



Noctua PWM specifications white paper

Scope of this paper

The scope of this white paper is to provide a detailed technical documentation of the PWM (Pulse Width Modulation) speed control features of Noctua's 4-pin PWM fans. Detailing aspects such as connector types, pin configuration or RPM speed signal output as well as signal specifications and circuit design questions, it enables engineers to implement PWM based speed control for Noctua fans in custom circuit designs and applications. While using PWM based fan speed control in PC environments is usually straightforward and does not require any of the background knowledge that is contained in this paper, it can be vital when it comes to controlling fans via PWM in other environments. Unless otherwise noted, the following information applies to all Noctua 5V, 12V and 24V 4-pin fan models.

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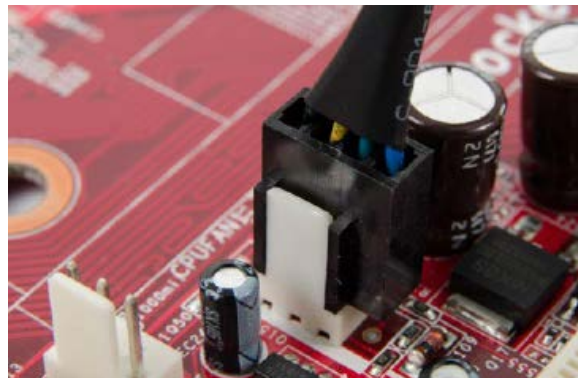


Connectors and cables

The cables of Noctua's fans terminate with a female connector that can be connected to corresponding male connectors or PCB headers. Please refer to the following table for a list of compatible connector models:

Female connector (fan)	Male PCB header	Male connector
Wieson 2510C888-001	Wieson 2366C888-007	Everconn CH2510CH-04-03
Molex 47054-1000	Molex 47053-1000	
Everconn 2510Z series	Foxconn HF27040-M1	
	Tyco 1470947-1	
	Everconn 2600PSZ series	

Note that female 4-pin connectors are compatible with male 3-pin PCB headers provided adequate space next to the header is available:



The default cable length of Noctua fans varies from model line to model line (see table below). If you need extension cables, please purchase the NA-SEC1 set that contains three 30cm 4-pin extension cables. For industrial clients, 60cm extension cables are available on request.

Product line	Cable length
Standard	20cm + 30cm extension included
industrialPPC	40cm
chromax	1cm + 30cm extension included
redux	40cm

If you would like to control two Noctua 4-pin PWM fans via a single PWM fan header, you can use a NA-YC1 y-cable to do so. The NA-YC1 is supplied with many Noctua fans (see scope of delivery specifications on www.noctua.at) and can be purchased in the NA-SYC1 set (contains two pieces).

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Pin configuration

4 pin 5V fans (PWM)



- Blue = PWM Signal (+5V)
- Green = RPM Speed Signal
- Yellow = +5V
- Black = Ground (GND)

4 pin 12V fans (PWM)



- Blue = PWM Signal (+5V)
- Green = RPM Speed Signal
- Yellow = +12V
- Black = Ground (GND)

4 pin 24V fans (PWM)

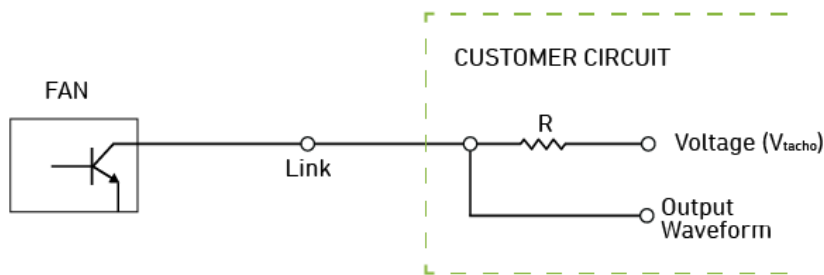


- Blue = PWM Signal (+5V)
- Green = RPM Speed Signal
- Yellow = +24V
- Black = Ground (GND)

Tachometer output signal and RPM speed calculation

All Noctua fans provide a tachometer output signal of the following characteristics:

- two cycles per revolution
- open collector output
- Maximum current is 5mA for 5V and 12V fans and 2mA for 24V fans, so for example, when using a 12V fan a resistor value of 2.7K Ohm or larger is suitable.



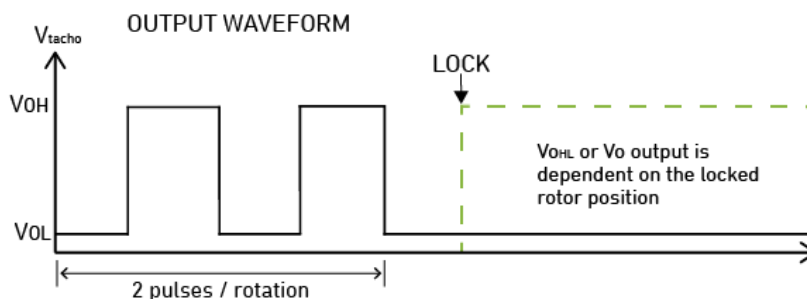
Please select "R" to make "Link" less than 5 mA (2mA for 24V fans)

V_{tacho} for 12V fans:
5V recommended (13V max.)

V_{tacho} for 5 & 24V fans:
5V recommended (6V max.)

Link for 5V & 12V fans:
5mA

Link for 24V fans:
2mA

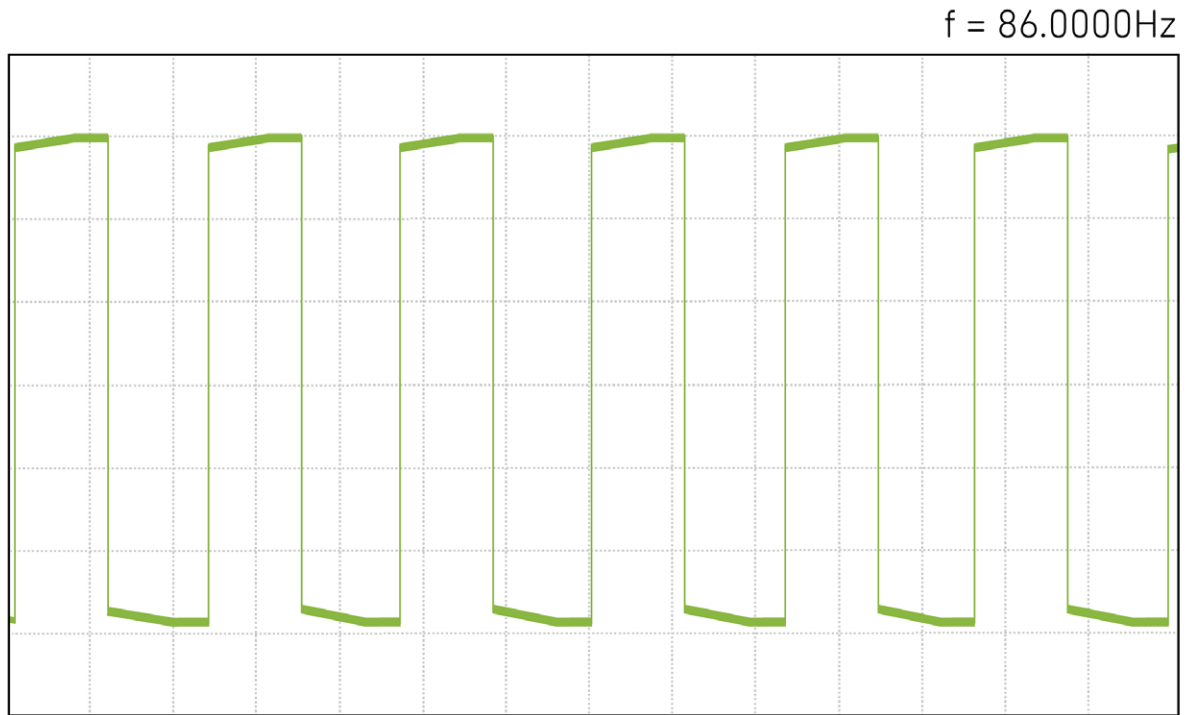


If the fan rotor is locked, the tachometer output signal will remain either at high or low depending on the position of the rotor.

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Wave form examples and RPM speed calculation



Note that while the tachometer output signal is in Hertz (= per second), fan speeds are usually specified in RPM (= revolutions per minute). This means that the signal must be multiplied by 60 in order to convert it to RPM. However, as the fan puts out two impulses per revolution, the reading must also be divided by 2.

Therefore, the formula for obtaining correct RPM speed is:

$$\text{fan speed [rpm]} = \text{frequency [Hz]} \times 60 \div 2$$

The calculation for the above example waveform is:

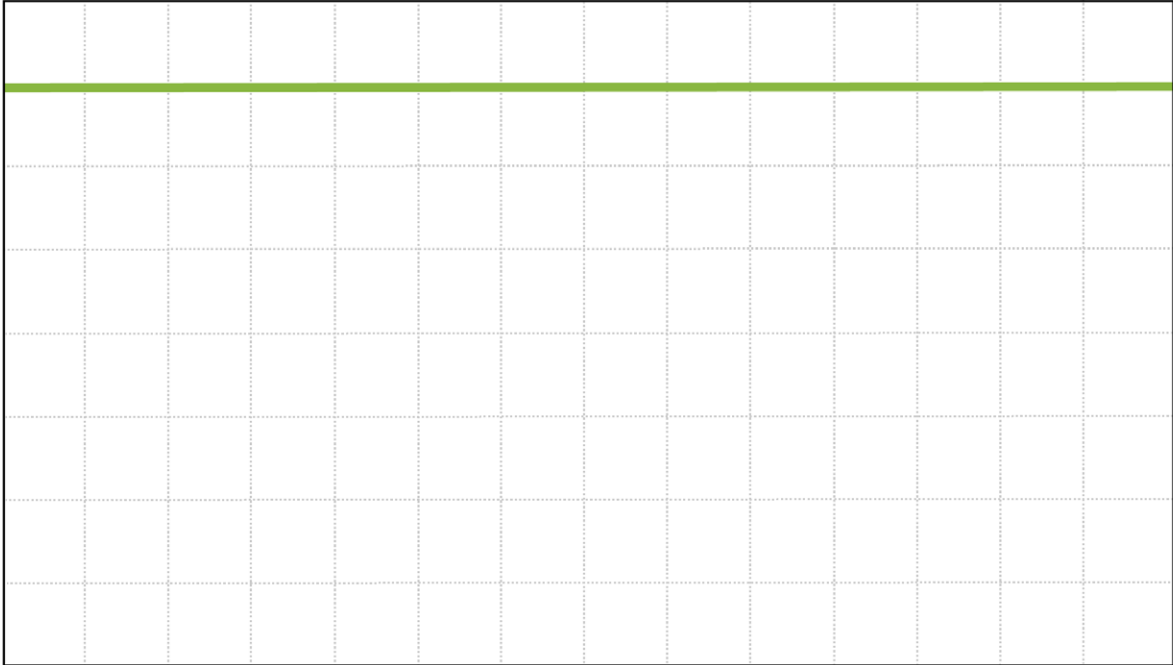
$$86 [\text{Hz}] \div 2 \times 60 = 2580 [\text{rpm}]$$

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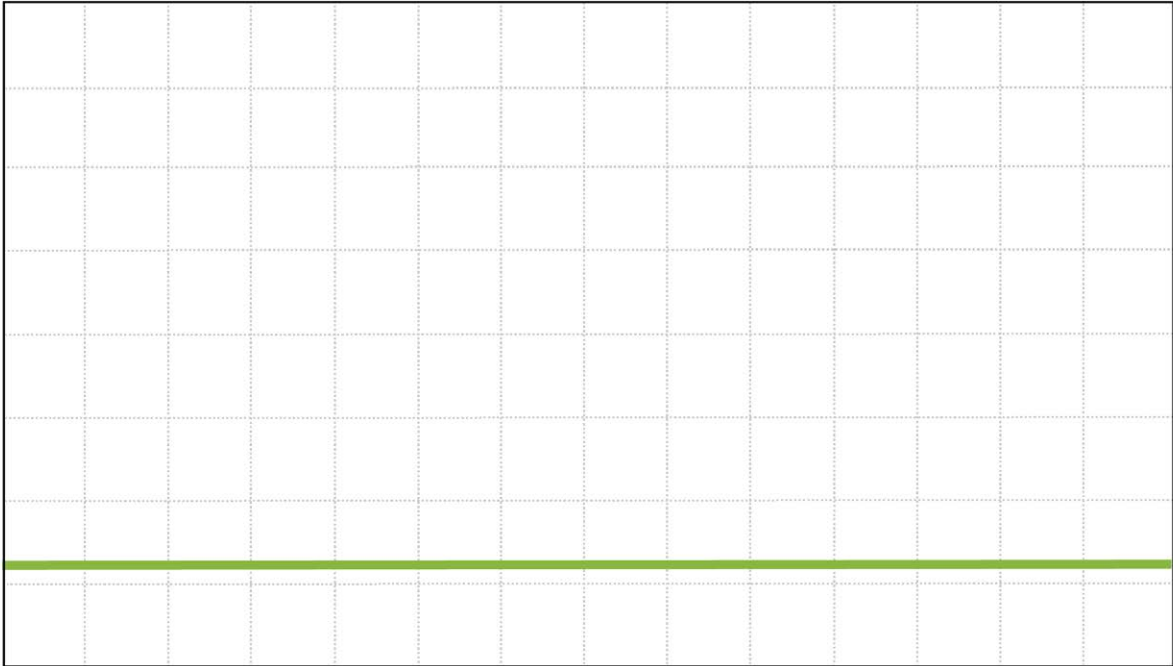


Locked rotor wave forms

$f = < 10\text{Hz}$



$f = < 10\text{Hz}$



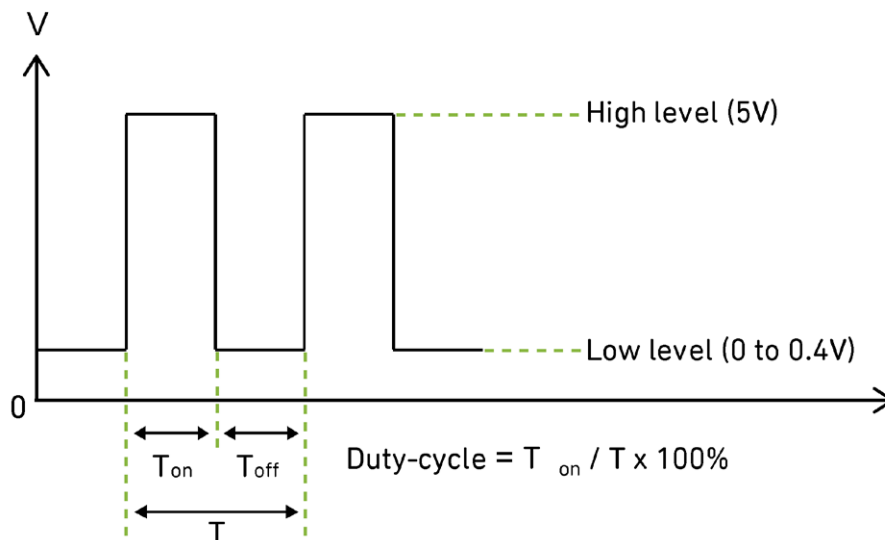
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PWM control input signal

As specified by Intel (c.f. "4-Wire Pulse Width Modulation (PWM) Controlled Fans", Intel Corporation September 2005, revision 1.3), the square wave type PWM signal has to be supplied to the PWM input (pin 4) of the fan and must conform to the following specifications:

- Target frequency: 25kHz, acceptable range 21kHz to 28kHz
- Maximum voltage for logic low: $V_{IL}=0,8V$
- Absolute maximum current sourced: $I_{max}=5mA$ (short circuit current)
- Absolute maximum voltage level: $V_{Max}=5,25V$ (open circuit voltage)
- Allowed duty-cycle range 0% to 100%



The signal is not inverted, 100% PWM duty cycle (= 5V DC) results in maximum fan speed.

External pull-up is not necessary as the signal is pulled up to 3,3V/5V inside the fan.

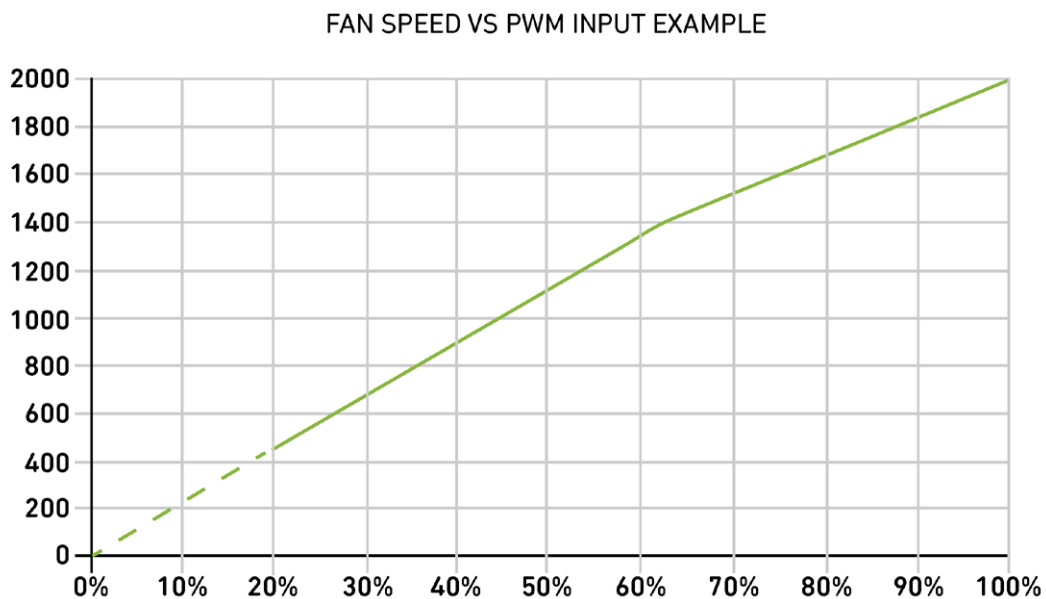
WARNING: Connecting 12V or 24V supply voltage to the PWM pin (pin 4) will instantly damage the fan.

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Fan speed response to PWM control signal

The fan's speed scales broadly linear with the duty-cycle of the PWM signal between maximum speed at 100% PWM and the specified minimum speed at 20% PWM (see www.noctua.at for individual fan specifications): For example, the NF-A12x25 PWM has a maximum speed of 2000rpm and a minimum PWM speed of 450rpm, so it will run at 2000rpm at 100% PWM, 450rpm at 20% PWM and around 1100rpm at 50% PWM:



Operation below 20% PWM duty-cycle is not officially supported in the Intel specification (undefined behaviour). However, most Noctua PWM fans can be operated at below 20% and will stop at 0% duty-cycle. Only the following models keep running at their specified minimum speed when the input is below 20%: NF-A20 PWM, NF-S12B redux 1200 PWM and NF-B9 redux 1600 PWM

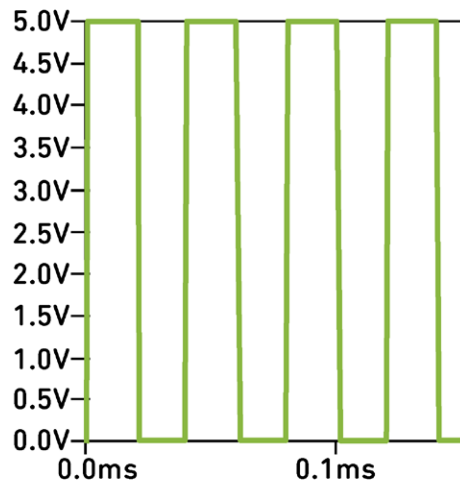
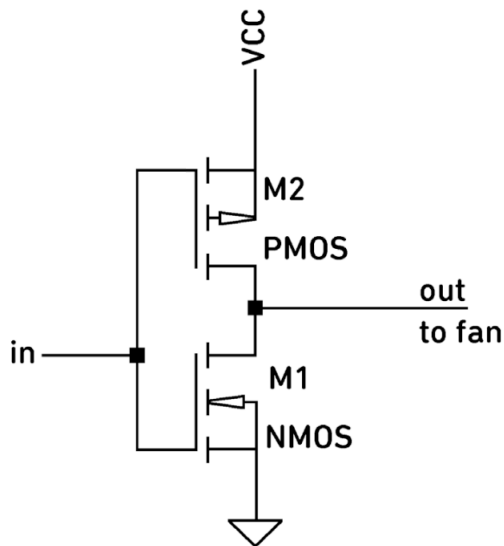
The fans operate at full rated speed if there is no PWM input signal.

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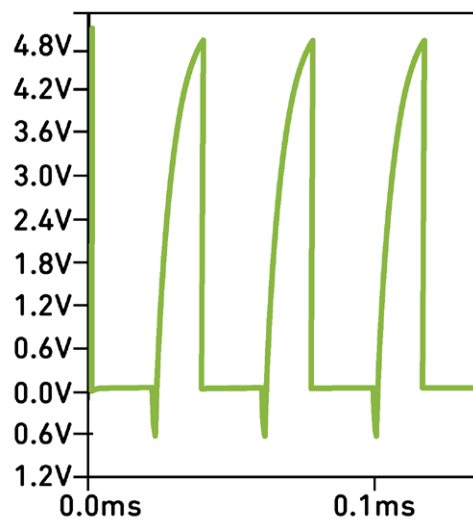
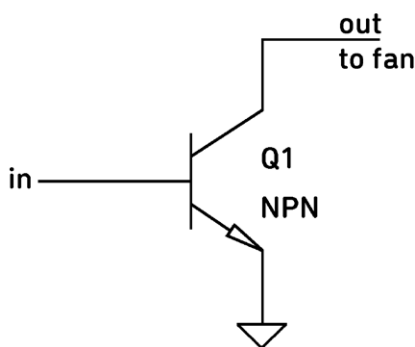


Driving circuit

There are no special requirements for the circuits that generate the PWM signal. However, Noctua recommends to use a CMOS-inverter type circuit as shown below. This is the very circuit that is used for GPIO pins inside most micro-controllers.



Open collector designs as shown below are not recommended, because as there is very little current sourced from the fan the waveform may become deformed. This can lead to erroneous fan behavior.



Additional recommendations

For applications that only require manual rather than automatic speed control, Noctua's NA-FC1 is a small, easy and straightforward way to control 5 and 12V PWM fans in non-PC environments.