PRODUCT

SynJet® MR16 LED Cooler with Heat Sink

Design Guide

Version 1.1
June 2009

NUVENTIX

Version History

Document Name: SynJet MR16 LED Cooler with Heat Sink Design Guide

Document Number: MKTG-DOC-00029

Version and Date	Changes
Version 1.0, January 2009	Initial release.
Version 1.1 June 2009	Changed length of screw used for attachment of heat sink to SynJet housing from 6mm to 5mm in Table 1 on page 2.

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Table of Contents

Chapter 1
Introduction

The SynJet MR16 LED Cooler with Heat Sink is a patented, highly adaptable, quiet, active cooling solution for the solid state lighting industry.

Specially designed to provide active cooling, the SynJet MR16:

- allows maximum lumens output for long life
- provides excellent thermal management
- provides low energy consumption
- can double or triple lumen output over a passive cooling solution in the same form factor.

Audience

The audience for this design guide is the luminaire design team to include:

- thermal engineers
- mechanical engineers
- electrical engineers
- luminaire industrial designers.

Sections of this document may also provide valuable SynJet MR16 application background for the luminaire marketing team and luminaire manufacturing engineers.

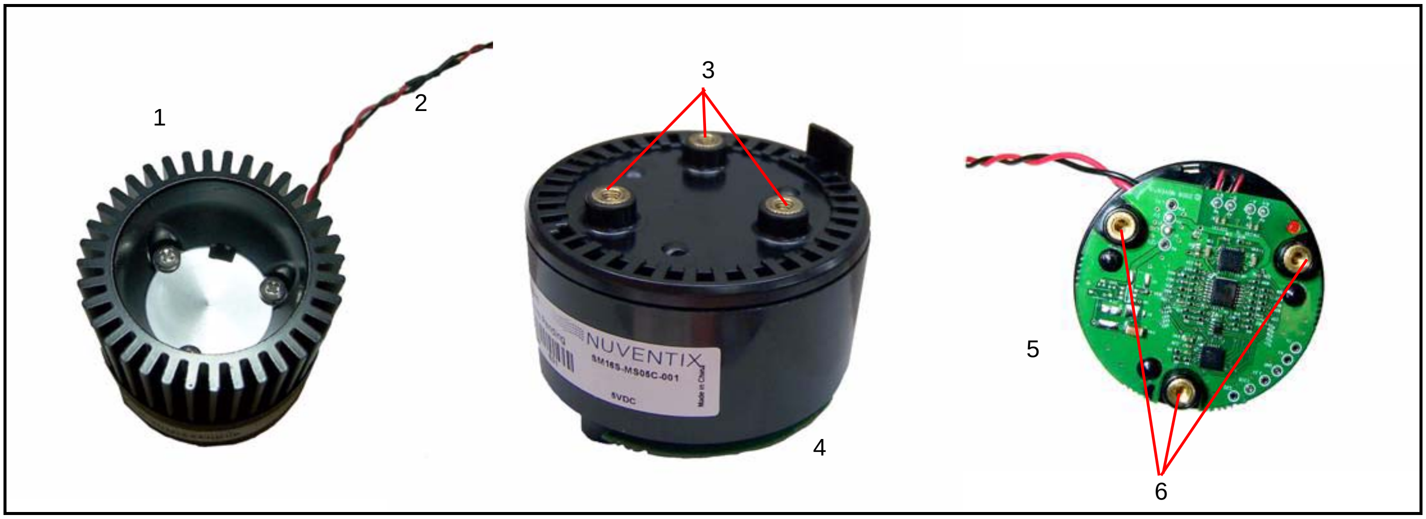
Related Documents

For additional information, refer to the following:

- *Nuventix Technology Overview*
- *SynJet MR16 LED Cooler with Heat Sink Assembly Instructions*
- *SynJet MR16 LED Cooler w/HS Product Specification*
- The Nuventix web site at www.nuventix.com for:
  - latest Document Updates
  - new Application Notes

Components

The following figure illustrates the components of the SynJet MR16.



1	heat sink	2	power lead	3	mounting screw bosses heat sink to SynJet MR16
4	SynJet MR16	5	SynJet MR16 driver board	6	mounting screw bosses SynJet MR16 to external attachment

Figure 1: Components of the SynJet MR16

The following table describes each component.

Table 1: Component Description

Component	Description
SynJet MR16	The SynJet MR16 is the air mover of the cooling system. The SynJet MR16 creates turbulent pulses of air, i.e., synthetic jets, which are directed between heat sink fins.
Heat Sink	The heat sink spreads the heat dissipated from the LEDs over a large surface area. The heat sink is die cast aluminum and is coated with an electro-coating for protection.
SynJet MR16 Driver Board	The driver board contains the components needed to operate the SynJet MR16.
Power Leads	The power leads are the electrical interface to an external DC power supply. The leads have stripped and tinned ends for easy soldering or connection to a connector.
Mounting Screws	Three M3x 5mm screws secure the SynJet MR16 to the heat sink.
Product Label	The product label contains pertinent information such as part number, revision, operating voltage, manufacturing information, and patent notification.

Design for Handling

The thermal, mechanical, and electrical aspects of the luminaire are key design challenges.

Electrostatic Discharge (ESD) is a significant cause of electronic circuit failure.

The LED drive circuit, the SynJet drive circuit, and other power and control circuits in the luminaire, are susceptible to ESD damage.

IMPORTANT! Electrostatic Discharge (ESD) is a significant cause of electronic circuit failure. A failure may:

- be immediate
- occur later due to a weakened component
- appear as an early service life failure.

An industry-standard assembly and test area must have proper ESD protected work stations. In addition, the staff must have ESD prevention education.

The SynJet MR16 electronics require industry-standard care and use of proper ESD protection during assembly and test.

Excessive mechanical force can cause immediate failure or set the stage for an early service life failure.

To prevent ESD or mechanical force induced failures, integrate precautions in the design process for handling, assembly, and testing of the final product.

Chapter 2
Thermal Design

This section discusses thermal design considerations for SynJet MR16 luminaire design.

SynJet MR16s generate turbulent pulses of air which efficiently dissipate heat from any surface. The SynJet MR16 comes with a standard heat sink. Its design has been tested and qualified.

SynJet MR16 Airflow

SynJet MR16 airflow is generated from a ring of rectangular nozzles that are directed at the channels between the heat sink fins (see the following figure).

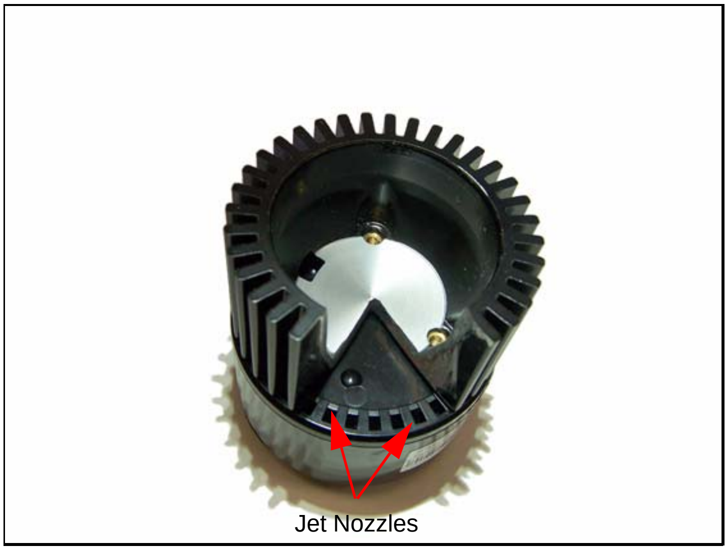


Figure 2: SynJet MR16 Nozzles

The SynJet MR16 nozzles:

- provide for air intake
- provide for exhaust
- create synthetic jets.

In addition to the flow that is directly created by the SynJet MR16 jet nozzles, air is also entrained due to the phenomenon known as the jet ejector effect. This is the same effect felt when a large vehicle passes by and air rushes in to follow it. The entrained air adds to the overall flow generated by the SynJet MR16 (see the following figure). The SynJet MR16 heat sink helps air entrainment flow into the heat sink channels. This increases the amount of cool air mixing with the hot air next to the fin surfaces that has been disturbed by the synthetic jet turbulent pulse. These actions significantly improve heat transfer from the fins to the ambient air. If the SynJet MR16 operates in free air with no flow restrictions, the best thermal performance is achieved.

Figure 3: Air Flow — SynJet MR16 Nozzles to Heat Sink Channels

Restricted Flow

As discussed in the *SynJet MR16 Airflow* section, the SynJet MR16 gets additional flow from entraining ambient air. If the SynJet MR16 is installed in restricted flow areas, thermal performance could degrade. Several types of blockage that may occur are discussed in the following sections. Usually, testing a physical model is required to determine the actual performance.

Blocking Heat Sink Channels

The heat sink fin exit channel openings should not be obstructed. If the channels are obstructed, thermal performance degrades. Mounting structures or trim rings can create flow blockages, so the design of a luminaire to heat sink support structure and possible ceiling trim ring should be evaluated for air flow interference. The following figure is an example of a square ceiling opening where the ceiling trim piece partially blocks the exit flow. Although not shown here, a mounting bracket clamped to the heat sink, instead of using the three bosses on the end of the to hold the assembly could be another form of channel blockage. Its effect should be evaluated with a physical model test.

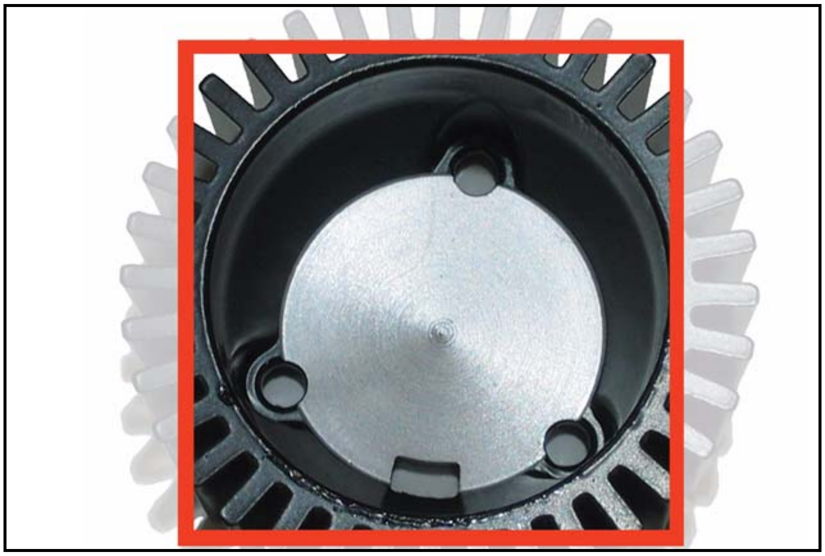


Figure 4: **Partially Blocked Heat Sink Channels**

Adding Ventilation

If the application requires the SynJet MR16 be installed in a restricted flow installation, such as a recessed ceiling can, better thermal performance can be achieved by adding ventilation to enable entrainment as shown in the following figure.

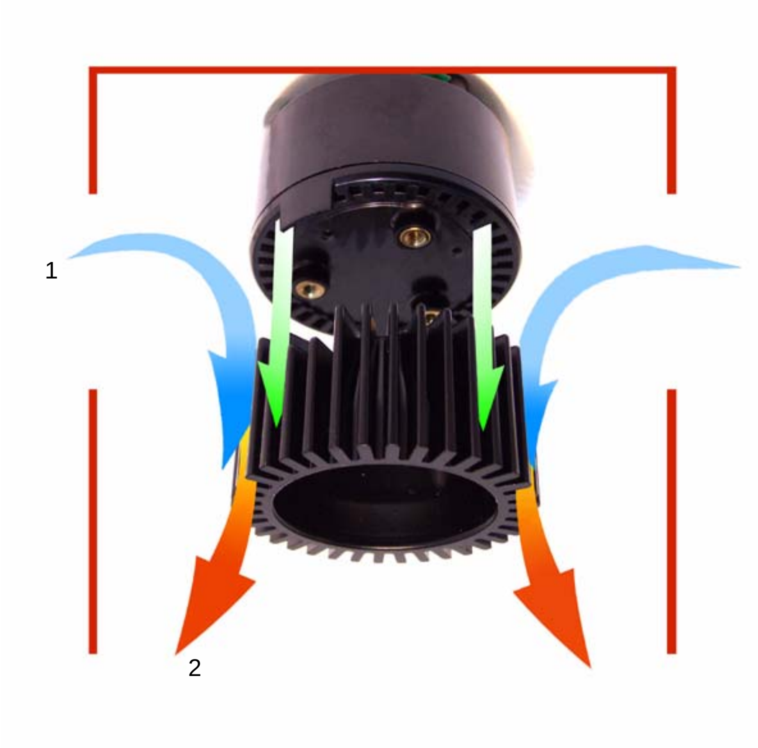


Figure 5: Recessed Can with Vents

1 Cool entrained air enters the can through the side or top vents cut in the can.

2 High velocity hot air exits through the gap between the edge of the can and the heat sink.

Examples of Restricted Air Flow

The following figures show examples of restricted air flow to and from the SynJet MR16.

Example 1 - Track Light with Narrow Vents Added

In this example, air enters through the narrow vents due to entrainment, passes through the heat sink fins and exits thru the face of the heat sink.

Figure 6: Track Light with Vents Added to Step Cylinder

Example 2 - Recessed Eyeball (Gimbal) Can with Vents

In this example, air enters through the vents due to entrainment, passes through the heat sink fins, and exits through the face of the heat sink.

As shown in the following three figures, air:

- enters through a vent
- passes along the side of the SynJet MR16
- becomes entrained
- exits into the room thru the face of the fixture.

A gap exists between the heat sink perimeter and the can. If the gap is not blocked with a solid ceiling trim piece, additional entrained flow can occur. This provides improved cooling.

Figure 7: **Back View Eyeball Recessed**

Figure 8: **Side View Eyeball Recessed**

Figure 9: Eyeball Recessed Can with Vents

Example 3 - Pendant Light with Gap

In this example, cool air is entrained through the holes in the perimeter of the pendant. The hot air exits through the gap between the heat sink and the pendant shell at the light exit end. The size of this gap and the size and location of the holes can significantly influence the thermal performance.

Figure 10: Pendant Light with Gap

Thermal Interface Material (TIM)

The thermal design discussion to this point has focused on improving forced-convection air flow to transfer heat from the heat sink to the ambient air. Also important is good conduction of heat from the LED to the heat sink. TIM is a critical component of the design. Several choices are available to the designer:

- thermal grease
- paste

- thermal epoxy
- thermal pads, etc.

Selection depends on the LED/heat sink attachment design and planned assembly process. Refer to *LED Mounting* in this document for additional information.

Because applications using the SynJet MR16 vary widely, Nuventix does not specify a TIM. Nuventix Sales can provide suggestions and consultation regarding your unique implementation.

It is the customer's responsibility for final selection of the material and verification of its effectiveness.

Design Consultation and Support

Nuventix Thermal/Mechanical Applications Engineers are available to review the SynJet MR16's thermal and mechanical integration into luminaire concept designs. The review can also include:

- thermal performance testing plan and preliminary data
- acoustic testing plan and preliminary data
- SynJet MR16 air flow and entrainment optimization

SynJet MR16 design and optimization is significantly different from traditional fan cooling design. To maximize the benefits of SynJet MR16 cooling, Nuventix recommends a joint consultation and review early in the luminaire design concept development stage. This consultation should include the luminaire design team and Nuventix Applications Engineering.

To achieve the best cooling solution a custom modification to the SynJet MR16 cooler or to the heat sink may be desirable. Nuventix can provide optional custom design services. Specifications, costs, and timing are subject to mutual agreement.

For design consultation and review of the integration process of a luminaire with the SynJet MR16, contact Nuventix Sales.

Chapter 3
Acoustic Design

This section discusses acoustic considerations for your SynJet MR16 installation.

The SynJet MR16 and heat sink design has been optimized for maximum cooling and minimum air flow acoustics.

Customer-added features such as housings, reflectors, ducting, attachment structures, etc. may change the acoustic performance. These features can also change the cooling performance as discussed in Chapter 2 *Thermal Design*.

When air flow is forced to change velocity, direction, or pressure; then the local disturbance creates acoustic artifacts. The following are some examples of features that increase acoustic air flow noise and vibration.

- Narrow ducts or flow constrictions

  The velocity increases and then decreases. Local turbulences can be created. This produces forces on walls and support structures that can cause vibration. Each of these can be the source of acoustic wave (noise) creation.

- Ducting or a cowling placed closely along or surrounding the heat sink.

  This may create constriction and vibration issues similar to those described for narrow ducts or flow constrictions. If the ducting or cowling are close fitting, the vibration may cause it to hit a nearby structure. This produces additional noise.

- Sharp turns in the flow path.

  Disrupted, uneven flow causes additional noise.

- Obstructions in the flow path such as posts, fins, dividers

  Obstructions can produce local turbulences and acoustics.

- Loosely attached items, deflectors, metal or plastic tabs, wiring, that may vibrate in the flow.

  Additionally, the loose item may hit another part of the assembly which adds to noise generation

- Delicate support structures that do not hold the assembly firmly.

To obtain the best acoustic performance, these considerations along with standard engineering practices should be followed. Building mechanical models of the design and measuring acoustic and cooling performance is recommended. Nuventix Sales can provide suggestions and consultation.

Chapter 4
Mechanical Design

This chapter discusses mechanical design considerations for your SynJet MR16 LED luminaire installation.

PCBA Mounting Features

This section discusses mounting features for the LED drive printed circuit board assembly (PCBA).

The bosses provided extend above the SynJet MR16 drive PCBA. These bosses may be used for attachment of a PCBA to provide LED drive power.

They are also designed to be used as attachment points for the entire SynJet and heat sink assembly.

The bosses are located on the SynJet MR16 top side around the perimeter of the PCBA. Figure 11 shows the locations for the bosses.

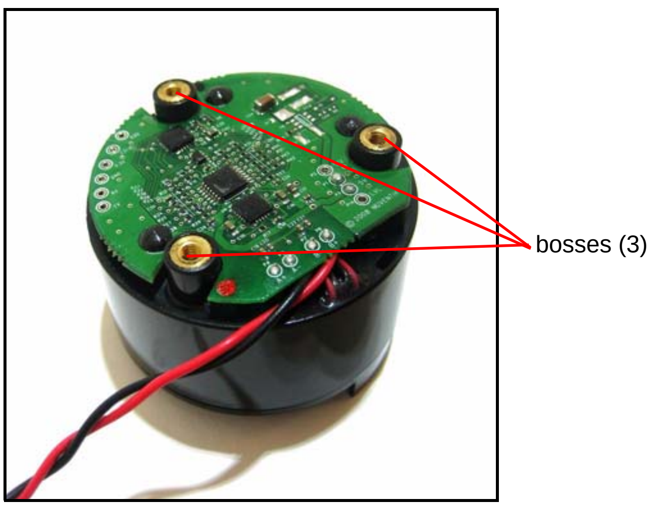


Figure 11: Mounting Features

Heat Sink Attachment to Luminaire

Refer to the *SynJet MR16 Mechanical Drawing Data Sheet* for details. Figure 12 shows the SynJet MR16 with a customer-added LED driver card attached above the SynJet MR16 driver card. In this case, the screws used have threaded caps so the assembly can be attached to a mounting bracket. Figure 13 shows the addition of a U-shaped attachment bracket. Figure 14 shows a completed track mount assembly.

Figure 12: **PCBA Mounting Features**

Figure 13: **SynJet MR16 with U bracket Insert**

Figure 14: **SynJet MR16 Completed Track Mount Assembly**

LED Mounting

This section discusses mounting the LED or LED array to the heat sink.

Mounting Surface for LEDs

To mount the SynJet MR16 to an LED, there is a flat area on the inner surface of the heat sink where contact is made. Dimensions for the area are given in the *SynJet MR16 LED Cooler w/HS Product Specification*.

This surface is machined but not electro-coated. This gives a flat surface to make good thermal contact with the LED MCPCB or other mounting boards (see the following figure).

Figure 15: **Bottom Inner Surface for LED Attachment**

The mounting surface is intentionally left without mounting features (such as threaded holes) because it is difficult to anticipate all the applications that use this product. The customer must either use a thermal epoxy method (if sufficient for the design) or perform a secondary machining operation to add in mounting features. As an alternative, Nuventix can add a custom hole pattern. For example, a three-hole pattern may be added for a Metal Core Printed Circuit Board (MCPCB) mounted LED. The SynJet Cooler should not be attached to the heat sink during secondary machining. This avoids damage to the circuit card or the housing.

Requests for specific mounting features or a custom hole pattern should be reviewed with Nuventix Sales, and may be available as an option.

Wire Routing for LED Array

The SynJet MR16 heat sink has a clearance slot to accommodate the power leads required to route from the LED board through the heat sink to the LED driver circuitry. The slot used to pass power leads through is shown in the following figure. The green arrow in the center of the following figure shows the routing from the LED mounting area. Leads go through the heat sink base notch and into the tunnel on the perimeter of the SynJet plastic housing. This path bypasses the SynJet MR16. The wires can then be attached to the LED driver card located just above the SynJet MR16 driver card. The three circles in the following figure show the pathway openings.

Figure 16: Clearance Slots for Routing LED Power Leads

Integrating SynJet MR16 with Customer-Designed Heat Sink

This section shows you how to integrate the SynJet MR16 with a customer-designed heat sink.

The housing stand-offs space the SynJet MR16 housing from the heat sink with a space that prevents excessive heat conduction from the heat sink to the housing. Your design should also provide this spacing.

IMPORTANT! For your customer-designed heat sink, consideration should be given to the direction the jets enter the heat sink as well as the spacing from the jet nozzle to the heat sink. Aim the jets so they flow through the center of the fin spacing. Space them at least 3 mm from the heat sink and above the channel so entrainment flow is maximized.

The standard SynJet MR16 heat sink is optimized for maximum effectiveness. Review the heat sink design, and all design comments in this document, before developing your custom designs. Keep in mind the SynJet air flow with the synthetic jets and entrainment is not the same as a traditional fan's air flow. Traditional fan design practices should not be used. Additionally, it is important to review your design concept with Nuventix Sales early in the process.

A CAD model giving dimensions and design details of the SynJet MR16 is available from Nuventix Sales.

Figure 17 shows a side view of the SynJet MR16 housing, screw attachment, and stand-off. The screw attachment points are used to hold the SynJet MR16 to the heat sink and the stand-off spaces the housing from the heat sink. Your custom design should also use these features for heat sink attachment to the SynJet MR16 housing.

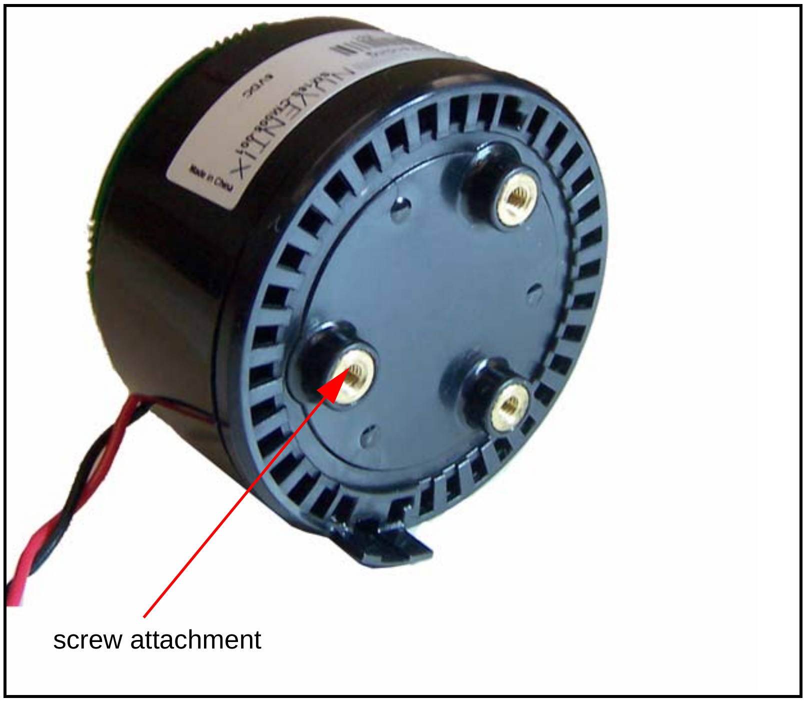


Figure 17: **Heat Sink Attachment End of SynJet MR16**

Chapter 5
Electrical Design

This chapter discusses electrical considerations for SynJet MR16 installation.

Requirements

The following table summarizes electrical specifications from the *SynJet MR16 w/HS Product Specification.*

Table 2: Electrical Requirements

	Voltage, VDC		Ripple	Current, mA		Power, W
Configuration	Min	Max	Max	Min	Max	Avg
5V	4.75	5.25	150 mv	10	310	.75
12V	10.8	13.2	150 mV	10	180	1.0

IMPORTANT! LEDs are typically driven using a constant-current source, but the SynJet MR16 requires a constant-voltage source. Driving the SynJet MR16 with a constant-current source causes the input voltage to rise above the maximum allowed value, damaging the SynJet MR16 electronics and voiding the warranty.

If the voltage source has current overload limiting built in, the level should be set above the maximum current noted in Table 2.

Current Waveform

The SynJet MR16 current waveform is sinusoidal and varies between the minimum and maximum specifications shown in Table 2. This waveform is a sine wave with a DC offset. The 5-V or 12-V power source must handle this load variation and remain within specification. When power is switched on, it also must supply sufficient current to charge input capacitance (22uF typical) to 5 V or 12 V in 10 ms.

Connection Specifications

The SynJet MR16 comes with two input power leads described in the following table. The length includes 10 mm of the wire stripped and tinned at the end. The total wire run length from the source to theSynJet MR16 PCBA should not exceed 300 mm. For total wire lengths beyond the 150 mm supplied with it, use 24AWG or larger wire. For wire lengths beyond 300 mm, consult with Nuventix Sales.

Carefully review wire routing design and check for sources of noise coupling to see if additional filter circuitry is needed to ensure reliable operation. Do not subject the SynJet MR16 to voltage spikes greater than a 6-V peak for the 5-V configuration, or 14-V peak for the 12-V configuration when applying power through a switch or relay. You may need a filter/snubber when using electromechanical contacts to switch power on or off to the SynJet MR16. This keeps the voltage spikes at or below the specified limit. The SynJet MR16 meets applicable international specifications for EMI (radiated, conducted, and susceptibility) when properly installed. Keep the power wiring as short as possible to avoid the creation of potential problems. Refer to the *SynJet MR16 Cooler w/HS Product Specification* for a list of applicable certifications met.

Table 3: Power Lead Specifications

Configuration	Lead Color		Overall Length	AWG (stranded)	Wire Diameter (mm)
	Power	Ground			
5V	Red	Black	150 mm	26	1.02
12V	Yellow	Black	150 mm	26	1.02

Disclaimer/Warranty

Customers are responsible for testing products for their unique applications. Any information furnished by Nuventix and its agents is believed to be accurate and reliable. However, since every potential application cannot be anticipated, Nuventix makes no warranties as to the fitness, merchantability, or suitability of any Nuventix products for any specific or general uses. Nuventix shall not be liable for incidental or consequential damages of any kind.

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