4-Wire Pulse Width Modulation (PWM) Controlled Fans

Specification

September 2005

Revision 1.3

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Revision History

Revision Number	Description	Revision Date
1.0	Initial Release	Nov 2003
1.1	Corrected Tachometer input signal, added definitions to operating modes	Dec 2003
1.2	Corrected Section 2.4 PWM input parameter	July 2004
1.3	Clarified & Expanded requirements on PWM for Hardware Monitor Devices	Sept 2005

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1 Introduction

1.1 Overview

This specification defines the intended operation of a fan that implements the Pulse Width Modulation (PWM) control signal on the 4-wire fan interface. The introduction of 4 wire PWM controlled fans is a means to reduce the overall system acoustics. The expectation is a 4 wire PWM controlled fan when properly implemented will be significantly quieter than a similar 3 wire fan.

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2 Electrical Specifications

2.1 Fan Requirements

2.1.1 Fan Input Voltage

Fan operating voltage shall be within the range 12 V ±5% V.

2.1.2 Current

Steady state operation fan current draw (with 12.6 V applied, with fan operating in the free stream condition) shall not exceed 1.5 A.

Fan current spike during start-up operation (with 12.6 V applied, with fan operating in the free stream condition) shall be allowed to exceed 1.0 A, up to 2.2A maximum for a duration of no greater than 1.0 sec.

2.1.3 Tachometer Output Signal

Fan shall provide tachometer output signal with the following characteristics:

- Two pulses per revolution
- Open-collector or open-drain type output
- Motherboard will have a pull up to 12V, maximum 12.6V

2.1.4 PWM Control Input Signal

The following requirements are measured at the PWM (control) pin of the fan cable connector see Figure 7 and Table 1:

PWM Frequency: Target frequency 25 kHz, acceptable operational range 21 kHz to 28 kHz

Maximum voltage for logic low:	VIL = 0.8 V
Absolute maximum current sourced:	Imax = 5 mA (short circuit current)
Absolute maximum voltage level:	VMax = 5.25 V (open circuit voltage)

This signal must be pulled up to a maximum of 5.25V within the fan.

Note: New fan designs are strongly encouraged to implement a 3.3V pull up for compatibility with buffer design limits on Hardware Monitor Devices e.g. Super IO devices.

2.2 Test Methodology

To measure the pull up and current sourced from the fan, power the fan to 13.2V and use a DMM (Digital Muli-meter).

To verify the pull up value in the fan, measure the voltage between pin 4 (control) and pin 1 (ground).

To verify the current sourced by the fan, measure the current between pin 4 (control) and pin 1 (ground).

2.3 Hardware Monitor Device

2.3.1 PWM Output Signal

The Hardware Monitor Devise is required to provide an open-drain or open-collector type output for the PWM signal on pin 4 (see Table 1 and Figure 8) with the following properties:

Frequency:	25kHz nominal, 21-28kHz is acceptable
Current sink capability:	5mA required, 8mA recommended
Maximum voltage capability:	5.25V
Maximum VOL:	0.8V

Signal is not inverted, 100% PWM results in Max fan speed

Figure 1. Screen Shot of PWM Duty Cycle

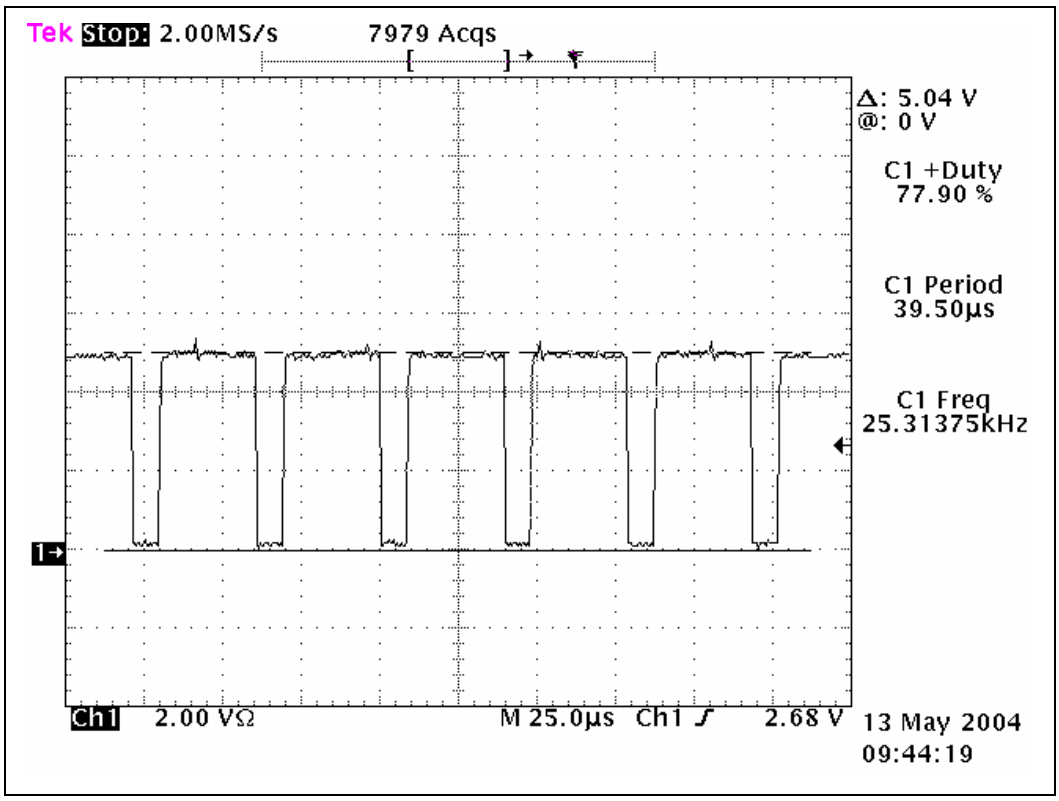

Figure 1 shows a PWM output operating at 25.3 kHz with a 77.9% duty cycle output with a fan having a ~ 5V pull up on the PWM signal.

A 100% duty cycle would be a constant 5V signal with this fan and Hardware Monitor device.

2.4 Considerations for Motherboard Designers

1. The trace from PWM output to the fan header must not have a pull up or pull down. The pull up is located in the fan hub. The presence of a pull up on the motherboard will alter the fan response to the PWM Duty Cycle. In some cases this may prevent the fan from achieving full speed even with the Hardware Monitor device issuing a 100% duty cycle.
2. If driving multiple fans with a single PWM output, an open-drain / open collector output buffer circuit is required. Consult your Hardware Monitor vendor for layout suggestions.

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3 Fan Speed Control

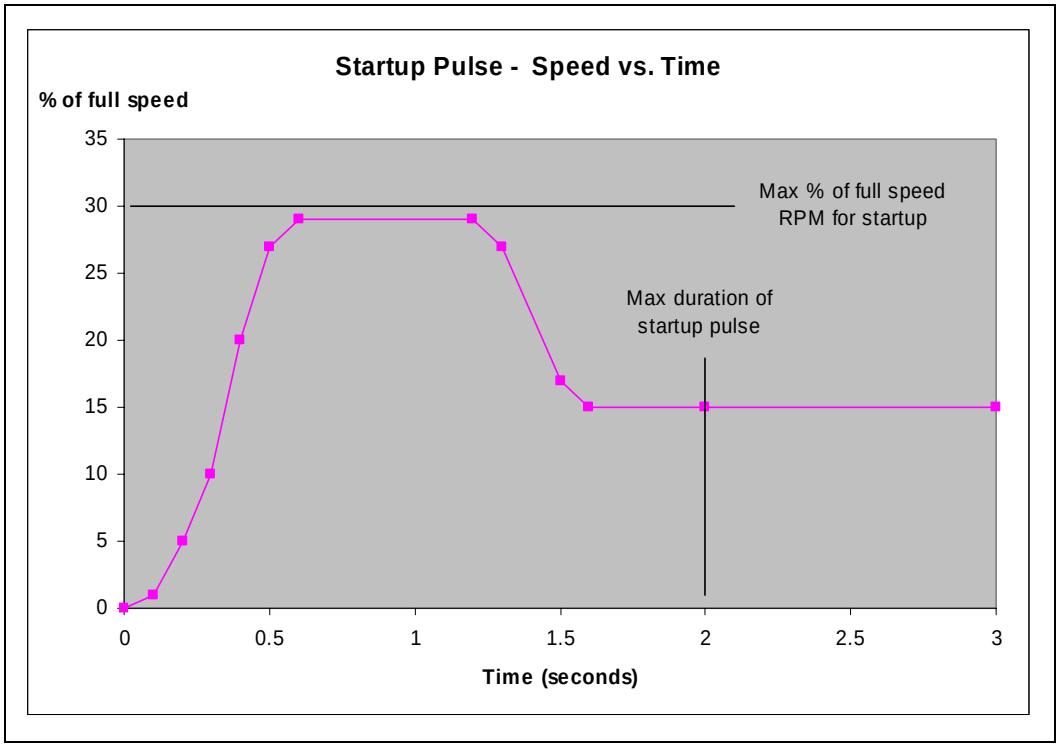
3.1 Maximum Fan Speed Requirements

The maximum fan speed shall be specified for the fan model by the fan vendor and correspond to 100% duty cycle PWM signal input.

3.2 Minimum Fan Speed Requirements

The vendor shall specify the minimum RPM and the corresponding PWM duty cycle. This specified minimum RPM shall be 30% of maximum RPM or less. The fan shall be able to start and run at this RPM. To allow a lower specified minimum RPM, it is acceptable to provide a higher PWM duty cycle to the fan motor for a short period of time for startup conditions. This pulse should not exceed 30% maximum RPM and should last no longer than 2 seconds. See Figure 2.

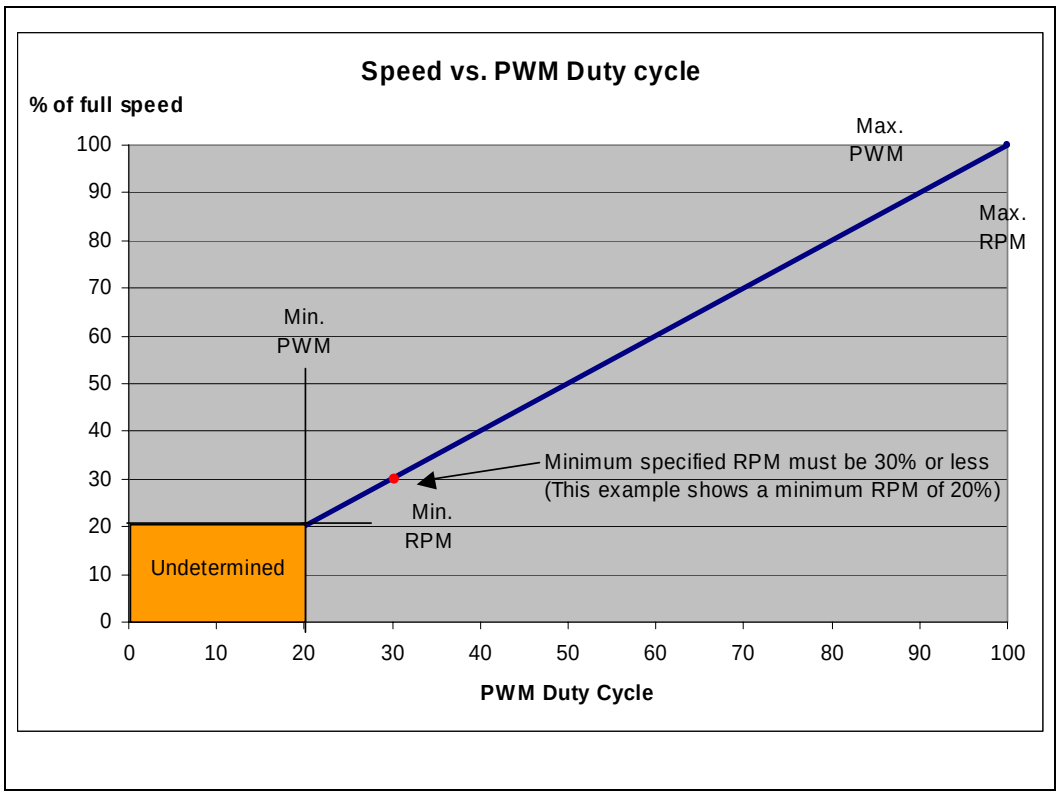
Figure 2 Minimum Fan Speed Requirements: Start Pulse



3.3 Fan Speed Response to PWM Control Input Signal

The PWM input shall be delivered to the fan through the control signal on Pin 4 (see Section 2.1.4). Fan speed response to this signal shall be a continuous and monotonic function of the duty cycle of the signal, from 100% to the minimum specified RPM. The fan RPM (as a percentage of maximum RPM) should match the PWM duty cycle within ±10%. If no control signal is present the fan shall operate at maximum RPM. See Figure 3.

Figure 3 Fan Speed Response to PWM Control Input Signal

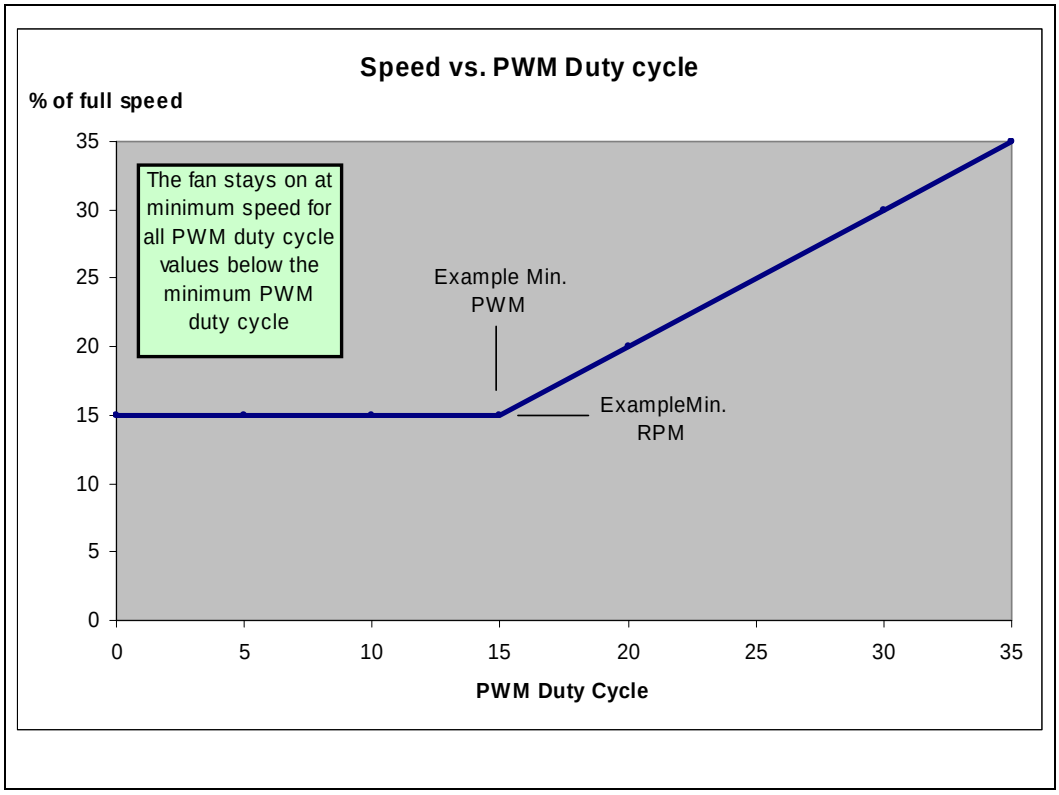


3.4 Operation below Minimum RPM

For all duty cycles less than the minimum duty cycle, the RPM shall not be greater than the minimum RPM. The following graphs and definitions show three recommended solutions to handle PWM duty cycles that are less than the minimum operational RPM, as a percentage of maximum.

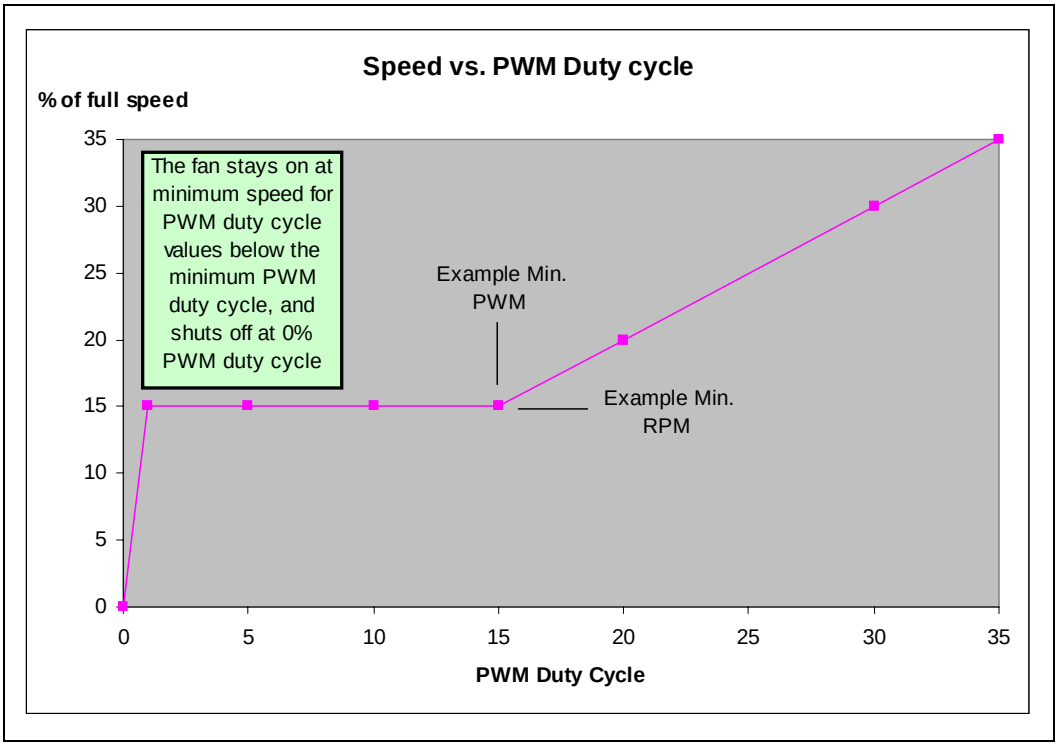
In a Type A implementation the fan will run at minimum RPM for all PWM duty cycle values less than minimum duty cycle. The minimum fan speed is controlled by design and can not be overridden by the external fan speed controller. See Figure 4.

Figure 4 Type A Operation, Minimum RPM, Stay on at Minimum RPM



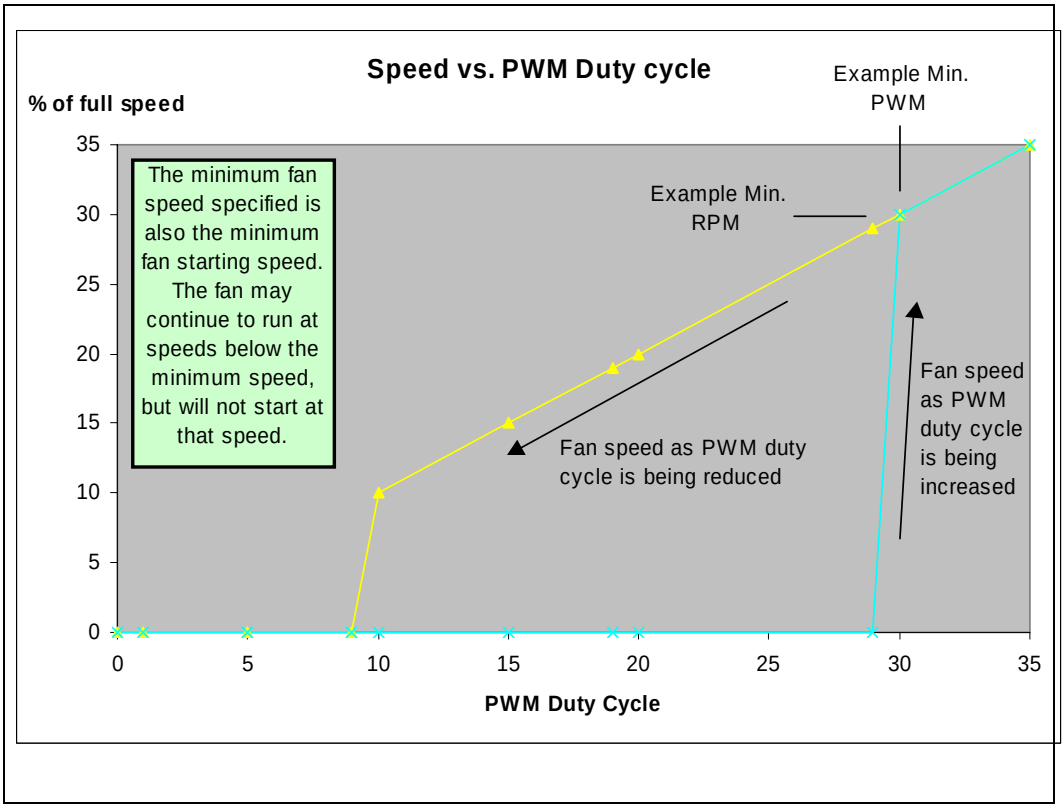
In a Type B implementation the fan will run at minimum RPM for all non-zero PWM duty cycle values less than minimum duty cycle and turn off the motor at 0% PWM duty cycle. See Figure 5.

Figure 5 Type B Operation, Stay On at Minimum RPM, Off at 0% RPM



In Type C implementation the fan will stop running when the current provided to the motor windings is insufficient to support commutation. The fan should not be damaged from this. The fan would also turn off the motor at 0% PWM duty cycle input. See Figure 6.

Figure 6 Type C, Operation below Minimum RPM, Min, RPM = Starting RPM



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4 Required Features

4.1.1 Polarity Protection

Fan motor shall have polarity protection.

4.1.2 Rotor Lock Protection

Fan rotor shall have lock protection and auto-restart

4.1.3 Wire Length

To be specified in individual fan specification based on application

4.1.4 Wire Type

Wire type shall meet the following minimum qualifications: UL recognized appliance wiring, style UL1430, rated minimum 105C, 300V, 26 gauge.

4.1.5 Connector Housing

Wire shall be terminated with 4-pin connector housing, Wieson part number 2510C888-001, Molex 47054-1000 or equivalent. See Figure 7 for reference drawing

The intended mating header for this connector housing, is Wieson part number 2366C888-007 Molex 47053-1000, Foxconn HF27040-M1, Tyco 1470947-1 or equivalent See Figure 8 for reference drawing.

4.1.6 Fan Connector Pinout and Wiring Colors

Table 1 Connector Pinout

Pin	Function	Wire Color
1	GND	Black
2	12 V	Yellow
3	Sense	Green
4	Control	Blue

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5 Environmental and Reliability

5.1.1 Operating Temperature

Fan shall be capable of sustaining normal operation over an ambient inlet temperature range of 0°C to 70 °C.

5.1.2 Non-operating Humidity

Fan shall be capable of sustaining normal operation at +55 °C / 85 %R.H.

5.1.3 Non-operating Thermal Cycling

Fan shall be capable of sustaining normal operation after being subjected to -5 °C to +70 °C for 1000 cycles; ramp = 20 °C/min; 10 min dwell.

5.1.4 Power Cycling

Fan shall be capable of sustaining normal operation after being subjected to 7,500 on/off cycles, each cycle specified as 3 minutes on, 2 minutes off at 70°C ambient temperature. The sample size is 12 units for this test.

5.1.5 Reliability

Mechanical wear out represents the highest risk reliability parameter for fans. The capability of the functional mechanical elements (ball / sleeve bearing, shaft, and tower assembly) must be demonstrated to a minimum useful lifetime of 50,000 hours.

The fan must pass the reliability test criteria with the fan operating at rated voltage in a high temperature environment. Readouts include RPM, Icc and Noise. No infant mortality defects allowed.

Note: These are minimum requirements. The end customer should review vendor collateral and have their specific requirements reflected in a purchasing specification.

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6 Reference Drawings

The following pages contain reference drawings for the Connector Housing, and Baseboard Connector.

Figure 7 Connector Housing

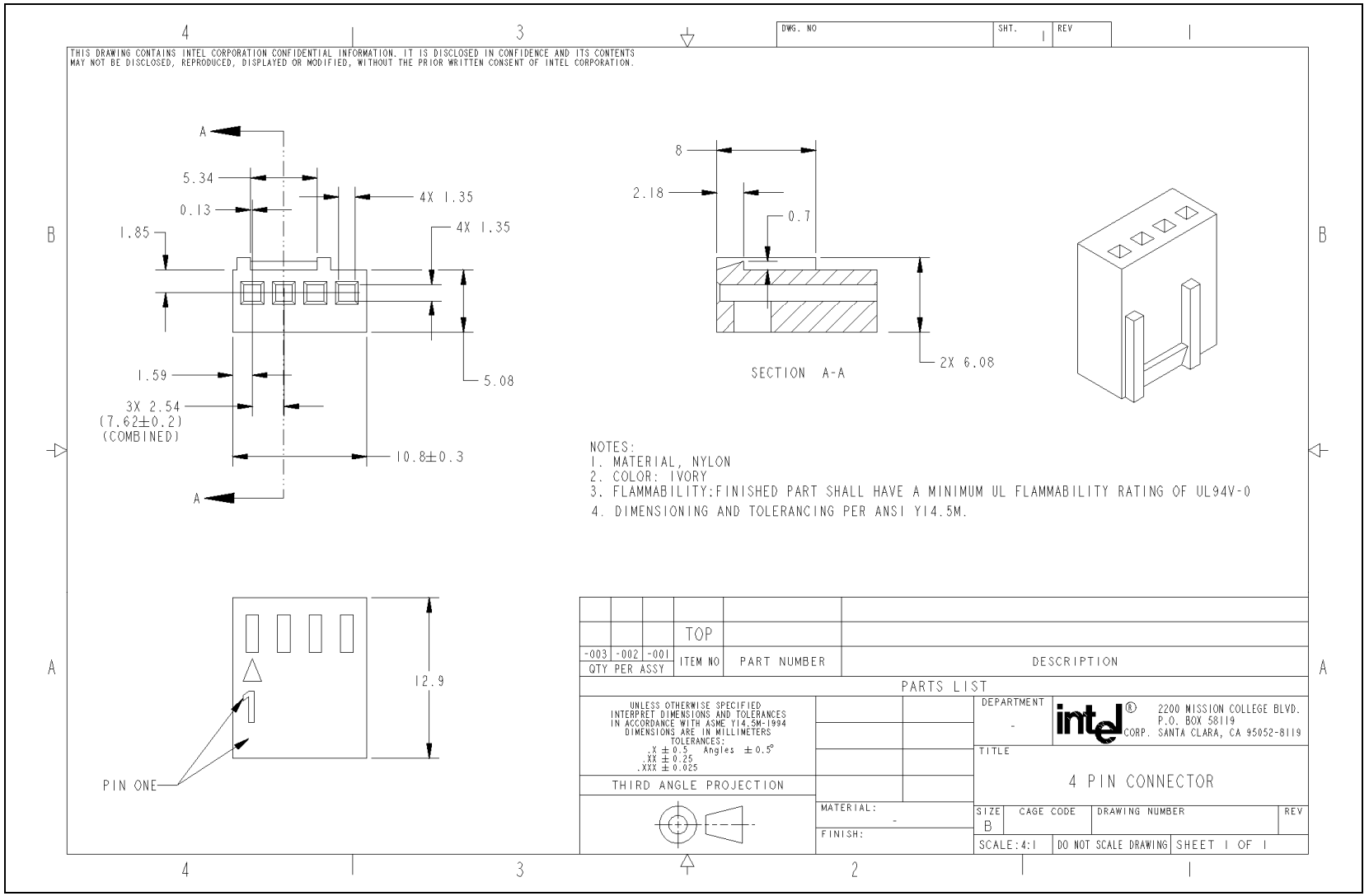

Figure 8 Baseboard Connector