

Monitoring Fan Tachometers Using the UCD908x Family

Steven Dunbar

PMP - Analog Field Applications

ABSTRACT

The UCD908x family of power supply sequencers/monitors provides a flexible platform for managing the power sub-system of projects having a variety of power supply rails. Typically, these projects also require thermal management and utilize fans to provide cooling air flow. The supervisor inputs can be used to monitor fan tachometer outputs using a minimal amount of inexpensive external circuitry. This Application Report describes methods to implement fan tachometer monitoring capabilities.

Contents

1	Introduction	1
2	Frequency-to-Voltage Conversion using the SN74HC123	2
3	Error Stack-up and Monitoring Requirements	3
	3.1 Numerical Example #1	4
	3.2 Numerical Example #2	5
4	Conclusion	5
5	References	6

List of Figures

1	Functional Block Diagram of the SN74HC123	2
2	Single Input, Single Output Fan Tachometer Interface to the UCD908X	2
3	Dual Input, Dual Output Fan Tachometer Interface to the UCD908X	3
4	Dual Input, Single Output Fan Tachometer Interface to the UCD908X	3
5	Frequency-to-Voltage Gain Variation Due to Component Tolerances	4
6	Frequency-to-Voltage Function Using an 8 ms Pulse Duration	5

1 Introduction

This Application Report demonstrates how to add fan tachometer monitoring capability to the UCD908x family of power supply supervisors/sequencers. Using a single SN74HC123 package as a frequency-to-voltage converter, two fans tachometers may be monitored independently. Alternatively, two fans can be monitored with a single supervisory channel by combining the two outputs of the SN74HC123.

Note: In order to make the most sense out of this document, please make certain you are familiar with the features and capabilities of the UCD9080 by reviewing its datasheet and EVM User's Guide. References to these documents are found at the end of this document.

2 Frequency-to-Voltage Conversion using the SN74HC123

The SN74HC123 logic device is a dual mono-stable multi-vibrator (one shot). It is an edge-triggered device that emits a logic pulse, of programmable duration, for each edge that it receives on its trigger input. The average DC value of the pulse train emitted by the SN74HC123 is proportional to fan tachometer frequency since each output pulse has a fixed duration. The SN74HC123 is capable of triggering on either rising or falling edges, but in this particular application the falling edge is used. Most fan tachometer outputs are open-drain or open-collector outputs connected to a pull-up resistor. As such, the falling edge will be a faster edge and is thus a better candidate for triggering the 'HC123.

Figure 1 shows the functional diagram for the dual one-shot, SN74HC123.

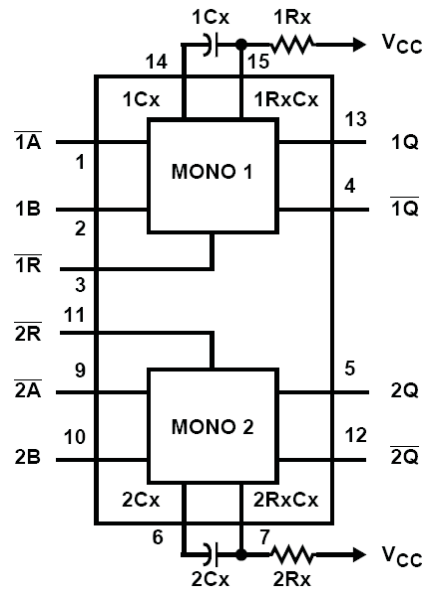


Figure 1. Functional Block Diagram of the SN74HC123

The duration of the timing pulse generated by each edge detected by the device is determined by the RC time constant of C_x and R_x . For the SN74HC123, the duration of the timing pulse is typically $t_w = 0.45 \times R_x \times C_x$, though over process, temperature, and component variation this can vary the timing significantly. Please note that this timing formula may vary from other vendors and should be verified if attempting to dual source this device.

The schematic for a single channel fan tachometer is as follows:

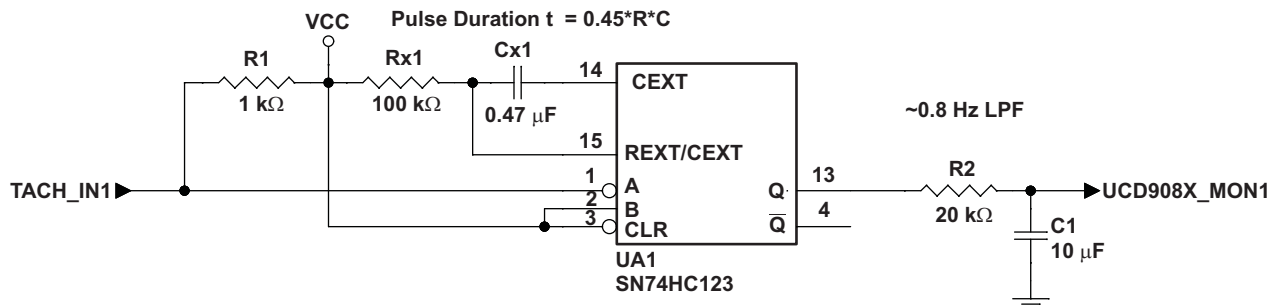


Figure 2. Single Input, Single Output Fan Tachometer Interface to the UCD908X

The schematic for a dual channel, dual output fan tachometer is as follows:

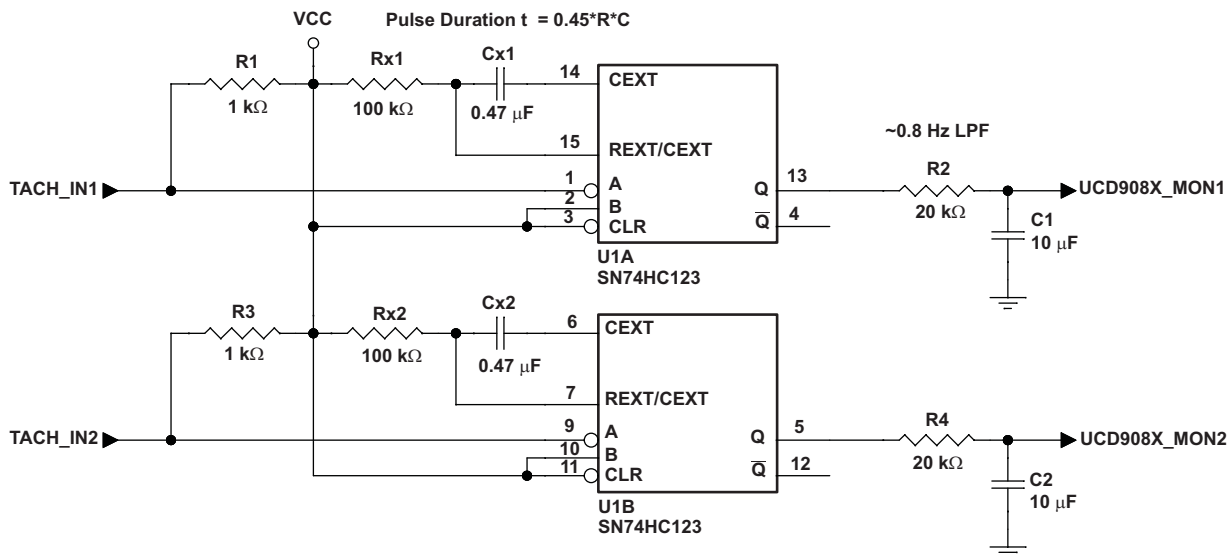


Figure 3. Dual Input, Dual Output Fan Tachometer Interface to the UCD908X

If only a single supervisory input is available on the UCD908X, the outputs of the SN74HC123 can be combined, shown in Figure 4, to generate an averaged signal monitoring two fans.

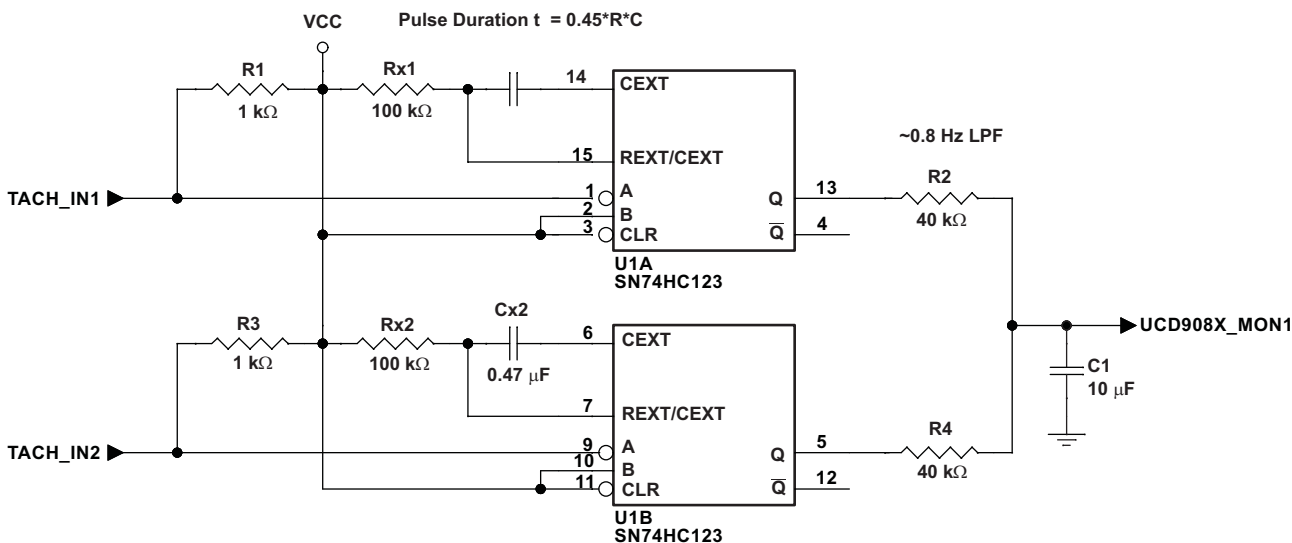


Figure 4. Dual Input, Single Output Fan Tachometer Interface to the UCD908X

3 Error Stack-up and Monitoring Requirements

This approach to monitoring the fan tachometer has noticeable linearity. At 0 Hz input, the output of the above circuits will be 0.0 Volts, and will increase in a straight line up to VCC, or 100% duty cycle. However, due to IC process variation of about $\pm 11\%$, resistor variation of $\pm 1\%$, and capacitor variation of 10%, the overall slope of the aforementioned straight line can vary significantly, as shown in Figure 5.

The "typical" line shown in Figure 5 is obtained using typical values when the SN74HC123 is programmed to output an 18 ms pulse. The -Tol and +Tol lines represent the deviation from "typical" when using a $\pm 23\%$ pulse variation to account for worst case component tolerances.

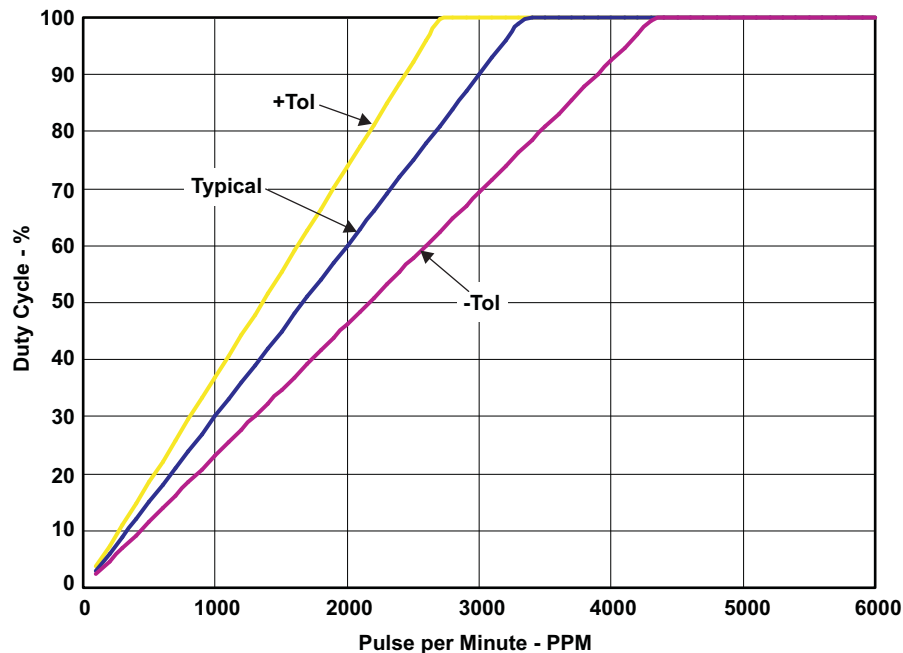


Figure 5. Frequency-to-Voltage Gain Variation Due to Component Tolerances

Note that not all fans emit 1 pulse per revolution of the fan. The x-axis of [Figure 5](#) is normalized to *Pulse-per-Minute* rather than RPM to account for this. When designing a fan tachometer, the Pulse-per-RPM ratio must be understood in order to achieve useful results.

3.1 Numerical Example #1

Assume for this example that the fan requiring monitoring typically emits 5000 PPM during healthy operation, and that the SN74HC123 is programmed to emit pulses of 18 ms duration for each falling edge received from the fan tachometer output. In this case [Figure 5](#) applies to this example. Further, let's assume that a desired error flag generates if the output of the tachometer falls to approximately 2500 PPM, or about half speed.

From [Figure 5](#) notice that the output of the SN74HC123 will typically average out to 80% of V_{DD} at about 2500 PPM; $80\% \cdot 3.3V = 2.64V$. The supervisor threshold of the UCD908x should then be set to 2.64V. Also from [Figure 5](#), uncompensated component variations can cause the assured measurement limits to fall at 2200 PPM and 3500 PPM respectively. Therefore detection of a fault by the UCD9080 indicates that the fan is operating within this range of values, and well below that expected for a normally operating fan.

While the effects of component variation may seem dramatic, given the *go, no-go* nature of most fan tachometer applications (either the fan is turning or it's not) this is still a robust and simple method for detecting fan failures.

If additional accuracy is desired there are at least two ways to adjust this circuit. First, the RC timer network that programs the SN74HC123 may be implemented with a traditional or digital potentiometer or a trim-DAC to compensate for the variation. Second, the threshold of the UCD908x may be trimmed up or down to account for component variation such that an alarm is generated at a specific PPM reading. The later method requires no additional hardware, and either method would be trimmed during the final electrical testing of the system.

Stacking multiple tachometers onto a single UCD908x Supervisor input, such as that shown in [Figure 4](#), becomes problematic without compensating for both tachometers due to the component variation issues. Even with two tachometers, care must be taken to design the timing circuitry around the SN74HC123 and the threshold of the UCD908x such that a fault can be detected easily. In the case of [Figure 4](#), the supervisor effectively measures the average of the two 'HC123 outputs and without proper consideration for tolerance, either a failure to detect a fault condition or a false-failure can result.

3.2 Numerical Example #2

Certain applications can not tolerate the saturating characteristic of Figure 5, and instead a completely linear transfer function is desired. By reprogramming the 'HC123 for a shorter output pulse the linear range may be extended to higher PPM rates. For instance, programming the 'HC123 with an 8 ms pulse width results in the following transfer function:

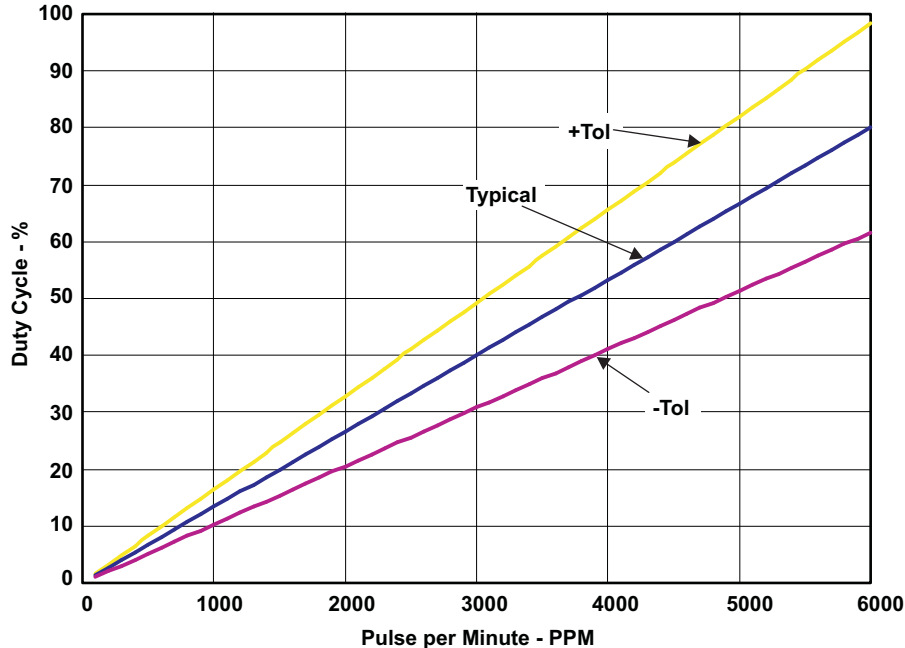


Figure 6. Frequency-to-Voltage Function Using an 8 ms Pulse Duration

In this case, a fan that typically generates 5000 PPM will output a duty cycle of 67% using typical-valued components. Without compensating for component variations the actual output could vary from 51% to 82%. However, if we make the rather safe assumption that the components will vary little over time once a unit is built, then we can rely on relative changes in the output for the detection of faults.

For example, assume that a unit is built and the component variation stack-up is such that the 'HC123 output falls along the -Tol line of Figure 6. At 5000 PPM this generates 51% duty cycle. Since we know the output falls along a straight line intersecting the origin, if the fan were to slow to 2500 PPM due to bearing wear, the output would also be only half of the healthy value or 25.5%. Further, if the fan were to begin spinning faster due to a vacuum induced by a plugged inlet that would also be reflected in the pulse rate increasing beyond the initial healthy value.

Using this form of fan detection requires that a calibration value be noted during healthy operation so that deviations may be detected in light of inevitable component variations. The UCD908X is then used to sample the output of the 'HC123 and embedded firmware in the host processor performs the fault detection.

4 Conclusion

The UCD908x family of Power Supply Sequencers/Monitors is capable of monitoring many other analog parameters found in a typical system implementation beyond power rail integrity. Using voltage-mode inputs with digitally programmable thresholds it is capable of measuring other quantities such as temperature. With the appropriate external interface hardware it can measure fan speed. This Application Report outlines how to implement such a fan monitor using an inexpensive logic device, as well as describes the details and issues associated with component variation so that a robust tachometer can be constructed.

5 References

1. SN74HC123, High-Speed CMOS Logic Dual Retriggerable Monostable Multivibrators with Resets ([SCHS142F](#))
2. UCD9080, 8-Channel Power Supply Sequencer and Monitor ([SLVS692D](#))
3. Expanded System Monitoring Functions with UCD9080 (Rev. A) ([SLUA426A](#))
4. Programming the UCD9080 ([SLUA441](#))
5. UCD9080 Power Supply Sequencer and Monitor EVM User's Guide(Rev. A) ([SLVU184A](#))

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated