

### Features and Benefits

- ❑ Soft Switching for low noise applications
- ❑ Slope control setting by dedicated pin
- ❑ One-chip solution (*Hall + Drivers*)
- ❑ Advanced Protection (*enhanced locked rotor, reverse voltage, thermal, output clamping*)
- ❑ Integrated tachometer (US65) or alarm (US66) signal output

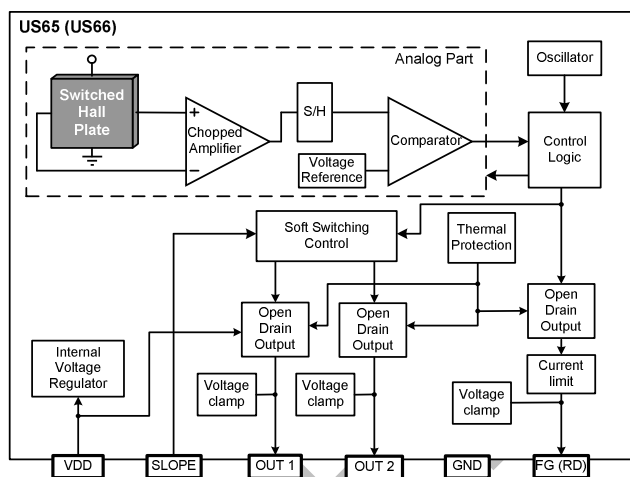
### Application Examples

- ❑ 5V/12V DC brushless motors
- ❑ Continuous output current up to 600mA
- ❑ Low noise brushless cooling fans
- ❑ PC, server, laptop cooling fan
- ❑ Power supply cooling fan
- ❑ Large and small fan size

### Ordering Information

Part No.	Temperature Code	Package Code
US65	E (-40°C to 85°C)	DC (8-pin narrow SOIC8)
US66	E (-40°C to 85°C)	DC (8-pin narrow SOIC8)

### 1 Functional Diagram



### 2 General Description

The US65/66 is a one-chip solution for driving two-coil brushless DC fan and motors. It is especially suitable for relatively high-current rated operation as it can drive up to 600mA continuous output current.

The use of Melexis Soft Switching concept lowers the acoustic and electrical motor noise and provides smoother operation. This efficient solution is combined with an innovative slope control design controllable via a dedicated pin.

The device includes reverse voltage protection, locked rotor protection and thermal protection. Therefore, the IC robustness perfectly suits for consumer and automotive-on-board applications.

Tachometer (FG) or Alarm (RD) open-drain output is available. It makes the connectivity with external interface such as hardware monitoring or Super I/O IC easier.

The device is delivered in RoHS compliant DC package (SMD) for automatic soldering

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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
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 $R_{DS(ON)}$ .
Continuous output current	Average absolute value of the output current when the fan is spinning.
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

### 4 Absolute maximum ratings

Parameter	Symbol	Value	Units
Supply Voltage	$V_{DD}$	-12 to 18	V
FG / RD voltage	$V_{FG} (V_{RD})$	-7 to 18	V
Voltage on pin SLOPE	$V_{SLOPE}$	-0.5 to 18	V
Peak output current	$I_{OUTP}$	1200	mA
Continuous output current	$I_{OUTC}$	600	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
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	Function	Pin number (DC)
FG (RD)	Tachometer (Alarm) open-drain output	1
VDD	Power Supply pin	2
SLOPE	Slope Control pin	3
OUT1	Open Drain Coil Driver 1	4
GND	Ground pin	5
OUT2	Open Drain Coil Driver 2	6
NC	Not connected	7
NC	Not connected	8

Table 2: Pin definitions and descriptions

### 6 General Electrical Specifications

DC Operating Parameters  $T_J = 25^\circ\text{C}$ ,  $V_{DD} = 12\text{V}$  (unless otherwise specified)

Parameter.	Symbol	Test Conditions	Min	Typ	Max	Units
Supply Voltage	$V_{DD}$	Operating	3	12	18	V
Supply Current	$I_{DD}$			3	5	mA
OUT1, OUT2 ON Resistance	$R_{DSON\ 1,2}$			1	2	$\Omega$
OUT1, OUT2 Clamp Voltage	$V_{OUT\ 1,2}$		36			V
FG / RD Output Low Voltage	$V_{OL}$	$I_{OL} = 4\text{mA}$		0.35	0.5	V
FG / RD Output Clamp Voltage	$V_{CLMP}$		18			V
FG / RD Output Leakage Current	$I_{LEAK}$	$V_{FG} (V_{RD}) = 5\text{V}$			10	$\mu\text{A}$
FG / RD Output Current Limit	$I_{FGLIM}$	$V_{FG} (V_{RD}) = 12\text{V}$		20		mA
Output Switching Slope Duration <sup>(1)</sup>	$T_{SW}$	$V_{DD} = 12\text{V}$ , pin SLOPE left open	40	70	160	$\mu\text{s}$
Output Switching Slope Duration <sup>(1)</sup>	$T_{SW}$	$V_{DD} = 12\text{V}$ , $R_{SLOPE} = 100\text{k}$	87	120	189	$\mu\text{s}$
Output Switching Slope Duration <sup>(1)</sup>	$T_{SW}$	$V_{DD} = 5\text{V}$ , pin SLOPE left open	73	126	250	$\mu\text{s}$
Output Switching Slope Duration <sup>(1)</sup>	$T_{SW}$	$V_{DD} = 5\text{V}$ , $R_{SLOPE} = 100\text{k}$	87	120	189	$\mu\text{s}$
Locked Rotor Period	$T_{ON}$	$V_{DD} = 12\text{V}$	0.24	0.29	0.39	s
Locked Rotor Period	$T_{OFF}$	$V_{DD} = 12\text{V}$	1.44	1.5	2.34	s
Locked Rotor Period	$T_{ON}$	$V_{DD} = 5\text{V}$	0.48	0.6	0.89	s
Locked Rotor Period	$T_{OFF}$	$V_{DD} = 5\text{V}$	2.88	3.65	5.34	s
Thermal Protection Shutdown	$T_{SD}$	Note 2		160		$^\circ\text{C}$
Thermal Protection Release	$T_{REL}$	Note 2		130		$^\circ\text{C}$
DC Package Thermal Resistance	$R_{TH}$	Single layer PCB		150		$^\circ\text{C}/\text{Watt}$

Table 3: Electrical specifications

**Note 1:** Measured with active load connected to the output, from 10% to 90% of the  $V_{DD}$  voltage.

**Note 2:** Guaranteed by design

### 7 Magnetic Specifications

DC Operating Parameters  $T_J = 25^\circ\text{C}$ ,  $V_{DD} = 12\text{V}$  (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 Output Behaviour vs Magnetic Pole

Parameter	Test Conditions	OUT1	OUT2	FG
North pole	$B < B_{rp}$	Low	High	Low
South pole	$B > B_{op}$	High	Low	High

Table 5: Driver output vs magnetic pole

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

## 9 Detailed General Description

The US65/66 is a one-chip solution for driving two-coil brushless DC fans. Based on CMOS process, the chip contains a Hall-effect sensor with dynamic offset correction, logic control and two low-ohmic open-drain output drivers.

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

In case the junction temperature  $T_J$  exceeds  $T_{SD}$ , the thermal protection stops the current flowing through the full bridge by setting the outputs OUT1 and OUT2 low and setting the output FG (RD) high. The IC stays in this state until the junction temperature decreases below  $T_{REL}$ .

Reverse voltage protection is integrated on the  $V_{DD}$  pin.

The FG/RD open drain output has an internal current limit which protects the driver in case of accidentally big current flow through the logic driver. It could occur if a low-ohmic pull-up resistor is used or if the FG/RD output is directly short connected to a supply voltage.

The US65 has an open-drain tachometer FG output that follows the Hall signal, thus enabling to determine the rotation speed of the fan.

In the US66, the open-drain alarm output RD is a safety signal which allows detecting if the fan rotates or not. It is active low during normal spinning of the motor. It goes high when the magnetic flux switching frequency drops below nearly:

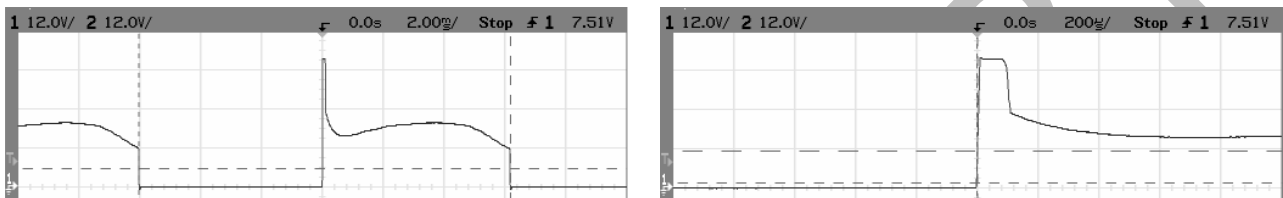
- 2Hz for 12V application (60RPM for 2 pole-pair fan)
- 1Hz for 5V application (30RPM for 2 pole-pair fan)

## 10 Unique Features

### 10.1 Soft Switching & Slope setting

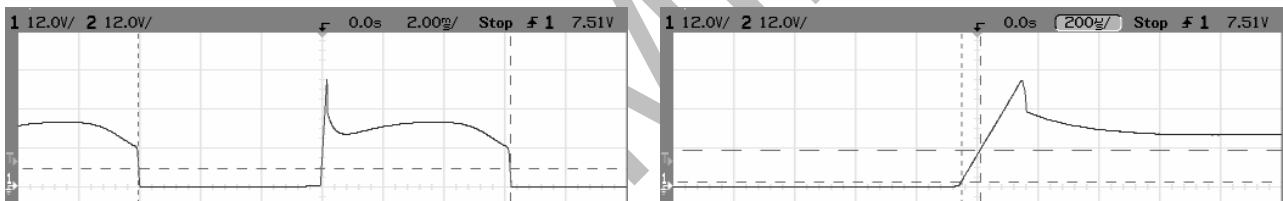
The US65/66 provides an efficient solution for low noise application with internal slope control circuit, controllable via a dedicated pin.

In Two-coil fan driver, the predominant source of electrical noise is when the output driver is switched off. Due to the electromotive force of the fan coil, the output voltage sharply increases but is internally clamped by the fan driver. This effect lasts until the energy in the coil is dissipated, then the output voltages decreases to a normal value, equal to the sum of the fan supply voltage plus the back EMF of the fan in rotation. The resulting swift change in the coil current increases the overall acoustic noise.



(a) – General view  
 (b) – Enlarged view on output switching  
**Figure 1** – US65/66 output voltage without slope control ( $R_{SLOPE} = 0\Omega$ )

In the above Fig.1a is observed the US65/66 output voltage with traditional driving technique, also referred as “hard switching”. In this case, the output driver is directly switched on and off which results in large voltage spikes, clamped at the output clamping voltage value (Fig.1b).



(a) – General view  
 (b) – Enlarged view on output switching  
**Figure 2** – US65/66 output voltage with internal slope control ( $R_{SLOPE}$  not connected, SLOPE pin left open)

When the SLOPE pin is left open (not connected), the US65/66 provides internally defined output slope duration. In contrast with the “hard switching”, the “soft switching” technique controls the output voltage at the switching event and a rise/fall time is implemented to the driving signal. On Fig.2b, the output clamping voltage is even not reached, result of a smoother recirculation of the fan coil current.



(a) – General view  
 (b) – Enlarged view on output switching  
**Figure 3** – Output voltage with long output slope duration ( $R_{SLOPE} = 500k$ )

When a simple resistor is connected between the SLOPE pin the ground, the US65/66 modifies the output slope duration in relation with the value of the resistor  $R_{SLOPE}$ . The output slope duration can be increased so that the output voltages spikes from Fig.1 are totally removed on Fig.3.

For most of the application, the internal soft switching mode from the Fig.2 represents the simplest solution and most adequate balance between low fan acoustic noise and IC power dissipation.

It is also possible to run into the 3 different modes as “hard switching”, “internal soft switching” and “external soft switching”, giving the possibility to adapt the fan design to stringent requirements. For example, high speed fan generally requires longer output slope compared to usual middle or low speed fan.

Increasing the output slope duration inevitably leads to high power dissipation of the IC itself. However, the device is well protected against over power dissipation thanks to the integrated thermal shutdown.

### 10.2 Enhanced Locked Rotor Protection

Specially designed for driving large fans, the Locked Rotor Protection is optimised for low start-up voltage.

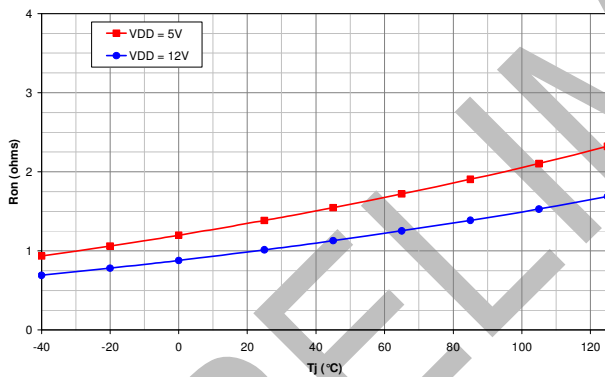
At low voltage, fans inevitably starts rotating slower than at higher voltage. Big fans with large inertia have slow start-up causing a longer first output pulse after power-on. If this pulse duration is longer than the LRP  $T_{ON}$  period, the fan may falsely enter locked rotor condition.

The US65/66 provides an adequate and simple solution to prevent this by automatically increasing the locked rotor protection period at low voltage. The device internally compares the supply voltage applied on the  $V_{DD}$  and automatically double the LRP periods at 5V (0.6s, 3.65s) compared than 12V (0.29s, 1.5s).

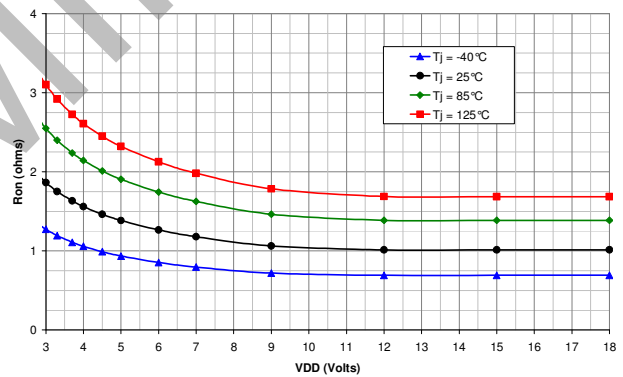
This facilitates driving heavier fans and motors with large inertia without any external component ( $T_{ON}/T_{OFF}$  is increased or decreased depending on the fan supply voltage  $V_{DD}$ ).

## 11 Performance Graphs

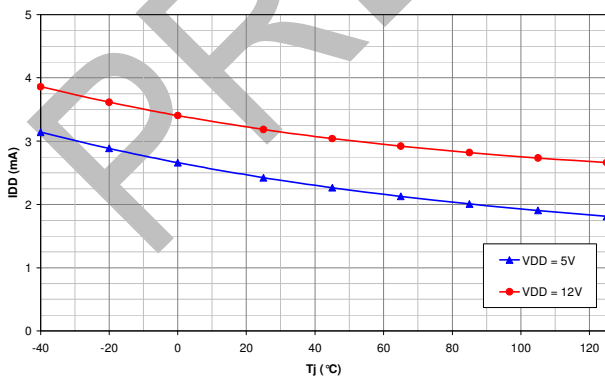
### 11.1 $R_{DS(ON)}$ vs $T_J$



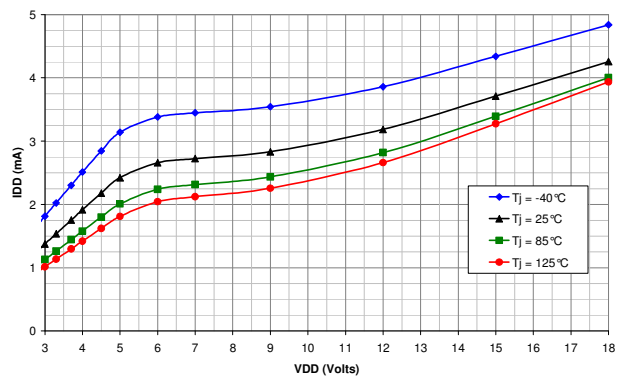
### 11.2 $R_{DS(ON)}$ vs $V_{DD}$



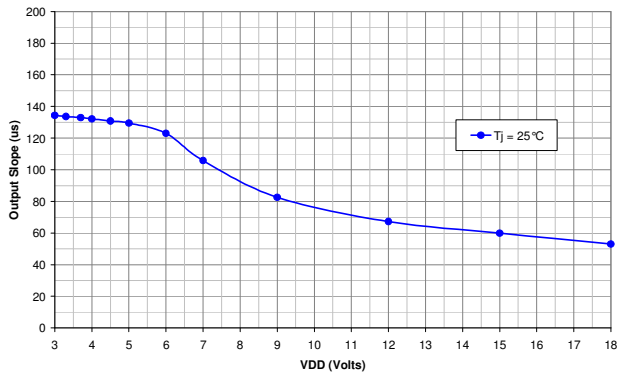
### 11.3 $I_{DD}$ vs $T_J$



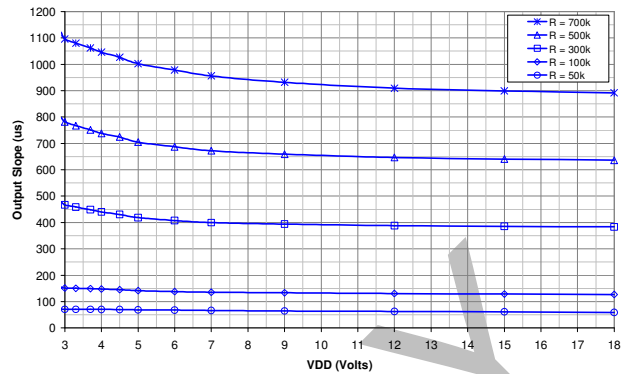
### 11.4 $I_{DD}$ vs $V_{DD}$



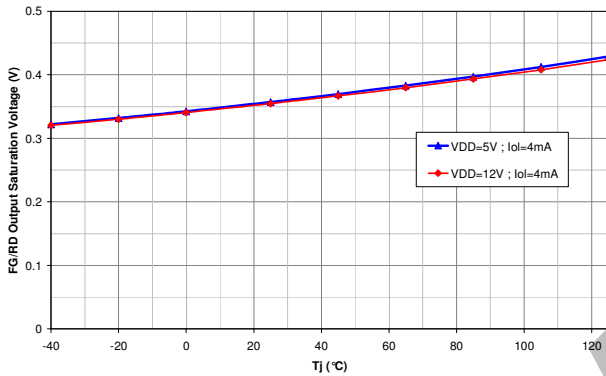
#### 11.5 Internal Slope Duration vs $V_{DD}$



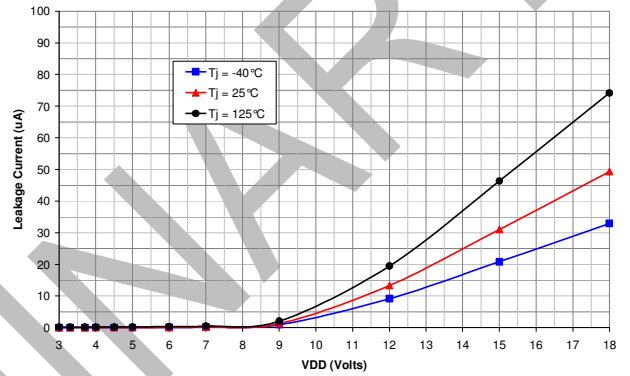
#### 11.6 Slope Duration vs $V_{DD}$



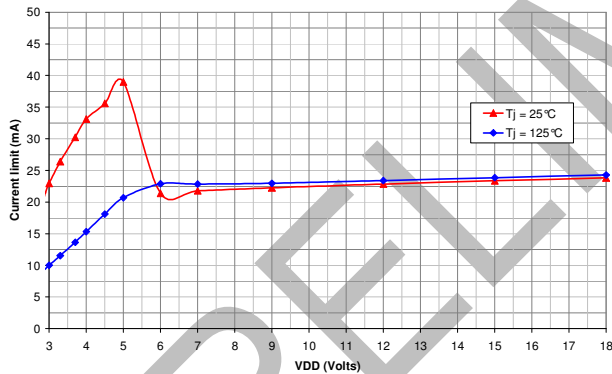
#### 11.7 $V_{OL}$ vs. $T_J$



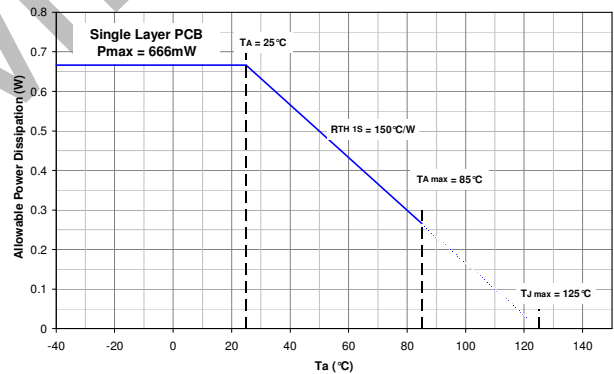
#### 11.8 $I_{LEAK}$ vs. $T_J$



#### 11.9 $I_{FGLIM}$ vs. $V_{DD}$

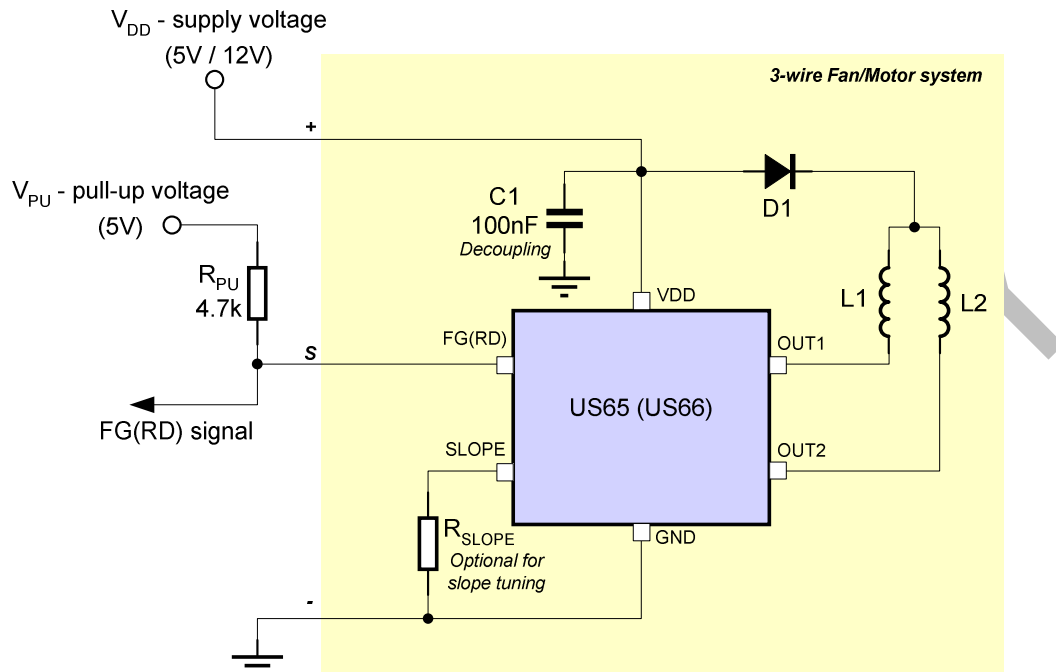


#### 11.10 $P_{Dmax}$ vs. $T_A$





## 12 Application Information



Typical computer fan application circuit

## 13 Application Comments

During fan rotation, the coils may affect the stability of the  $V_{DD}$  voltage. To filter eventual spikes, it is recommended to add a 100nF decoupling capacitor between  $V_{DD}$  pin and GND, closer to the chip.

If the FG/RD pull-up resistor is connected to  $V_{DD}$ , a diode should be connected between the fan supply voltage and the common point of the fan coils to avoid parasitic effects on FG/RD output.

The voltage  $V_{DD}$  and  $V_{PU}$  can be physically the same voltage source. However, the pull-up voltage  $V_{PU}$  is generally connected to a different digital power source at 5V as it feeds the FG or RD signal to an IC interface.

When the default slope is sufficient, the pin SLOPE may just be left open.

For slope adjustment, it is required to connect a resistor  $R_{SLOPE}$  between the SLOPE pin to ground. The value of the resistor modifies the output slope as shown in the performance graph.

## **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)

### **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

### **Iron Soldering THD's (Through Hole Devices)**

- EN60749-15  
Resistance to soldering temperature for through-hole mounted devices

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

- EIA/JEDEC JESD22-B102 and EN60749-21  
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.

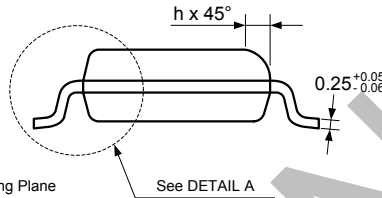
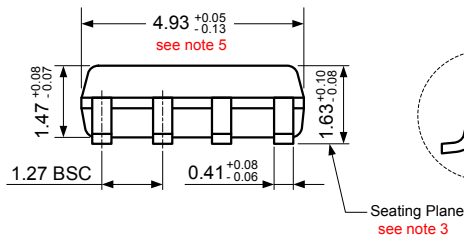
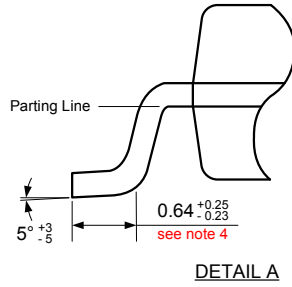
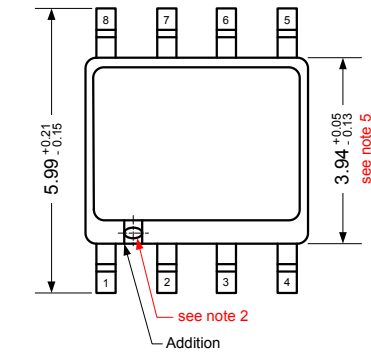
Melexis is contributing to global environmental conservation by promoting **lead free** solutions. For more information on qualifications of **RoHS** compliant products (RoHS = European directive on the Restriction Of the use of certain Hazardous Substances) please visit the quality page on our website:

<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 DC Package Information (8-pin narrow SOIC)



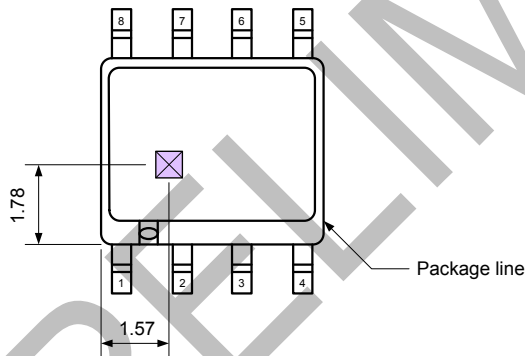
**Notes:**

1. Controlling dimensions in millimeters
  2. The appearance of pin 1 is optional, round type on single leadframe and rectangular type on matrix leadframe.
  3. Formed leads shall be planar with respect to one another within 0.0792 mm at seating plane.
  4. Length of terminal for soldering to a substrate.
  5. Package length and width are reference datums and do not include mold flash or protrusions, but does 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.
- x. This part is compliant with JEDEC standard MS-012.

**Marking:**

- Line 1 : US65 (US66) - Name of the Device  
 Line 2 : XXXXXX - Assembly lot number (6 digits)  
 Line 3 : YYWW - Assembly date  
 YY = year  
 WW = calendar week

### Hall plate location



**Notes:**

1. All dimensions are in millimeters

## 17 Disclaimer

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