Designing Industrial Ethernet Systems for Industry 4.0

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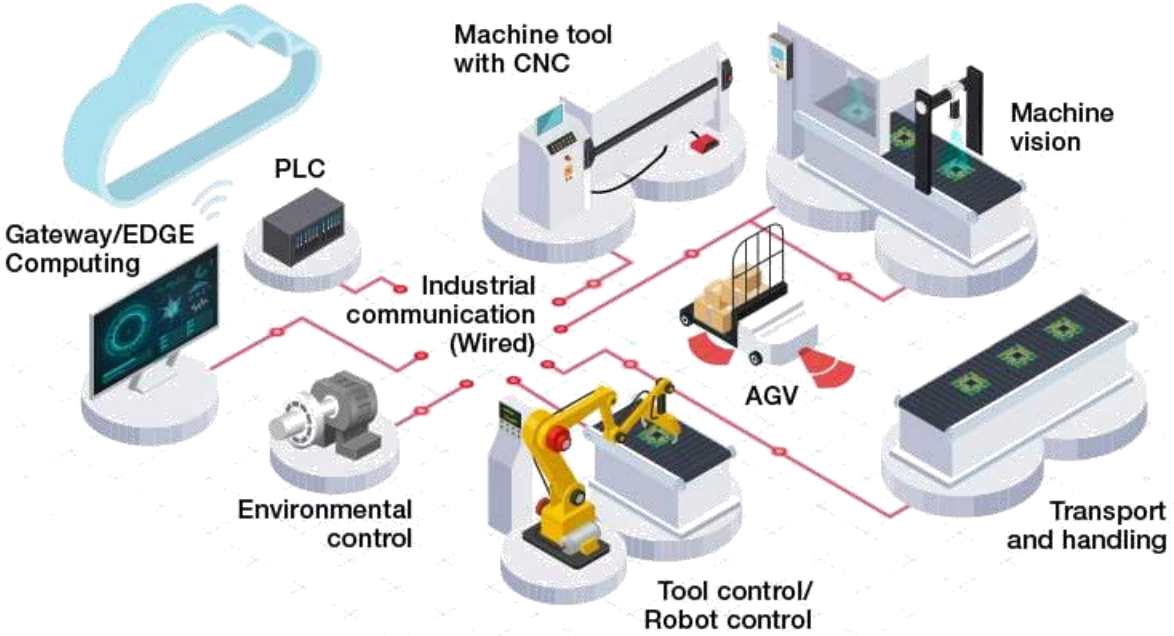
What is Ethernet?



Ethernet is an **established, easy-to-use, robust, fast, price-competitive** communication protocol that enables easy connection to internet (industry 4.0), **scales** from factory floor to enterprise and beyond

Let’s review traditional industrial communications

Field Bus	Longest Reach	Highest Rate
PROFIBUS DP	9.6Kbps @ 1200m	12Mb/s @ 100m
CANopen	10Kbps @ 5000m	1Mb/s @ 20m
Modbus RTU	100Kbps @ 1200m	2Mb/s @ 50m
CC-Link	156Kbps @ 1200m	10Mb/s @ 100m
HART	1200 baud @ 1524m (24AWG)	No enhanced rate
PROFIBUS PA	31.25Kbps @ 1900m	No enhanced rate
INTERBUS	500Kbps @ 400m	No enhanced rate

Industrial systems require communication to be reliable, accurate and deterministic with a high data rate and long cable reach in factory and process automation environments.

Conventional versus industrial Ethernet

Conventional Ethernet

- Interoperable
- Cable reach 100m
- Data rate 10M/100M or higher

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Industrial Ethernet

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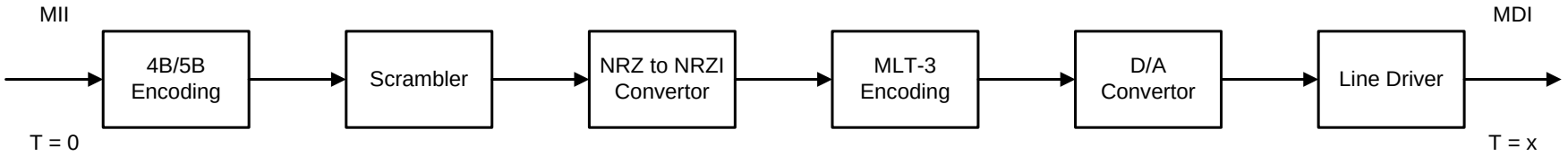
- Robust & reliable
- Accurate
- **Deterministic**

Latency

Why does low latency & determinism matter?

Longer latency and wider variation means that you have to build **more time** into your system, **reducing throughput** and ultimately impacting **$$$**.

What is PHY latency?



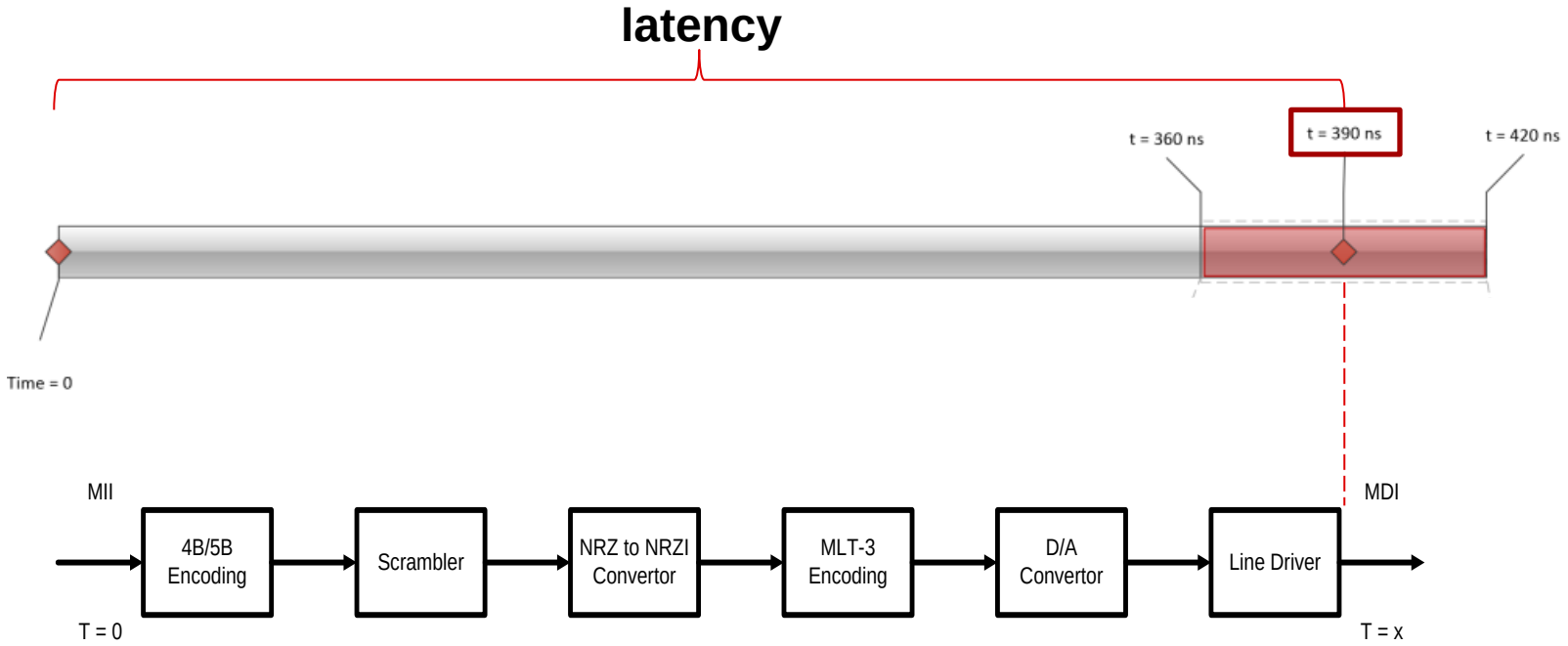
PHY TX process example

Device latency refers to the amount of time it takes for information to be processed by that device.

What is determinism?

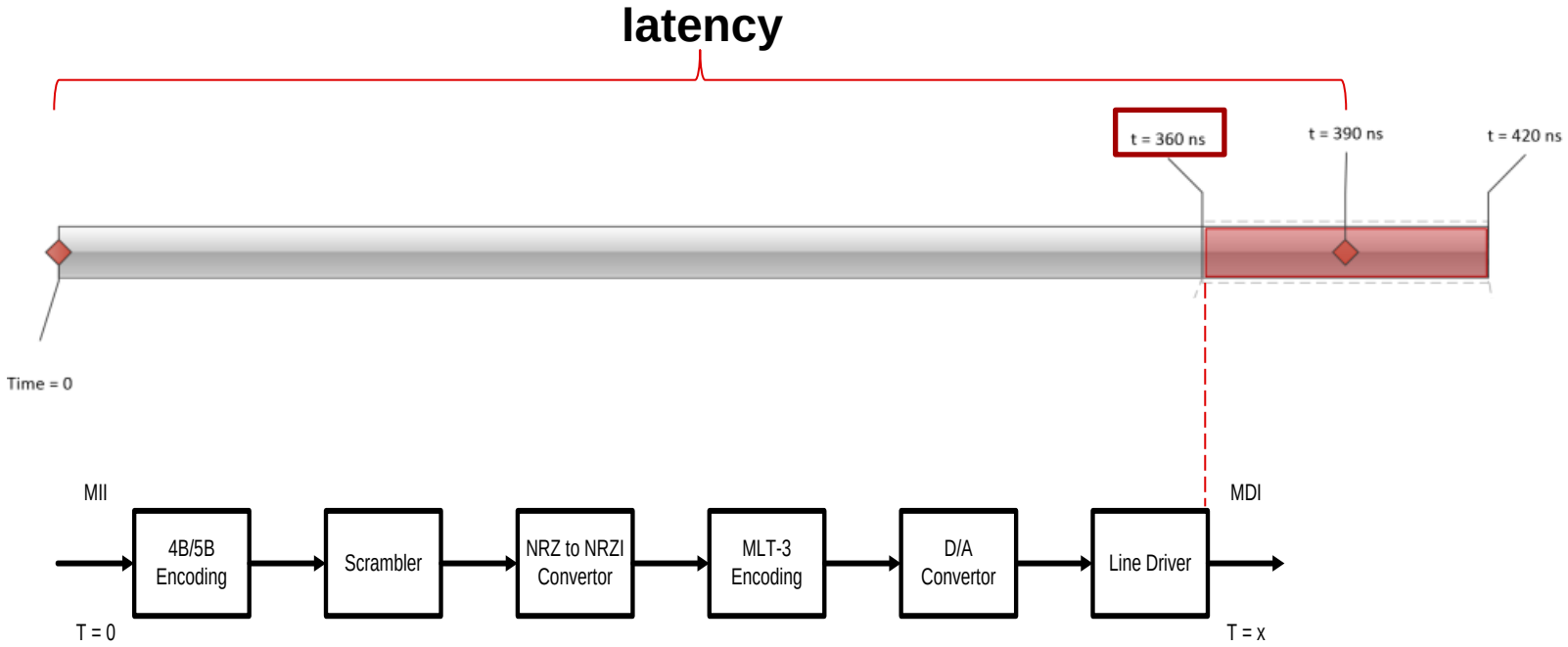
Determinism refers to the variance in this latency. PHYs are available with different timing characteristics. Choosing the right one can improve your system's efficiency & throughput.

What is determinism?



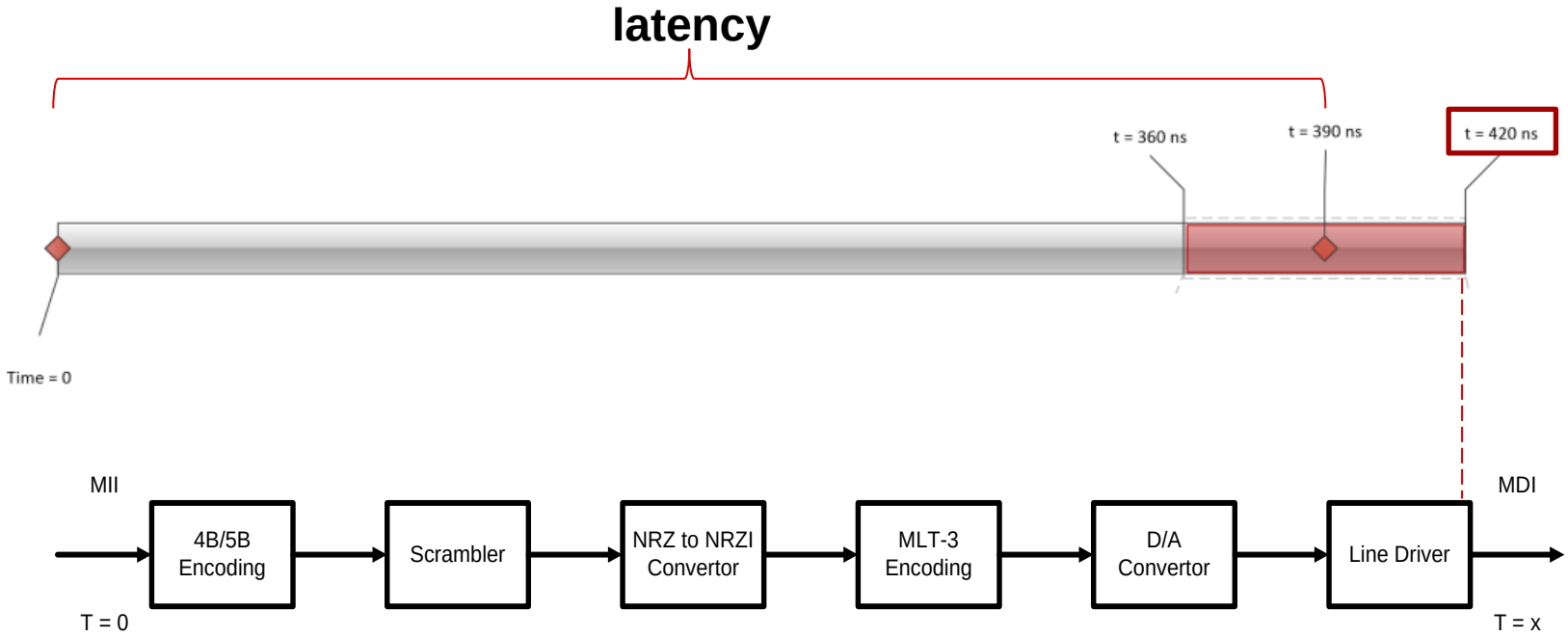
achieves target latency

What is determinism?



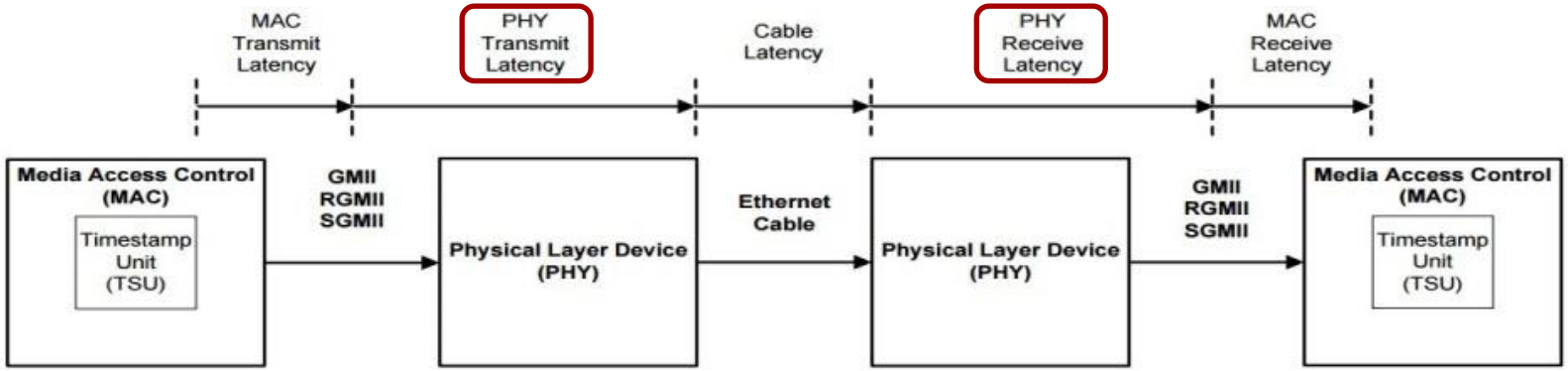
-30 ns variation

What is determinism?



+30 ns variation

What is system latency?



Ethernet PHY latency occurs when a frame is being transmitted (TX) or received (RX). TX & RX times can be different. System latency includes all system delays.

Maximize operations on your production floor

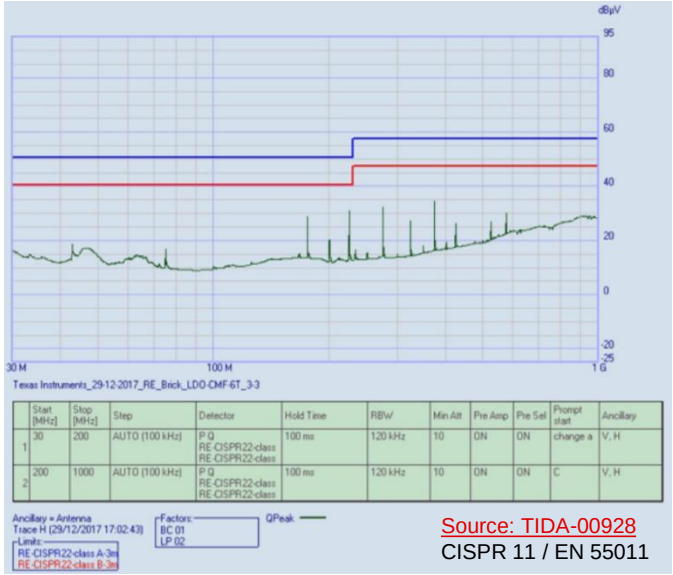
Minimizing **latency** and its **variation** from cycle to cycle enables faster cycle times or the ability to add more nodes on a single bus, helping you to get the most from your system.

EFT/ESD mitigation

Why is EFT/ESD mitigation important?

Device robustness in harsh environments and low impact to surroundings helps both in **compliance testing** and **conformance** to desired operation.

Achieving compliance, conformance & robustness

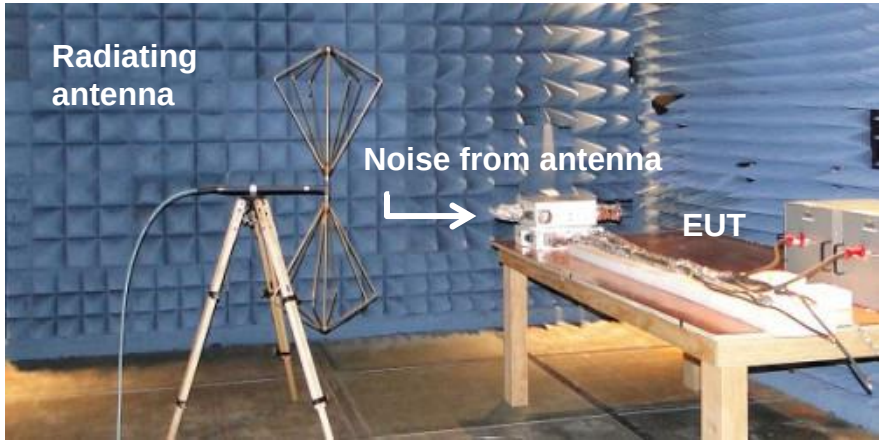


Source: TIDA-00928
CISPR 11 / EN 55011

Hardened systems must first, do no harm (EMI)

- Electrical systems both generate, and are sensitive to, electromagnetic radiation
- The system must not exceed specific limits of radiation so as not to affect surrounding systems

Achieving compliance, conformance & robustness



Class	Description
A	No effect on EUT performance
B	Some effect during test. EUT self-recovers after interference is stopped.
C	Some effect during test. EUT needs user intervention for proper operation.
D	Device Damaged

Hardened systems must survive a harsh environment (ESD & EMC)

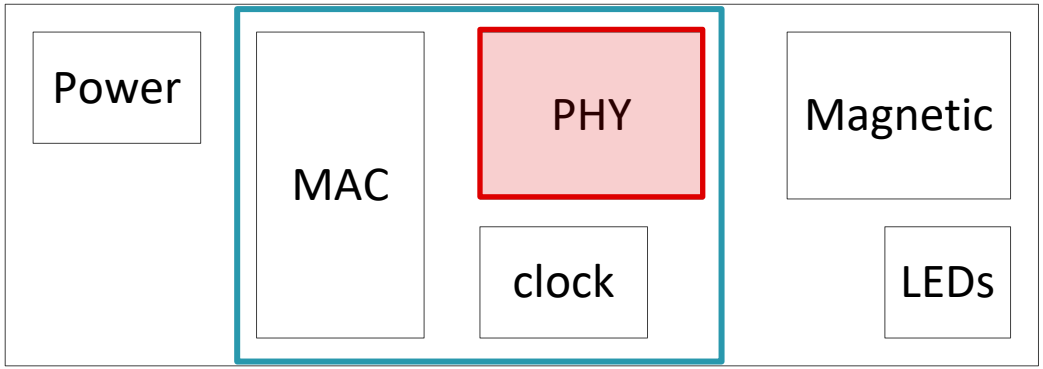
- Electrostatic discharge (ESD) is a sudden flow of electricity which can impair or destroy components
- Electrical systems both generate, and are sensitive to, electromagnetic radiation, the system must not be affected by external radiation (EMC)

Board optimization

Why does board optimization matter?

Maximizing signal integrity with good design principles ensures no undesirable effects are introduced to the system degrading its performance.

Board zoning to maximize signal integrity



- High frequency components should be centrally located
- Differential signals should be routed before single-ended signals
- Keep high frequency paths close to destination and away from analog signals
- Lower frequency devices can be moved away from the higher frequency components

Get the most out of your system

- **Maximize throughput** by minimizing system latency and keeping the latency deterministic → faster production rate & lower cost per unit
- **Ease development** compliance testing by using components already designed & tested to industry standards
- **Reduce maintenance costs** with purpose-built, robust components on well-implemented designs

What’s next?

With **big data** and **industry 4.0**, industrial communications need to be able to take information through the network faster & farther.

Where is industrial Ethernet going?

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Tomorrow

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Faster and farther with a single protocol

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IEEE802.3cg	10Mb/s @ 200m (1V)	No enhanced rate
10BASE-T1L	10Mb/s @ 1000m (2.4V)	
IEEE 802.3bw	100Mb/s @ 50m	No enhanced rate
100BASE-T1		
IEEE 802.3bp	1000Mb/s @ 15m	No enhanced rate
1000BASE-T1		

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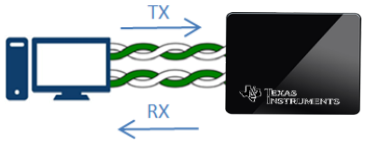
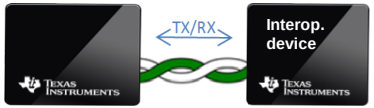
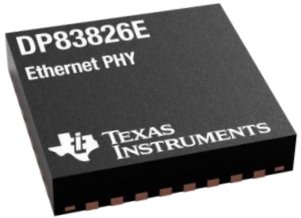
Key types of Ethernet PHYs

	Standard ENET			Single twisted pair ENET		
Cable type	2+ twisted pairs / 4+ wires			1 twisted pair / 2 wires		
IEEE standard	802.3i	802.3u	802.3ab	IEEE802.3cg	IEEE802.3bw	IEEE802.3bp
Description	10BASE-T	100BASE-TX	1000BASE-T	10BASE-T1L	100BASE-T1	1000BASE-T1
Maximum bandwidth (Mbps)	10	100	1000	10	100	1000
Standard cable reach (m/link)		100		1000	50	15
Data Transfer	Full-duplex	Full-duplex	Full-duplex	Full-duplex	Full-duplex	Full-duplex
Sample Applications	Harsh environments, diagnostics Firmware/Software Upgrades End of line programming Ethernet fieldbuses			Harsh environments Factory & process auto. Building auto.	Harsh environments Domain to domain connections ADAS/Infotainment Body Control Module	





Achieve real-time, deterministic industrial Ethernet



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