

### 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 (US90A) or alarm (US91A) signal output
- ❑ 2-coil fan driver with FG/RD output in 4-pin VK / VA and 8-pin narrow SOIC packages (all RoHS Compliant)

### Application Examples

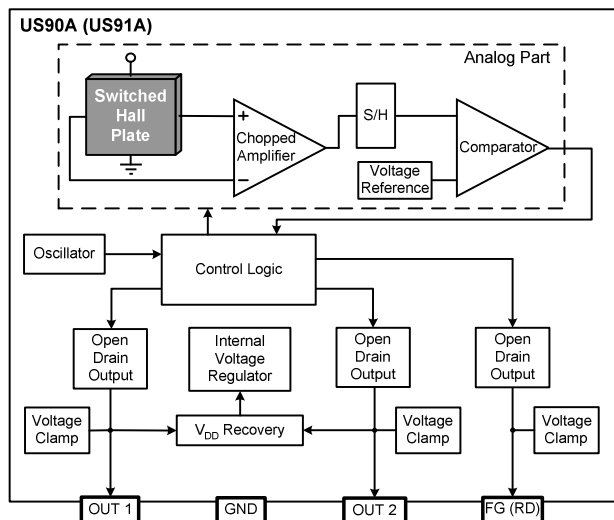
- ❑ 12V/24V fans
- ❑ Peak current up to 500mA

### Ordering Information

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Part No.	Temperature Code	Package Code
US90A	E (-40 °C to 85 °C)	VK (4-pin TO-92)
US90A	E (-40 °C to 85 °C)	DC (8-pin narrow SOIC)
US90A	E (-40 °C to 85 °C)	VA (4-pin TO-92 flat)
US91A	E (-40 °C to 85 °C)	VK (4-pin TO-92)
US91A	E (-40 °C to 85 °C)	DC (8-pin narrow SOIC)
US91A	E (-40 °C to 85 °C)	VA (4-pin TO-92 flat)

## 1 Functional Diagram



## 2 General Description

The US90A/91A 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 the connectivity with any external interface such as hardware monitoring or Super I/O IC easier.

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

The device is also delivered in DC package for automatic assembly.

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### 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 <sub>DD</sub>	Voltage on the coils common node.
I <sub>DD</sub>	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 <sub>COIL</sub> and the output driver resistance R <sub>DSON</sub> .
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

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### 4 Absolute Maximum Ratings

Parameter	Symbol	Value	Units
Fan Supply Voltage	V <sub>DD</sub>	30	V
Peak Output Current	I <sub>OUTp</sub>	500	mA
Continuous Output Current	I <sub>OUTc</sub>	250	mA
FG / RD Output Current	I <sub>FG(RD)</sub>	20	mA
Operating Temperature Range	T <sub>A</sub>	-40 to 85	°C
Junction Temperature	T <sub>J</sub>	125	°C
Storage Temperature Range	T <sub>S</sub>	-55 to 150	°C
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)	Pin number (VA)	Function
FG (RD)	1	1	1	FG (RD) open drain output signal
OUT1	2	2	2	Open Drain Coil Driver 1
OUT2	3	4	4	Open Drain Coil Driver 2
GND	4	3	3	Ground pin
-	-	5, 6, 7, 8	-	Not Connected

Table 2: Pin definitions and descriptions US90A (US91A)

### 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 <sup>(1)</sup>		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	$\mu\text{A}$
DC Thermal Resistance	$R_{THja}$	One-sided PCB, zero LFPM		150		$^\circ\text{C/Watt}$
VK Thermal Resistance	$R_{THja}$	One-sided PCB, zero LFPM		200		$^\circ\text{C/Watt}$
VA Thermal Resistance	$R_{THja}$	One-sided PCB, zero LFPM		170		$^\circ\text{C/Watt}$
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	$B < B_{rp}$ – all packages	High	Low
South pole	$B > B_{op}$ - all packages	Low	High

Table 5: Driver output vs. magnetic pole

**Note 3:** The magnetic pole is applied facing the branded side of the package

### 9 Detailed General Description

The US90A/91A 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.

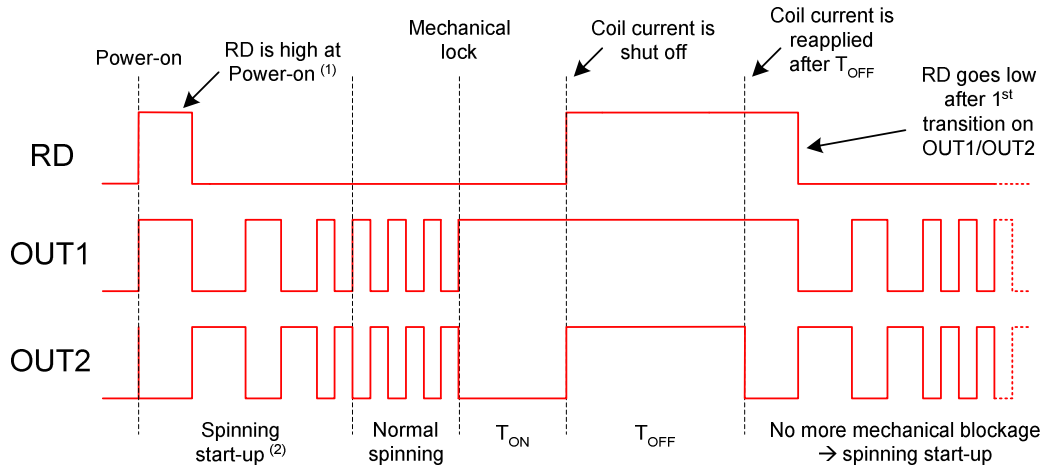
The US90A has an open-drain integrated tachometer FG output that follows the Hall signal. In the US91A, the open-drain rotation detection output RD is active low during normal spinning of the motor. It goes high when the flux switching frequency becomes too low, which means the motor is blocked.

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### 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 US90A and US91A have this feature.



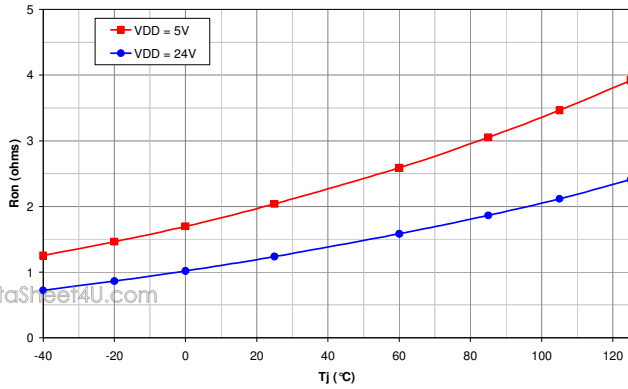
Note 1 : At Power-on, RD is high until the 1<sup>st</sup> transition on OUT1/OUT2.

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

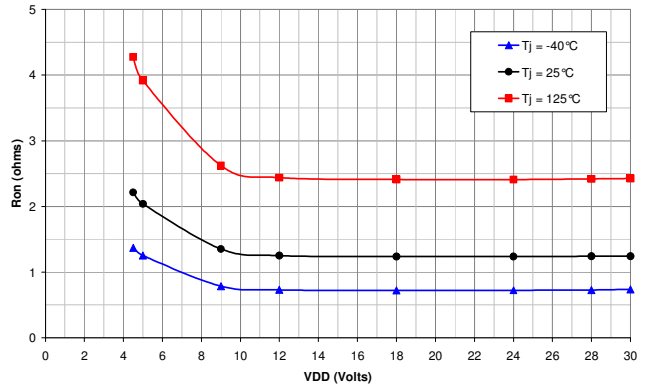
Note 3 : This graph does not represent the EMF effect.

### 11 Performance Graphs

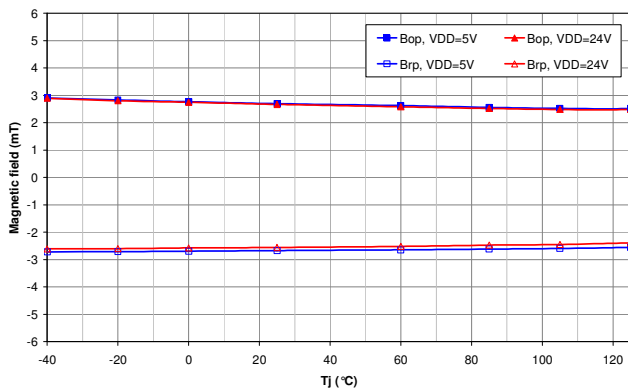
#### 11.1 $R_{DSON}$ vs $T_J$



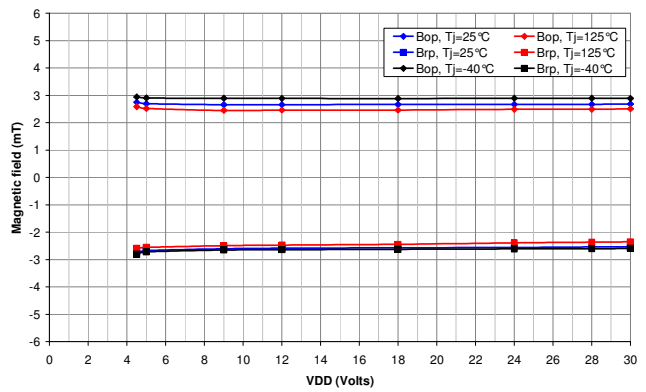
#### 11.2 $R_{DSON}$ vs $V_{DD}$



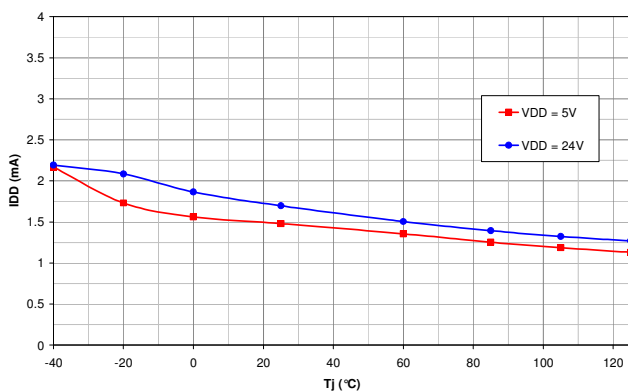
#### 11.3 Magnetic parameters vs $T_J$



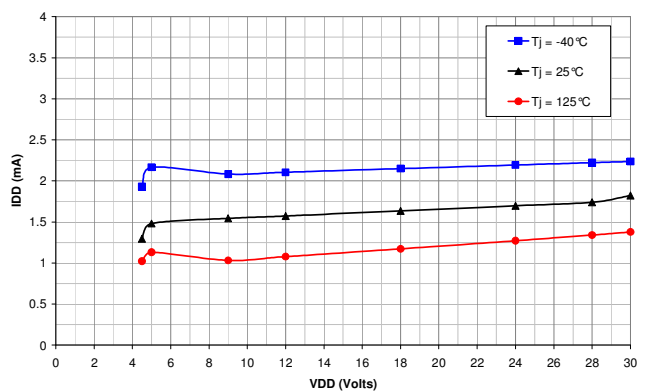
#### 11.4 Magnetic parameters vs $V_{DD}$



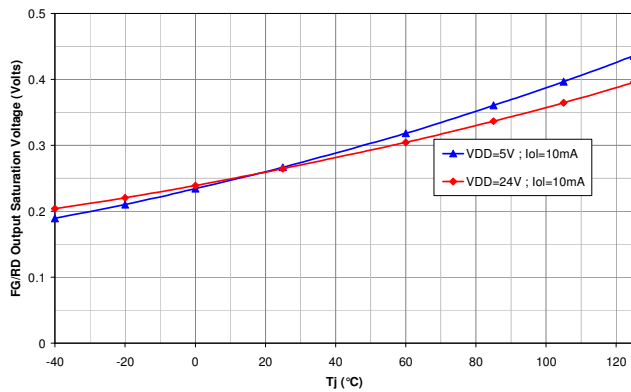
#### 11.5 $I_{DD}$ vs $T_J$



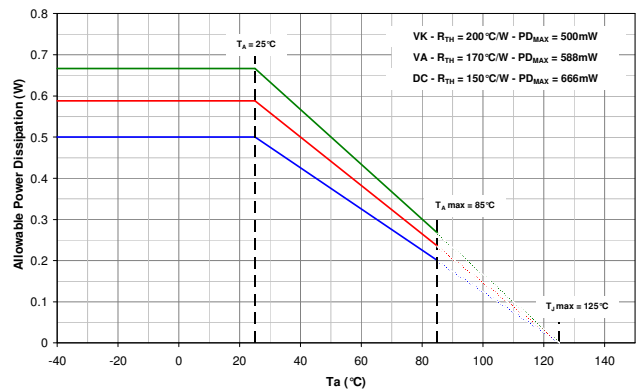
#### 11.6 $I_{DD}$ vs $V_{DD}$



### 11.7 $V_{OL}$ vs $T_J$



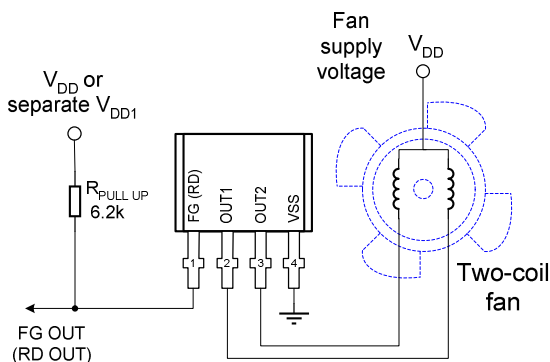
### 11.8 Power Dissipation vs. $T_A$



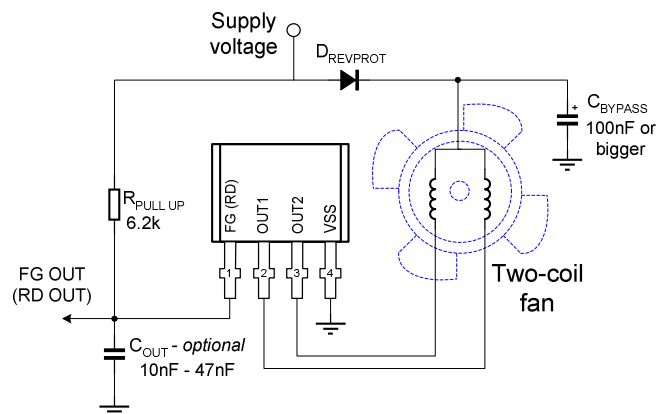
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## 12 Application Information

### 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 at relatively high value 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.aspx>

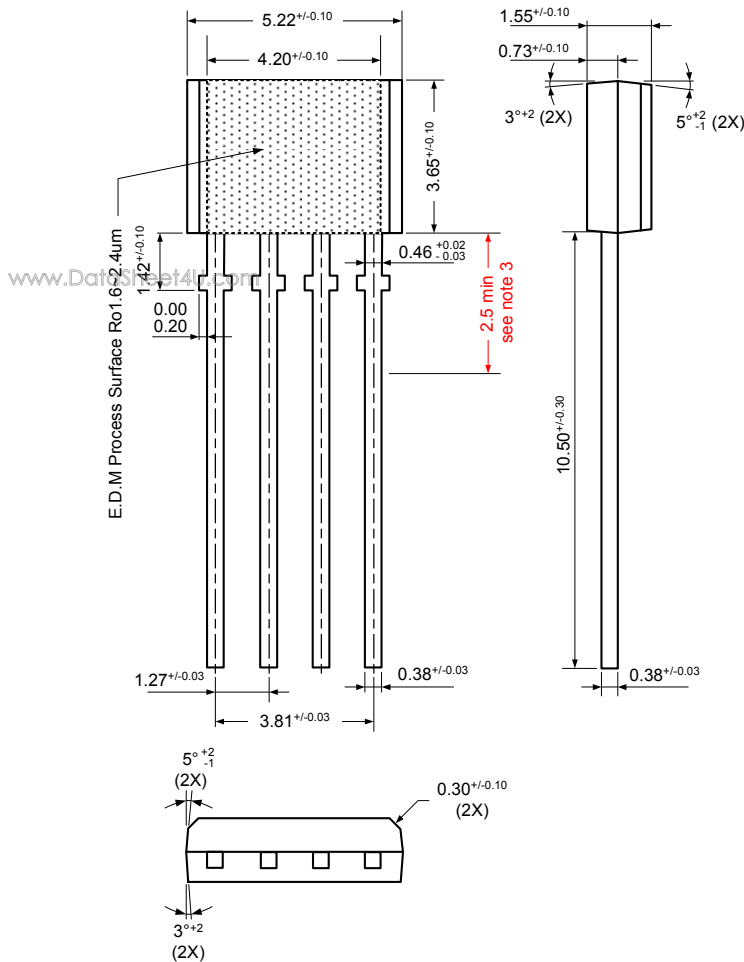
## **15 ESD Precautions**

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)



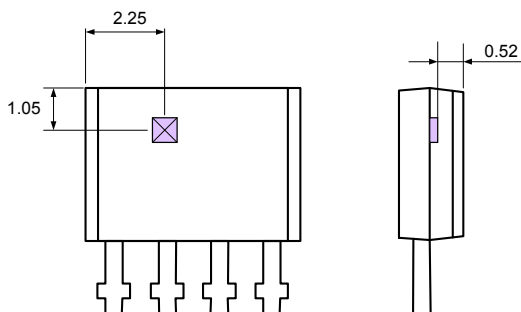
#### Notes:

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:

- 1<sup>st</sup> Line : US90A (US91A) - Name of the device  
 2<sup>nd</sup> Line : xxxx - Assembly lot number (4 last digits)

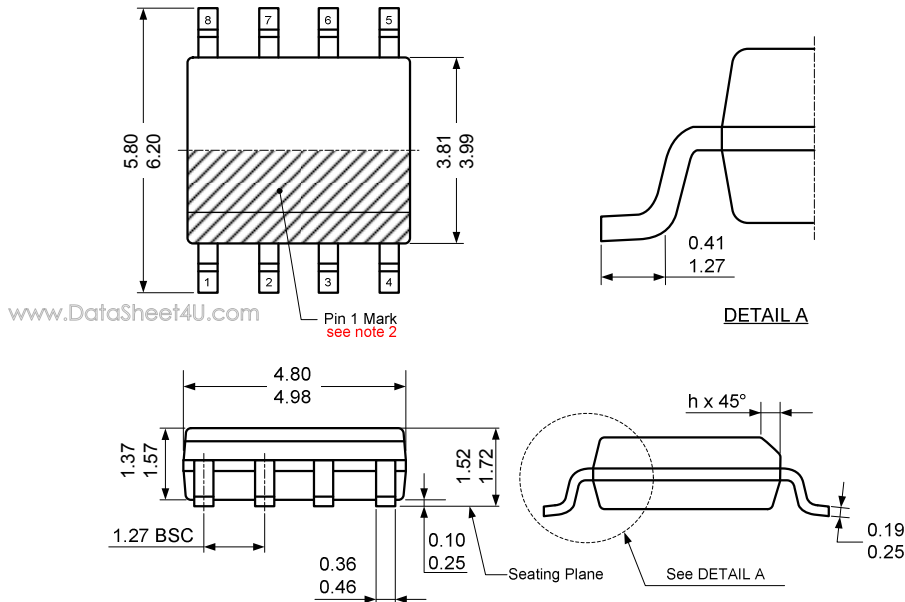
#### Hall plate location



#### Notes:

1. All dimensions are in millimeters
2. Typical values

### 16.2 DC Package Information (8-pin narrow SOIC)



**Notes:**

1. Controlling dimensions in millimeters
2. Detail of pin #1 identifier are optional but must be located within the zone indicated.
3. Lead coplanarity should be to 0.10mm max.
4. All dimensions exclude mold flashes  
End flash from the package body shall not exceed 0.25mm per side.

**Marking:**

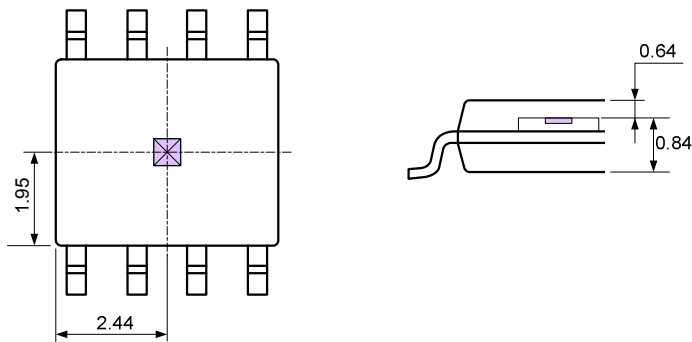
Top Side:

- 1<sup>st</sup> Line : US90A (US91A) - Name of the device
- 2<sup>nd</sup> Line : xxxxxx - Assembly lot number

Bottom Side:

- yyww : yy = year
- ww = week

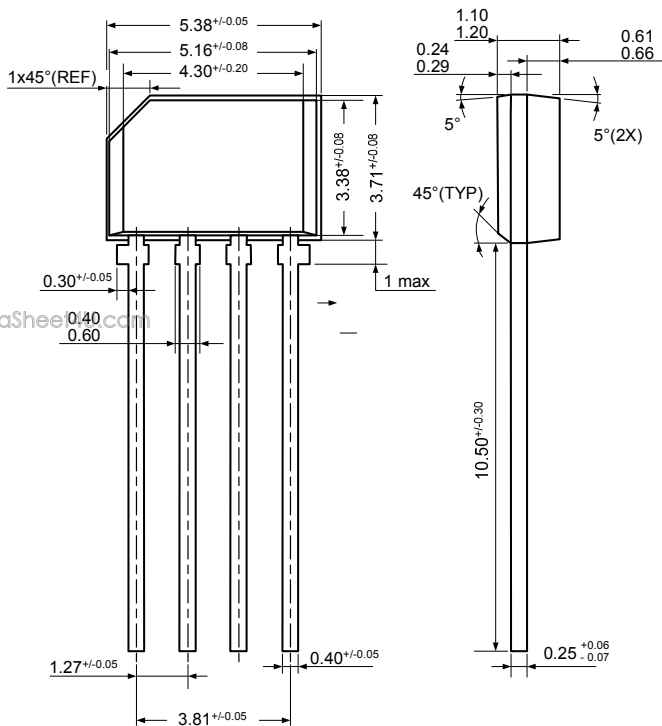
### Hall plate location



**Notes:**

1. All dimensions are in millimeters
2. Typical values

### 16.3 VA Package Information (4-pin TO92 flat)



**Notes:**

1. All dimensions are in millimeters
2. Package dimension exclude end flash

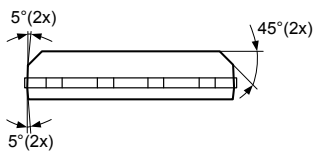
**Marking:**

Top Side:

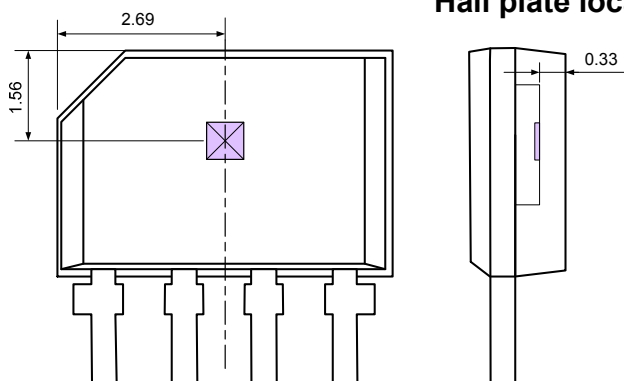
- 1<sup>st</sup> Line : US90A (US91A) - Name of the device
- 2<sup>nd</sup> Line : xxxxxx - Assembly lot number (last 6 digits)

Bottom Side:

- yyww : yy = year
- ww = week



### Hall plate location



**Notes:**

1. All dimensions are in millimeters
2. Typical values

## 17 Disclaimer

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