

# DATA SHEET

## **P82CF201**

Low power, low price dual fan manager

Product data  
Supersedes data of 2002 Nov 04

2002 Nov 18

# Low power, low price dual fan manager

# P82CF201

## GENERAL DESCRIPTION

The P82CF201 is a 20-pin single-chip dual digital fan controller designed for use with brushless DC fan motors. A thermistor (or temperature resistive sensor) connected to the  $R_{thermC}$  input provides the required resistance of 10K to 1.75 K $\Omega$  for 30% to 98% PWM duty cycle.

With temperature less than 25 °C (thermistor resistance more than 10 K $\Omega$ ) and THRESHOLD is set to LOW, the fan will be off. When temperature rises above 25 °C (NTC thermistor at 10K or less), the PWM turns the fan on. The P82CF201 features a Turn-on Delay for a second fan when both fans have to turn-on. This reduces the in-rush current and suppresses acoustic noise.

The P82CF201 also features fan fault sensing for enhancing system protection and reliability. It detects the presence of a fan, when the running fan fails or jams using the voltage on  $V_{SENSE}$  pin and asserts the fault signal. The fault condition also triggers the maximum PWM applied to the running fan. The fault is also asserted when the thermistor resistance is less than 1.5 K $\Omega$  (temperature is over 76 °C).

## FEATURES

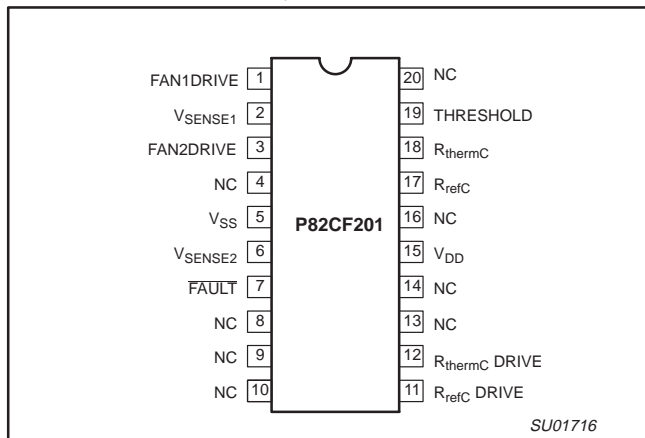
- Temperature proportional fan speed control resulting in low acoustic and longer fan life
- 3.0 V to 5.5 V operating range
- Dual PWM fan drive

- Constant temperature monitoring ensure reliable motor start-up at turn-on, coming out of fault condition, or following a transient fault
- Constant fan sensing protect against fan failure and fault condition
- Over temperature and fan fail output pin
- 20 mA direct drive to LED indicators for fan power supply failure, fan failure, overheat warning, no fan connect
- 500 mS turn-on delay for the second fan when both fans have to turn-on, reducing high surge current and noise
- On-chip power-on reset allows operation with no external components
- The watchdog timer performs self-check and reset function
- On-chip oscillator allows operations with no external oscillator components
- Supports low cost NTC thermistors (for PTC use P82CF202)
- Hysteresis control (when THRESHOLD pin is connected to  $V_{ss}$ /Ground) for resistance between 10K (25 °C) and 15K (20 °C) during cooling to avoid unnecessary fan turning during cool down
- Constant cooling (when THRESHOLD pin is not connected or tied to  $V_{DD}$ ) for resistance above 10K
- Maximum PWM is asserted when one fan fails, cooling the system during fan failure
- 20-pin TSSOP package.

## ORDERING INFORMATION

Type number	Package			
	Name	Description	Thermistor Range	Version
P82CF201BDH	TSSOP20	plastic thin shrink small outline package; 20 leads; body width 4.4 mm	NTC – 1.7 to 32 K $\Omega$	SOT360-1

## PIN CONFIGURATION, 20-PIN TSSOP PACKAGES



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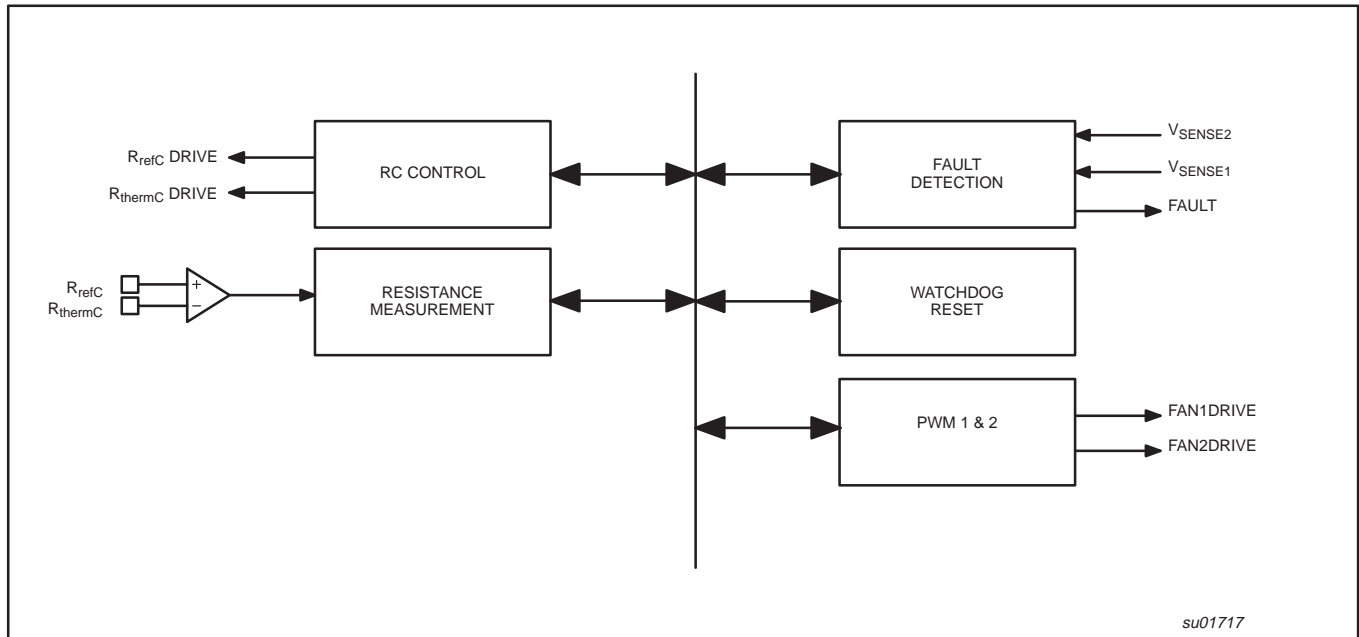


Figure 1. Functional Block Diagram.

## FUNCTIONAL DESCRIPTION

### PWM Description

The PWM controls the fan speed by comparing the thermistor resistance to a reference resistance. This ratio translates into the duty cycle of the PWM.

The PWM controls the fan speed proportionally to the thermistor resistance. The 30Hz PWM duty cycle has resistance control range from 10K to 1.75 KΩ (typical for NTC thermistor) for 30% to 98% output duty cycle. The PWM pins drive a low cost PNP transistor to give a good drive into the N-channel MOSFET as the low side power switch element in the system. Example of drive circuits will be shown Figure 4. This output has asymmetric complementary drive. Since the system relies on PWM rather than linear power control, the dissipation in the power switch is kept to a minimum. Generally, very small devices (TO-92 or SOT package) will suffice.

### 500 mS Delay Turn-On Description

When temperatures rise above 25 °C and THRESHOLD is tied to GND (NTC thermistor at 10K or less) for both fans, there is a turn-on delay of 500 mS for the second fan. This reduces the inrush current and suppresses acoustic noise.

### Thermistor Measurement Description

A resistor can be measured using a comparator, which compares the RC time of a known reference resistance with the RC time of an unknown resistor value. Since the same capacitor and internal voltage reference are used throughout, it results in a simple calculation.

$$R_{unknown} = \frac{(R_{known} \cdot ChargingTime_{known})}{ChargingTime_{unknown}}$$

The RC circuits are charged in sequence, until they reach an internal voltage reference of 1.23 V.

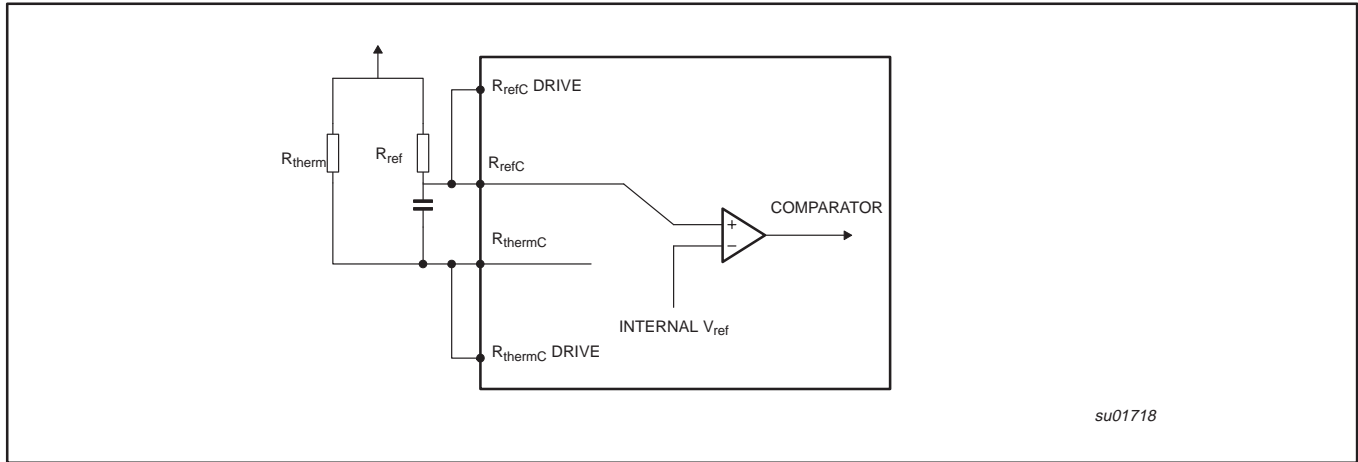
The RC charging time is measured in the 256µSec - 65535µSec. This range is divided up in 256 time increments. Values of R and C have to be chosen so that it will be within that window.

The RC charging time of the reference resistor and thermistor are measured. The thermistor value is calculated by comparing the RC time of the Reference resistor and RC time of the thermistor.

$$R_{thermistor} = \frac{(R_{reference} \cdot CTime_{reference})}{CTime_{thermistor}}$$

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Figure 2.

### Fan Drive

Depending on the value of the thermistor, the fans will be driven by MOSFET with a PWM signal.

When the thermistor resistance is higher than 10 K $\Omega$  and THRESHOLD is set to "0", the fan will be turned off.

However when the thermistor resistance is higher than 10 K $\Omega$  and THRESHOLD is set to "0", the fan will be driven by a 30% duty cycle.

When the thermistor resistance is 10 K $\Omega$ , the fan will be driven by a 30% duty cycle PWM signal.

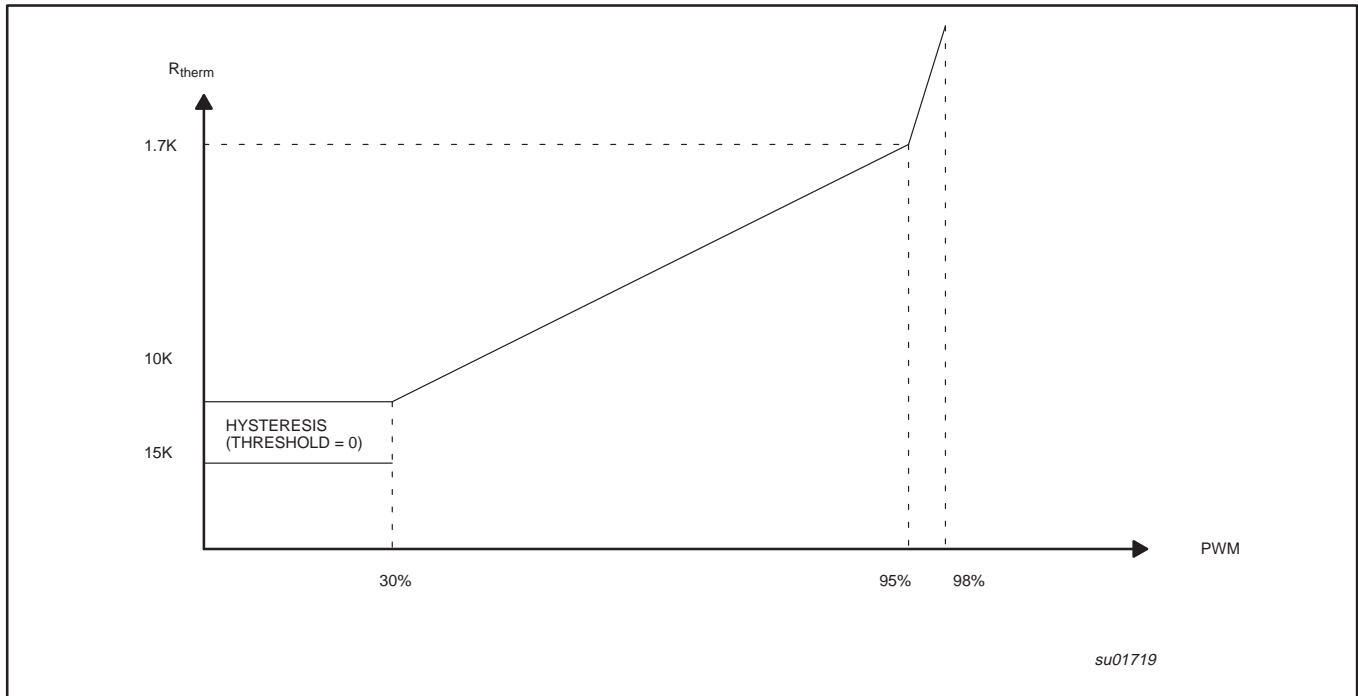
When the thermistor resistance is 1.7 K $\Omega$ , the fan will be driven by a 95% duty cycle PWM signal.

Any value in between is linear.

A Hysteresis with 30% PWM duty cycle (when THRESHOLD = 0) is introduced to maintain constant cooling when the thermistor cools from 10K (approx. 25 °C) to down 15K (approx. 20 °C). This reduces on/off cycling for small temperature fluctuation.

When THRESHOLD is not connected or tied to "1", the fans will have a 30% PWM duty cycle to maintain constant cooling whenever power is applied.

In most application, the  $V_{GS}$  (Gate-Source Turn-on voltage) of the MOSFET is lower than the  $V_{OH}$  ( $V_{DD}-0.7$ ) of the fan drive pins. When the  $V_{GS}$  of MOSFET is higher than  $V_{OH}$ , a non-inverting amplifier (for N-type MOSFet) is needed. For easy reference, this circuit is shown in Figure 5.



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Figure 3.

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## Motor Failure Detection and fault Reporting (including watchdog reset)

As shown in Figure 4, the  $V_{SENSE}$  input is connected to the collector of NPN transistor through an inverting buffer transistor (2N3904 or PMBT3904D) which amplifies the signal from the low-value current sensing resistor in the ground return leg of the fan circuit. During normal fan operation, communication occurs as each pole of the fan is energized.

The fan current develops across the sense resistor ( $R_{SENSE}$ ). This a voltage follower of the PWM pin.

In a running motor, a current will flow through the resistor  $R_{SENSE}$  resulting in a voltage drop. The commutation will cause a narrow window where there is no current flow. Motor detection is done by the presence of commutation pulses. If there is constant voltage level on the  $V_{SENSE}$  pin when the motor is driven by a PWM signal, the motor is jammed. When there is no voltage at all, the motor might not be connected or the MOSFET is defective. The fault condition also triggers the maximum PWM applied to the running fan.

To detect the commutation pulses correctly, the  $V_{SENSE}$  input needs a logic high level of  $0.2 \cdot V_{DD} + 0.9$  V. (For example:

$1.56$  V @  $V_{DD} = 3.3$  V). The design of proper sense circuitry is a matter of scaling the  $R_{SENSE}$  and the gain in buffer transistor to meet the logic high as shown in Figure 4. Assuming the  $V_{BE}(\min)$  of the transistor is approx.  $0.5$  V. Table 1 lists some recommended  $R_{SENSE}$  values according to the nominal operating current.

**Table 1. Recommended values of  $R_{SENSE}$  per Figure 4**

Nominal Fan Current(mA)	Min $R_{SENSE}$ (ohms)
100	5.1
200	2.5
450	2.2
800	1.0

In addition, when the thermistor resistance falls below  $1.7$  K $\Omega$  (for NTC thermistor) indicating temperature above  $76$   $^{\circ}$ C, the fault line will be asserted.

When the fan fails continuously, the fault signal will be held on LOW.

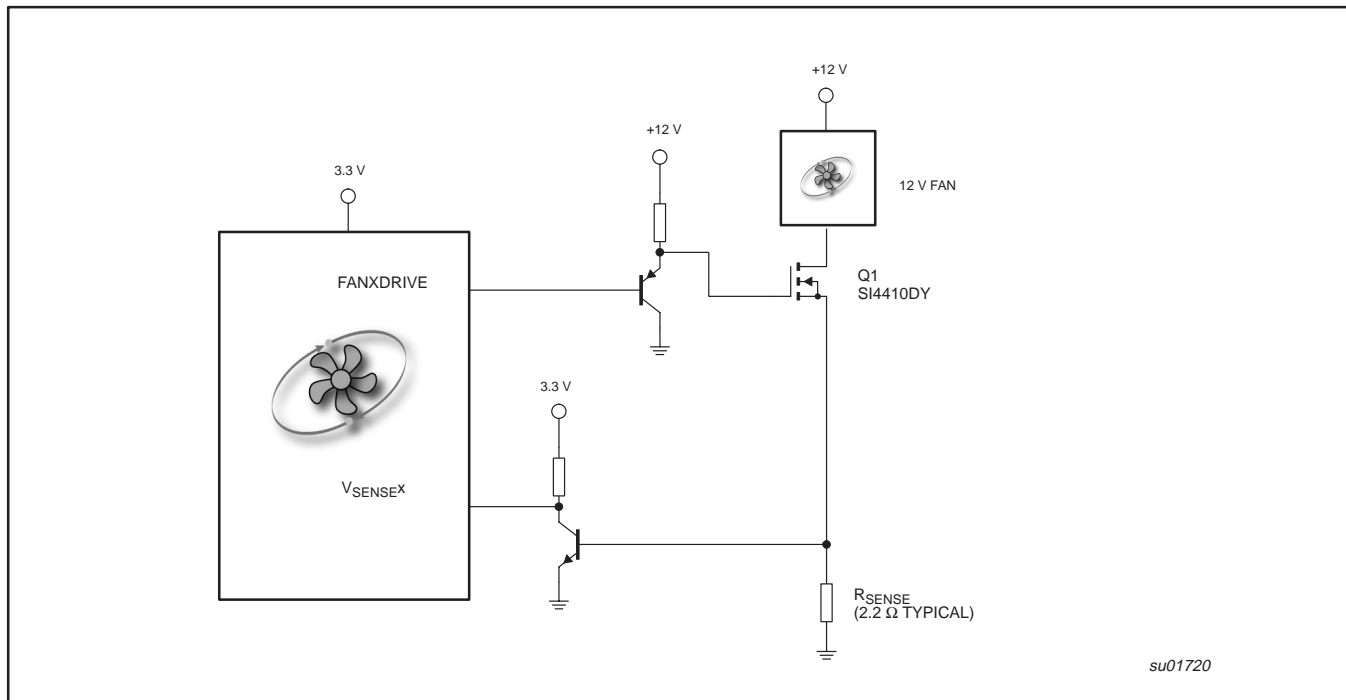


Figure 4. Interfacing the 82CF201 to a 2-Wire fan.

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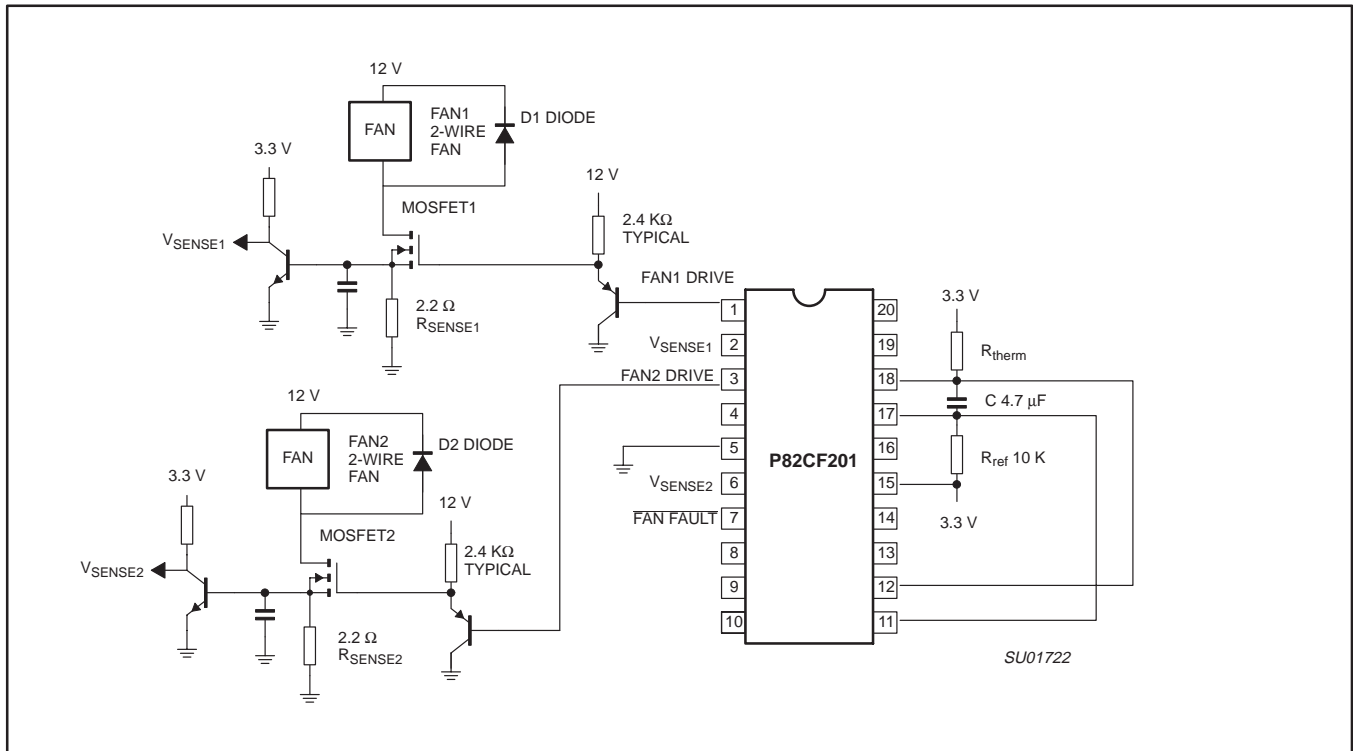


Figure 5. Typical application diagram.

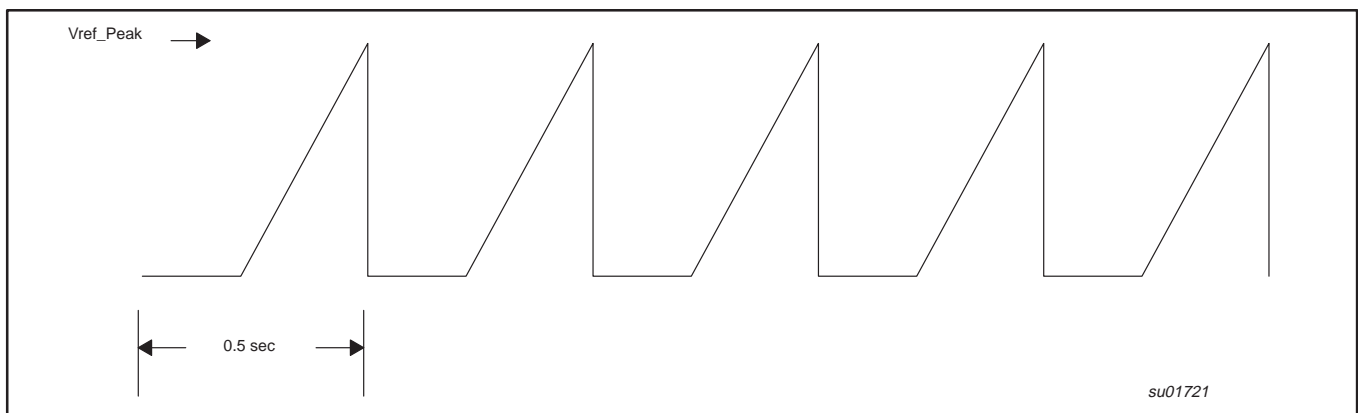


Figure 6. Waveform at Capacitor wrt Ground.

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## ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING	UNIT
Operating temperature under bias	-55 to +125	°C
Storage temperature range	-65 to +150	°C
Voltage on any other pin to $V_{SS}$	-0.5 to 5.5 V	V
Maximum $I_{OL}$ per I/O pin	20	mA
Power dissipation (based on package heat transfer, not device power consumption)	1.5	W

## NOTES:

- Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions other than those described in the AC and DC Electrical Characteristics section of this specification are not implied.
- This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maximum.
- Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to  $V_{SS}$  unless otherwise noted.
- Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to  $V_{SS}$  unless otherwise noted.

## DC ELECTRICAL CHARACTERISTICS

$V_{DD} = 3.0$  V to 5.5 V unless otherwise specified;  $T_{amb} = 0$  °C to +70 °C, unless otherwise specified

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
$I_{DD}$	Power supply current operating current	PWM =off, no fault $3.0$ V < $V_{DD}$ < 5.5 V	2.2		5.5	mA
$V_{IL}$	Input LOW voltage (TTL input) all $R_{sense}$	$4.0$ V < $V_{DD}$ < 5.5 V	-0.5		$0.2 V_{DD} - 0.1$	V
		$3.0$ V < $V_{DD}$ < 4.0 V	-0.5		0.7	V
$V_{IH}$	Input HIGH voltage (TTL input) all $R_{sense}$		$0.2 V_{DD} + 0.9$		$V_{DD} + 0.5$	V
$V_{OL}$	Output LOW voltage all fan drive pins	$I_{OL} = 3.2$ mA, $V_{DD} = 3.0$ V	-		0.4	V
$V_{OL1}$	Output LOW voltage all fan drive pins	$I_{OL} = 20$ mA, $V_{DD} = 3.0$ V	-		1.0	V
$V_{OH}$	Output HIGH voltage all fan drive pins	$I_{OH} = -20$ $\mu$ A, $V_{DD} = 3.0$ V	$V_{DD} - 0.7$ V		-	V
		$I_{OH} = -30$ $\mu$ A, $V_{DD} = 4.5$ V	$V_{DD} - 0.7$ V		-	V
$V_{OH1}$	Output HIGH voltage all fan drive pins	$I_{OH1} = -1.0$ mA, $V_{DD} = 3.0$ V	$V_{DD} - 0.7$ V		-	V
$C_{IO}$	Input/Output pin capacitance		-		15	pF
$I_{IL}$	Logical 0 input current, all $R_{sense}$	$V_{IN} = 0.4$ V	-		-50	$\mu$ A
$I_{LI}$	Input leakage current, all $R_{sense}$ , $R_{thermC}$ , $R_{ThermDrive}$ , $R_{refC}$ and $R_{refCDrive}$	$V_{IN} = V_{IL}$ or $V_{IH}$	-		$\pm 2$	$\mu$ A
$I_{BOLOW}$	Brownout trip voltage with $BOV = 1$		2.35		2.69	V

## COMPARATOR (R\_THERMC AND R\_REF\_C) ELECTRICAL CHARACTERISTICS

$V_{DD} = 3.0$  V to 5.5 V unless otherwise specified;  $T_{amb} = 0$  °C to +70 °C, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP	MAX	
$V_{IO}$	Offset voltage comparator inputs <sup>1</sup>		-		$\pm 10$	mV
$V_{CR}$	Common mode range comparator inputs		0		$V_{DD} - 0.3$	V
$I_{IL}$	Input leakage current, comparator	$0 < V_{IN} < V_{DD}$	-		$\pm 10$	$\mu$ A

## NOTE:

- This parameter is guaranteed by characterization but not tested in production.

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**AC ELECTRICAL CHARACTERISTICS**

$T_{amb} = 0\text{ }^{\circ}\text{C}$  to  $+70\text{ }^{\circ}\text{C}$ ,  $V_{DD} = 3.0\text{ V}$  to  $5.5\text{ V}$  unless otherwise specified;  $V_{SS} = 0\text{ V}^1$

SYMBOL	FIGURE	PARAMETER	LIMITS		UNIT
			MIN	MAX	
VRef_Peak	6	Charge_Peak at RefC and RthermC	1.1	1.55	V
PWM_DC	6	PWM Duty Cycle at fan drive Pin	30	98.4	%

**NOTE:**

- Parameters are valid over operating temperature range unless otherwise specified.

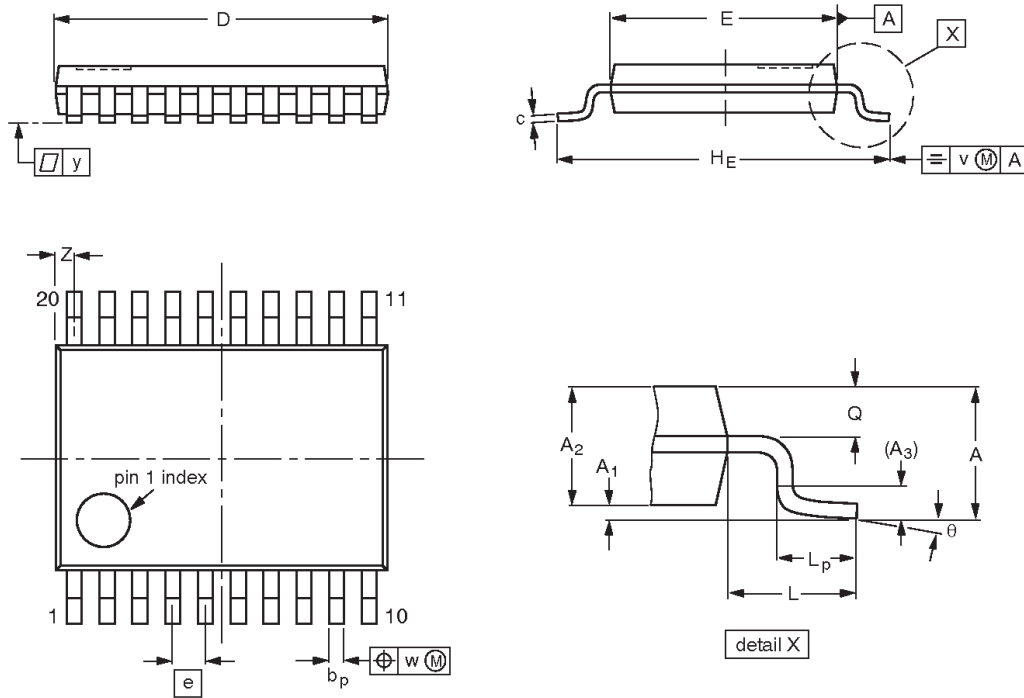


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TSSOP20: plastic thin shrink small outline package; 20 leads; body width 4.4 mm

SOT360-1



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A <sub>1</sub>	A <sub>2</sub>	A <sub>3</sub>	b <sub>p</sub>	c	D <sup>(1)</sup>	E <sup>(2)</sup>	e	H <sub>E</sub>	L	L <sub>p</sub>	Q	v	w	y	Z <sup>(1)</sup>	θ
mm	1.10	0.15 0.05	0.95 0.80	0.25	0.30 0.19	0.2 0.1	6.6 6.4	4.5 4.3	0.65	6.6 6.2	1.0	0.75 0.50	0.4 0.3	0.2	0.13	0.1	0.5 0.2	8° 0°

Notes

- 1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
- 2. Plastic interlead protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT360-1		MO-153				95-02-04 99-12-27

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**REVISION HISTORY**

Rev	Date	Description
_2	20021118	<b>Product data (9397 750 10751); supersedes P82CF201_1 of 2002 Nov 04 (9397 750 10645)</b> Engineering Change Notice 853–2393 29207 (date: 20021115) Modifications: <ul style="list-style-type: none"><li>• Corrected FET type number in Figure 4</li></ul>
_1	20021104	<b>Product data (9397 750 10645); initial version.</b> Engineering Change Notice 853–2393 29144 (date: 20021104).

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## Data sheet status

Level	Data sheet status <sup>[1]</sup>	Product status <sup>[2] [3]</sup>	Definitions
I	Objective data	Development	This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice.
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