Simple PSE Solution Delivers High Power-Over-Ethernet to 31–35-W PD Over Four Pairs

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ABSTRACT

This application report discusses a solution to the additional power required in those PoE applications that exceed the power requirements defined in the current IEEE802.3af standard. Specifically, the document offers a four-pairs solution for 31-W to 35-W powered devices.

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1 Introduction

The Power-over-Ethernet (PoE) technology provides electrical power via standard Cat-5 Ethernet cables, thereby eliminating the need for wall adapters or other external power sources for equipment connected in an Ethernet network. The two major components in a PoE system are the power sourcing equipment (PSE), that provides the power, and the powered device (PD), that receives and uses this power (see Figure 1).
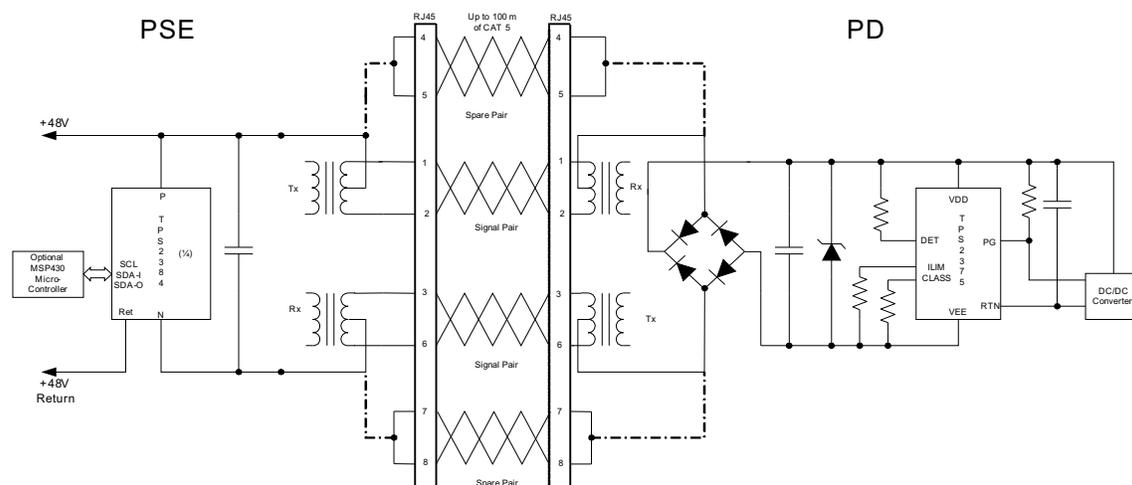
Figure 1. Typical PoE Application Diagram

Recently, practical applications using PoE have been developed. Many of these new applications require more power than the power limit defined in the current 802.3af standard (approximately 13 W at the PD end). For example, a sophisticated security system with motor-controlled cameras would benefit from high-power PoE.

2 Recommended Characteristics

Any high-power solution must meet the following basic criteria:

- Must not result in overheating of the Ethernet cables
- Must not result in imbalance of current within a pair of wires, so as not to risk saturating Ethernet transformers
- Must be useable with the existing cabling system, based on Cat-5 cable type.
- No overheating in PSE nor in PD
- Operating voltage within the 802.3af standard voltage range

Also, any four-pair solution providing more than 30 W should provide (if possible) the following features:

- Compatible with 802.3af standard PDs: discovery, classification, current consumption, inrush current, current limit, etc.
- Power management capability
- Use of magnetic components compatible with 802.3af standard
- No additional heating in PSE, PD, or in between
- No loss of efficiency of complete system; even better if efficiency increases

3 Simple Four-Pair High-Power PSE Solution

The IEEE802.3af standard stipulates a PSE output voltage from 44 V to 57 V, with an I_{CUT} (represents a level beyond which power consumption is regarded as an overload) of 350 mA minimum and an I_{LIM} (represents the highest consumption level possible) of 400 mA minimum. Using 100 m of Cat-5 cable with a worst-case feed resistance of 20 Ω (from IEEE802.3af) results in a limit of 12.95 W at the PD's input, when operating at the minimum allowed voltage.

Integrated power controllers like the TPS2384 are factory set to meet this requirement. The TPS2384 is capable of delivering 425 mA (I_{LIM}) nominally to the port for a short time. Also, if the port current exceeds 375 mA (I_{CUT}) for more than 62 ms (T_{OVLD}), the TPS2384 turns off the port.

The high-power solution, based on use of the TPS2384, involves operating at higher bus voltage and using two PSE ports; each one is connected to a separate PD, isolated from each other on the PD end of the cable. Each PD then has its own switching power supply, electrically isolated from input to output. The outputs of these two power supplies then are connected in series to provide the total required voltage to a common load.

Today, Cat-5 communication wiring is the recognized minimum for broadband services. Its specific designation is EIA/TIA-568 and is built with 24 AWG conductors which results in a worst-case feed resistance of 12.5 Ω. In the following demonstration, it is assumed that such cable is used.

The minimum operating voltage must increase to 53 V, with 55 V nominal and 57 V maximum. This results in more power available per PSE port.

Having two PSE ports operating in tandem almost doubles the total PD input power available. Note that power is not exactly doubled because of some imbalance due to several factors including efficiency and output voltage tolerance of PD power supplies (see Figure 2).
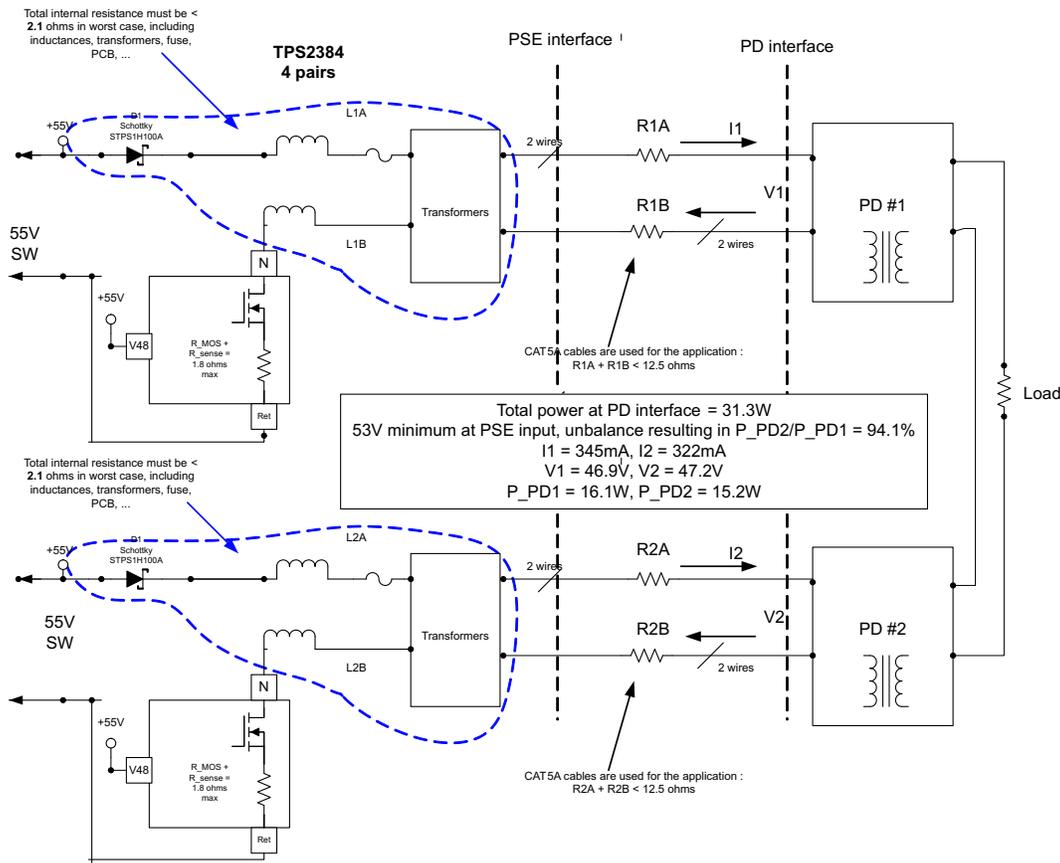

Total power at PD interface = 31.3W
53V minimum at PSE input, unbalance resulting in P_PD2/P_PD1 = 94.1%
I1 = 345mA, I2 = 322mA
V1 = 46.9V, V2 = 47.2V
P_PD1 = 16.1W, P_PD2 = 15.2W

**Figure 2. Diagram of a Simple Four-Pairs Solution for 31-W PD
(Minimum Worst Case)**

The benefits of such a solution include:

- System efficiency increases by 2.5%.
- Dissipation in the cables, PSE, and PD front-end does not increase even if PD input power increases by 138%.
- Existing Cat-5 cable installations are still useable.
- The risk of imbalance on wires and saturation of magnetics is no greater than with standard PoE. However, good design rules must be followed to ensure that no such situation becomes a problem. In some cases, resistor-capacitor ballast networks may have to be installed.
- Compatible with 802.3af standard PDs
- Operating voltage of 53 V to 57 V is within the 802.3af standard voltage range of 44 V to 57 V.

- Power management achievable with the MSP430 microcontroller
- The magnetic components are the same as those used for a standard 802.3af PSE.

However, for this solution to work, the switching power supply providing the 55 V must regulate at a tighter tolerance (±3.5%).

Because the operating voltage is high, the 55-V overvoltage protection (OVP) function must be disabled by the MSP430 software. The TPS2384 allows disabling both the OVP and Port Under Voltage Protection on all four ports simultaneously. The 55-V power supply must incorporate OVP to ensure that any power supply failure does not propagate to the PSE, the loads, or the end-users (as should always be the case in any standard PoE application).

The PD should have the following characteristics:

- Electrical isolation from its input to its power supply output
- The total power available at the PD inputs is based on the usage of a well-designed PD power supply. Imbalance between pairs is determined by differences in efficiency and output voltage level between both PDs, including their power supplies. The total power available could be lower than indicated depending on the performance and quality of those power supplies.

For applications requiring even more power, it is possible to increase the minimum PD input power to as much as 35 W, using a special release of the MSP430 software.

The characteristics of such a system are:

- Power provided at the PD input increases by 168% versus a standard PoE system while the system efficiency increases by 1.3%.
- Operating voltage of 53 V to 57 V is within the 802.3af standard voltage range of 44 V to 57 V.
- Power management achievable with the MSP430 microcontroller
- The magnetic components are the same as those used for a standard 802.3af PSE.
- Existing Cat-5 cable installations are still useable.
- This level of power requires operation up to 400 mA. This is within the capability of the magnetic components, cables (Cat-5), and connectors used in PoE applications, and it is within the 802.3af standard.
- Current balancing between wires within each pair is required and is even more important at this current level.
- The I_{CUT} function is disabled, but the I_{LIM} (400 mA to 450 mA) is still in operation.
- In overload, the output is limited to the I_{LIM} current level. The difference is that the port shutdown is triggered by a thermal detection mechanism rather than by a timer.
- This extra power requires that the PD input current limit is not below 400 mA
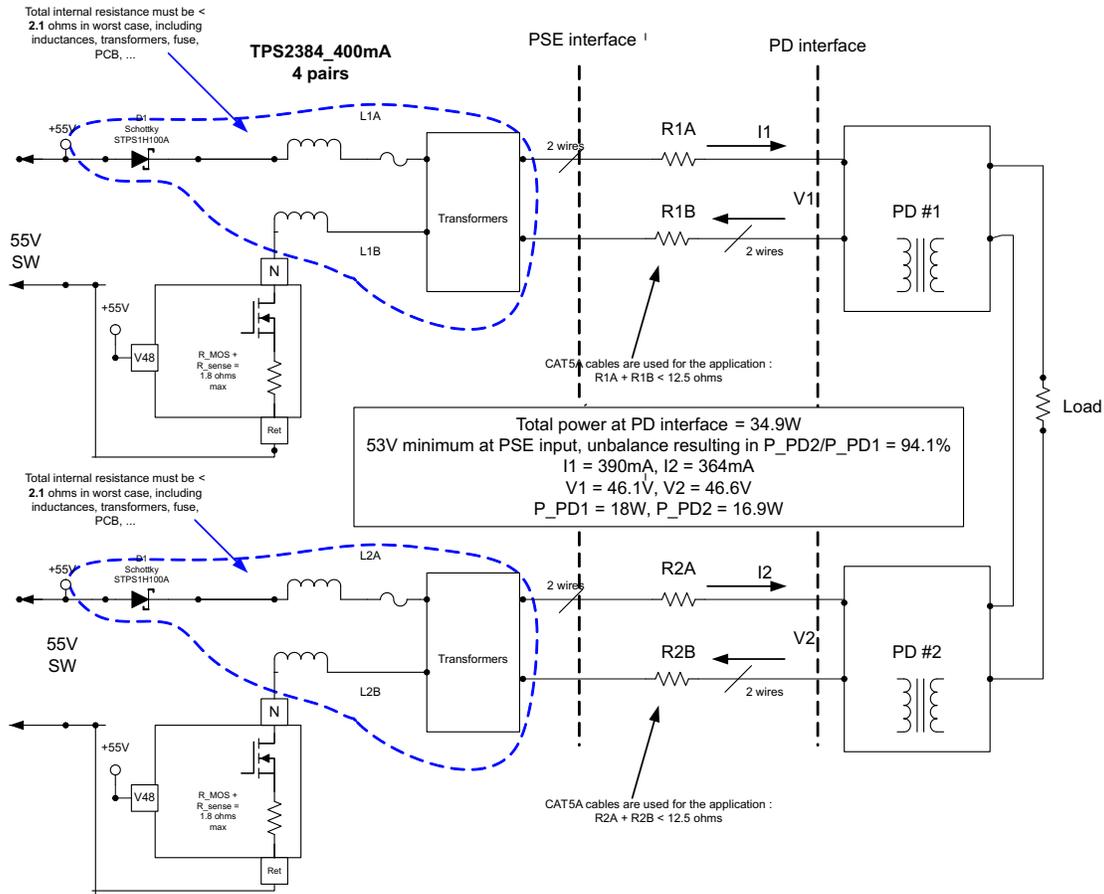
Figure 3. Diagram of a Simple Four-Pairs Solution for 35-W PD (Minimum Worst Case)

4 Conclusion

For higher power close to 35 W, a four-pair (Cat-5 cable) simple solution based on usage of a tighter tolerance power supply and operating two PSE ports in tandem is possible, using the TPS2384. Available power then can be increased anywhere from 138% to 168%.

5 References

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