

Features and Benefits

- ❑ Low cost
- ❑ High sensitivity Hall Sensor
- ❑ Locked rotor protection and auto-restart
- ❑ Power-efficient CMOS and power MOSFETs
- ❑ Built-in output protection clamping diode
- ❑ Integrated tachometer (US90) or alarm (US91) signal output
- ❑ 2-coil fan driver with FG/RD output in 4-pin VK and 8-pin narrow SOIC packages (both RoHS Compliant)

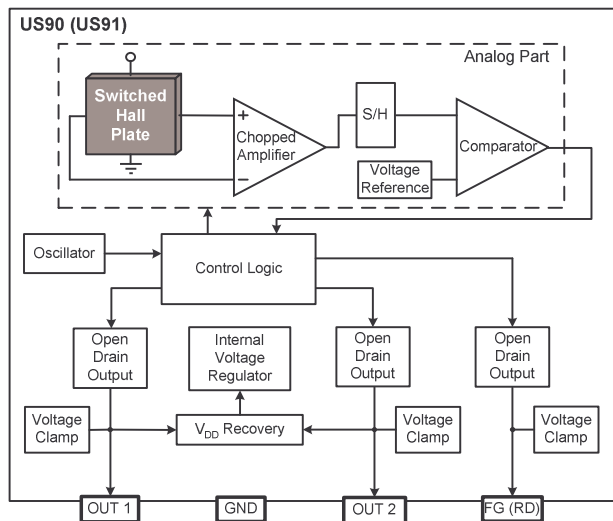
Application Examples

- ❑ 12V/24V fans
- ❑ Peak current up to 500mA

Ordering Information

Part No.	Temperature Code	Package Code
US90	E (-40°C to 85°C)	VK (4-pin TO-92)
US90	E (-40°C to 85°C)	DC (8-pin narrow SOIC)
US91	E (-40°C to 85°C)	VK (4-pin TO-92)
US91	E (-40°C to 85°C)	DC (8-pin narrow SOIC)

1 Functional Diagram



2 General Description

The US90/91 is a one-chip solution for driving two-coil brushless DC cooling fans.

Based on the advanced Melexis CMOS process, the IC contains a Hall-effect sensor, dynamic offset correction and low side output drivers.

Frequency Generator or Rotation Detection is available. The open-drain output makes easier the connectivity with any external interface such as hardware monitoring or Super I/O IC.

These features are combined with the Melexis patented no- V_{DD} design to fit the IC in a small 4-pin VK package.

Table of Contents

1 Functional Diagram	1
2 General Description	1
3 Glossary of Terms	3
4 Absolute Maximum Ratings	3
5 Pin Definitions and Descriptions	3
6 General Electrical Specifications	4
7 Magnetic Specifications	4
8 Driver Output vs Magnetic Pole	4
9 Detailed General Description	5
10 Unique Features	5
11 Performance Graphs	6
11.1 $R_{DS(ON)}$ vs T_J	6
11.2 $R_{DS(ON)}$ vs V_{DD}	6
11.3 Magnetic Parameters vs T_J	6
11.4 Magnetic Parameters vs V_{DD}	6
11.5 Typical Maximum Continuous Current vs Temperature, Fan Voltage	6
11.6 Typical Maximum Continuous Current vs Fan Voltage, Temperature	6
12 Application Information	7
12.1 Typical application with pull-up resistor	7
12.2 Configuration for reverse voltage / ground hot-switch protection and enhanced ESD module protection	7
13 Application Comments	7
14 Standard information regarding manufacturability of Melexis products with different soldering processes	8
15 ESD Precautions	8
16 Package Information	9
16.1 VK Package Information (4-pin TO92)	9
16.2 DC Package Information (8-pin narrow SOIC)	10
17 Disclaimer	11

3 Glossary of Terms

Two-coil fan	A fan with two-coil windings where current alternates from 1 coil to the other depending on the direction of the magnetic field.
MilliTesla (mT), Gauss	Units of magnetic flux density : 1mT = 10 Gauss
V _{DD}	Voltage on the common point of the fan coils.
I _{DD}	Current supplying the chip which flows through the coil connected to the switched off output driver.
Peak output current	The current flowing in the coil at start-up, only limited by the coil resistance R _{COIL} and the output driver resistance R _{DSON} .
Continuous output current	The current flowing in the coil when the fan is spinning normally.
Locked rotor	The state when the fan stopped spinning due to mechanical blockage.
FG	Frequency generator or tachometer output
RD	Rotation detection or alarm output
LFPM	Linear Feet Per Minute – Unit of airflow velocity

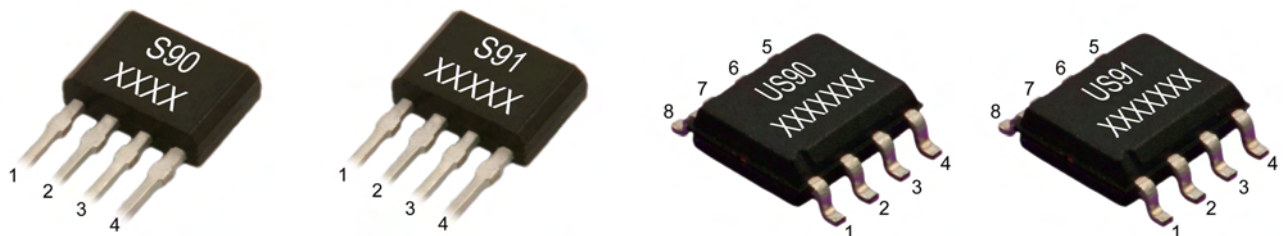
4 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Fan Supply Voltage (overvoltage)	V _{DD}	30	V
Peak Output Current	I _{OUTp}	500	mA
Continuous Output Current	I _{OUTc}	250	mA
FG / RD Output Current	I _{FG(RD)}	20	mA
Operating Temperature Range	T _A	-40 to 85	°C
Junction Temperature	T _J	125	°C
Storage Temperature Range	T _S	-55 to 150	°C
ESD Sensitivity (AEC Q100 002)		2	kV
Magnetic Flux Density	B	Unlimited	mT

Table 1: Absolute maximum ratings

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

5 Pin Definitions and Descriptions



Pin Name	Pin number (VK)	Pin number (DC)	Function
FG (RD)	1	1	Frequency Generator (Rotation Detection) open drain output signal
OUT1	2	2	Open Drain Coil Driver 1
OUT2	3	4	Open Drain Coil Driver 2
GND	4	3	Ground pin
-	-	5, 6, 7, 8	Not Connected

Table 2: Pin definitions and descriptions US90 (US91)

6 General Electrical Specifications

DC Operating Parameters $T_A = 25^\circ\text{C}$, $V_{DD} = 24\text{V}$ (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Fan Supply Voltage	V_{DD}	Operating, $R_{COIL} = 50\Omega$	4.7 ⁽¹⁾		30	V
Supply Current	I_{DD}			2	4	mA
Output Saturation Voltage	$V_{DSON\ 1,2}$	$I_{OUT} = 150\text{mA}$		375		mV
Output Saturation Voltage	$V_{DSON\ 1,2}$	$I_{OUT} = 250\text{mA}$		625		mV
Output Clamp Voltage	$V_{OUT\ 1,2}$		60			V
FG / RD Output Low Voltage	V_{OL}	$I_{OL} = 10\text{mA}$		250	500	mV
FG / RD Output Clamp Voltage	V_{CLAMP}		28			V
FG / RD Output Leakage Current	I_{LEAK}	$V_{FG} (V_{RD}) = 18\text{V}$			10	μA
DC Thermal Resistance	R_{TH}	One-sided PCB, zero LFPM		150		$^\circ\text{C/Watt}$
VK Thermal Resistance	R_{TH}	One-sided PCB, zero LFPM		200		$^\circ\text{C/Watt}$
Locked Rotor Period	T_{ON}			0.25		S
Locked Rotor Period	T_{OFF}			1.5		S
Output Switching Delay	T_{DELAY}	"Dead time" when both drivers are off		200		us

Table 3: General electrical specifications

Note 1: The minimal value of V_{DD} should be determined using the following equation:

$$V_{DD} = 4.5\text{V} + R_{COIL} * I_{DD}$$

7 Magnetic Specifications

DC Operating Parameters $T_A = 25^\circ\text{C}$, $V_{DD} = 24\text{V}$ (unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Units
Operate point	B_{OP}			3	6	mT
Release point	B_{RP}		-6	-3		mT
Hysteresis	B_{HYST}		2	6		mT

Table 4: Magnetic specifications

8 Driver Output vs Magnetic Pole

Parameter	Test Conditions	OUT1	OUT2
North pole	$B < B_{rp} - \text{VK and DC packages}$	High	Low
South pole	$B > B_{op} - \text{VK and DC packages}$	Low	High

Table 5: Driver output vs magnetic pole

Note 1: The magnetic pole is applied facing the branded side of the package

9 Detailed General Description

The US90/91 is a one-chip solution for driving two-coil brushless DC fans. Based on advanced Melexis CMOS process, the IC contains a Hall-effect sensor, dynamic offset correction and low side output drivers.

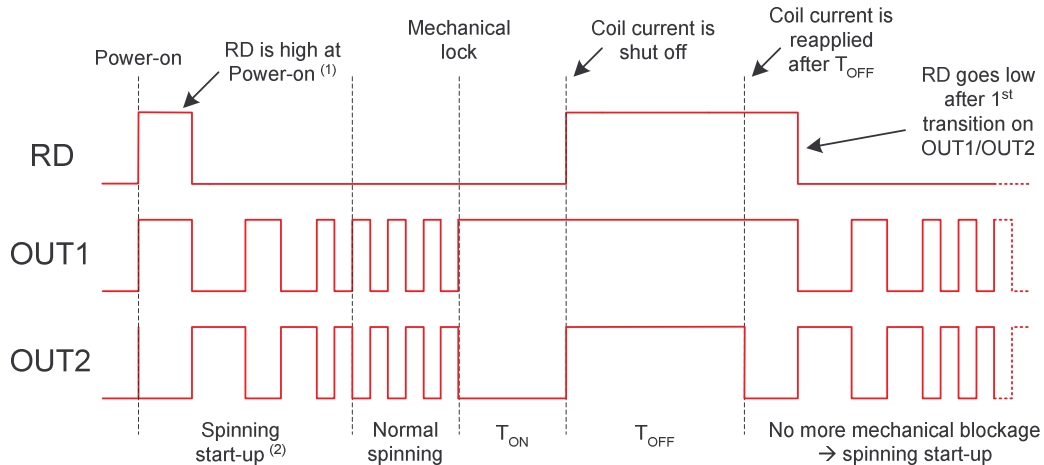
The output drivers OUT1 and OUT2 are fully protected against switching transients. So there is no need for an external zener diode to cut the high voltage spikes induced by the fan coils.

The US90 has an open-drain integrated tachometer FG output that follows the Hall signal. In the US91, the open-drain rotation detection output RD is active low during normal spinning of the motor. It goes high when the flux switching frequency becomes too low, which means the motor is blocked.

10 Unique Features

The absence of a V_{DD} pin enables the two low side output drivers and FG/RD signal output to fit in a four-pin VK package. The lack of a V_{DD} pin decreases also the probability to damage the chip due to reverse voltage connection, using the coil resistance to limit the reverse current. In this condition, the total reverse current is twice the peak current value of the fan used.

The built-in locked-rotor protection will automatically shut off the coil current when the rotor is mechanically blocked, or the rotational speed drops below 60 RPM (4-pole rotor magnet). The fan will try to restart every 1.5 seconds until the obstruction is clear. The On / Off cycling reduces the average stall current to 1/7 normal; this is enough to prevent overheating or damage to most fans. Both the US90 and US91 have this feature.



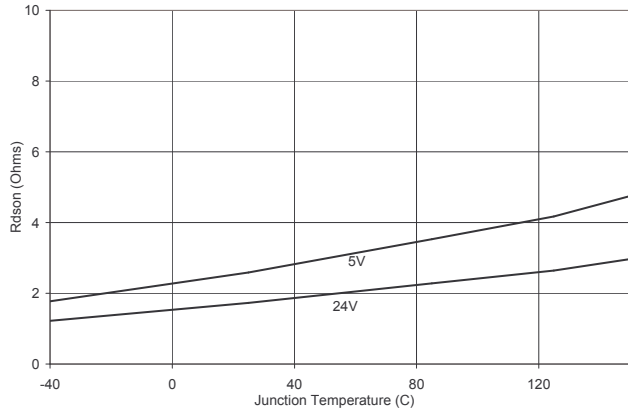
Note 1 : At Power-on, RD is high until the 1st transition on OUT1/OUT2.

Note 2 : The spinning start-up is the ramp between the zero speed and maximal speed. It depends on the motor characteristics.

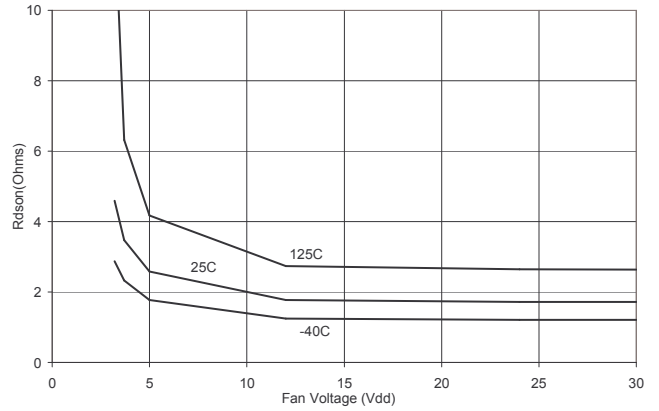
Note 3 : This graph does not represent the EMF effect.

11 Performance Graphs

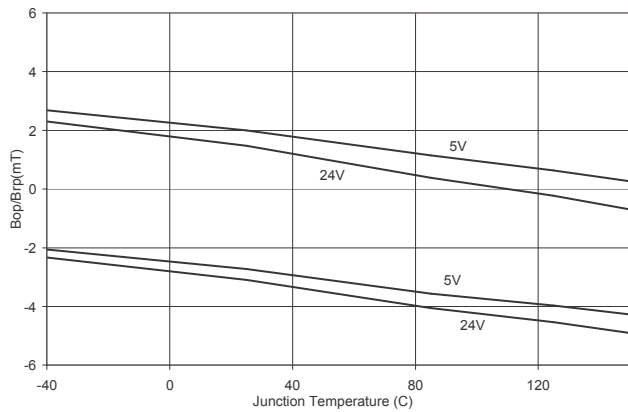
11.1 $R_{DS(on)}$ vs T_J



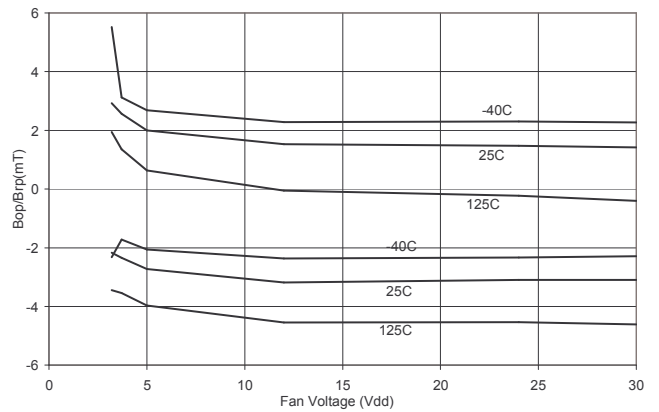
11.2 $R_{DS(on)}$ vs V_{DD}



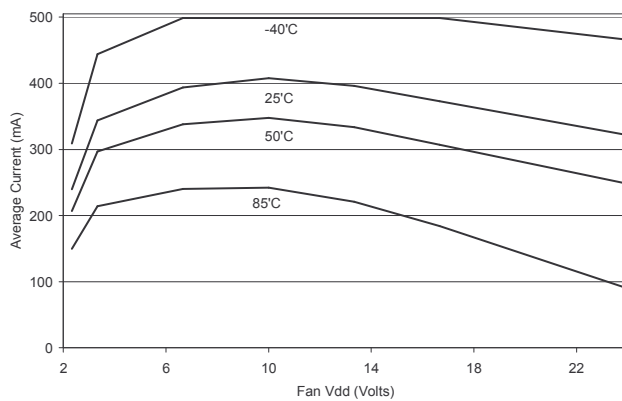
11.3 Magnetic Parameters vs T_J



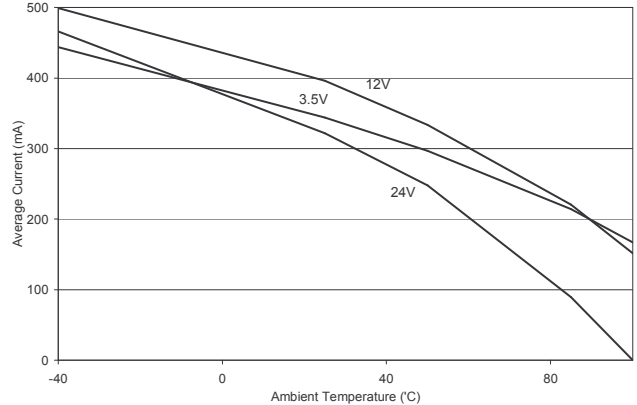
11.4 Magnetic Parameters vs V_{DD}



11.5 Typical Maximum Continuous Current vs Temperature, Fan Voltage

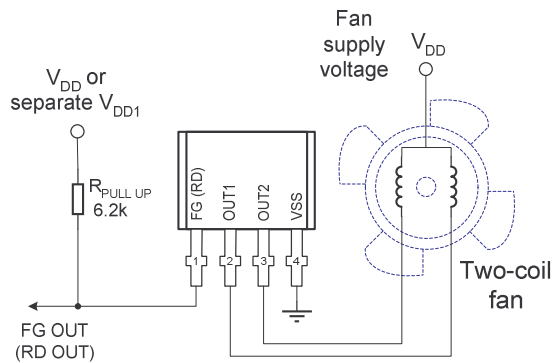


11.6 Typical Maximum Continuous Current vs Fan Voltage, Temperature

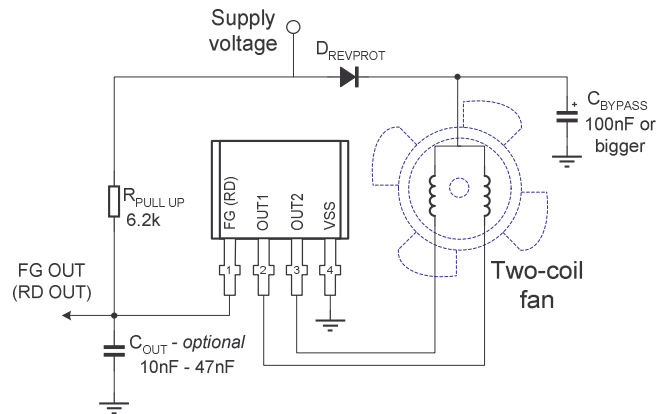


12 Application Information

12.1 Typical application with pull-up resistor



12.2 Configuration for reverse voltage / ground hot-switch protection and enhanced ESD module protection



13 Application Comments

Figure 12.2 shows the application including several external protections.

The diode $D_{REVPROT}$ best protects the chip and fan coils for reverse voltage condition.

The capacitor C_{BYPASS} is recommended if the supply ground may be disconnected while running even though the positive supply point is still connected. This capacitor provides a path to ground for the remaining energy in the coil which has to be evacuated. Without it, the energy can flow from OUT1/OUT2 to the FG/RD driver, without any limitation and may cause EOS damage.

Its value has to be tuned depending on the coils characteristics. Bigger inductance requires bigger capacitor.

The no- V_{DD} design enables ESD protection at fan module level to be easily improved. The fan coils prevent and filter fast current stress on OUT1 and OUT2, resulting in better ESD protection. Adding the optional capacitor C_{OUT} enhances the ESD protection of the logic output. Hence, the fan module is able to withstand ESD stress above 2kV HBM without damage.

14 Standard information regarding manufacturability of Melexis products with different soldering processes

Our products are classified and qualified regarding soldering technology, solderability and moisture sensitivity level according to following test methods:

Reflow Soldering SMD's (Surface Mount Devices)

- 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)
- Melexis Working Instruction 341901308

Wave Soldering SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EN60749-20
Resistance of plastic- encapsulated SMD's to combined effect of moisture and soldering heat
- EIA/JEDEC JESD22-B106 and EN60749-15
Resistance to soldering temperature for through-hole mounted devices
- Melexis Working Instruction 341901309

Iron Soldering THD's (Through Hole Devices)

- EN60749-15
Resistance to soldering temperature for through-hole mounted devices
- Melexis Working Instruction 341901309

Solderability SMD's (Surface Mount Devices) and THD's (Through Hole Devices)

- EIA/JEDEC JESD22-B102 and EN60749-21
Solderability
- Melexis Working Instruction 3304312

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.

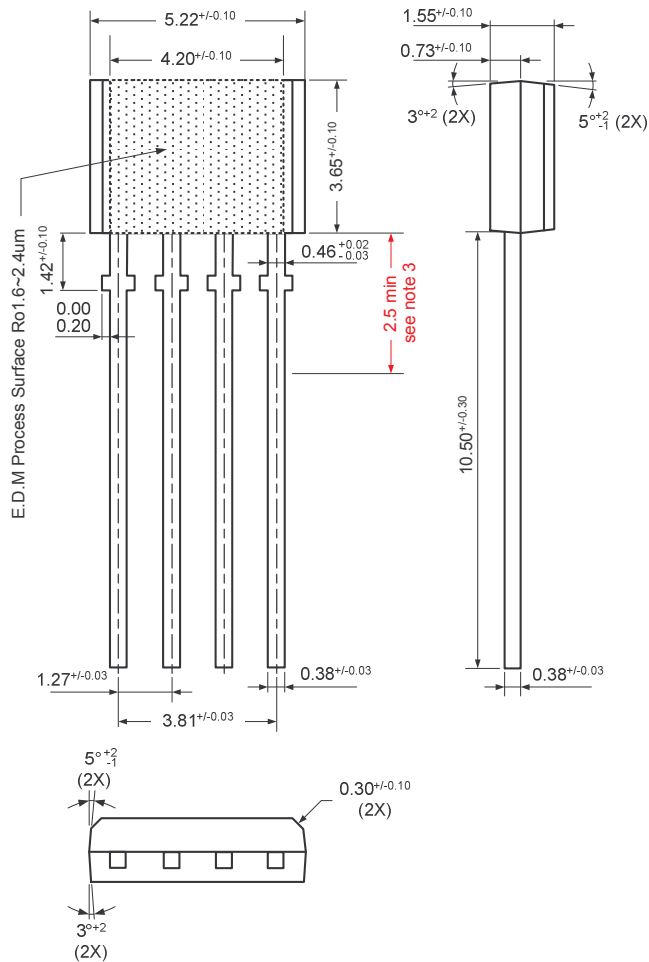
For more information on the lead free topic please see quality page at our website:
<http://www.melexis.com/quality.asp>

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

16.1 VK Package Information (4-pin TO92)



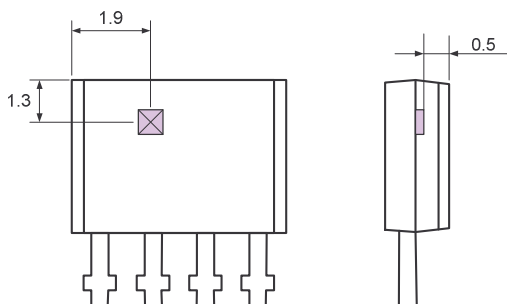
Notes:

1. All dimensions are in millimeters
2. Package dimension exclude molding flash. Mold flash shall not exceed 0.127mm.
3. To preserve reliability, it is recommended to have total lead length equal to 2.5mm minimum, measured from the package line.
4. VK package is a pin through-hole package, hence adapted for wave soldering process. A reflow soldering process is not recommended with VK package as it may seriously affect device reliability.

Marking:

- 1st Line : S90 (S91) - Name of the device
- 2nd Line :
 (x)xxxx - last 4 digits (US90) or last 5 digits (US91) of lot number

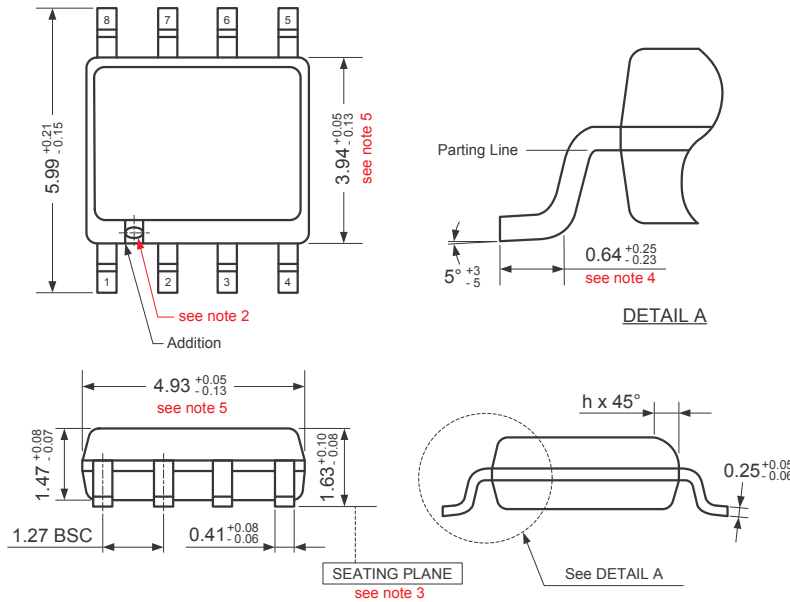
Hall plate location



Notes:

1. All dimensions are in millimeters
2. Typical values only

16.2 DC Package Information (8-pin narrow SOIC)



Notes:

- Controlling dimensions in millimeters
- The appearance of pin 1 is optional, round type on single leadframe and rectangular type on matrix leadframe.
- Formed leads shall be planar with respect to one another within 0.0792 mm at seating plane.
- Length of terminal for soldering to a substrate.
- Package length and width are reference datums and do not include mold flash or protrusions, but do include mold mismatch and are measured at the mold parting line. Mold flash or protrusions shall not exceed 0.1524 mm at end and 0.254 mm at window.
- This part is compliant with JEDEC standard MS-012.

Marking:

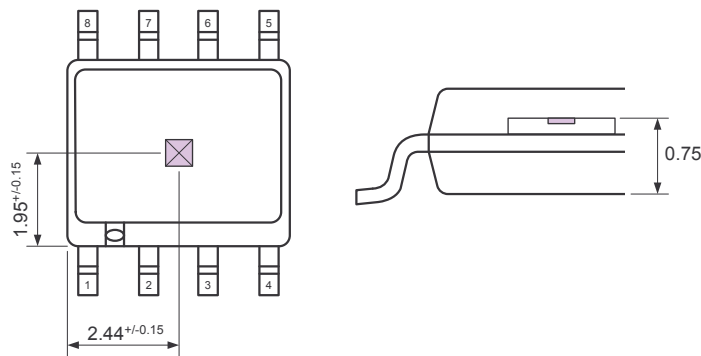
Top Mark :

- Line 1 : US90 (US91) - Name of the Device
- Line 2 : XXXXXXX - Assembly lot number (7 digits)

Bottom Mark :

- YYWW - Assembly date
- YY = year
- WW = calendar week

Hall plate location



Notes:

- All dimensions are in millimeters

17 Disclaimer

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