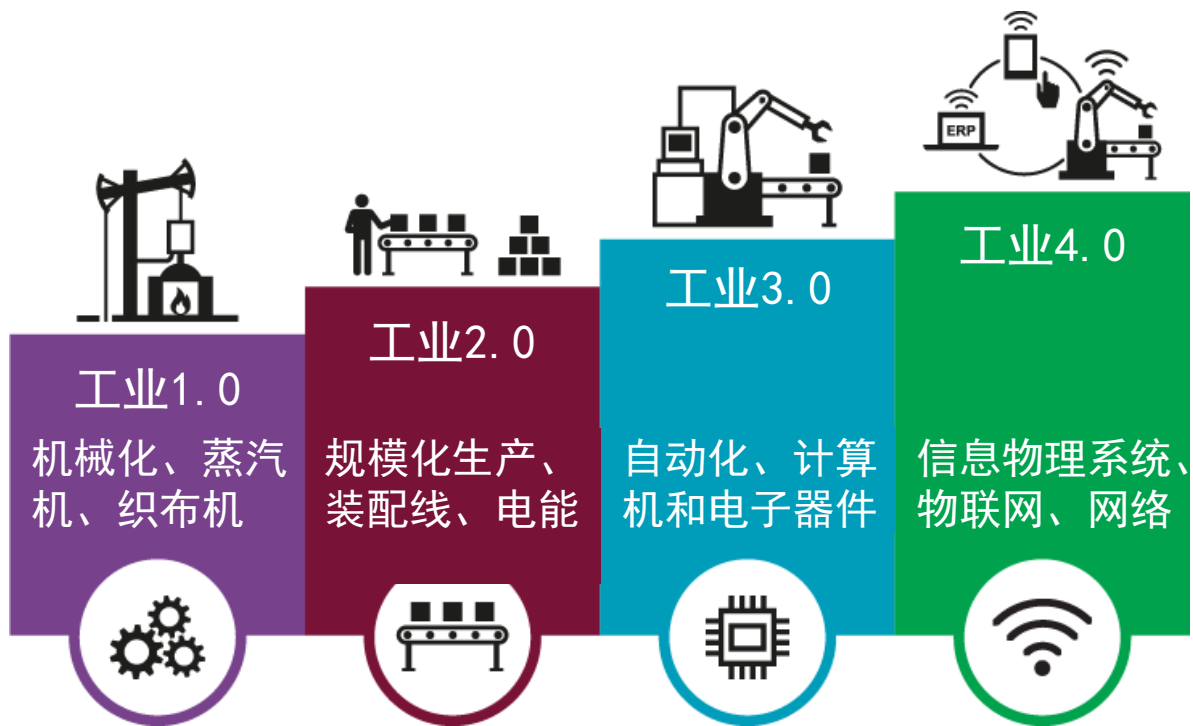




**安森美全新10BASE-T1S PHY+MAC控制器NCN26010
推进工业以太网发展**

工业4.0革命与市场趋势

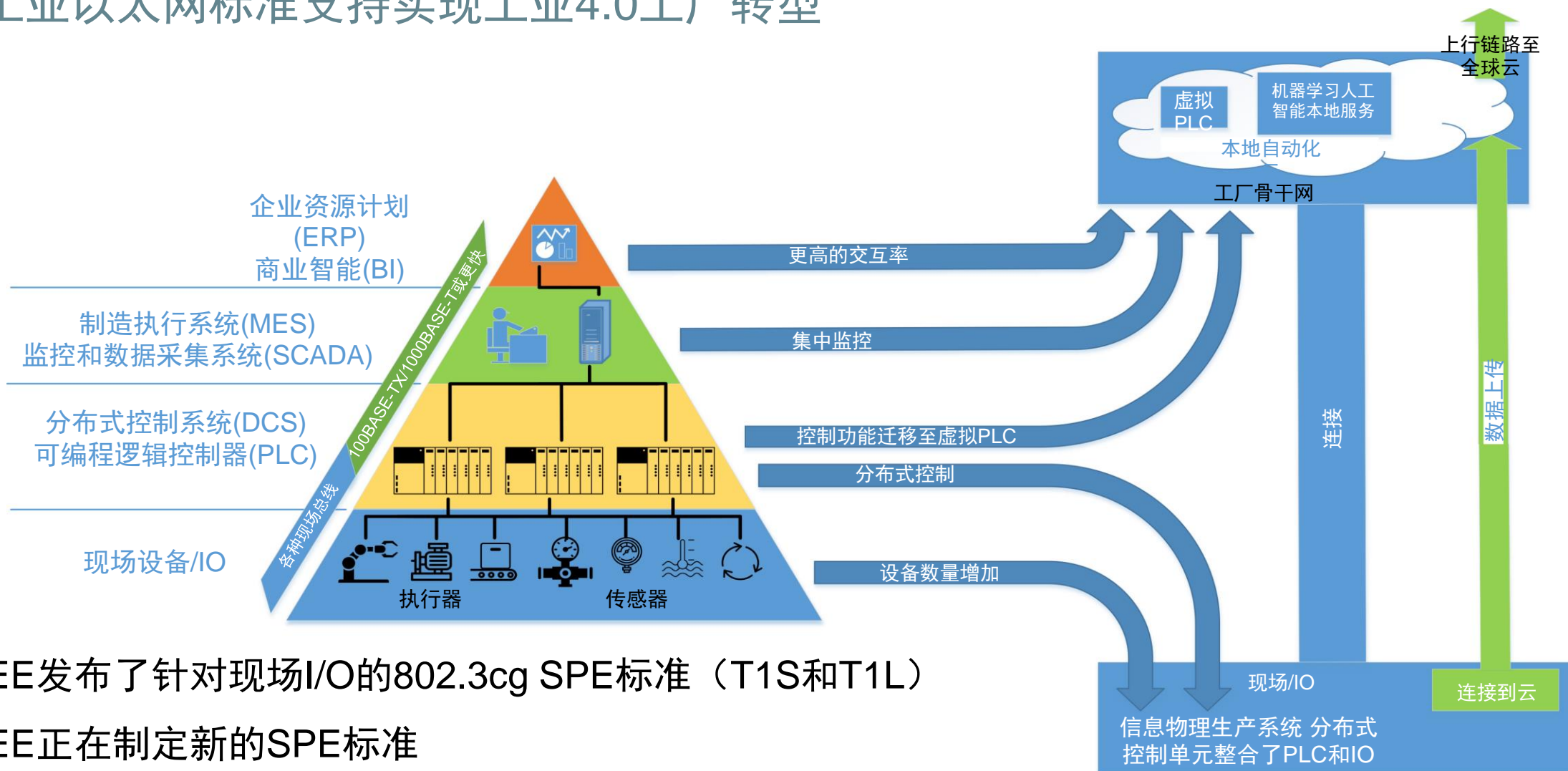


工业市场对半导体产品的需求迅猛增长，以支持更高速率连接、感测和边缘计算



10BASE-T1S自上而下的单对以太网(SPE)

全新工业以太网标准支持实现工业4.0工厂转型



- IEEE发布了针对现场I/O的802.3cg SPE标准 (T1S和T1L)
- IEEE正在制定新的SPE标准
 - 802.3da: 多点(Multi-drop)增强功能(10BASE-T1M)
 - 802.3dg: 100Mbps, 500m点对点SPE

IEEE 802.3cg多点功能亮点

该标准在2019年第4季度获得批准

面向工业、汽车、建筑和系统内10Mb/s网络

- 10BASE-T1S：短距离（15米点对点 / 25米多点）
- 可选的全双工点对点, 半双工点对点, 半双工多点连接

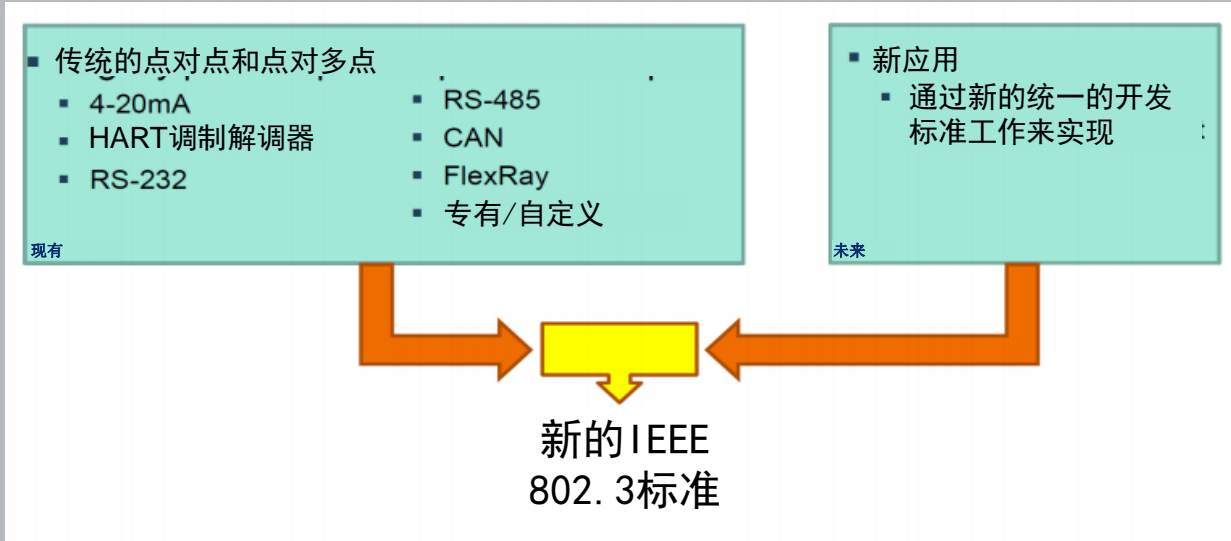
演进的媒体访问协议

- 物理层冲突避免 (PLCA)方案，用于增强多点性能
- 在高负载情况下，相对于普通以太网的传统CSMA-CD协议，可以改进性能
- 如果网络设置正确，由于采用了“轮询调度”方法，可以避免冲突

在MAC接口保留IEEE 802.3/以太网帧格式

- MAC子层以上的层保持不变
- 开发人员仍可在更高层使用现有的软件/IP
- 从半导体的视角来看，仅PHY和MAC有所不同

为什么制定802.3cg标准？统一通信和提高吞吐量

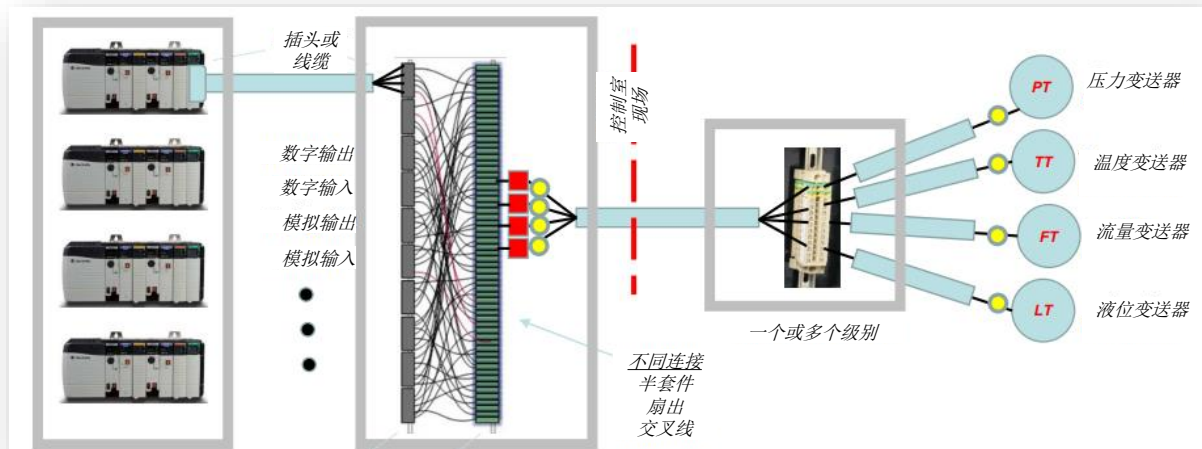


- 将多个点对点通信标准整合为一个标准
- 现有的边缘网络混合使用多种协议
 - HART、RS-232、RS-485、CAN、FlexRay、专有/自定义协议等
- 安装和维护多种边缘协议非常困难，而且成本高昂

- 802.3cg PLCA对节点使用“轮询调度”仲裁进行传输
 - 每个PHY分配ID
- 在高利用率下提高吞吐量（无冲突）

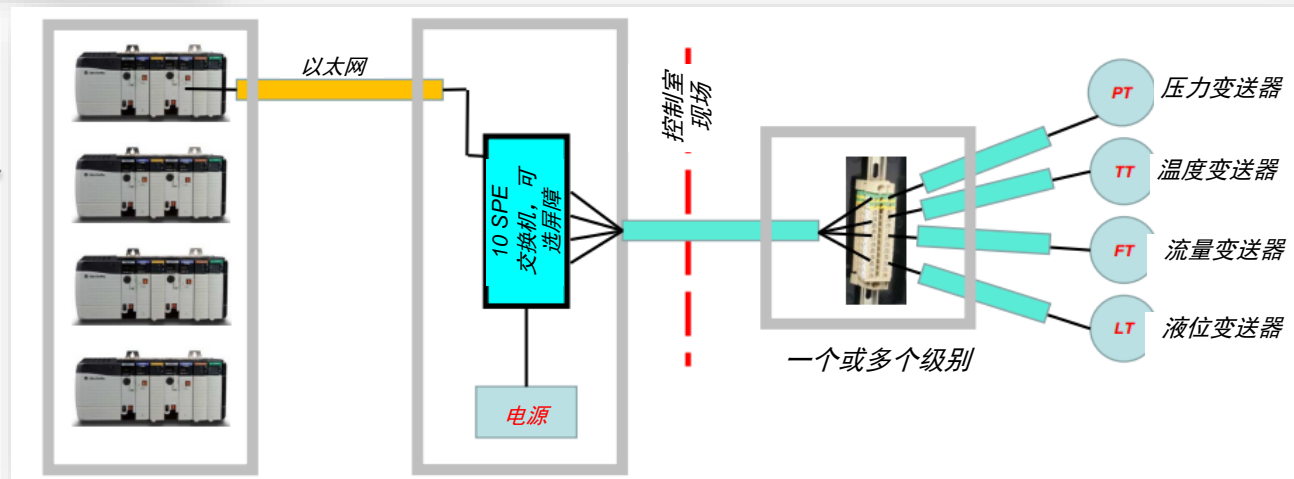


为什么制定10BASE-T1S标准？多点连接并减少线缆



在新的安装方案中，一条单对线缆可以取代10BASE-T1S之前所需的所有黄色控制线缆

使用安森美的10BASE-T1S MAC/PHY演示25米单对以太网(SPE)网络上的40个节点。

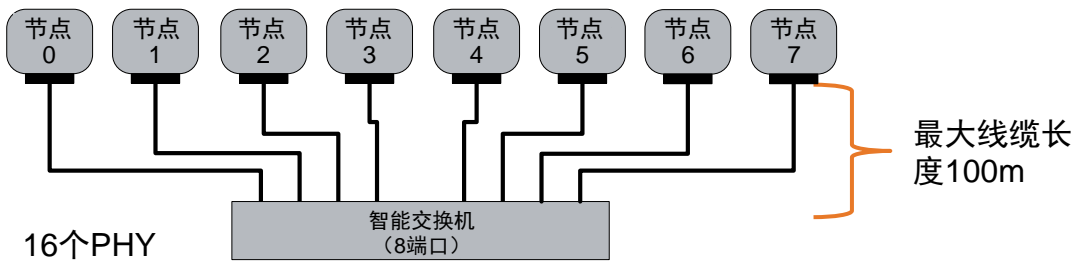
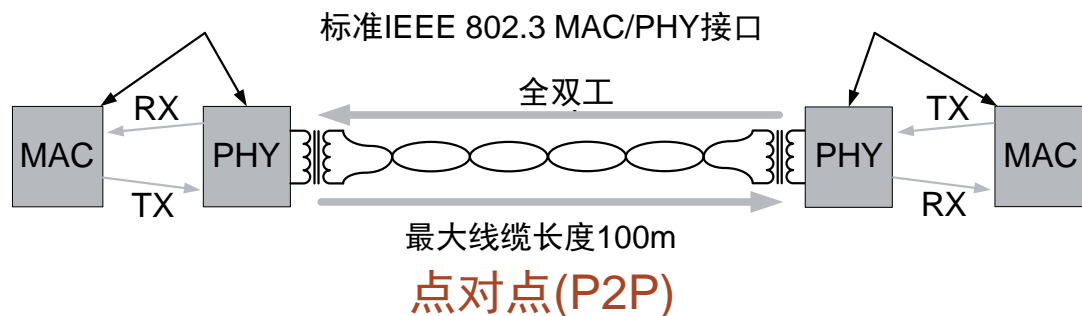


多分支需要的线缆大幅减少：
线缆数量减少70%
安装成本降低80%

以太网拓扑

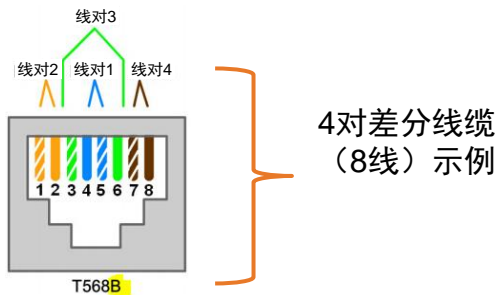
最短的以太网帧：64字节
最长的以太网帧：1,518字节

标准以太网：

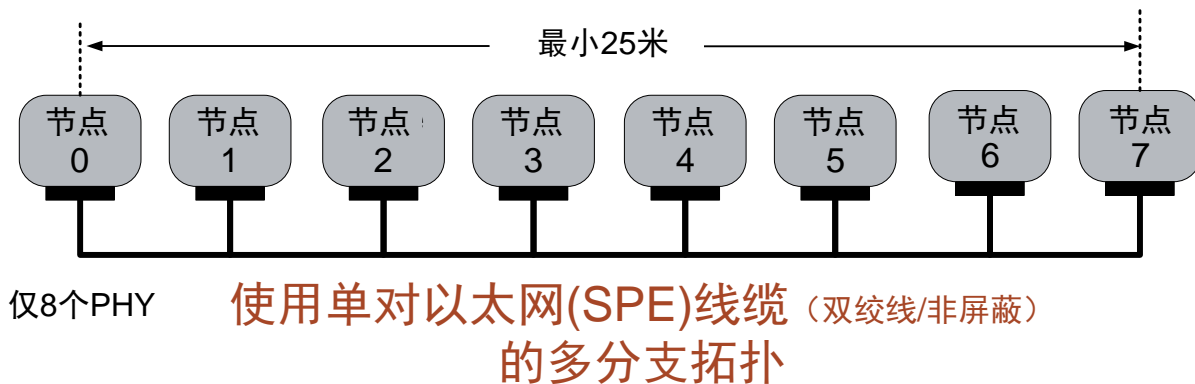


LAN交换机防止冲突

MPE:
多对以太网
2对/4对



10Base-T1S:



优势:

- PHY较少:
- 节省线缆:
- 类型 (SPE与MPE)
- 与P2P相比布线较少
- 成本较低



PLCA: 物理层冲突避免



NCN26010XMNTXG

10BASE-T1S MACPHY以太网控制器

NCN26010: 10BASE-T1S工业以太网

价值定位

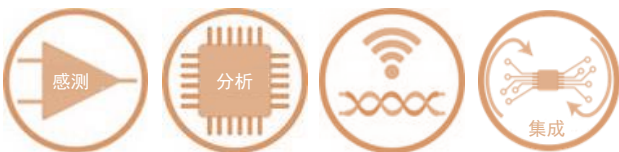
将以太网连接扩展到工业网络边缘，同时简化架构，降低网络安装和维护成本

特性和优点

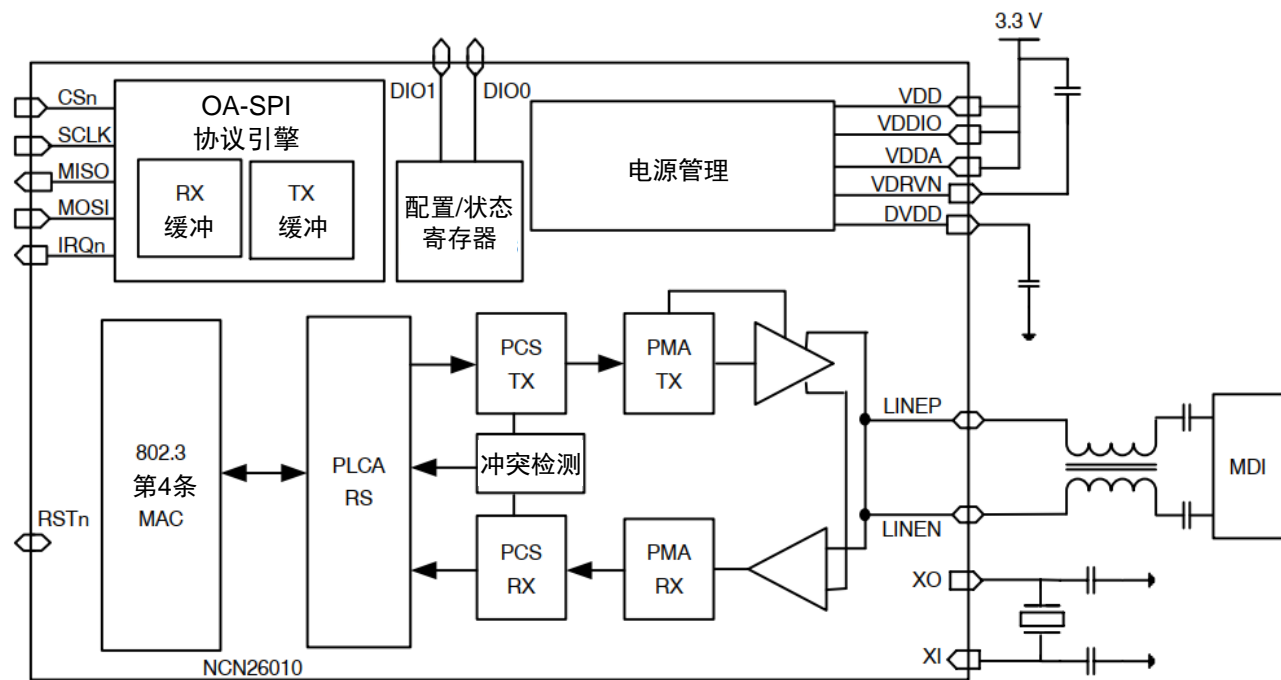
- 符合IEEE 802.3cg 10BASE-T1S规范
- 符合OPEN Alliance的MACPHY规范（TC14规范）
- 数据速率为10MB/s，半双工
- 带SPI的MACPHY控制器
- 物理层冲突避免(PLCA)
- 增强抗噪声能力
- 取代各种有线协议：HART、FieldBus、CAN、RS485、RS232、FlexRay等
- 32引脚QFN，4mm x 4mm
- 32引脚TQFP，5mm x 5mm

市场与应用

- 流程和工厂自动化
- 工业有线连接
- 接触器/过载保护器
- 阀门/执行器
- 数据中心管理



应用框图



注意：电源模块的内部配电和GND线路未显示

NCN26010关键规格

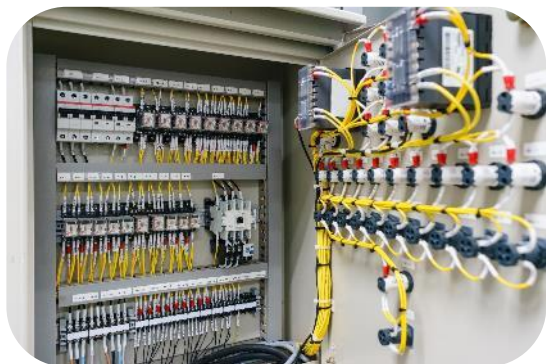
关键规格	
环境温度	-40° 至125° C
封装类型	NCN26010XMNTXG: QFN-32、4mm x 4 mm NCN26010XFBR2G: TQFP-32、5mm x 5mm
数据速率	10 Mbps
IEEE标准	802.3cg-2019 10BASE-T1S
线缆覆盖范围	具有8个节点的非屏蔽单对线缆最远50米
节点	单个25米网段内最多40个节点

应用示例

对于以下应用，NCN26010能够降低成本并提高数据速率：



电梯



工业机柜



联网传感器



照明



系统内通信



楼宇和工业自动化



火车/电车/公交车



暖通空调(HVAC)

NCN26010标准特性和主要优点



- 使用单对以太网(SPE)线缆
 - 使用成本更低的非屏蔽单根双绞线线缆



- 多点连接
 - 每端口使用一个MACPHY，在单对线缆上连接多个设备



- MACPHY
 - 使用中低端MCU，连接到控制器、传感器和其他器件，无需集成MAC



- 物理层冲突避免
 - 采用多分支拓扑可实现更高吞吐量



- MAC地址过滤
 - 主机仅处理特定节点的以太网帧，从而降低了负载



- 使用成本更低的非屏蔽单对线缆
- 单个25米网段内最多40个节点，达到IEEE 802.3cg标准要求的5倍
- 线缆减少70%，安装成本降低80%
- 最远50米，具有8个节点，达到IEEE 802.3cg标准要求的2倍
- 软件维护成本较低
- 以太网能够一直延伸到边缘节点设备
- 采用数据线供电(PoDL)设计，符合PHY规范
- 无需网关和协议转换器，从而减少网络维护

NCN26010与常规T1S器件的定位比较

增强抗噪声能力(ENI)

安森美的NCN26010 10base-T1S解决方案提供特别的ENI模式

ENI提升PHY抗噪声能力，达到远高于IEEE T1S标准的参数值。此特性让器件能够耐受最坏情况的DPI和BCI抗扰度测试。事实证明，启用ENI模式能够显著增加网络覆盖范围。启用ENI模式时，NCN26010的抗噪声能力达到竞争产品的将近2倍。

很低的线路引脚电容

出色的线路引脚电容（典型值为5.5pF）

线路引脚电容越低，每网段的节点数越高。IEEE标准要求兼容器件支持每网段最少8个节点。NCN26010支持25米网段内最多40个节点

PLCA优先模式

较低的PLCA ID优先于较高的PLCA ID

PLCA优先模式提供类似于CAN的仲裁：一旦任何站点传输信号，协调器（即头节点）就会发送新的信标。请注意，此模式是NCN26010的特性，无法与其他T1S器件实现互操作。

冲突检测屏蔽

将检测到的冲突屏蔽，从而能够在嘈杂的条件下运行

通过冲突检测屏蔽可防止高噪声环境中出现冲突检测误报。将冲突屏蔽与ENI结合使用时，NCN26010具有出色的抗噪声能力。

PLCA Leader模式

使用PLCA Leader模式可将协调器角色传递给其他节点

如果头节点出现故障，上控制层可将协调器责任传递给网络上的其他节点，而无需分配新的PLCA地址。

地址过滤和唯一编程MAC地址

安森美NCN26010 10base-T1S解决方案的特殊功能。

按照目标地址来过滤帧，主机仅处理特定节点的以太网帧，从而降低了负载。MAC将查看帧，处理地址，并根据过滤原则来丢弃帧，因而主机无需处理帧。此外，与市场上的其他T1S器件不同，NCN26010带有预编程的全球唯一MAC地址。

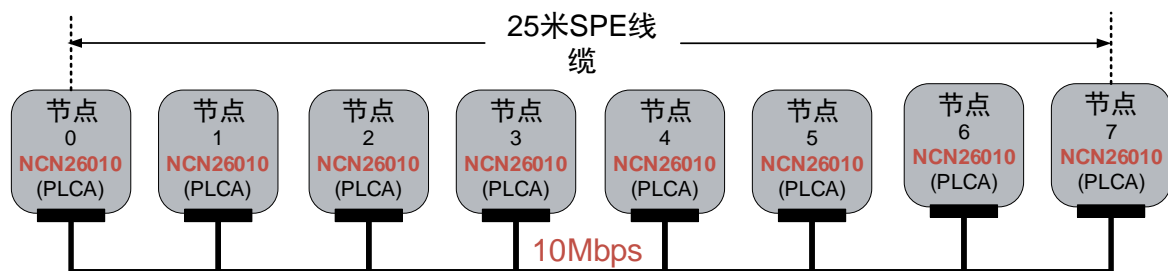
NCN26010的优势： ENI

在噪声环境下实现稳定可靠的通信！！！！

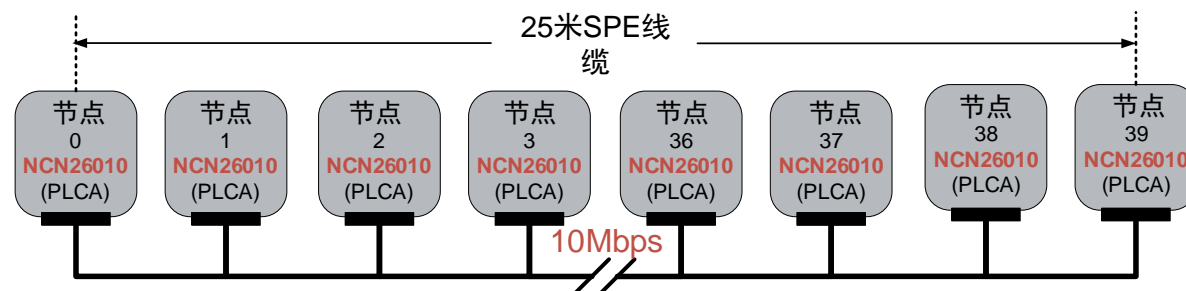
NCN26010 ENI禁用/启用：

NCN26010 ENI启用：

8个节点，25米

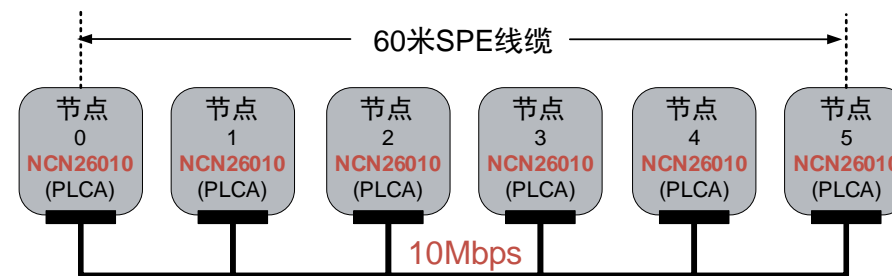


约40个节点，25米



或

6个节点，60米



ENI：增强抗噪声能力
SPE：单对以太网
PLCA：物理层冲突避免
UTP：非屏蔽双绞线

NCN26010 MDI电容

在噪声环境下实现稳定可靠的通信!!!

IEEE802.3cg MDI电容规范:

NCN26010 MDI电容:

147.9.2 MDI electrical specification

When not in multidrop mode, the MDI shall meet the return loss limits as specified in Equation (96-12) in 96.8.2.1.

When in multidrop mode, the MDI shall present a minimum parallel impedance across the MDI attachment points per Equation (147-8) and the limits for R, L, C_{tot}, and C_{node} given in Table 147-4 over the stated frequency range. C_{tot} is the maximum total capacitance across all MDI attachment points, while R, L, and C_{node} are the resistance, inductance, and capacitance for each MDI attachment point.

Inductive elements are often used when power is applied across the data lines, and may be absent in non-powered implementations. Removing the parallel inductance is equivalent to setting L to infinity in Equation (147-8). The parasitic capacitance of inductive elements forms a portion of C_{node}.

$$|Z| = \frac{1}{\sqrt{R^2 + \left(\frac{1}{2\pi \cdot f \cdot L} - 2\pi \cdot f \cdot C_{\text{node}}\right)^2}} \quad (147-8)$$

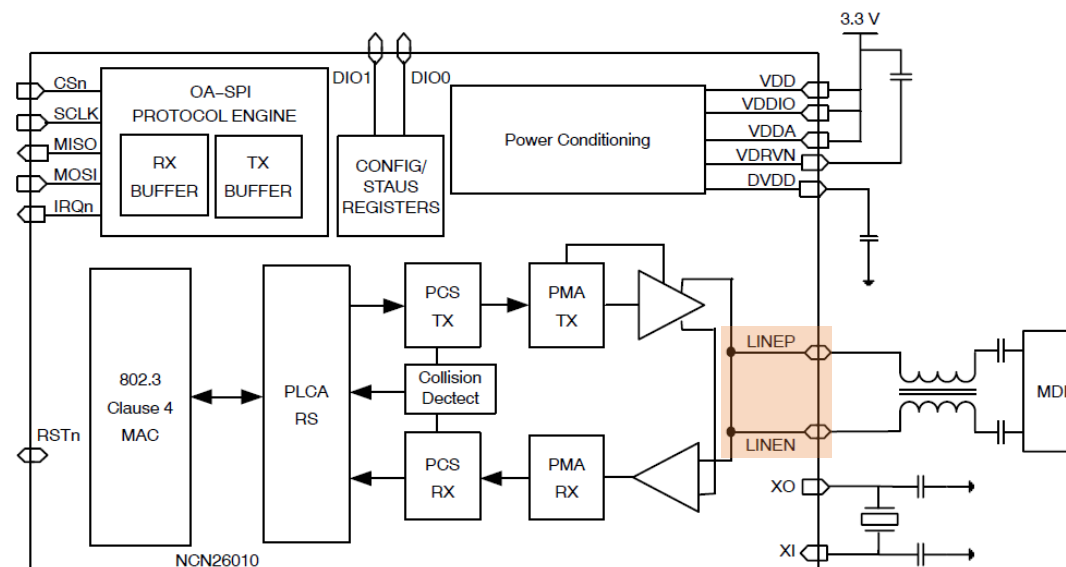
where

f is the frequency in MHz; 0.3 ≤ f ≤ 40

Table 147-4—MDI impedance limit parameters

Parameter name	Unit of measure	Minimum value	Maximum value
R	kΩ	10	—
L	μH	80	—
C _{tot}	pF	—	180
C _{node}	pF	—	15

NOTE—The implementer is cautioned that loading the mixing segment with multiple nodes with worst case capacitance at the same location on the mixing segment may cause the mixing segment to exceed its return loss specification.



NOTE: Internal power distribution and GND lines from Power Supply block are not shown.

LINE RECEIVER CHARACTERISTICS (at the MDI)

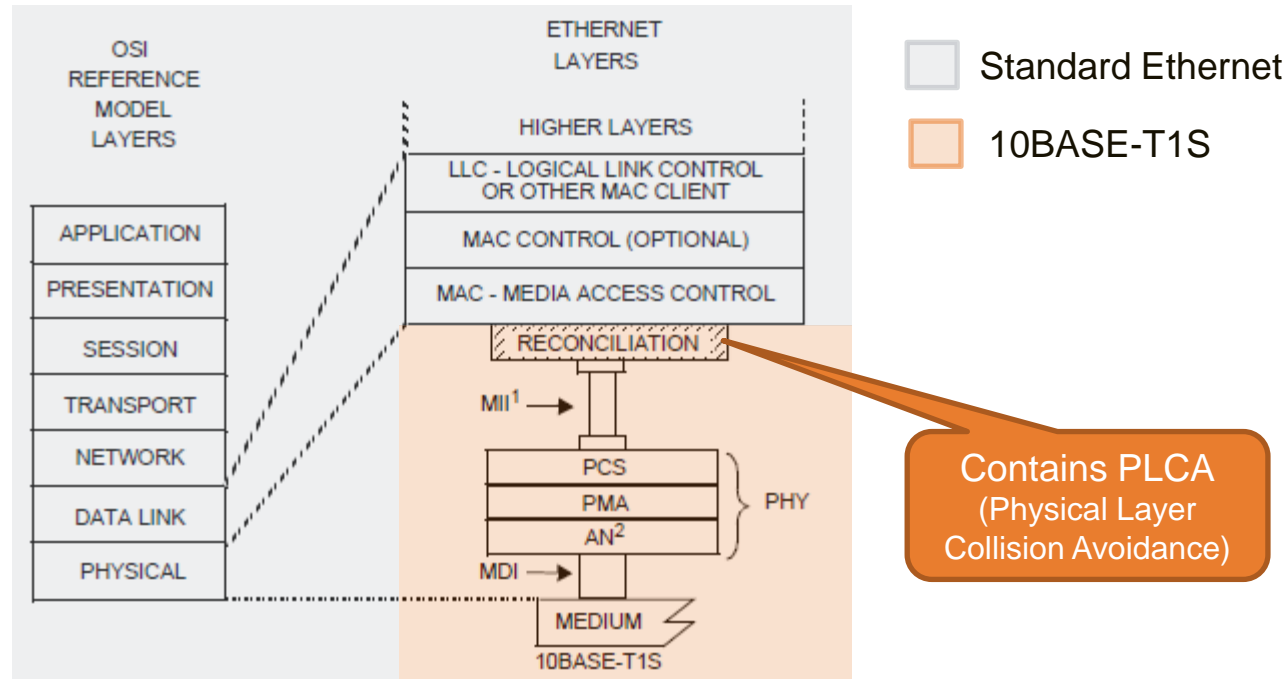
Parameter	Description	Typical Value	Minimum Value	Maximum Value	Unit
V _{THR}	Receiver Threshold	0	—	—	mV
V _{EDRX}	Energy Detection Threshold (Note 2)	250	—	—	mV
V _{acc}	Threshold Accuracy	—	-30	30	mV
V _{CM}	Common Mode Voltage Range	—	-20	20	V
R _{IN}	Differential Input Resistance	40	25	60	kΩ
C _{IN}	Differential Input Capacitance (at 20 MHz)	5.5	—	7.5	pF

MDI: 介质相关接口

PLCA 和现行IEEE 802.3以太网架构的关系

148.3 Relationship with other IEEE standards

The relationship between the PLCA Reconciliation Sublayer, the ISO Open Systems Interconnection (OSI) Reference Model, and the IEEE 802.3 Ethernet model is shown in Figure 148-1. The Reconciliation Sublayer (shown shaded) in Figure 148-1 connects one Clause 4 Media Access Control (MAC) layer to the PHY. MII is defined in Clause 22.

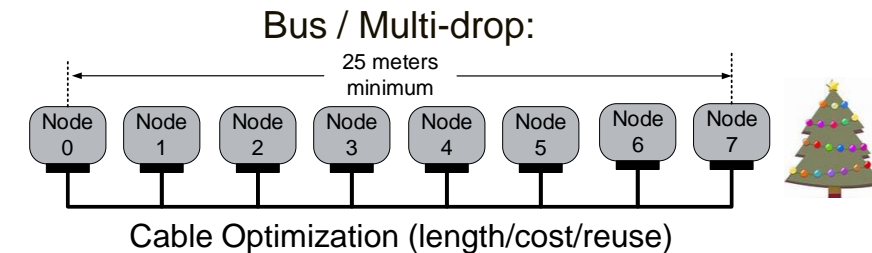
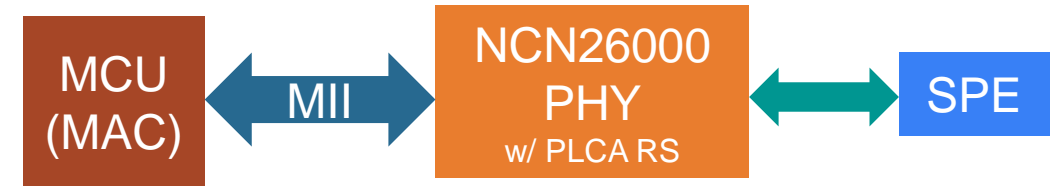


MDI = MEDIUM DEPENDENT INTERFACE
MII = MEDIA INDEPENDENT INTERFACE

NOTE 1—MII is optional
NOTE 2—Auto-Negotiation is optional

PCS = PHYSICAL CODING SUBLAYER
PMA = PHYSICAL MEDIUM ATTACHMENT
PHY = PHYSICAL LAYER DEVICE
AN = AUTO-NEGOTIATION

Figure 148-1—Relationship of PLCA Reconciliation Sublayer to the ISO/IEC OSI reference model and the IEEE 802.3 Ethernet model

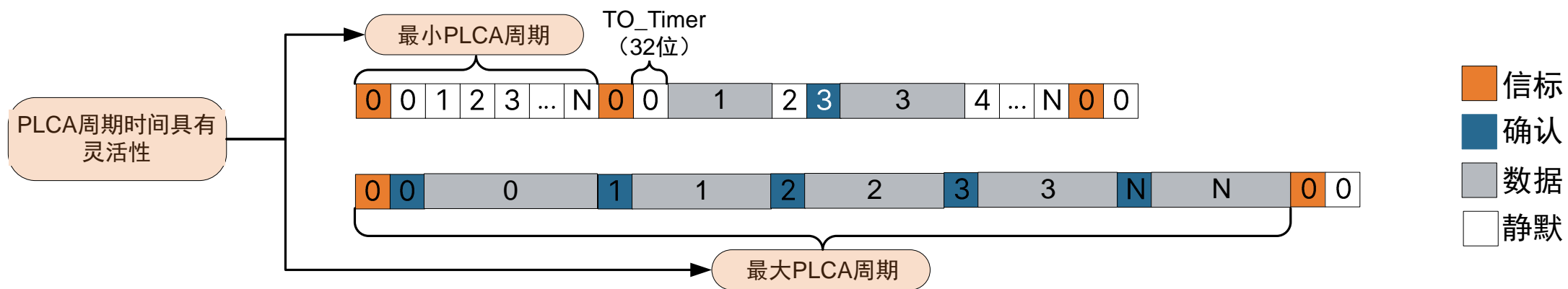


10Base-T1S: IEEE Std 802.3cg -2019
MAC: Media Access Control
MII: Media Independent Interface
SPE: Single Pair Ethernet



冲突避免：10BASE-T1S和PLCA周期

最短的以太网帧：64字节
最长的以太网帧：1,518字节



为每个PHY分配唯一节点ID（与MAC地址无关）

ID #0（头节点/协调器）为PLCA协调器。其他节点是“从节点”。协调器必须知道节点总数，包括其自身。

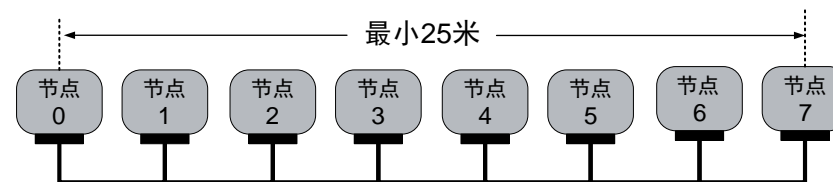
ID #0发出信标（20位符号），触发PLCA周期（上图），然后所有节点重置其“传输机会定时器”

根据节点的#ID，每个节点（以轮询调度方式）轮流（获取机会）“确认”在总线上进行传输，从节点0开始。

如果轮到某节点时没有要传输的数据，它会发出静默（20位符号），所有“传输机会定时器”快速超时，触发下一个ID的机会，以“确认”进行传输。

NCN26010的默认TO_Timeout为24位。IEEE802.3cg指定该值为32位。连接到同一总线的所有节点都必须使用相同的TO_Timeout值，因此TO_Timeout越快，可用带宽越高。

总线/多分支：

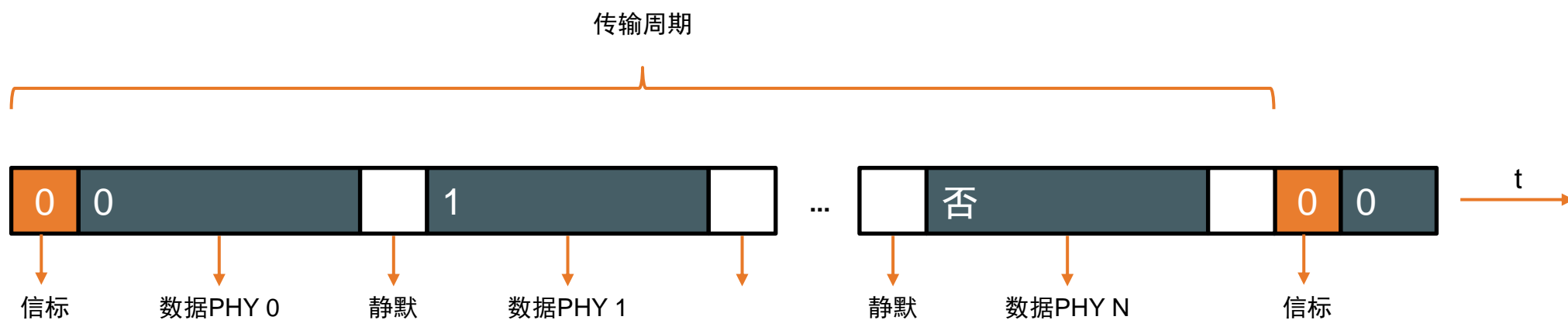


线缆优化（长度/成本/重复使用）：以圣诞树灯光作为类比

PLCA：物理层冲突避免

物理层冲突避免

- 启用PLCA时，仅拥有传输机会的PHY器件才被允许发送数据
- 传输机会通过轮询调度方式进行分配
- 每个PHY在传输机会期间可以发送一个数据帧
- 当主节点发送信标时，即启动新周期
- 可确保最大延迟，同时提高吞吐量和访问公平性
- 可实现很多工业应用必需的确定性实时性能



PLCA与CSMA/CD：8节点，64字节有效负载

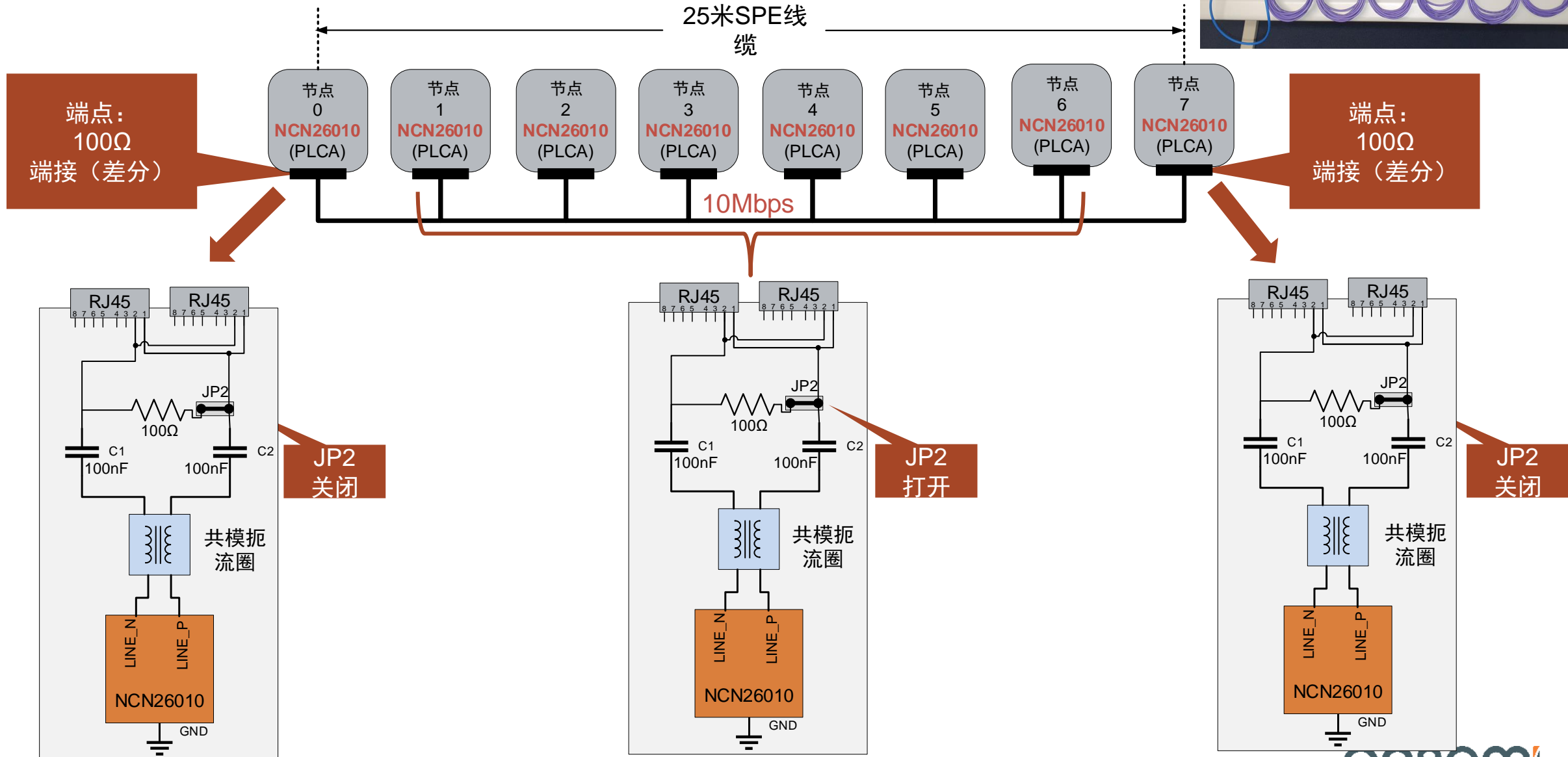
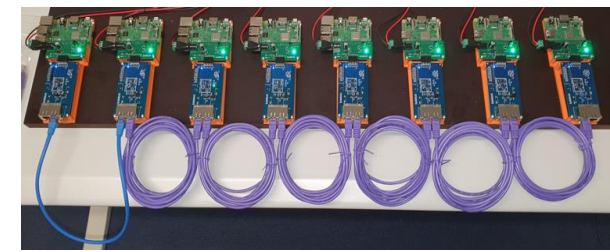
MAC地址过滤

- NCN26010自带四个MAC地址过滤器
- 以太网帧可按照目标地址进行过滤
- 让您能够限制指定节点与其他节点进行通信，从而减少不必要的流量，并降低负载
- 提供支持L2多播寻址的高效方式

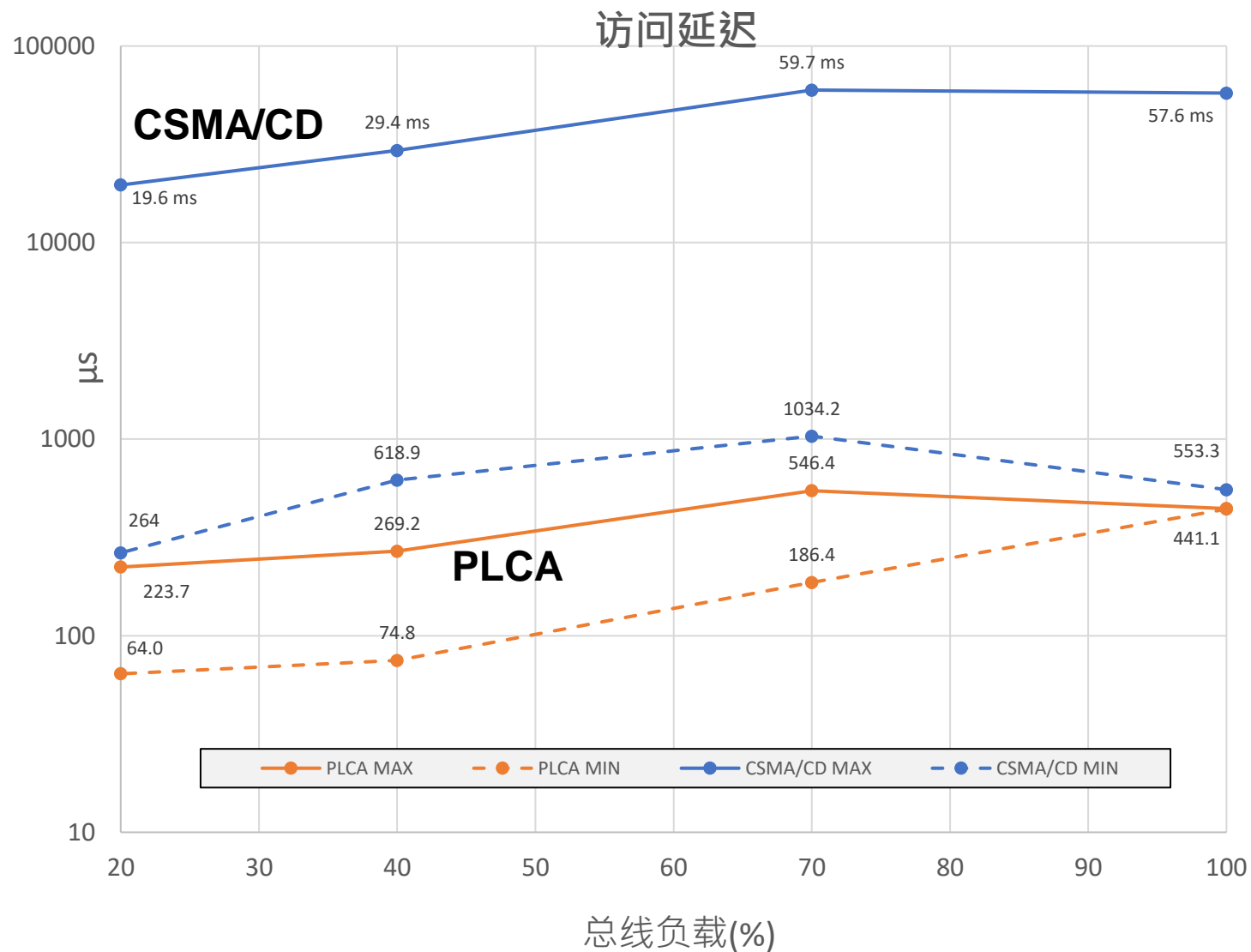
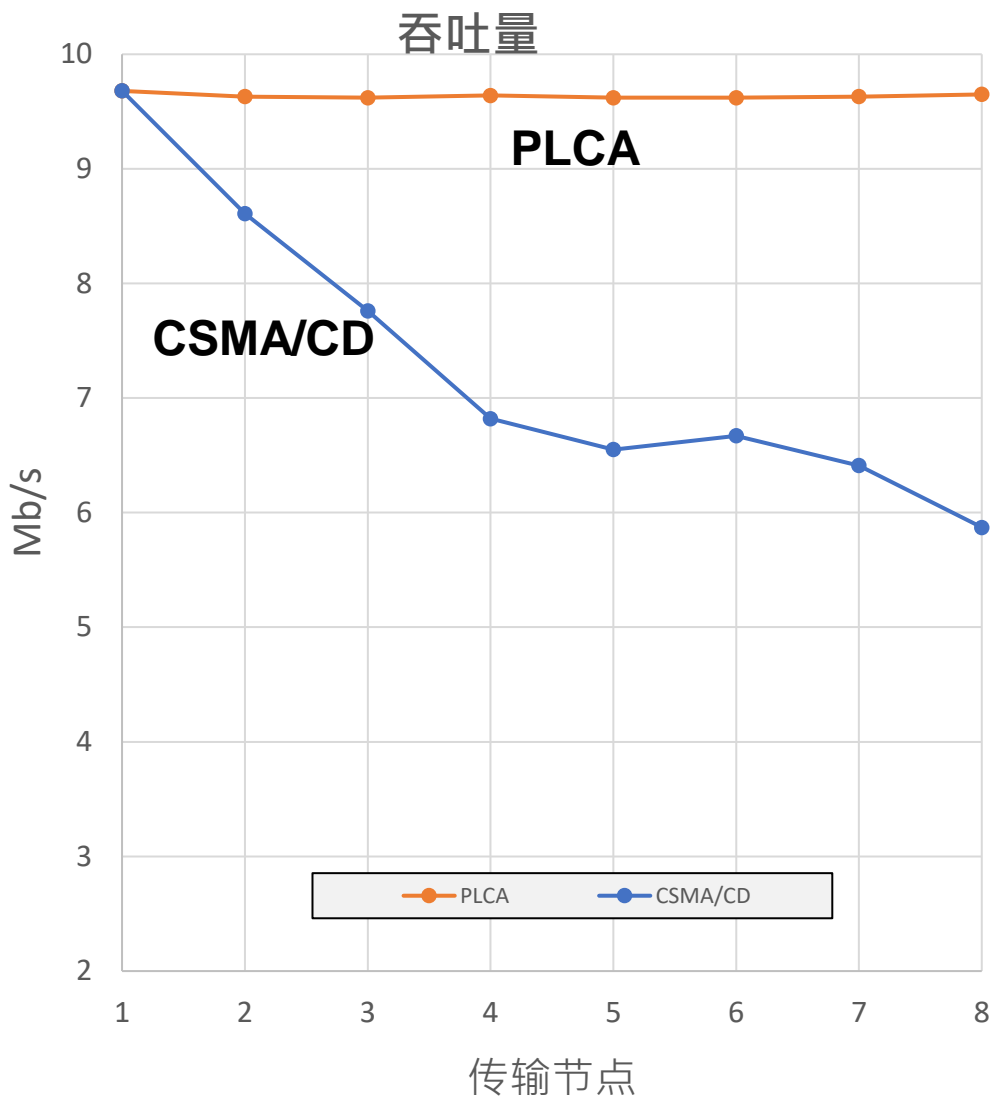
其他功能

- PLCA Leader模式
 - ID不是0的站点可以启动PLCA周期
- 两个可配置的数字输出，能够驱动低电流 LED(< 20mA)
 - 支持通过两个LED提供状态指示灯的系统
- Open Alliance兼容SPI接口：
 - 符合Open Alliance TC6规范，包括配置以及发送到主机MCU的数据帧
- 支持IEEE802.3 CSMA/CD冲突检测，从而实现向后兼容性
 - 发生故障的情况下，PLCA模式将恢复CSMA/CD工作方式，符合IEEE 802.3cg标准的要求

多点网络端接



PLCA与CSMA/CD: 8节点, 64字节有效载荷



NCN26010文档资料

数据表

onsemi DATA SHEET
www.onsemi.com

10 Mb/s Industrial Ethernet MAC + PHY IC Controller

(802.3cg 10BASE-T1S Compliant)

NCN26010

The NCN26010 device is an IEEE 802.3cg compliant Ethernet Transceiver including a Media Access Controller (MAC), a PLCA Reconciliation Sublayer (RS) and a 10BASE-T1S PHY designed for industrial multi-drop Ethernet. It provides all physical layer functions needed to transmit and receive data over a single unshielded twisted pair. NCN26010 communicates to host MCUs via the Open Alliance MACPHY SPI protocol.

Features

- 10BASE-T1S – IEEE 802.3cg Compliant
- 3.3 V Supply Voltage
- Two Configurable Digital Outputs that can Drive Low Current LEDs
- Low Profile – 4 mm x 4 mm QFN32, TQFP32 (5 mm x 5 mm)
- Integrated MAC and 10BASE-T1S PHY
- Open Alliance Compatible SPI Interface for Exchanging Configuration and Data Frames to Host
- Supports IEEE802.3 CSMA/CD Collision Detection
- Physical Layer Collision Avoidance (PLCA) through Local Configuration for Collision-Free Operation on a Shared Medium (Multi-Drop)
- Enhanced Noise Immunity Mode, Allowing Communication at Noise Levels Exceeding IEEE 802.3cg Specifications
- Supports >8 Nodes over >25 m UTP Cable
- Fast Startup: <100 ms
- Support for Bootstrap in Isolated Mode
- These are Pin-Free Devices

Typical Applications

- Industrial Automation
- Sensor Interfacing
- Home / Building Control
- Security and Field Instrumentation

MARKING DIAGRAM

PIN CONFIGURATION

ORDERING INFORMATION

See detailed ordering and shipping information on page 25 of this data sheet.

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入门指南

onsemi APPLICATION NOTE
www.onsemi.com

NCN26010 - Getting Started Basic Configuration, Communication and Exception Handling

AND90155/D

Introduction

The NCN26010 10Base-T1S device has been developed to adhere to the IEEE 802.3cg specifications, as well as the SPI protocol of the Open Alliance (TO3) with various optional additional capabilities.

For correct and reliable operation, there are a few things to keep in mind when configuring NCN26010, especially since the device cannot participate in communication in a multi-drop segment without correct configuration. Also, there is a risk of permanently disrupting the entire segment in the event of improper configuration.

This application note is intended to provide users with a guideline for configuring NCN26010 for their specific application.

Only the basic settings needed are described here, and these are discussed using configuration examples.

Operating Modes

NCN26010 offers mandatory and optional operating modes as defined in the IEEE 802.3cg Standard as well as some features that offer extended functionality:

- CSMA/CD as the basic operation and full back
- Physical Layer Collision Avoidance (PLCA)
- Burst Mode
- Precedence Mode
- Enhanced Noise Immunity (ENI)

As a MAC-PHY device, the NCN26010 integrates both a 10Base-T1S Physical Layer Device and an IEEE802.3 Clause 4 Compliant Media Access Controller into a single device. This combination offers Ethernet communication to low cost MCUs that offer a SPI interface capable of running at least 15MHz and having a TCP/IP stack (e.g., FreeRTOS) implemented in software.

We will highlight the basic functionality of the Open Alliance MACPHY SPI protocol. For in depth details, users are recommended to consult the OPEN Alliance TCO document in revision 1.0.

To illustrate the basic use of the part, this application note starts with discussing how to read and write configuration registers as well as sending actual ethernet frame data through the SPI interface.

Further down in the text a set of basic configurations and the use of Address Filters and Filter Masks inside the MAC will be explained.

Reference Documents

[1]	IEEE802.3cg-2019 "IEEE Standard for Ethernet Amendment 5: Physical Layers Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors" IEEE Computer Society, ISBN 978-1-5044-4600-8
[2]	OPEN Alliance TCO – 10BASE-T1S MACPHY Serial Interface Version 1.0 from 14 September 2020

Figure 1. Simplified Block Diagram

Eval Bd用户手册

onsemi EVAL BOARD USER'S MANUAL
www.onsemi.com

NCN26010BMNEVB 10BASE-T1S Power Supply and Adapter Board User's Manual

EVBUM2834/D

Introduction

The NCN26010BMNEVB is a PCB designed to allow customers to connect to onsemi's NCN26010XMNEVB 10BASE-T1S SPI enabled 10BASE-T1S MACPHY Evaluation board to Raspberry Pi single board computers (SBC). Its main purpose is to act as a physical interface adapter, routing the PMOD connection of the NCN26010XMNEVB to the appropriate pins on the 40 pin Raspberry Pi SBC.

Features

The NCN26010BMNEVB bridge board includes all circuitry to allow powering both a Raspberry Pi and an onsemi NCN26010XMNEVB 10BASE-T1S MACPHY evaluation board as well as establish a connection between the MAPHY evaluation board and the Raspberry Pi. It features a DC/DC SMPS buck converter (NCY89130PD50K2G) that accepts any voltage between 8V and 28V and generates a regulated 5V supply, capable of sourcing 3A of continuous current. This is sufficient to power any Raspberry Pi model available today.

The board also contains a linear 3.3 V Voltage regulator (NCP115ASN30F2G) that provides a stable 3.3 V supply to the Connected 10BASE-T1S MACPHY board.

Figure 1. Board Photo

Figure 2. Evaluation Kit Simplified Block Diagram

软件用户指南示例

NCN26010 Example Software Users Guide

Version 1.0.0

The NCN26010 device is an Ethernet Transceiver designed for industrial multi-drop Ethernet. It provides all physical layer functions needed to transmit and receive data over a single unshielded twisted pair. The example software provided by onsemi is designed to provide the necessary firmware and application examples to help designers quickly integrate the NCN26010 into their systems.

Software Architecture

The provided software follows a modular design to allow the software to be quickly adapted to be used with any microcontroller or to be used with various implementations of the TCP and IP layers of the network stack. As illustrated below, the standard network stack consists of five layers: Physical (PHY), Data Link (MAC), Network (IP), Transport (TCP), and Application. The NCN26010 provides a hardware implementation of the MAC and PHY layers of the network stack. There are many existing open source or proprietary implementations of the TCP and IP layers that a designer may choose from. The software provided with the NCN26010 is designed to provide the connection between the IP and MAC layers of the stack.

The provided software includes three required modules and one optional module. The required modules include a module to handle interaction with the TCP/IP implementation, a module to handle hardware specific details, and the core driver module that configures the NCN26010 and handles errors. The optional module handles interactions with the operating system to yield the CPU to other tasks when not processing messages. If no OS module is provided the system defaults to call functions in the hardware specific module to sleep the CPU until the NCN26010 signals data is available with an interrupt. The interfaces for these modules are described in T1S_TCP-IP.h, T1S_Hardware.h, NCN26010.h and T1S_OS.h, respectively.

The core driver module remains unchanged for any combination of hardware and TCP/IP implementations. The hardware specific module and the TCP/IP modules are intended to be implemented by the system designer to match their system. We provide the following example implementations to support systems with the following hardware and TCP/IP implementations:

NCN26010登录页面链接：
<https://www.onsemi.com/products/interfaces/ethernet-controllers/ncn26010>

BOM
原理图和光绘文件
测试程序

Ibis模型
封装图纸
视频

NCN26010评估板/套件



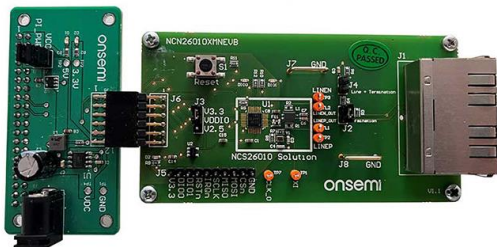
NCN26010XMNTXG
10BASE-T1S MACPHY以太网控制器产品



NCN26010XMNEVB
NCN26010XMNTXG的评估板



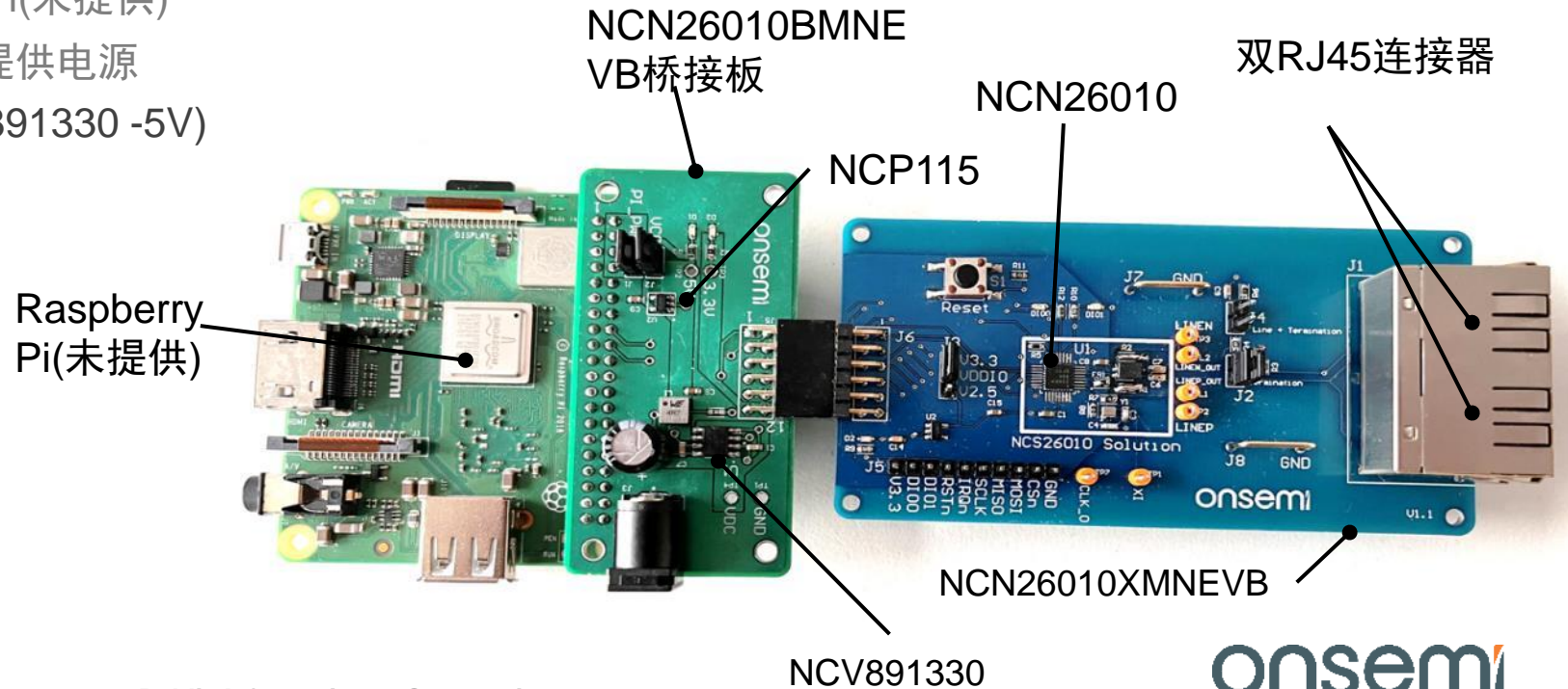
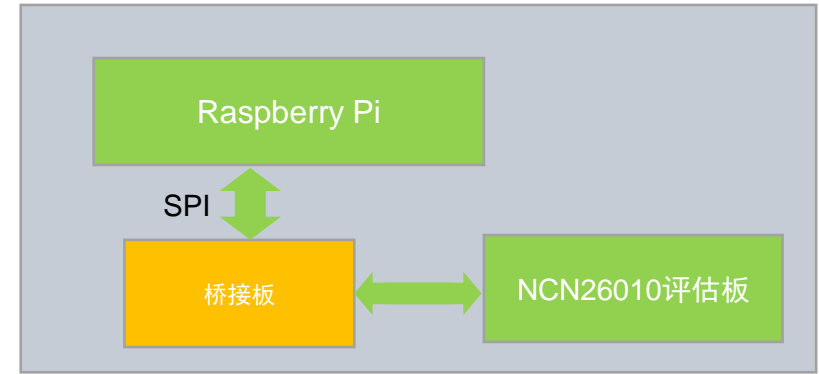
NCN26010BMNEVB
如果您希望使用Raspberry PI作为NCN26010XMNEVB的主机系统，
则可能需要适配器和电源板



NCN26010XMNEVK
包含NCN26010XMNEVB和NCN26010BMNEVB的套件。希望使用
Raspberry PI的客户可能需要订购此套件

NCN26010评估套件

- NCN26010XMNEVB评估板
 - 标准PMOD连接器（连接到主机MCU）
 - 双RJ45连接器
 - 允许使用市场上提供的3类/5e类线缆，但只能使用一根双绞线
- NCN26010BMNEVB桥接板
 - 连接至充当主机的Raspberry Pi(未提供)
 - 为NCN26010和Raspberry Pi提供电源
 - DC-DC降压稳压器(NCV891330 -5V)
 - 3.3V LDO (NCP115)



谢谢!

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