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Datasheet

DS-FanControl-TDA21801

TDA21801

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Power Management & Drive

Never stop thinking.

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TDA21801 Low Cost Fan Speed Controller

PG-DSO-8

1. Features

- **Low cost Fan Speed Controller for standard two wires fans**
- **No external components for fan speed loop compensation necessary**
- **Tacho output signal, FanM for speed measurement**
- **Adjustable minimum Fan Speed**
- **External control voltage for fan speed setting**
- **System Overtemperature Protection for early warning and for system shutdown.**

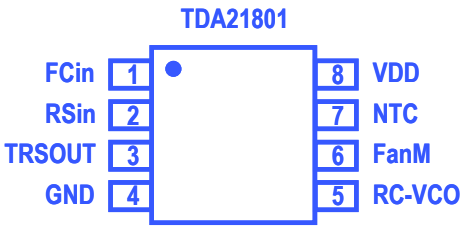
2. Applications

- **Fan Speed Control for PC Desktop Silver Box Power Supply**

Type	Package	Marking	Ordering Code
TDA21801	PG-DSO-8	21801	Q67042-S4257

3. Pinout and Description

TOP VIEW



N°	Name	Description
1	**FCin**	Analog input for external speed control
2	**RSin**	Sense-resistor input signal
3	**TRSOUT**	Output to drive the external PNP transistor
4	**GND**	Ground
5	**RC-VCO**	VCO adjustment for minimum (minimal) frequency and OTP-psu-shut-down.
6	**FanM**	Digital output for speed monitoring. Two pulses per revolution signal. Monitor for OTP-early warning and OTP-psu-shut-down warning.
7	**NTC**	Analog input for temperature sensor (NTC divider)
8	**VDD**	Supply voltage

4. General Description

The Fan Speed Controller is a fully integrated control with few external components to set up a flexible and low cost application. The device uses the waveform of the current in a standard two-wire fan to detect the speed of revolution and to control it.

The current flowing through the fan is sensed by the shunt resistor connected to **RSin**. For fans with a supply current between 50mA and 400mA, a good value for this resistor is between 0.5 and 1Ω as the maximum input voltage of **RSin** for linear operation is 330mV.

The Pulse Detector circuit creates one internal trigger pulse at every commutation of the fan motor. The internal trigger pulse will be processed if the current waveform through the motor shows appropriate variations at the commutation.

Monitoring and warning signal can be used to check the working condition.

Every two internal trigger pulses one is fed to the **FanM** output to monitor the speed of rotation.

The device controls the speed of revolution. The temperature is measured with the NTC thermistor and according to the voltage on the **NTC** the speed of the fan is set.

In Fig.1 the dependence of the fan speed with the temperature is shown (supposing a minimum speed of 1329 rpm).

The expression of the minimum VCO frequency @ minimum FAN Speed is given by:

$$fvco = \frac{16}{15} * n * P$$

n = Fan speed in rpm.

P =number of pole (Fans in use for desktop PC SMPS are normally 4 poles).

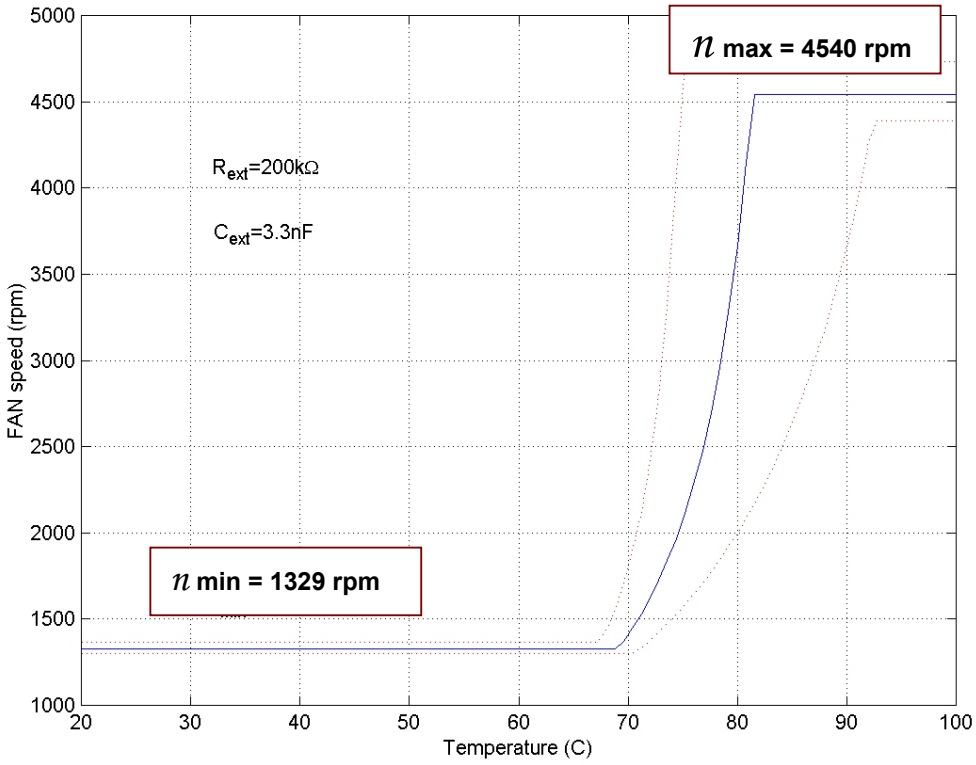


Fig.1 Fan Speed (rpm) vs. Temperature Consider only the typical curve (blue line)

4.1 Block Diagram

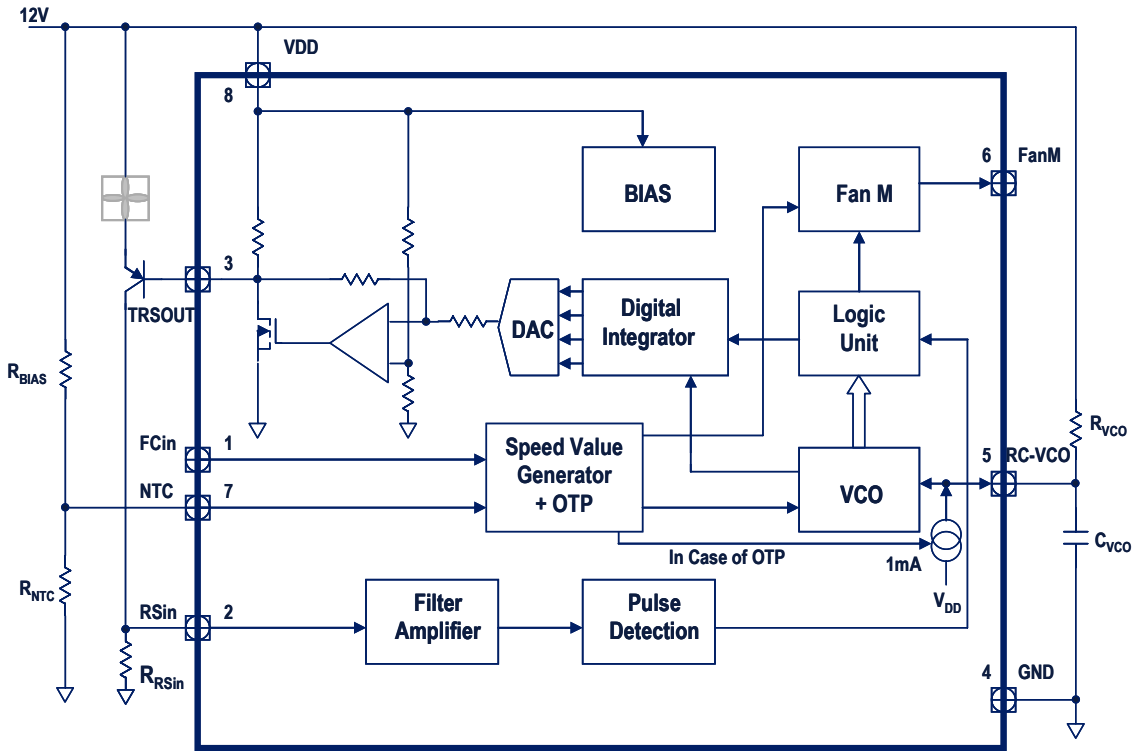
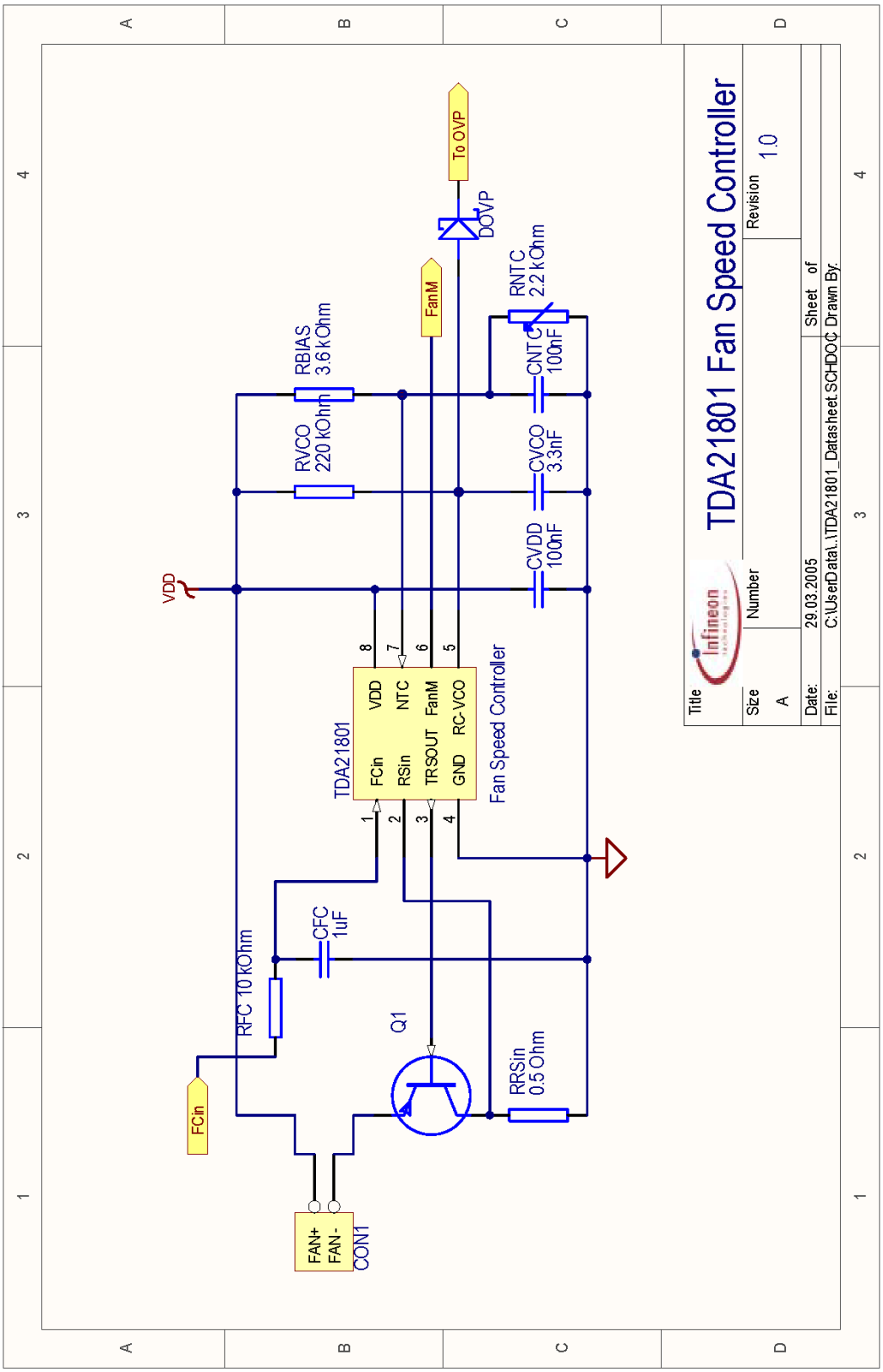


Fig. 2 TDA21801 Block Diagram

4.1.1 External Components Recommendation Values

Name	Description	Typ. Value	Tolerance
R_{BIAS}	Pull up resistor for NTC divider	3.6 kΩ	1%
R_{NTC}	NTC, thermally coupled e.g. with heat sink	2.2 kΩ	5%
R_{RSin}	Shunt Resistor to measure fun current	0.5 Ω ~ 1 Ω	5%
R_{VCO}	VCO frequency setting resistor and capacitor	220KΩ	1%
C_{VCO}		3.3nF	5%

4.2 Application Circuit



4.3 Absolute Maximum Ratings

At Tj = 25 °C, unless otherwise specified

Parameter	Symbol	Values		Unit
		Min.	Max.	
Voltage supplied to '**VDD**' pin; DC	V_{DD}	-0.3	13.2	V
Max voltage on '**TRSOUT**' pin; DC	V_{TRSOUT}	-0.3	13.2	
Max voltage on '**FanM**' pin; DC	V_{FanM}	-0.3	5.5	
Max voltage on '**RSin**' pin; DC	V_{RSin}	-0.3	5.5	
Max voltage on '**NTC**' pin; DC	V_{NTC}	-0.3	13.2	
Max voltage on '**FCin**' pin; DC	V_{FCin}	-0.3	5.5	
Max voltage on '**RC-VCO**' pin; DC	V_{RC-VCO}	-0.3	13.2	
Junction temperature	T_J	-25	125	°C
Storage temperature	T_S	-55	150	
ESD Rating; Human Body Model			2	kV
ESD Rating; Machine Model			200	V
IEC climatic category; DIN EN 60068-1		55/150/56		-

4.4 Thermal Characteristic

Parameter	Symbol	Values			Unit
		Min.	Typ.	Max.	
Thermal resistance, junction-soldering point (PG-DSO-8)	$Rth_{jc\text{-}PG\text{-}DSO\text{-}8}$		95		K/W
Thermal resistance, junction-ambient (PG-DSO-8)	$Rth_{ja\text{-}PG\text{-}DSO\text{-}8}$		125		

4.5 Operating Condition

At Tj = 25 °C, unless otherwise specified

Parameter	*Symbol*	Values			UNIT
		Min.	Typ.	Max.	
Voltage supplied to '**VDD**' pin; DC	$\mathbf{V_{DD}}$	10.8	12	13.2	V
Voltage supplied to '**TRSOUT**' pin; DC	V_{TRSOUT}	0		$\mathbf{V_{DD}}$	
FanM	V_{FanM}	0	3.3	5	
RSin	V_{RSin}	0		0.5	
NTC	V_{NTC}	0		$\mathbf{V_{DD}}$	
FCin	V_{FCin}	0		3.5	
RC-VCO	V_{RC-VCO}	0		$\mathbf{V_{DD}}$	
Junction temperature	T_j	0		100	°C
Ambient temperature	T_a	0		70	
Operating supply current[1]	I_{VDD}		8	12	mA

[1] *Without taking into account output current of **TRSOUT**, **FanM** and **RC-VCO**.*

6 Application Information

6.1 Filter and Amplifier parameters

The Fan current is measured by a shunt resistor R_{RSin} and connected to the **RSin** pin. This is the input signal to the pre-amplifier with a typical gain of 15 and a typical cut off frequency of 20k Hz and –6 dB/ octave.

Only an input signal between 40mV and 330mV will be properly detected and processed otherwise the recognition of the pulse cannot be guaranteed.

The value of the shunt resistor R_{RSin} has to be chosen according to the current of the fan. For example with spike current of 400mA a shunt resistor of typically 0.68Ω should be used.

At typical operating condition.

Parameter	*Symbol*	*Conditions*	Values			UNIT
			Min.	Typ.	Max.	
Gain	G_{RSin}	Verified by Design	14.7	15	15.3	
Cutoff frequency	F_{FA}	*Verified by Design*		20		kHz
RSin pin source current	I_{Rsin}	V_{RSin}= 100m V	0		4	uA

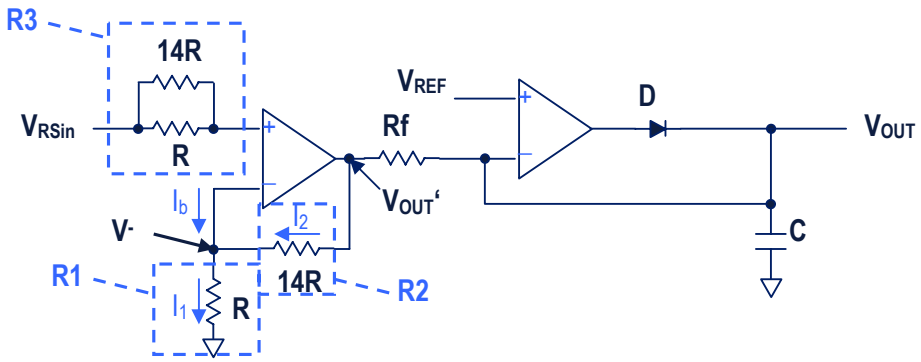


Fig. 3 Analog front end Block Diagram

6.2 Oscillator

The technology of oscillator is similar to the industrial standard 555-timer, with control voltage to increase frequency by a factor of up to 3.4. The external timing resistor, R_{VCO} and capacitor, C_{VCO} set the minimum frequency of **V**oltage **C**ontrolled **O**scillator. The minimum Fan Speed can be adjusted in the range from 750 to 4000 rpm. With tolerance of 3% at rated speed of 1322 rpm, $\mathbf{V_{DD}}$=12V and 25°C (without external components' tolerance), **RC-VCO** is switched to continuous VDD-output-voltage with open collector output stage if OTP-condition is detected at **NTC** input. Typical source current up to VDD-5V is 1mA. For this function the anode of a diode can be connected to **RC-VCO** and the cathode with the 5V input of an external Power-Good circuit. In the case of no OTP the oscillator works between VSP and VSPH and so the diode will not conduct due to lower voltage at Anode compared to Cathode (=5V-input of PowerGood circuit).

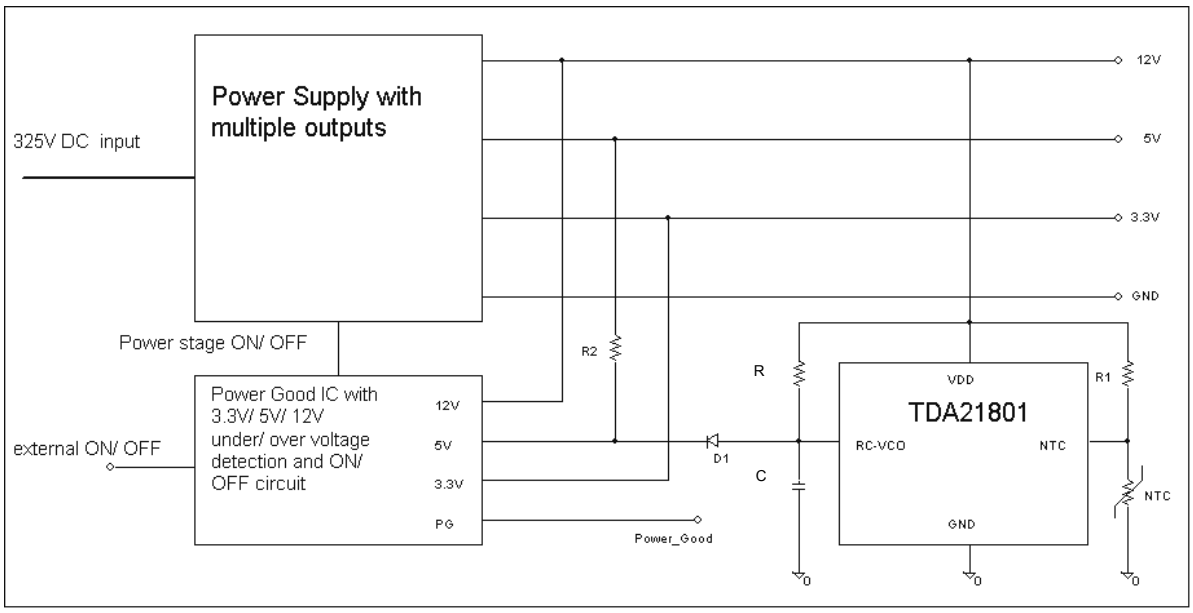


Fig. 4 OTP Application circuit

6.2.1 Electrical Characteristic - Oscillator

At typical operating condition.

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Minimum speed control voltage limit	VSP_{fmin}	Highest VSP voltage, which doesn't change the frequency: $f = f_{min}$ (VbD)	9.85	10	10.15	% of V_{DD}
High speed control voltage limit	VSP_{fmax}	Lowest VSP voltage, which produces the maximum frequency: $f = f_{max}$ (VbD)	25.25	25.5	25.75	% of V_{DD}
Upper threshold	VSPH	(VbD)	30.80	31.06	31.35	% of V_{DD}
Minimum VCO frequency	f_{min0}	V_{DD} = 12V, Tj=25°C, C = 3.3nF, R= 220kΩ Note 1 V_{NTC}=1.5V 0.42V <**FCin**<0.72V	5.005	5.160	5.315	kHz
Minimum VCO frequency	f_{min}	V_{DD} = 12V, 0°C <Tj<100°C, C = 3.3nF, R=220kΩNote 1 V_{NTC}=1.5V 0.42V <**FCin**<0.72V	4.902	5.160	5.418	kHz
Maximum VCO frequency	f_{max}	V_{DD} = 12V, 0°C <Tj<100°C, C = 3.3nF, R = 220kΩ [1] V_{NTC}=1.5V **FCin**>3V	16.55	17.80	19.05	kHz
External capacitor	C_{VCO}	to have a minimum frequency error better than 5%	1			nF
VCO sink current	$I_{VCO\ sink}$	At Vvco=2V	9			mA
VCO source current in OTP condition	$I_{VCO\ source}$	**25°C <Tj<100°C** At Vvco=V_{DD}-5V. [2]	0.7	1	1.45	mA

Verified by Design (VbD)

(1) Parasitic PAD capacitor is typically 2pF.

(2) In OTP condition a current generator (MOS current mirror is turned on).

The control loop regulates the fan rotation to a reference frequency. This reference is provided by the internal voltage controlled oscillator. The basic architecture of the VCO is the standard 555 topology. The minimum frequency setting is fixed by an external RC network. The voltage across C is forced to oscillate between the two thresholds V_{SPH} and V_{SP}. The period of oscillation is given by the expression:

$$T_S = T_{charge} + T_{discharge} = RC\ln\left(\frac{V_{DD} - V_{SP}}{V_{DD} - V_{SPH}}\right) + 500ns$$

Discharging the capacitor is achieved through an internal pull-down transistor. The discharge time is constant and very short compared to the RC time constant. The advantage of this topology is to be insensitive to variations on $\mathbf{V_{DD}}$ if the thresholds V_{SP} and V_{SPH} are directly derived from the V_{DD} itself

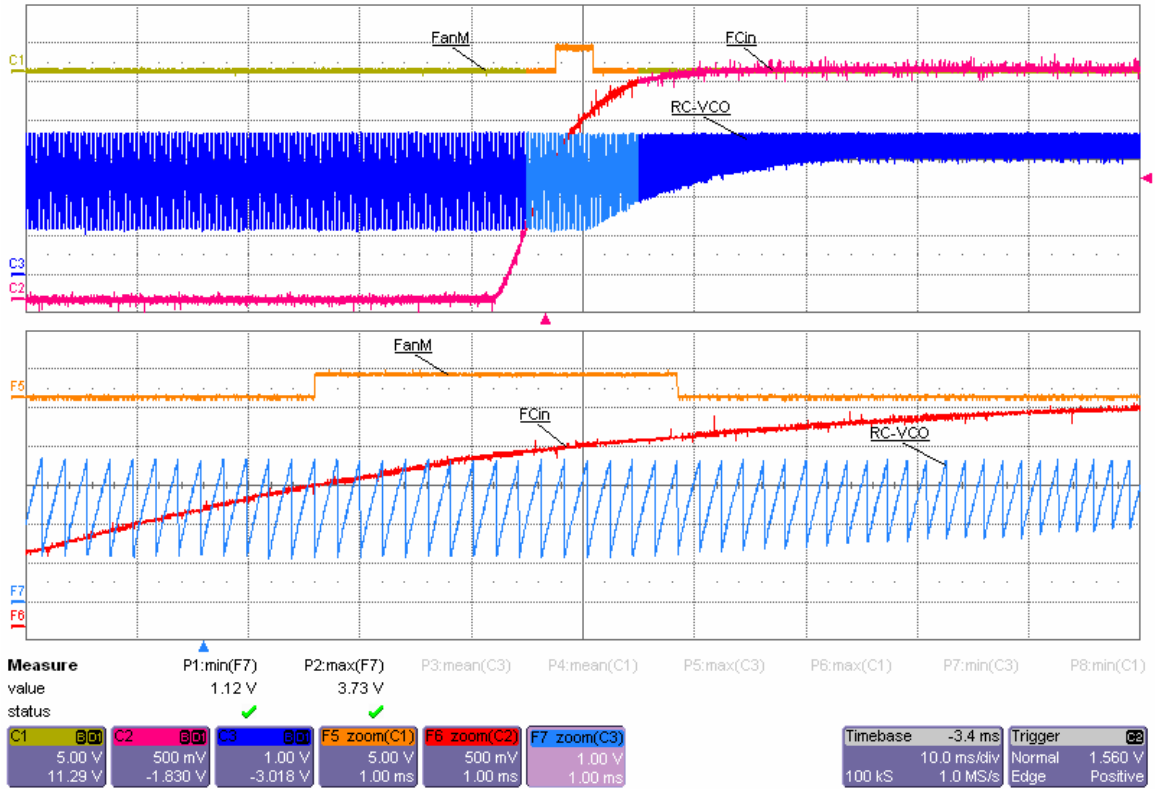


Fig. 5 RC-VCO Valley Voltage At Minimum and Maximum Frequency

6.3 Digital Control parameters

6.3.1 Function of the speed loop

The VCO sets the length of the **FanM** pulse (T_{FanM} = 16*Tvco). The length of this pulse is fixed for fixed VCO frequency. The speed loop tries to keep the **FanM** duty cycle of 12.5% stable. For fixed VCO frequency this means that the fan speed is stable. If the VCO frequency is increased, the **FanM** pulse length T_{FanM} is decreased, so with the previous fan speed the duty cycle is lower than 12.5%.

The speed loop then increases the fan speed to achieve 12.5% duty cycle. This happens by reducing **TRSOUT**.

If the duty cycle is too high, this means the **FanM** frequency and fan speed is too high, the **TRSOUT** output is increasing (voltage across fan is decreasing).

If the duty cycle is too low, this means the **FanM** frequency and fan speed is too low, the **TRSOUT** output is decreasing (voltage across fan is increasing). At power-on and every time the fan is turned on starting from not rotating condition the applied voltage on **TRSOUT** is 6.8V referenced to $\mathbf{V_{DD}}$.

6.4 Power Output Stage parameters

The output of the DAC is amplified to the output **TRSOUT**.

The power output stage is connected with an external transistor to control the fan. There is an intentional internal coupling of fast $\mathbf{V_{DD}}$ supply voltage variations to the output **TRSOUT** to keep the voltage across the fan stable. The ratio between supply variations and voltage variations across $\mathbf{V_{DD}}$-**TRSOUT** is expressed as PSRR in the table below.

6.4.1 Electrical Characteristic – Power Output Stage

At typical operating condition.

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Output saturation voltage	V_{TRSsat}	Isink = 20m A			0.4	V
Maximum output voltage	V_{TRSmax}		V_{DD}-1		V_{DD}	V
Startup Voltage	$V_{TRSstart}$	**TRSOUT** to V_{DD} voltage	6.46	6.8	7.28	V
Negative slew rate for minimum VCO speed	S_{lrn_fn0}[1]	F_{VCO} = fn = 5.160k Hz		-1.17		V/s
Positive slew rate	S_{lrp}		3*Slrn	3*Slrn	3*Slrn	
Output sink current	I_{sink}	V_{TRSOUT} = 1 V	30	50		mA
Power Supply Rejection Ratio	PSRR	**TRSOUT** refered to V_{DD}; Freq=20k Hz	-20	-40		dB

[3]Negative slew rate meaning decreasing of the V_{TRSout} and increasing of the voltage across the fan.

Value defined in order to have a stable global loop

6.5 Speed Value Generation parameters

This block generates the lower threshold for the oscillator: increasing the lower threshold the frequency of the VCO is increased as well. This threshold is given by the highest value of the NTC amplifier output, FCin amplifier output and $VSP_{n\,min}$ and it is limited to $VSP_{n\,max.}$ For $\mathbf{V_{DD}}$=12V and typical values following limits are valid:

V_{FCin} < 2.9% $\mathbf{V_{DD}}$: fan stops if the voltage at NTC is higher than 9% of $\mathbf{V_{DD}}$. If the voltage of the **NTC** decreases below 9% of $\mathbf{V_{DD}}$, the speed of the VCO is controlled by the voltage at the **NTC** pin. When the **NTC** increase back (in case of decreasing temperature) the VCO is controlled by the NTC up to 10% of $\mathbf{V_{DD}}$. If the '**NTC**' input voltage is increased above 10% of $\mathbf{V_{DD}}$, the fan is turned off again.

2.9% $\mathbf{V_{DD}}$ < V_{FCin} < 7.5% $\mathbf{V_{DD}}$: fan speed is controlled only by **NTC** (If the pin **FCin** is open, the open pin voltage is $V_{FC\,open}$ = 5.4% $\mathbf{V_{DD}}$ typical)

7.5% $\mathbf{V_{DD}}$ < V_{FCin}: VCO and fan speed are controlled by the highest between NTC amplified output or FCin amplified output.

V_{FCin} > 23% $\mathbf{V_{DD}}$: VCO oscillator is forced to work at max speed

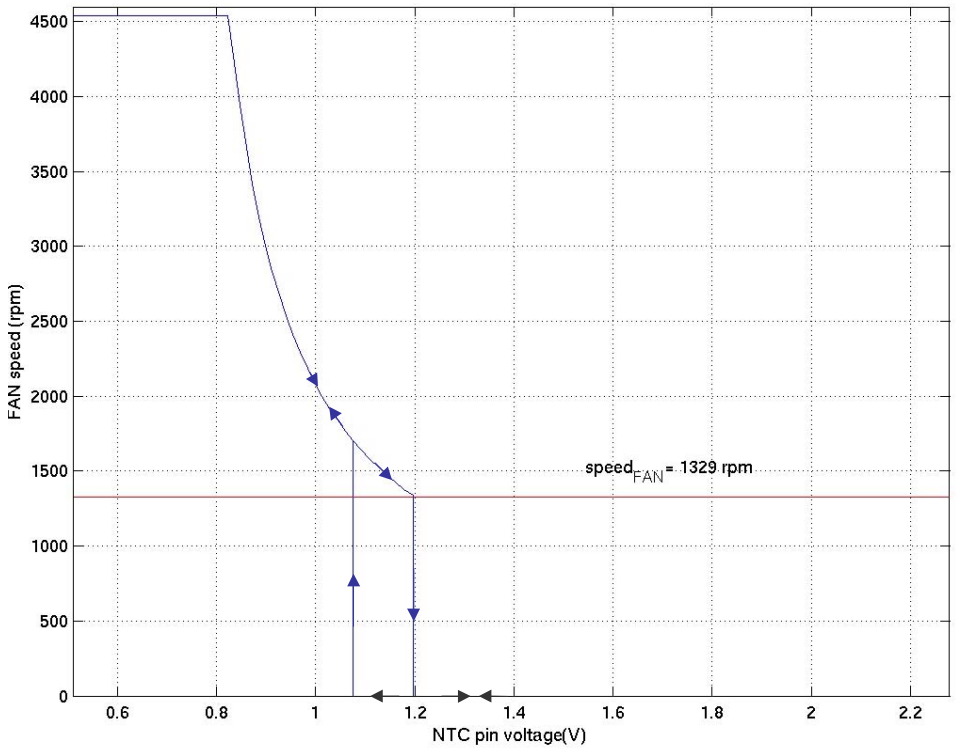


Fig. 6 FAN speed vs. NTC pin voltage (FCin < 2.9% of V_{DD})

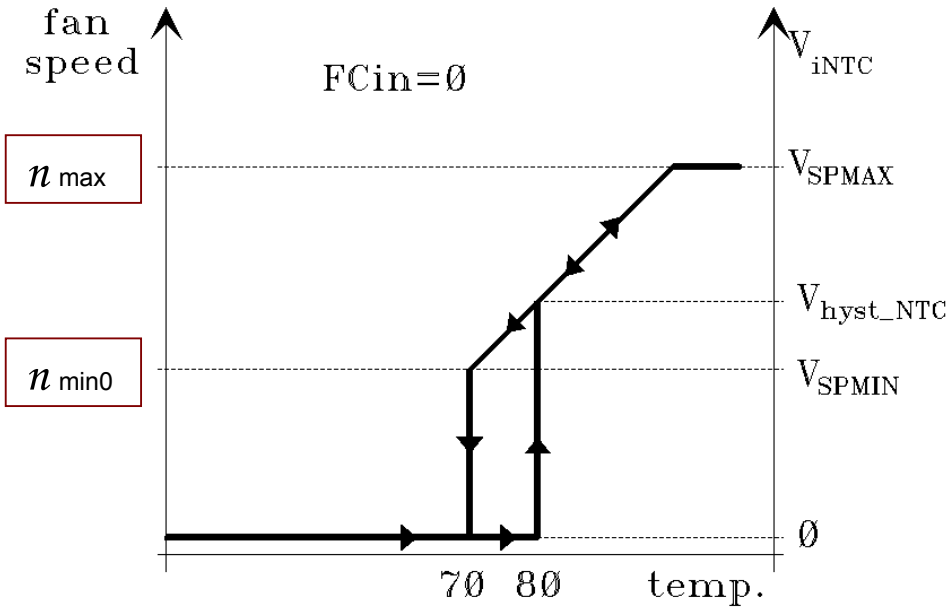


Fig. 7 FAN speed vs. temperature (FCin < 2.9% of V_{DD})

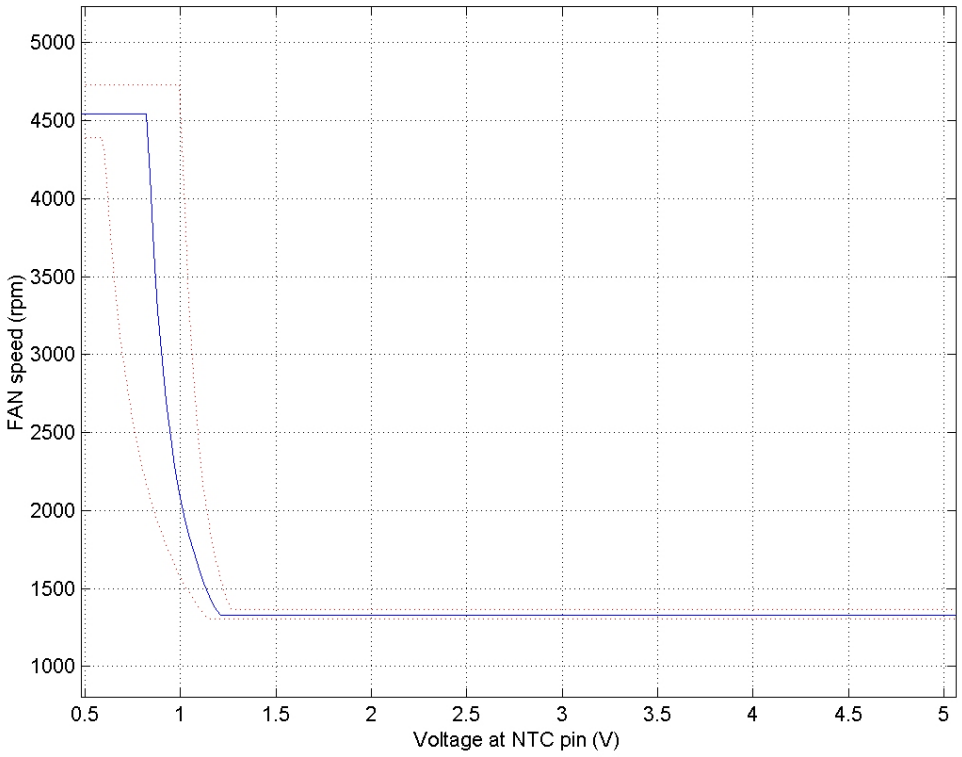


Fig. 8 FAN speed vs. NTC pin voltage (2.9% of V_{DD} <Fcin < 7.5% of V_{DD})

6.6 NTC input

The analog input for NTC divider gives speed information to the VCO (as indicated before) and detects two over temperature conditions for **RC-VCO** output and **FanM** output and **TRSOUT** output:

a) OTP-early-warning condition

This condition is detected, if the **NTC** input goes below V_{NTC_EW} (with a certain hysteresis V_{Hyst_EW}).
In this case the **FanM** signal will be inverted to give a warning signal to the PC-system that the power supply is becoming too hot and soon might be switched off.
Normally the **FanM** signal has a duty cycle of 12.5% or lower. In the case of OTP-early-warning condition this duty cycle will switch to 87.5% or higher. This can be easily detected by the PC-system.

b) OTP-psu-shut-down condition

This condition is detected, if the **NTC** input goes below V_{NTC_OT} (with a certain hysteresis V_{Hyst_OT}).
In this case actions will be started to shut down the Power supply via the **RC-VCO** pin, also to switch **FanM** to High-level and **TRSOUT** to Low-level.
OTP and Early warning output are filtered and delayed before they become active.

6.6.1 Electrical Characteristic - NTC

At typical operating condition.

Parameter	Symbol	Conditions	Values			UNIT
			Min.	Typ.	Max.	
Input voltage range	V_{NTC}		0		V_{DD}	V
Fan Off NTC voltage	V_{NTC_FanOff}	Rising	9.8	10	10.2	% of V_{DD}
Fan On NTC voltage	V_{NTC_FanOff}	Falling	8.8	9	9.2	
Early warning temperature detection level.	V_{NTC_EW}	Voltage falling	4.685	4.785	4.885	
Early warning temperature detection hysteresis.	V_{Hyst_EW}	To be added to the V_{NTC_EW}	0.19	0.25	0.29	
Overtemperature detection level -	V_{NTC_OT}	Voltage falling	4.075	4.175	4.275	
Overtemperature detection hysteresis	V_{Hyst_OT}	To be added to the V_{NTC_OT}	0.19	0.25	0.29	
Voltage gain	G_{NTC}	without external resistor - VbD	-5.2	-5	-4.8	

Input resistance	R_{NTC}		**26.3**	40	**51.4**	kΩ
OTP and Early Warning delay	Td $_{OTP-EW}$			10.4		us

Verified by Design (VbD)

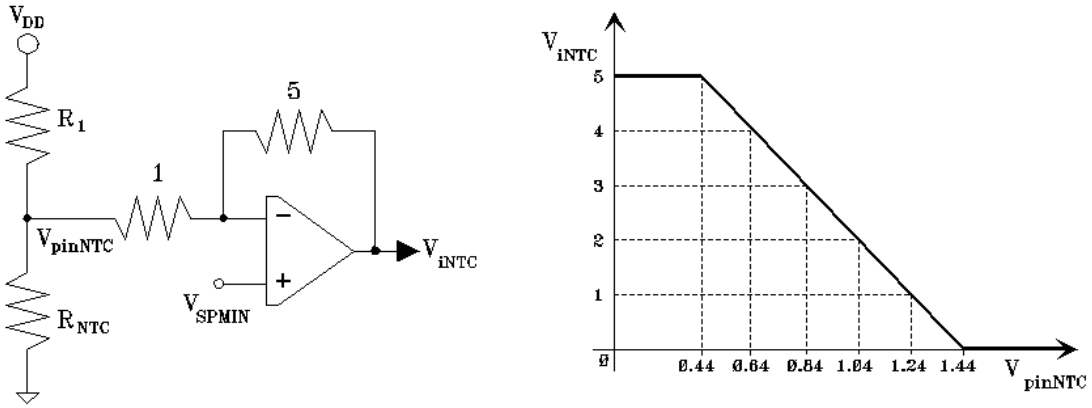


Fig. 9 Amplification of the NTC input signal

6.7 FCin Input

It is an analog input for external speed control. It gives speed information to the VCO and detects fan off condition. If no external voltage source is connected, an internal resistor divider fixes the voltage level at 5.4 % of $\mathbf{V_{DD}}$. FCin signal is processed in order to make the compare the **FCin** signal with the NTC one. See Fig. 9

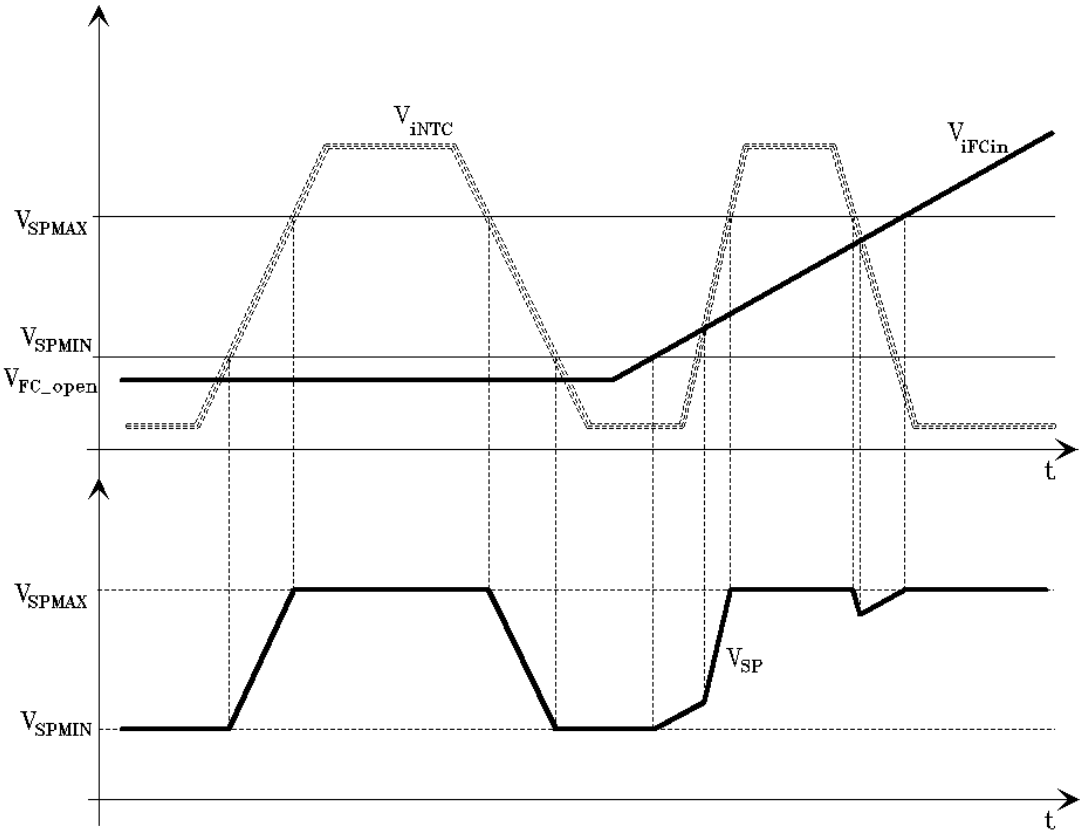


Fig. 10 NTC and FCin signal processing

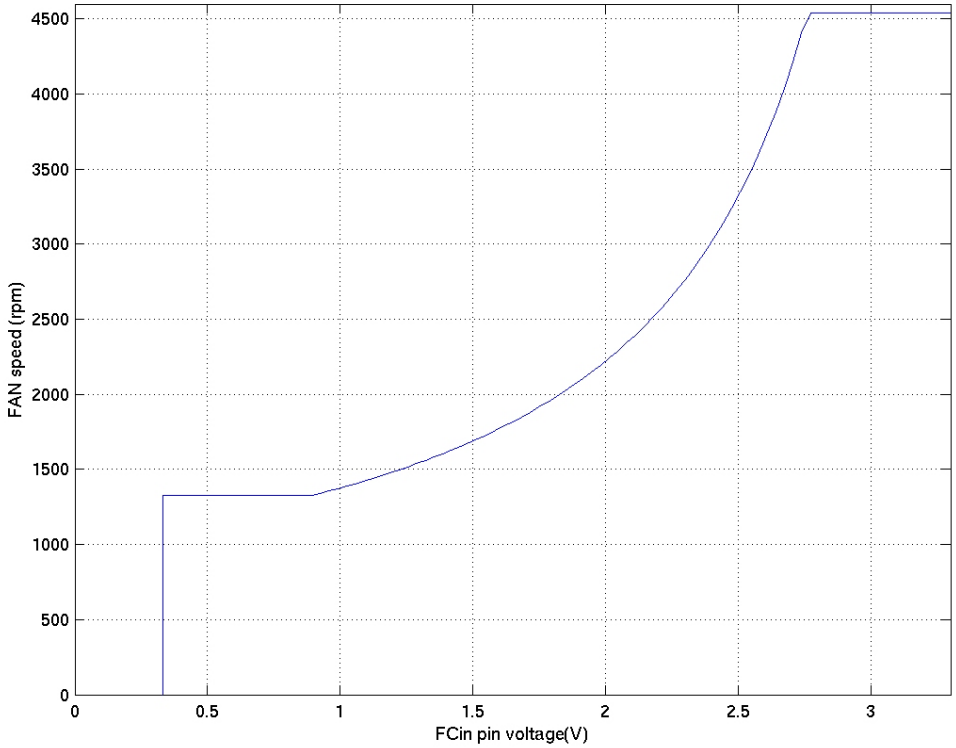


Fig. 11 FAN speeds vs. FCin pin voltage (FCin falling and NTC >10% of V_{DD})

6.7.1 Electrical Characteristic - FCin

At typical operating condition.

Parameter	***Symbol***	***CONDITIONS***	**Values**			**UNIT**
			Min.	**Typ.**	**Max.**	
OFF voltage limit	V_{FCoff}	Voltage Falling	2.32	2.9	3.48	% of V_{DD}
OFF voltage limit Hysteresis	$V_{FCoff-Hyst}$	To be added to the V_{FCoff}	0.3	0.4	0.5	
Voltage limit for minimum speed	V_{FCmin}		6	7.5	9	
Voltage limit for maximum speed	V_{FCmax}		20.7	23	25.3	
Open pin voltage	$V_{FC\ open}$		5.1	5.4	5.7	
Input resistance	R_{FC}		100	160		kΩ

6.8 Under Voltage Lockout Block

At the power ON/OFF, until the V_{DD} is below 3V the **FanM**, **RC-VCO** and **TRSOUT** pins are all set up to high impedance state (oscillation and OTP warning not allowed). When V_{DD} is crossing between 3 and 7V, **FanM** is switched to Low level, OTP is still not activated and **TRSOUT** pulled up to V_{DD}.

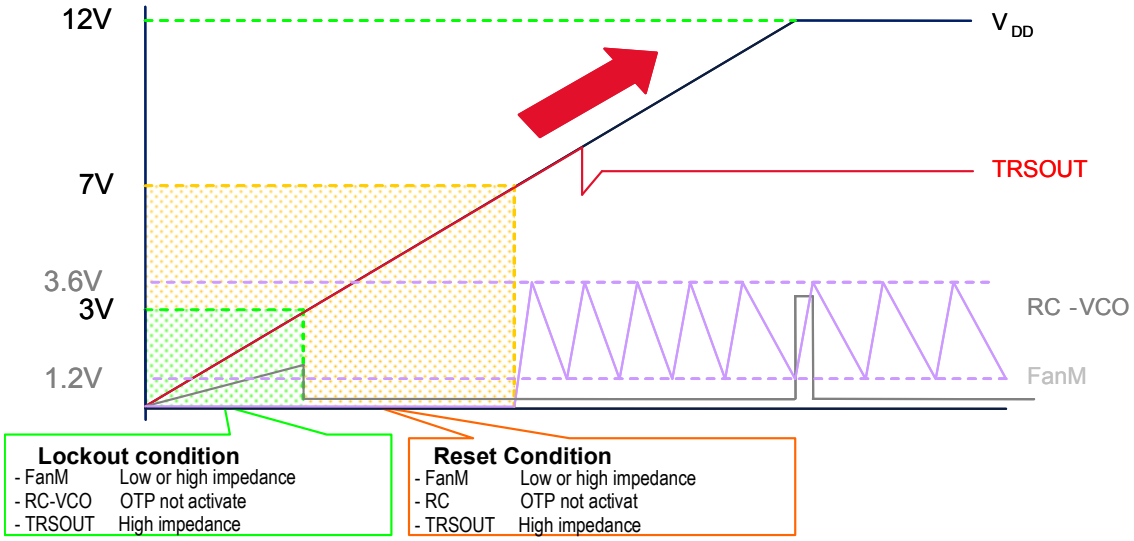


Fig.12 Power Up main waveforms transitory

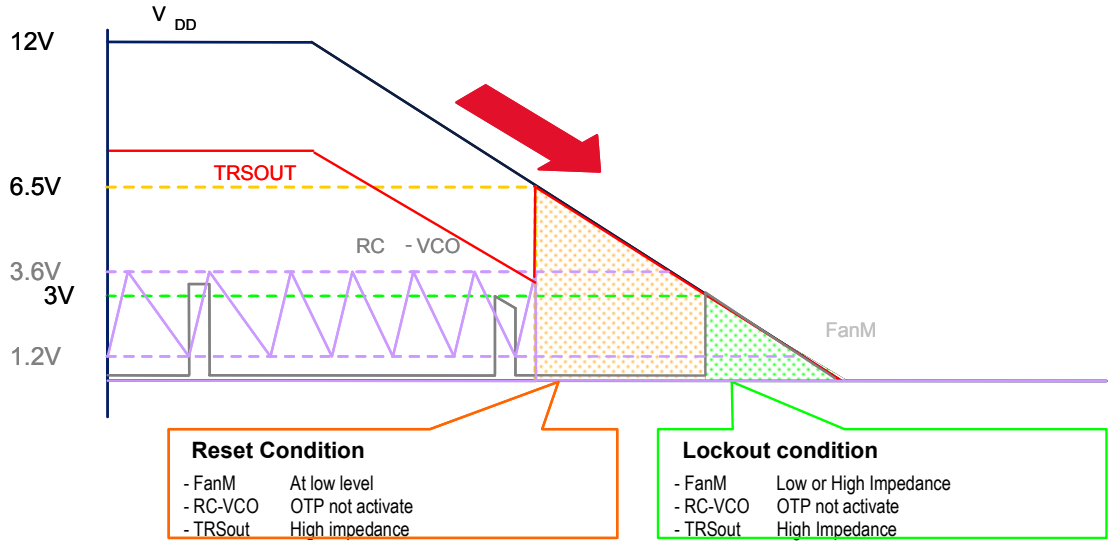


Fig.13 Power Down main waveforms transitory

6.8.1 Electrical Characteristic – Undervoltage Lockout

At typical operating conditions

Parameter	Symbol	CONDITIONS	Values			Unit
			Min.	Typ.	Max	
Lockout Mode Voltage Limit	V_{TLOCK}	slew rate < 5V/ms			3	V
Reset Mode Limit Voltage for rising transient	V_{RH}			7	8	
Hysteresis	Hyst		-0.46	-0.58	-0.7	

6.8 FanM

The **FanM** is a digital output to show the fan speed. The output is an open drain MOSFET with internal pull up and pull down to have same behavior like a 3.3V pull up of 10K.
If there is no OTP-condition detected by the analogue-speed-value block, the **FanM** signal with running fan will have a duty cycle of 12.5% in steady state condition and if the fan is able to run at the loop speed). If the fan is not able to run at the loop speed the duty cycle is lower than 12.5%.
The **FanM** signal is generated to give two pulses per revolution for a four poles fan. Each of the 2 pulses has the same time length of t = 16 / frequency of VCO
There are 2 exceptions:

a) FanM output with OTP-early-warning condition at NTCin-pin:

This condition is detected, if the **NTC** input goes below V_{NTC_EW} (with a certain hysteresis V_{Hyst_EW}).
In this case the FanM-signal will be inverted to give a warning to the PC-system, that the power supply is becoming too hot and soon might be switched off.
In this case the **FanM** duty cycle will switch to 87.5% or higher.

b) FanM output with OTP-psu-shut-down condition at NTCin-pin:

FanM goes to continuous HIGH-position = open Drain MOSFET off. This is a way that an external control system can detect that there is an OTP condition. This signal is a static signal, because the RC-VCO pin will also be used as OTP output. This will stop the oscillator.

6.8.1 Electrical Characteristic – FanM Signal

At typical operating conditions

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Output voltage high	V_{FanM_H}	Generated from V_{DD}=12 V	26.5	26.8	27.1	%of V_{DD}
Output voltage low	V_{FanM_L}	I_{sink} =6m A			0.4	V
Output impedance	R_{FanM}		6.6	10	12.8	kΩ

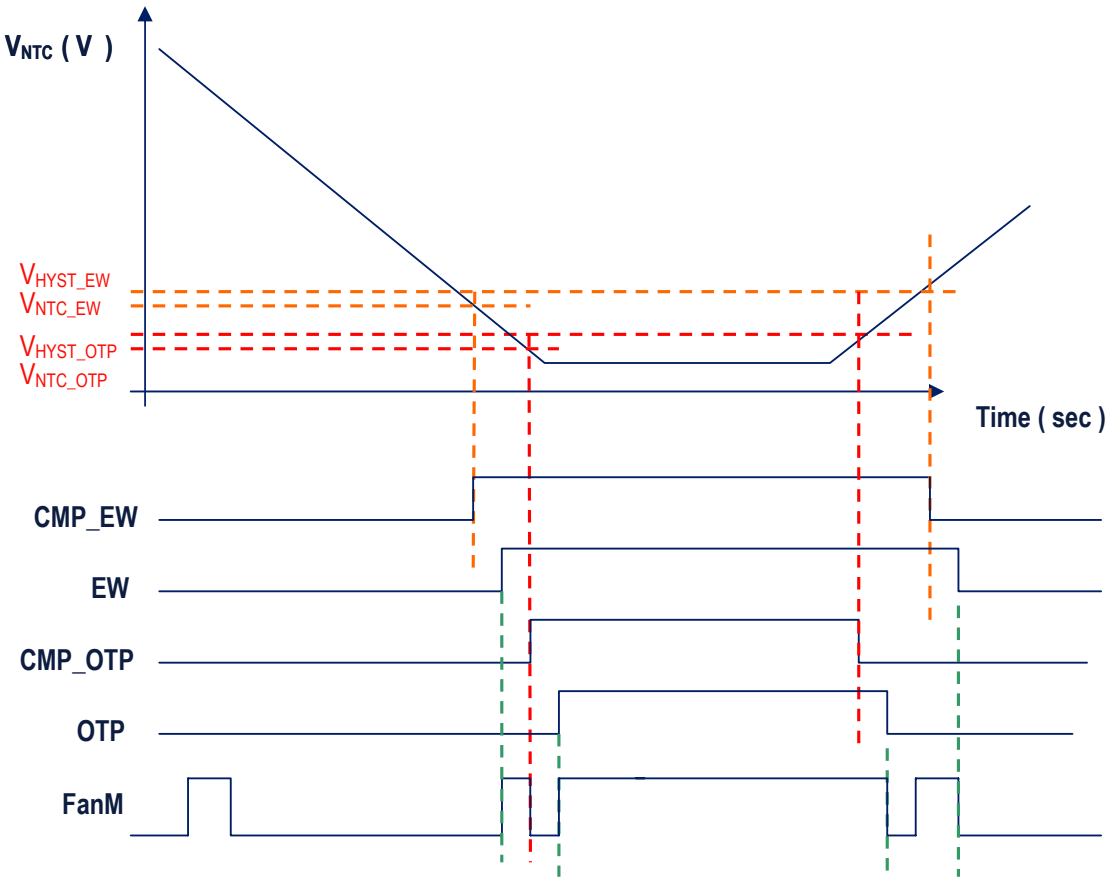
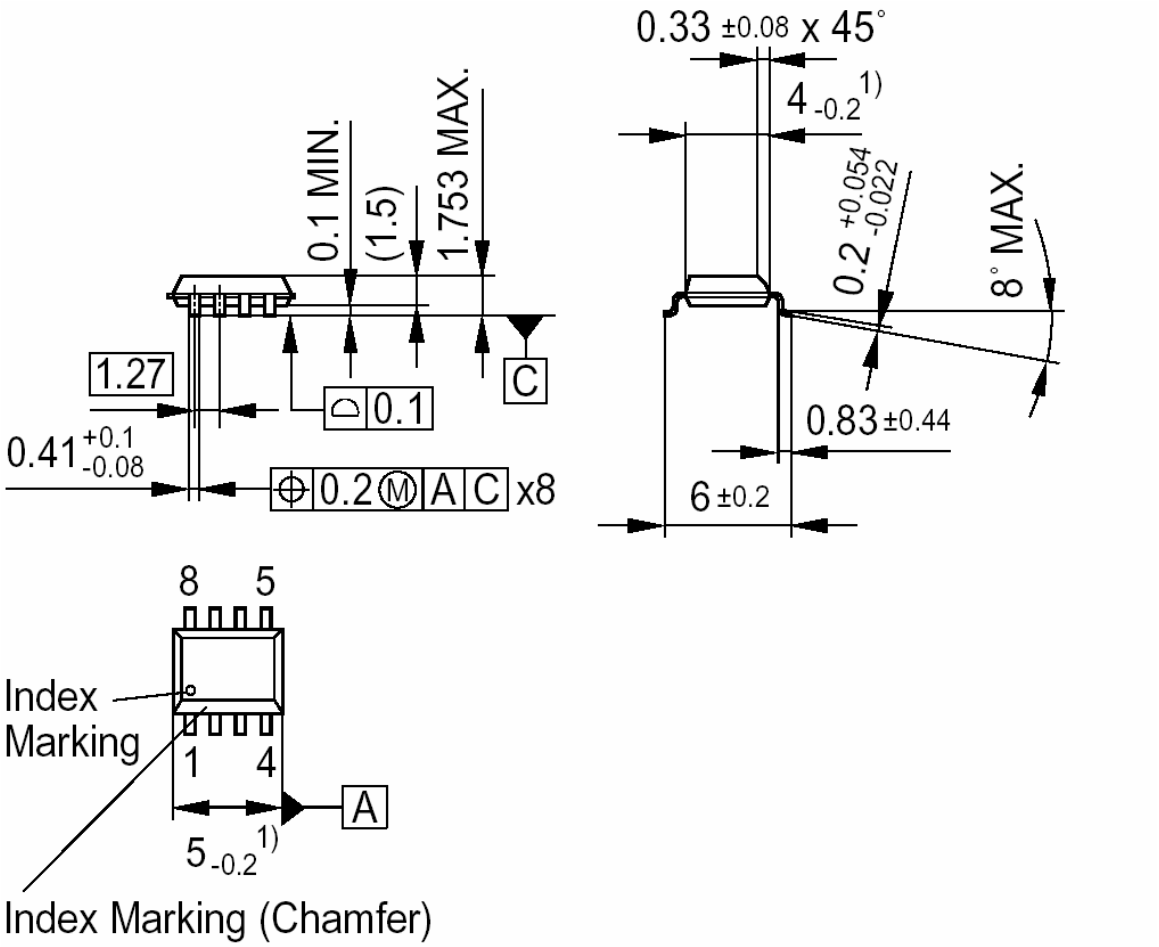


Fig. 14 Signal of the FanM vs NTC pin voltage

7. Outline Dimension:



1) Does not include plastic or metal protrusion of 0.15 max. per side

7.1 Footprint Drawing PG-DSO-8

e	A	L	B
1,27 mm	5,69 mm	1,31 mm	0,65 mm

Revision History			
Datasheet DS-FanControl-TDA21801			
Actual Release: V2.11	Date: 06.05.2005	Previous Release:V2.1	Date: 30.03.2005

Page of actual Rel.	Page of prev. Rel.	Subjects changed since last release
13	**13**	**Add test condition "25°C <Tj<100°C" to Ivco-source.**
20	**20**	**R_{NTC} Tolerance changes from "min=30kΩ,max=50kΩ" to "min=26.3kΩ,max=51.4kΩ"**
25	**25**	**R_{FANM} Tolerance changes from "min=7.5kΩ,max=12.5kΩ" to "min=6.6kΩ,max=12.8kΩ"**

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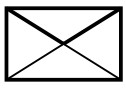

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