

SynJet[®] Cooler Heartbeat (Status) Signal Output Interface Specification

Overview

This Application Note covers design requirements for interfacing with the Heartbeat (Status) Signal Output of a SynJet cooler (CTL2 signal on Pin3, Purple Wire in the WALLS standard SynJet Power and Signal Cable). This interface allows the user to detect if the SynJet cooler is operating normally or outside of its specifications. It is applicable to SynJet Coolers with PWM Cooling Level Control and not applicable to SynJet Coolers using Level Select Cooling.

Details

The heartbeat signal is intended to give the user a way to detect fault conditions in the SynJet cooler. The SynJet will provide a square wave output with a frequency of $\frac{1}{2}$ the SynJet operating frequency and 50% duty cycle when the device is operating correctly. While this signal is similar to the tachometer output of a conventional fan, the signal does not represent how much cooling is being provided because a SynJet cooler's operating frequency is not the only variable that determines airflow output. Therefore it is not possible to use the heartbeat signal to implement closed loop control based on cooling level. Closed loop control can be implemented using a SynJet equipped with a variable level control input and an external controller with a temperature sensing device on the cooling target.

The SynJet electronics includes a circuit with Fault Detection logic that checks internal feedback signals to determine if the SynJet is operating outside its operating specifications. The state of the SynJet operation is continuously monitored so it is possible for the heartbeat to stop toggling if a momentary fault occurs and then resume toggling at a later time. The user's fault detection logic should include means to ignore these temporary fault conditions if they are not critical to system operation. Table 4, below, gives a list of scenarios that can cause a temporary loss of the heartbeat signal.

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APPLICATION NOTE

Electrical Specifications

The heartbeat signal is transmitted by the SynJet electronics to the user on the CTL2 signal, Pin 3, Purple Wire. This signal is an open-drain output with an internal pull-up resistor. On 5V coolers this internal pull-up is connected to Vcc. On 12V coolers the pull-up is connected to and internally generated 5V supply. Please refer to Table 1 for absolute max operating conditions and Table 2 for recommended operating condition for connection to CTL2 signal, Pin 3, Purple Wire.

Table 1 - Absolute Maximum Ratings

Over operating free-air temperature range unless otherwise noted⁽¹⁾

| | MIN | MAX | UNIT |
|-------------------------------|------|-----------|------|
| Voltage at CTL2 (5V coolers) | -0.3 | VCC + 0.3 | V |
| Voltage at CTL2 (12V coolers) | -0.3 | 5.3 | V |
| CTL2 Sink Current | | 5 | mA |
| ESD Rating, HBM | 2000 | | V |
| ESD Rating, CDM | 500 | | V |

- (1) Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Table 2 - Recommended Operating Conditions

| | MIN | MAX | UNIT |
|---|-----|-----|------|
| Voltage at CTL2 (5V coolers) | 0 | VCC | V |
| Voltage at CTL2 (12V coolers) | 0 | 5.0 | V |
| CTL2 Sink Current | | 4.5 | mA |
| Capacitive loading on CTL2 pin ⁽²⁾ | | 40 | pF |

- (2) Additional capacitive loading will reduce the rise-time of the heartbeat signal due to the resistance of the internal pull-up. This slower rise time can shift the duty cycle of the heartbeat signal and could prevent reaching the VIH threshold of the user’s input. The user is responsible for ensuring that the requirements of their input device are met when using larger capacitive loads.

Table 3 - Electrical Characteristics

| | Test Conditions | MIN | TYP | MAX | UNIT |
|--|--|------|------------------------|------|------|
| V _{OH-CTL2} | I _{CTL2} = -1μA, Vcc = 5V, based on max value of R _{pull-up} | 4.98 | | | V |
| V _{OL-CTL2} | I _{CTL2} = 1μA, Vcc = 5V | | | 0.05 | V |
| | I _{CTL2} = 1mA, Vcc = 5V | | | 0.16 | V |
| | I _{CTL2} = 4.5mA, Vcc = 5V | | | 0.5 | V |
| CTL2 Internal Pull-up Resistor (R _{pull-up}) | | 10 | 15 | 20 | kΩ |
| Heartbeat Signal Duty Cycle | Operating within specifications | | 50 | | % |
| Heartbeat Signal Frequency ⁽³⁾ | Operating within specifications | | F _{synjet} /2 | | Hz |

- (3) F_{synjet} refers to the frequency the moving diaphragms of the cooler are operated at. This frequency is factory specified to meet acoustic and cooling requirements for the customer application and will not be the same for all models. Consult with the Nuventix Applications Engineering to determine the frequency of your specific model.

CTL2 Internal Circuit Diagrams

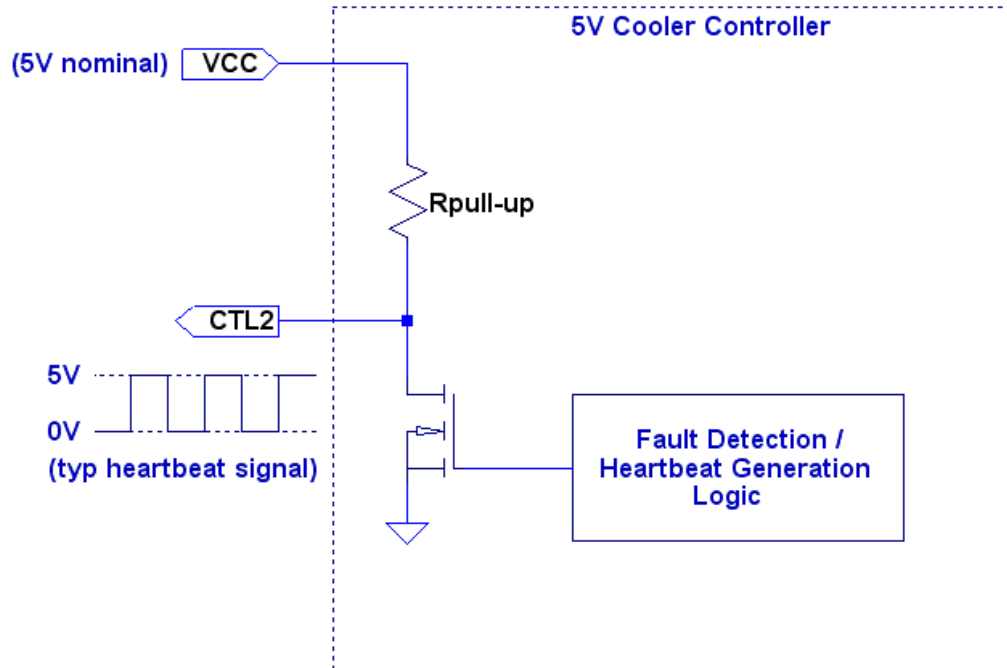


Figure 1 - 5V Cooler with Heartbeat Output – CTL2 Internal Circuitry

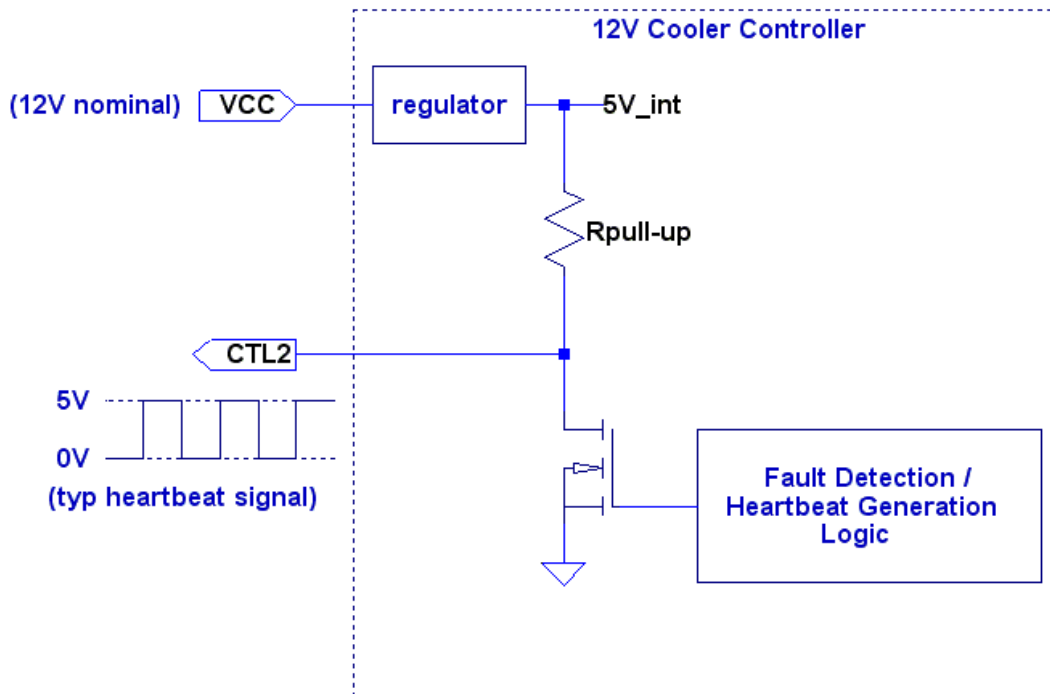


Figure 2 - 12V Cooler with Heartbeat Output – CTL2 Internal Circuitry

Table 4 – Temporary Loss of Heartbeat Signal Scenarios

| Cause | Description | Duration |
|------------------------|--|--|
| Obstructed Air Jets | A sudden change in the resistance to airflow through the SynJet air nozzles will cause diaphragm displacement error to increase until the internal closed loop control can compensate. A typical cause of this would be covering the air jet nozzles with your hand. | Typically < 1 second assuming obstruction is not severe enough to prevent reaching programmed operating conditions. |
| Vcc Glitch | If input voltage dips below the specified Vcc range, the SynJet controller may lack required voltage headroom to drive the diaphragms to the programmed operating conditions. The SynJet controller actively shuts down once Vcc is detected to be outside an additional tolerance of the specified Vcc range. | Determined by the time Vcc is outside of specified valid range. Heartbeat will return within 1 second of Vcc reaching valid level. |
| Operating Point Change | SynJets can be programmed to have several operating points selectable under digital control or continuously variable control via PWM or DC voltage control. Whenever an operating point is changed by a large amount using one of these methods the heartbeat signal could temporarily stop while the internal closed loop control tracks to the new target. | Dependant on difference between start and end operating points. For worst case consult Nuventix Sales for your specific model. |

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APPLICATION NOTE

External Connection Diagrams

The heartbeat output is optimally designed to interface with 5V CMOS logic with no extra components. Interfacing with 3.3V CMOS logic can be achieved with the addition of a resistor on the user's circuit as shown in Figure 5.

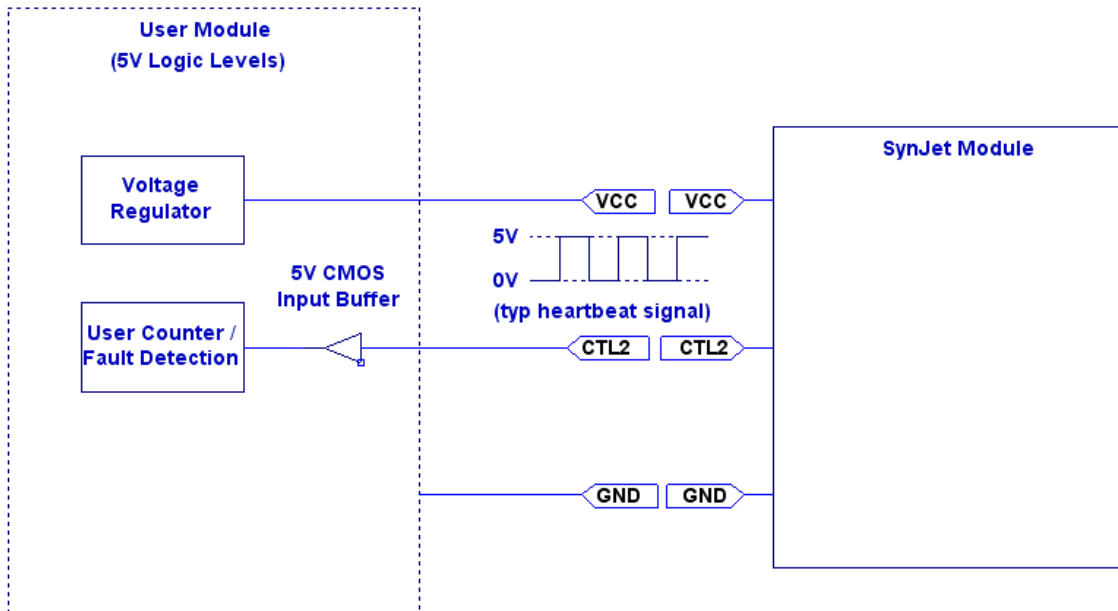


Figure 3 – Heartbeat Monitoring (5V logic levels) - External Connection Diagram

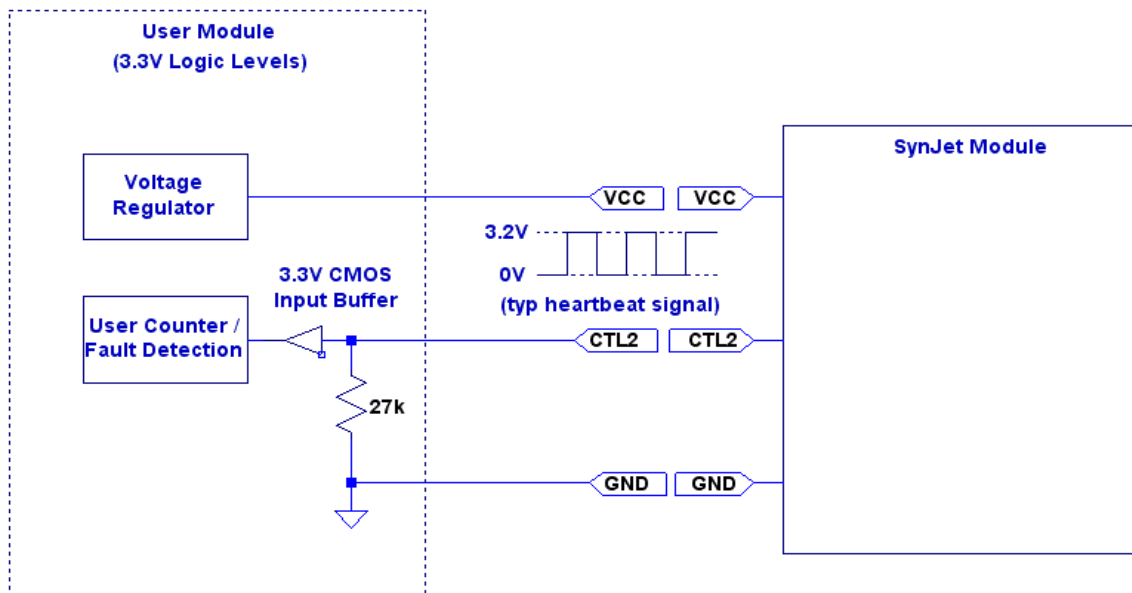


Figure 5 – Heartbeat Monitoring (3.3V logic levels) - External Connection Diagram

APPLICATION NOTE



Pin 1, Red, +5V or +12V

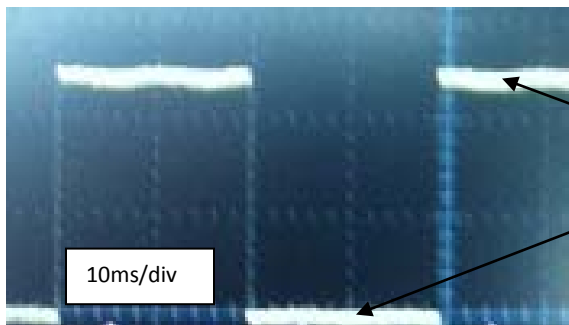
Pin 2, Black, GND

Pin3, CTL2, Purple, Heartbeat Output (0 to 5V)

Pin 4, CTL1, Blue, PWM Input (0 to 5V)

Figure 6 - SynJet Cooler with WALS Cable Attached

Heartbeat Scope Trace Example - Using SPARS-CM005-001, SynJet ZFlow65 Cooler, PWM, 5V



SynJet Heartbeat Signal
CTL_2 Pin3, Purple Wire
Normal Operation,
0V to 5V square wave at $\frac{1}{2}$ Frequency of
Actuator Displacement

The SynJet ZFlow65 Cooler nominal actuator displacement frequency is factory set and in the range of 50 to 60Hz. For this bench test example, the measured frequency is 50Hz, thus the Heartbeat Signal is 25Hz. Note, if a fault occurs, the signal level may be high or low but with no transitions. Thus, the user's fault detection circuit should look for transitions, not the high or low level.

Other SynJet Cooler models may have an actuator displacement frequency in the 40 to 80Hz range so the Heartbeat Output Signal frequency will be at $\frac{1}{2}$ this frequency.