



Keywords: Power Over Ethernet, Midspan, Endspan, 2x2, Cat 5E, Cat 6, Single Port Power Injection

APPLICATION NOTE 6161

# POE POWER INJECTOR

By: Brian Rosario and Phill Leyva

*Abstract: Many Power over Ethernet (PoE) applications require 25.5W or greater, Class 5 operation over a single port. The MAX5971A and MAX5971B PSE controllers with integrated MOSFET deliver up to 40W to a single port using endpoint or midspan modes. This design idea details a unique configuration for obtaining greater than 25.5W, and up to 80W, using two MAX5971A or MAX5971B controllers with integrated MOSFET and sense resistor.*

## Introduction

Many PoE end applications require 25.5W or greater, require Class 5 operation over a single port. The [MAX5971A](#) and [MAX5971B](#) PSE Controllers with Integrated MOSFET are capable of delivering up to 40W in to a single port using Endpoint or Midspan modes. This application note details how to obtain greater than 25.5W and up to 80W using two MAX5971A or MAX5971B Controllers with integrated MOSFET and sense resistor in a unique configuration.

## Delivery System

For Class 5 operation, minimizing the Ethernet cabling system resistance is critical to delivering all available PSE power to the PD. Cat 3 Ethernet copper-cabling has approximately 20Ω resistance per 100m (about 330 feet) of cable while Cat 5e cabling has approximately 12.5Ω resistance per 100m. These resistances are for a single Ethernet wire and the Ethernet cable has 8 wires, grouped into 4 pairs. For Class 5 operation, the cabling pairs are grouped in to a 2x2 pair configuration. See **Figure 1** below detailing wire, pair and 2x2 pair configurations.

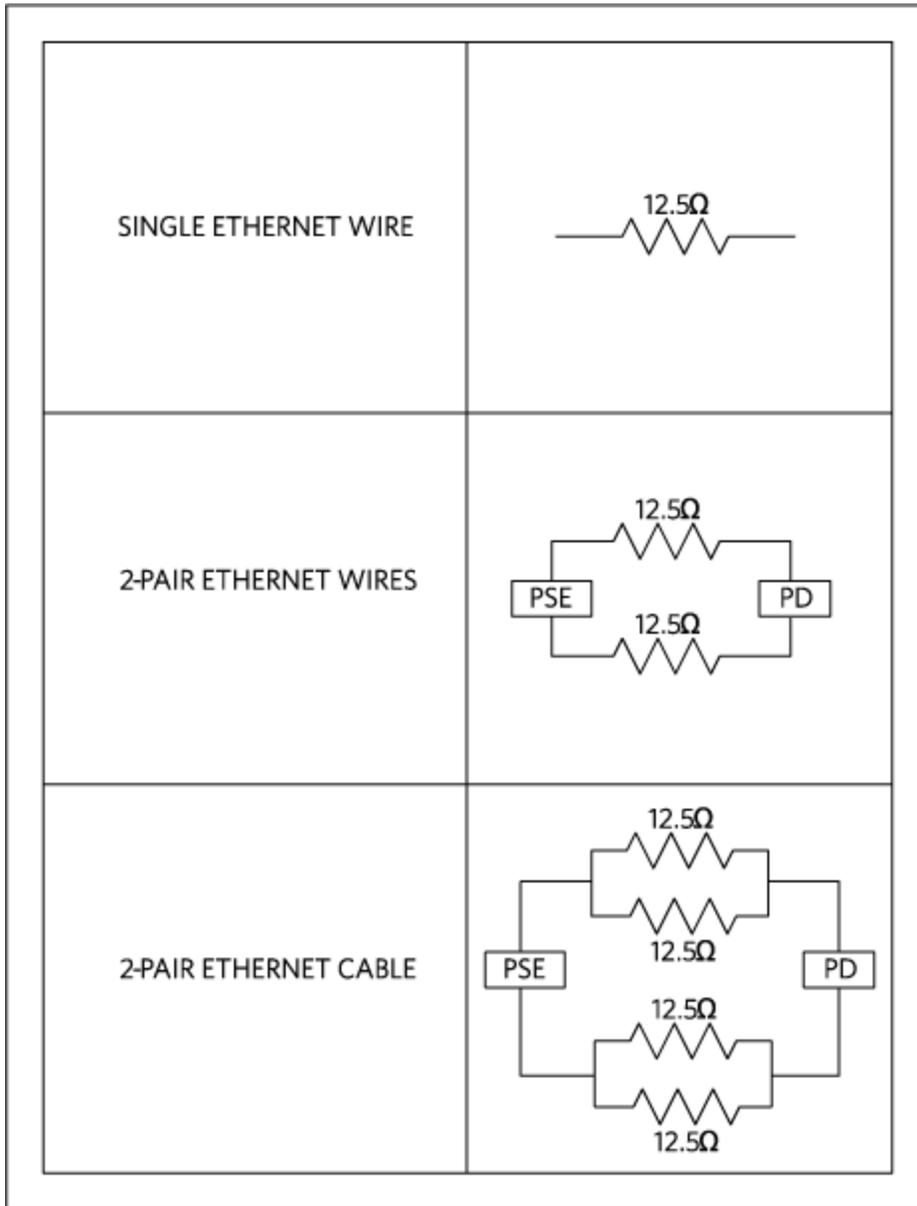


Figure 1. A 2 x 2 pair Ethernet cabling configuration.

The 2x2 pair configuration consists of paralleling two wires for a combined equivalent resistance of  $6.25\Omega$  ( $12.5\Omega \parallel 12.5\Omega$ ) and paralleling another set of wires for a combined resistance of  $6.25\Omega$ . Therefore the total loop resistance is  $12.5\Omega$  ( $6.25\Omega + 6.25\Omega$ ) when considering the PSR supply and return lines to the PD.

For a typical 2x2 pair PSE Endpoint configuration, this implies Ethernet wires 1 and 2 are connected in parallel and Ethernet wires 3 and 6 form the other side of the pair. Pairs 1 and 2 are one line and pairs 3 and 6 are the other side. For a second PSE supply operating in Midspan configuration, Ethernet wires 4 and 5 are connected in parallel and Ethernet wires 7 and 8 form the other side of the second pair.

The parallel pairs connections are typically implemented using a center tapped Ethernet magnetic transformer, such as a Bel 0823-1x1T-GH-F Gigabit MagJack. The Gigabit MagJack has maximum rating of 720mA at 57VDC and 1.2A at 57VDC for up to 200ms.

## PSE Configuration

The MAX5971A/B PSE controller can deliver up to 40W; thus, two MAX5971A/B PSE controllers are required for 2x2 pair Class 5 full power operation. One PSE controller must be configured for Endpoint and the other MAX5971A/B PSE controller configured for Midspan operation. Each controller's overcurrent threshold and current limit must be configured for the desired Class 5 power-level operation. Refer to the MAX5971A/B data sheet Class 5 PD Classification section for more information and the table below for configuring the controllers.

ILIM1 CONFIGURATION	ILIM2 CONFIGURATION	OVERCURRENT THRESHOLD(mA)	CURRENT LIMIT (mA)
Unconnected	Unconnected	Class 5 disabled	Class 5 disabled
$V_{EE}$	Unconnected	748	850
Unconnected	$V_{EE}$	792	900
$V_{EE}$	$V_{EE}$	836	950

## PD Reception

For 2x2 operation on the Powered Device (PD) side, another Bel 0823-1x1T-GH-F Gigabit MagJack is used to receive power and connect the respective pairs in parallel. Additionally a Multisource High Power PD Controller must be used since two PD controllers are required. The two PDs pass detection and classification separately and provide power when both are ready. One PD controller accepts the Endpoint PSE power and the second controller receives the Midspan PSE power.

## Lab Verification

Two MAX5971A PSE Evaluation kits were configured for full power Class 5 operation. One kit was configured for Endpoint and the other for Midspan operation. The Endpoint PSE, RJ45 Ethernet jack was utilized as the main power and data output. Referring to the MAX5971A Evaluation kit data sheet, page 5 and Tables 4 and 5, Jumper JU4 and resistors R5-R8 were configured for Endpoint on this kit.

For the Midspan PSE kit, resistors R5-R8 were removed and Jumper JU4 configured for Mid-span. A 16-gauge wire was utilized to connect the Midspan PSE kit RTN pad to the Endpoint PSE kit VC4 RJ45 Ethernet Jack connection using resistor R8 PCB pad. Another 16-gauge wire was utilized to connect the Midspan PSE kit GND pad to the Endpoint PSE VC3 RJ45 Ethernet-jack connection using resistor R7 PCB pad on this kit. See **Figure 2** below for the EV kit modifications.

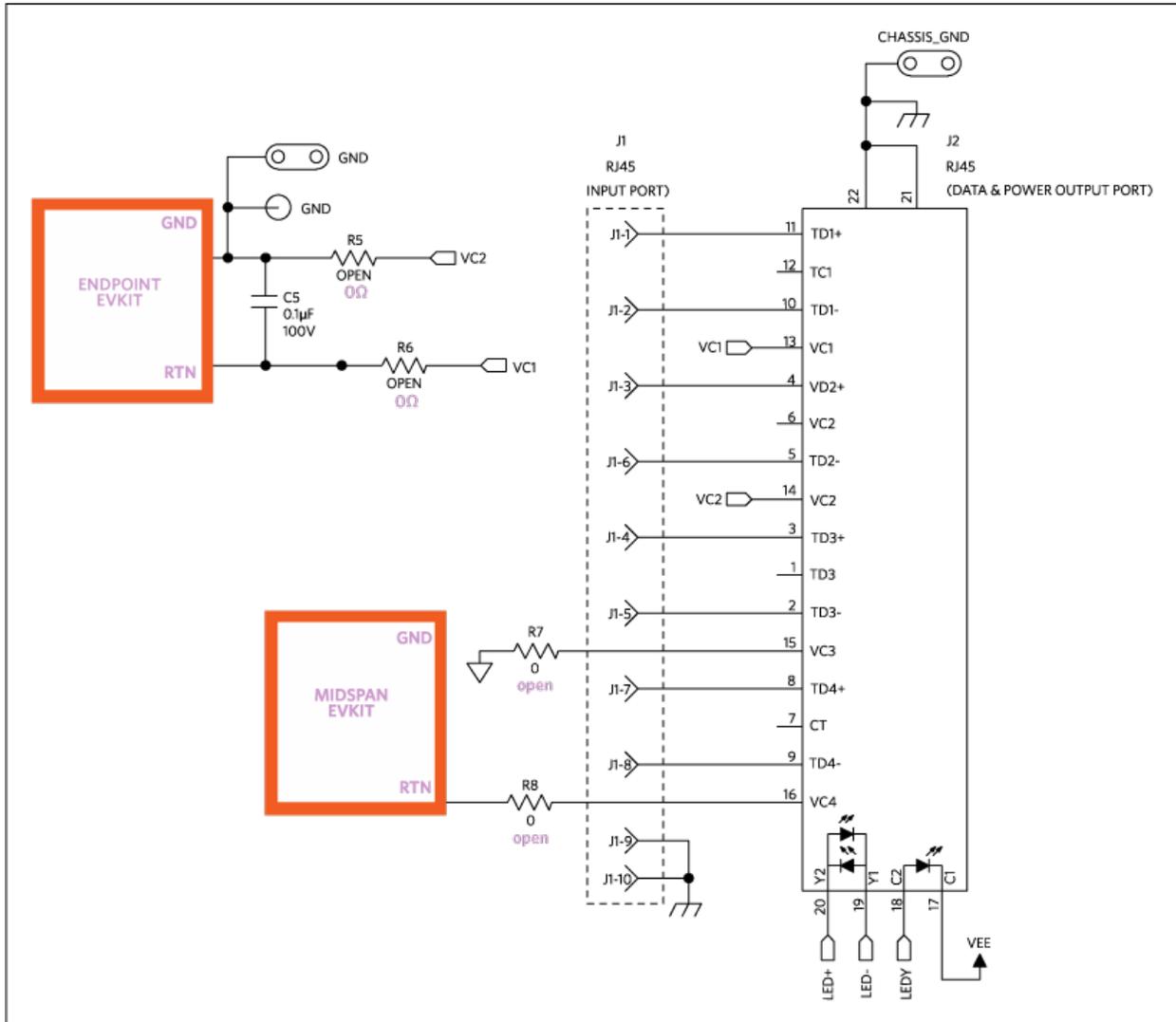


Figure 2. MAX5971A EV Kit modifications for a 2 x 2 Ethernet pair.

A seven foot (2.1m) Cat 6 Ethernet cable was used to connect the Endpoint PSE Ethernet RJ45 output port to a Multisource High Power PD Controller. The PD controller's raw 57V-48V output was connected to an HP6060B electronic load. Test data was taken at 0A, 0.35A, 0.7A, 1.05A and 1.40A PD loading for PSE input voltages of 57V, 54V and 48V input rails. Refer to the Excel spread sheet link below for the 57V, 54V and 48V cases data.

Using the Cat6 Ethernet cable and an input voltage of 57V, the dual MAX5971A PSE configuration successfully supplied up to 78.6W of power to the PSE output RJ45 Ethernet output jack connected to the Multisource High Power PD Controller feeding the electronic load.

This configuration total PSE input power was 80.4W.

Additional tests were performed using 330 feet (100m) of Cat 5e Ethernet cable and the test data is provided in the Excel spreadsheet. The dual MAX5971A PSE configuration successfully supplied up to 83.7W of power to the PSE output RJ45 Ethernet output jack when the input voltage was 57V. This configuration total PSE input power was 85.8W.

## Conclusion

For PoE end applications requiring Class 5 operation up to 80W through a single port, two MAX5971A or MAX5971B PSE Controllers with Integrated MOSFET are an excellent cost-effective solution. The dual controllers are capable of delivering up to 80W in to a single port using Endpoint and Midspan modes in a 2x2 configuration. The receiving PD must also be a Multisource High Power PD Controller for the dual PSE configuration.

Software associated with this article is available for [download](#).

Related Parts		
<a href="#">MAX5971A</a>	Single-Port, 40W, IEEE 802.3af/at PSE Controller with Integrated MOSFET	<a href="#">Samples</a>
<a href="#">MAX5971B</a>	Single-Port, 40W, IEEE 802.3af/at, PSE Controller with I <sup>2</sup> C	<a href="#">Samples</a>

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## More Information

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Application Note 6161: <https://www.maximintegrated.com/en/an6161>

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