Implementing IEEE's 802.3bt 71W PoE Standard Now

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Introduction

With Power over Ethernet (PoE) being a popular and mature technology, it's no surprise that Power Sourcing Equipment (PSE) and Powered Device (PD) developers are eager to jump onto the next IEEE bandwagon and start delivering higher levels of power down Ethernet cables. However, as with many industry standards, IEEE PoE standards often finalize much later than is needed by the market. The latest timeline from the IEEE PoE Task Force shows the 71W 802.3bt standard won't be ready until early 2018. That's a long time to wait in technology years, which can easily translate to missed business opportunities or markets. So, what are PSE and PD developers supposed to do in this case? Why, design and manufacture now of course! Developers who want to be first to the 802.3bt market have Linear Technology's LT4295 IEEE 802.3bt PD controller available to them today, compliant to draft 2.0 of the standard.

More Power, More Potential

Not surprisingly, the main focus for the IEEE PoE Task Force and developers has been how much power is ultimately provided to PDs. In 2003, the IEEE PoE Task Force established in the original IEEE 802.3af PoE standard that ~13W would be available at the PD input's RJ-45 jack. Since then, the market has continued to demand more power. So, in 2009, the IEEE PoE Task Force revised the standard and released IEEE 802.3at (also known as PoE+), which increased the maximum PD power level to 25.5W. Fast forward to today and it is expected that the current revision, IEEE 802.3bt draft 2.0 (also known as PoE++ or 4PPoE), will provide PDs with up to 71W of power.

With more power, developers can easily add more features and upgrade existing products. Take the security camera as an example of an application that has evolved throughout the PoE years. With only 13W available, the first PoE-powered security cameras were simple stationary units. However, when 25.5W was allocated by 802.3at, extra power was available to drive multiple embedded motors which provided security cameras with pan, tilt and zoom capabilities. Now, with 802.3bt's 71W to tap into, pan-tilt-zoom security cameras can also integrate fans and heating elements to support operation at extreme temperatures. For some, higher PoE power levels may unlock distinctly new markets. For example, a traditional LED lighting manufacturer, who only produced ceiling units controlled by wall switches, but can now produce PoE-enabled units that will help pave the way for smart homes or buildings. Whether more power evolves or revolutionizes the end product, there is clearly more market potential with each iteration of the PoE standard.

Changes to the PSE-PD Link

As you might have already guessed, 4PPoE stands for "4-pair PoE", since 802.3bt takes advantage of all four twisted pairs in the Ethernet cable to transmit power up to 100m; in older PoE standards, 4-pair power delivery was non-compliant. See Figure 1 for a typical block diagram of an IEEE 802.3bt PSE-PD link. Cabling requirements are still up in the air, but cabling committees and manufacturers are guessing

that 802.3bt will require at least Category 5E cabling in order to support the increased power levels while operating with 10GBASE-T (10Gbit/s Ethernet data speed). In any case, because we are now reaching the current handling limitations of the Ethernet cable, you may have to pay attention to cabling-system performance characteristics that were previously ignored.

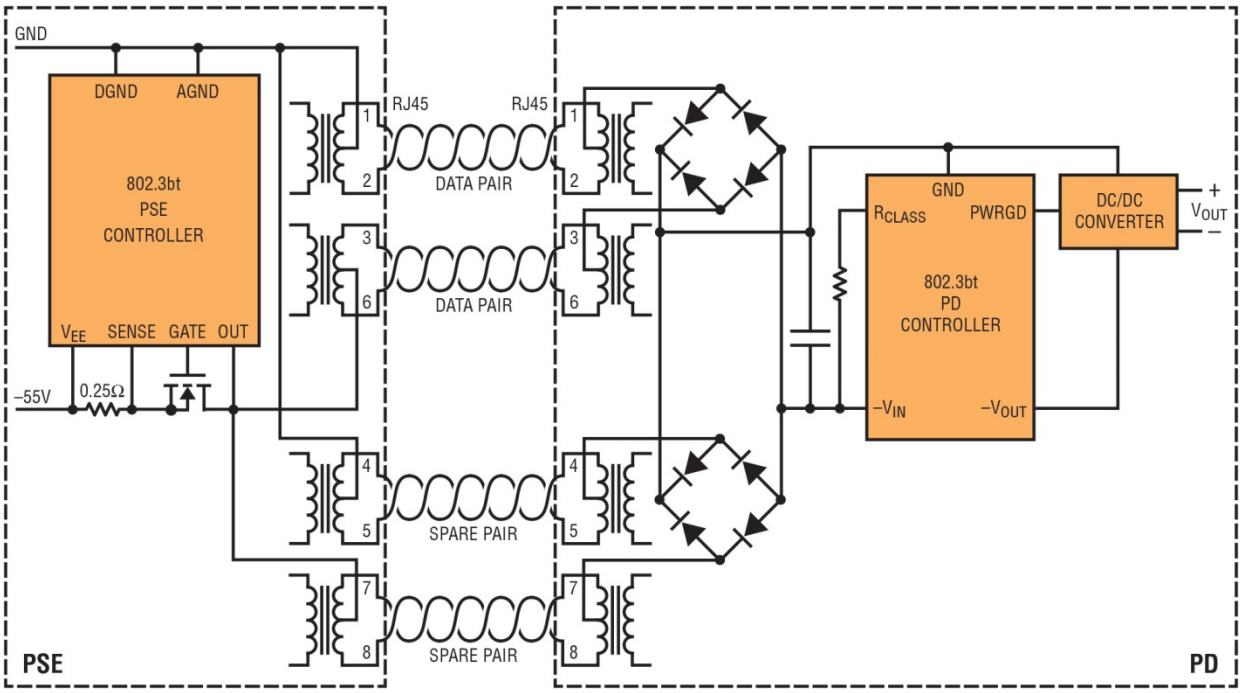

Figure 1. Typical Block Diagram of an IEEE 802.3bt PSE-PD Link

802.3bt introduces two new PD topologies: single-signature and dual-signature. That is, a single-signature PD is an 802.3bt PD that shares the same detection signature, classification signature and maintain power signature (MPS) between both pairsets, whereas a dual-signature PD is an 802.3bt PD that has independent signatures between both pairsets. New 802.3bt designs will, no doubt, gravitate towards the simpler and more cost-effective single-signature topology, which only calls for a single PD interface. Dual-signature PDs require two parallel PD interfaces, one for each pairset, where the power from two PSEs are summed up after each PD interface. Essentially, the dual-signature topology uses, for example, two 25.5W PDs to make a single 51W PD – a complex solution that can cost twice as much as a single-signature 51W PD.

The 802.3bt detection process has been expanded to be able to differentiate, not only that the connected PD is an 802.3-compliant PD, but also to determine whether a single or dual signature PD is connected. As such, detection is now augmented by a Connection Check to determine the single or dual signature PD configuration.

802.3bt introduces four new high power PD classes, bringing the total number of single-signature classes to nine as shown in Table 1. Classes 5 through 8 are new to PoE and translate to PD power levels ranging from 40.0W to 71.0W. PSEs still have their choice of using the physical layer (i.e. 5-event

classification for 71W) or data link layer (i.e. link layer discovery protocol, LLDP) to classify PDs, and PDs still need to be able to support both classification schemes in order to be compliant. 802.3bt PDs may also implement an optional extension of the physical layer classification, known as Autoclass, where an 802.3bt PSE measures the actual maximum power draw of a connected PD. This handy power management feature allows, for example, a PSE to allocate leftover power to additional light bulbs if it knows that a particular bulb will draw less than its class power.

SINGLE-SIGNATURE PDs		DUAL-SIGNATURE PDs	
CLASS	PD POWER AVAILABLE	CLASS	PAIRSET PD POWER AVAILABLE
0	13W	—	—
1	3.84W	1	3.84W
2	6.49W	2	6.49W
3	13W	3	13W
4	25.5W	4	25.5W
5	40W	5	35.5W
6	51W		
7	62W		
8	71W		

Table 1. IEEE 802.3bt PD Classes and Power Levels

For those of you with PDs that require a deep sleep mode, you'll be happy to know that 802.3bt introduced a lower power version of the maintain power signature (MPS), referred to as Low MPS. Under the older PoE standards, a PD has to sink a small DC current at a 32% duty cycle in order to tell the PSE to keep the PD on. However, this relatively high duty cycle can quickly become a burden in some applications, such as when you consider new "energy efficient" building standards. 802.3bt PDs are now only required to maintain a small DC current at a ~2% duty cycle, drastically reducing the standby current.

Table 2 summarizes the 802.3bt PD types and features. You may already be familiar with Type 1 and Type 2 PDs, which were introduced by 802.3af and 802.3at respectively and typically map to one or more unique classes (power levels). 802.3bt's new Type 3 and Type 4 PDs, however, are not as straightforward. As you can see from the "PD Class" column, with the exception of Class 0, Type 3 PDs cover and extend the classes in Type 1 and Type 2 PDs. Similarly, Class 5 is employed by both Type 3 single-signature and Type 4 dual-signature PDs. Moreover, from Figure 2, a Class 5 single signature PD is only allocated 40W, while a Class 5 dual signature PD is allocated 2x35.5W; to make things worse in dual signature PDs, because each pairset operates independently, each pairset can be of different class – for example, Class 1 (3.84W) on the first pairset and Class 2 (6.49W) on the second pairset makes for a dual signature Class 1.2 (10.3W) PD. With all of this class overlap and proliferation of non-standard power levels by dual signature PDs, it becomes important that developers and users alike no longer synonymize PD types with PD classes nor PD classes with PD power levels. Instead, it would be in everyone's best interest to explicitly identify a PD's signature topology and class, with a cautious look at what is really meant by a PD's "type."

PD TYPE	SINGLE-OR DUAL-SIGNATURE	PD CLASS	4-PAIR CAPABLE	LOW MPS SUPPORT	PHYSICAL LAYER CLASSIFICATION	DATA LINK LAYER CLASSIFICATION	OTHER OPTIONAL CAPABILITIES
Type 1		0-3	Optional	No	Single-Event	Optional	
Type 2		4	Optional	No	Multiple-Event	Mandatory	
Type 3	Single	1-6	Mandatory	Yes	Multiple-Event	Mandatory	Autoclass
	Dual	1-4	Mandatory	Yes	Multiple-Event	Mandatory	Autoclass
Type 4	Single	7-8	Mandatory	Yes	Multiple-Event	Mandatory	Autoclass
	Dual	0-5	Mandatory	Yes	Multiple-Event	Mandatory	Autoclass

Table 2. IEEE 802.3bt PD Types and Features Summary

It goes without saying that 802.3bt is backward compatible with 802.3at and 802.3af. A lower power 802.3at or 802.3af PD can connect to a higher power 802.3bt PSE without any issues. And, when the table has turned and a higher power 802.3bt PD is connected to a lower power 802.3at or 802.3af PSE, the PD just needs to be able to operate in the respective lower power state – this is referred to as demotion. If a PD ignores demotion and operates at its highest power state, the power-hungry PD will cause the PSE to repeatedly turn on, hit its current limit, then turn off – in effect, motor boating the PSE. For this reason, "demotion" is required by both 802.3at and 802.3bt, but is unfortunately overlooked in many implementations.

Squeezing Every Watt Out

The most important aspects of a high power PD design are generally cost and efficiency, which are largely driven by the ICs chosen to implement the PD interface. In addition, developers with space-constrained designs are painfully aware of how limiting a PD's size only becomes more of a challenge as higher power levels call for larger discrete components and larger heat sinks. For this reason, Linear Technology provides three ICs that are specifically designed to maximize 802.3bt PD performance and, perhaps more importantly, simplify your job. Figure 2 shows a simplified block diagram of a high efficiency single-signature 802.3bt PD interface with an auxiliary input. This solution provides an end-to-end (RJ-45 input to PD load) efficiency of greater than 94% and operates within the -40°C to 125°C temperature range.

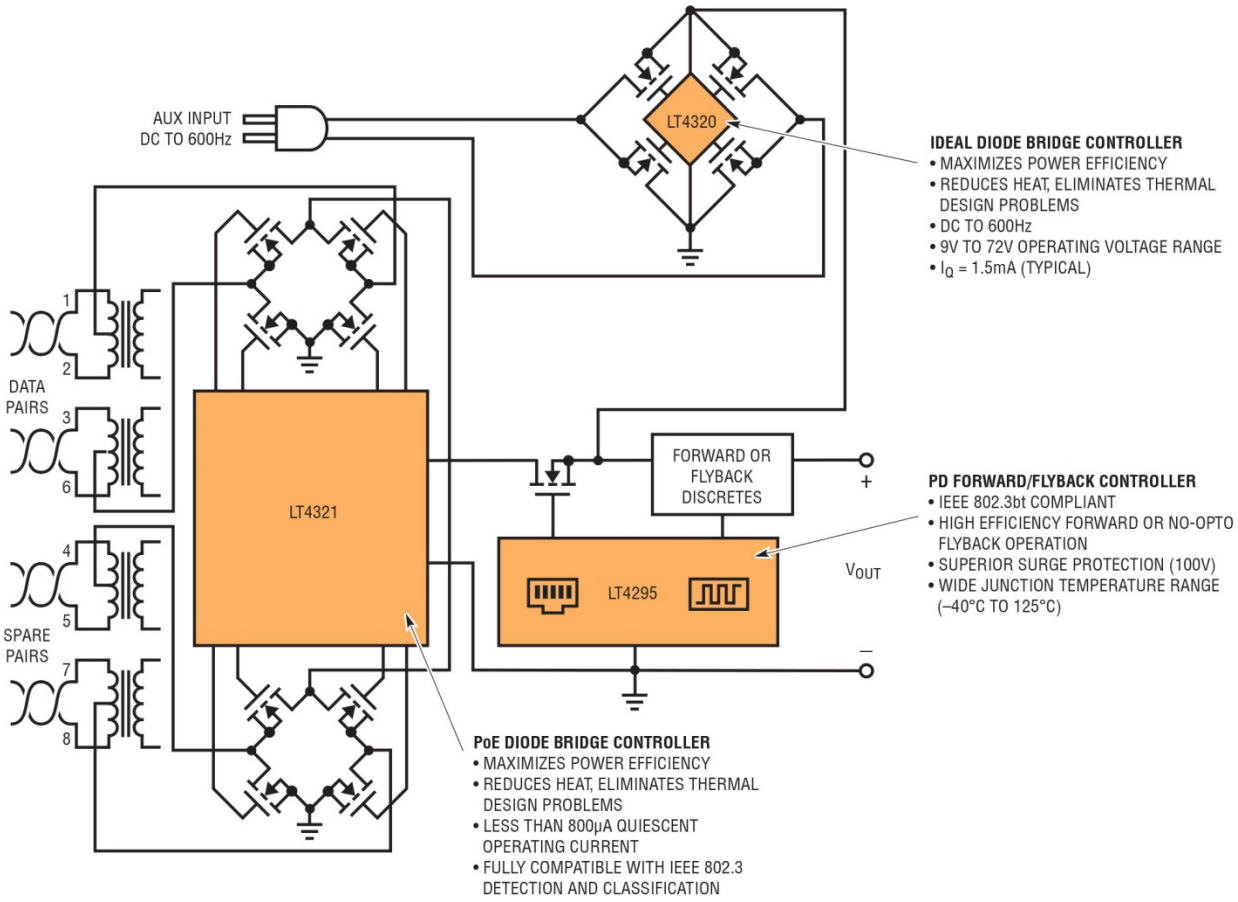

Figure 2. Simplified Block Diagram of a High Efficiency IEEE 802.3bt Single-Signature PD Interface with Auxiliary Input

The LT4321, shown on the RJ-45 interface in Figure 2, is an ideal diode bridge controller that replaces the two diode bridge rectifiers (Figure 1). The LT4321 uses low-loss N-channel MOSFET bridges to simultaneously increase the PD's available power and reduce heat dissipation. 802.3bt requires PDs to accept DC supply voltages of any polarity over their Ethernet inputs, so the LT4321 smoothly rectifies and combines power from the data and spare pairs into a single, polarity-correct supply output. Overall circuit size and cost are reduced as the enhanced power efficiency practically eliminates heat sinking requirements, and power savings of 10x or more enable PDs to stay within classification power budgets or add additional functionality.

Following the ideal diode bridge controller in Figure 2 is the brains of the PD interface – the LT4295 is an 802.3bt compliant PD interface controller that integrates a high efficiency forward or no-opto flyback controller. The LT4295 supports all nine PD classes and all four PD types with an integrated 25kΩ signature resistor, up to 5-event classification sensing, and a single-signature topology. Aside from providing more PD power, what gives the LT4295 an edge over traditional PD controllers is its use of an external power MOSFET to drastically reduce overall PD heat dissipation and maximize power efficiency, which, again, becomes more important at 802.3bt's higher power levels. This novel approach allows you to size the MOSFET to your application's specific heating and efficiency requirements, enabling the use of MOSFETs with as low as 30mOhm of on-resistance.

If 802.3bt's 71.0W leaves you thirsting for more, seek out Linear Technology's family of LTPoE++ PSE and PD controllers, which provide power levels up to 90W. The LTPoE++ standard employs a similar classification scheme to 802.3bt that enables LTPoE++ PSE controllers and LTPoE++ PD controllers to reliably communicate with one another while maintaining interoperability with 802.3at and 802.3af equipment. With just a single cable, you just plug-n-play an LTPoE++ PD into an LTPoE++ PSE – all of the hand shaking is automatically handled via hardware, no software required!

Finally, for those of you with 802.3bt PDs that need to be able to support an auxiliary supply, where the PD can be optionally powered by a power adapter in addition to PoE, the LT4320, shown at the top of Figure 2, is a 9V to 72V ideal diode bridge controller that replaces each of the four diodes in a full wave bridge rectifier with a low loss N-channel MOSFET to significantly reduce the power dissipation and increase available voltage. Power supply and wall wart sizes can be reduced as the enhanced power efficiency eliminates bulky and costly heat sinks. Low voltage applications can also benefit from the extra margin afforded by saving almost two full diode drops (~1.2V, which is 10% at 12V) inherent in hot-running diode bridges, increasing the application headroom.

Conclusion

IEEE's 802.3bt is far from being finalized, but developers can confidently go to market now with major aspects of the standard starting to settle down. 802.3bt's PD types, topologies, and classes support higher power levels up to 71.0W, while a new MPS signature supports lower standby power when PDs are asleep. As PoE pioneers and active members of the IEEE Task Force, Linear Technology continues to be at the forefront of PoE with released 802.3bt and LTPoE++ PD and PSE controllers. It's up to savvy well-informed developers, like yourself, to capitalize on these ICs – that simplify designs, maximize power efficiency, minimize size and reduce total BOM costs – and be the first to the 802.3bt market.