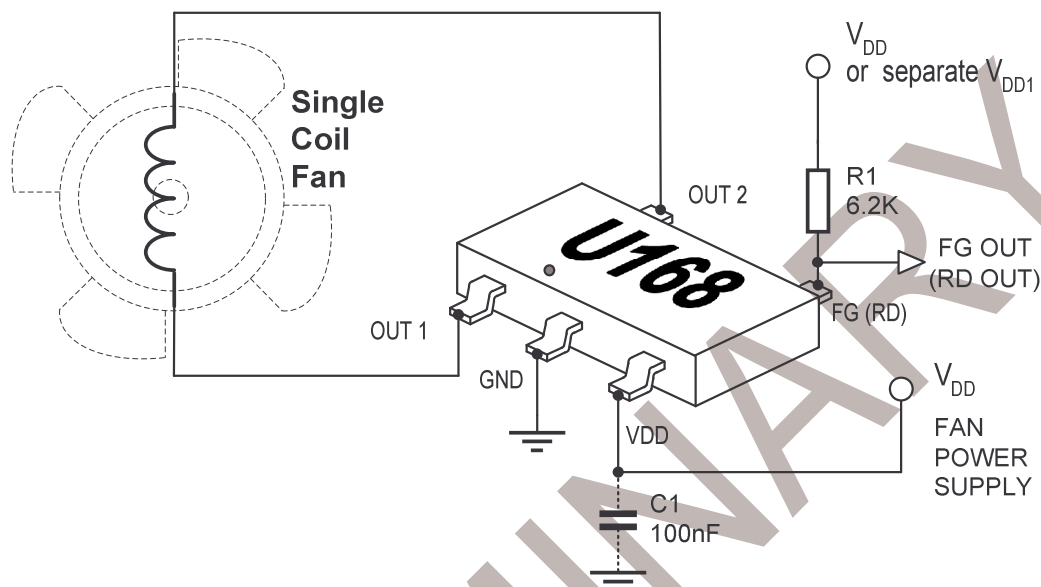
11.5 Maximum Power Dissipation vs Temperature



The thermal resistance and rated power dissipation are defined in accordance with EIA/JESD51-3 standard for single layer 1S test board and EIA/JESD51-7 standard for multi layer 1S2P test board.

12 Application Information

The Single Coil Motor Controller US168/169 is suitable for driving low voltage DC motors, especially for driving fan motors as shown in the figure below.



- The power supplies V_{DD} and V_{DD1} can be connected either commonly or separately (see the figure above). The V_{DD1} is not necessarily equal to V_{DD} .
- To prevent entry in thermal protection state or damage of US168/169 it is recommended to preserve the inequality:

$$R_{COIL} \geq \frac{V_{DD}}{I_{OUTp}},$$

where R_{COIL} stands for the DC resistance of the coil in ohms and I_{OUTp} stands for the maximal output peak current in amperes.

13 Application Comments

In order to suppress any wiring noise occurring on the V_{DD} voltage, it is recommended to place a $0.1\mu F$ bypass capacitor between V_{DD} and ground, located as close as possible to the chip.

14 Reliability Information

This Melexis device is classified and qualified regarding soldering technology, solderability and moisture sensitivity level, as defined in this specification, according to following test methods:

- IPC/JEDEC J-STD-020
Moisture/Reflow Sensitivity Classification For Nonhermetic Solid State Surface Mount Devices (classification reflow profiles according to table 5-2)
- EIA/JEDEC JESD22-A113
Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing (reflow profiles according to table 2)
- CECC00802
Standard Method For The Specification of Surface Mounting Components (SMDs) of Assessed Quality
- EIA/JEDEC JESD22-B106
Resistance to soldering temperature for through-hole mounted devices
- EN60749-15
Resistance to soldering temperature for through-hole mounted devices
- MIL 883 Method 2003 / EIA/JEDEC JESD22-B102
Solderability

For all soldering technologies deviating from above mentioned standard conditions (regarding peak temperature, temperature gradient, temperature profile etc) additional classification and qualification tests have to be agreed upon with Melexis.

The application of Wave Soldering for SMD's is allowed only after consulting Melexis regarding assurance of adhesive strength between device and board.

Based on Melexis commitment to environmental responsibility, European legislation (Directive on the Restriction of the Use of Certain Hazardous substances, RoHS) and customer requests, Melexis has installed a Roadmap to qualify their package families for lead free processes also. Various lead free generic qualifications are running, current results on request.

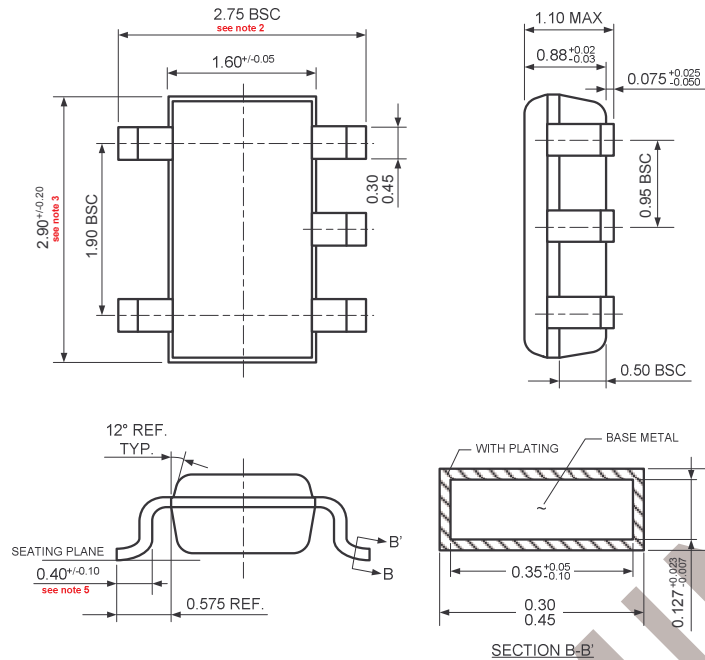
For more information on manufacturability/solderability see quality page at our website:
<http://www.melexis.com/html/pdf/MLXleadfree-statement.pdf>

15 ESD Precautions

Electronic semiconductor products are sensitive to Electro Static Discharge (ESD). Always observe Electro Static Discharge control procedures whenever handling semiconductor products.

16 Package Information

SE (SOT23 5L) Package



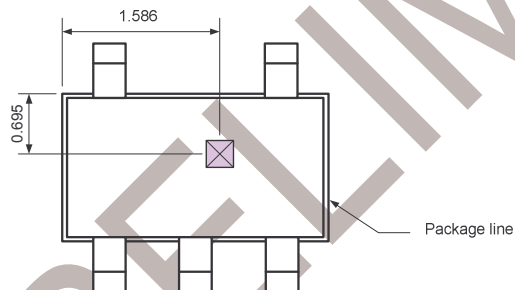
Notes:

1. All dimensions are in millimeters
2. Outermost plastic extreme width does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.15mm per side.
3. Outermost plastic extreme length does not include mold flash or protrusions. Mold flash and protrusions shall not exceed 0.25mm per side.
4. The lead width dimension does not include dambar protrusion. Allowable dambar protrusion shall be 0.07mm total in excess of the lead width dimension at maximum material condition.
5. Dimension is the length of terminal for soldering to a substrate.
6. Formed lead shall be planar with respect to one another with 0.076mm at seating plane.
7. This part is compliant with JEDEC specification MO-193. This part is full compliance to EIAJ specification SC-74.

Marking:

Top side: U168 (U169) - Name of the Device
 Bottom side: xyww x = last digit of lot number
 y = last digit of year
 ww = week

Hall plate location



Notes:

1. All dimensions are in millimeters
2. This hall plate location is a preliminary information and may change until the final release of the chip.

17 Disclaimer

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