DSProfinet

Profinet IRT Master Motion Controller and Network Manager

Siemens Sinamics Drives (CU320)

Siemens ET 200S I/O

IRT

DSProfinet IRT

Features

- Fully compliant with Profinet IRT standard
- Fully compliant with IEEE 802.3 standard
- Simultanous use of Profinet and Ethernet
- Maps Profinet I/O onto DPRAM
- 100 Mbps of Isochronous speed
- Maps motion commands onto network
- Includes Ethernet gateway
- Offered in PCI and Stand-alone forms
- Offered with a DSP Motion Control Based HW or Soft Motion (where PC generates motion commands.)

DSProfinet IRT: a single line industrial ethernet for real-time applications

DSProfinet IRT offers a simple digital alternative to traditional analog systems that functions over the Profinet IRT interface. By combining the power of Profinet IRT with the power of either DSP-based motion controller hardware or a software motion commands generated insider a PC, a powerful master IRT solution has been created. Of all the digital networking standards that have been created over the years, one of the oldest, most flexible, and most reliable is Industrial Ethernet. The robustness of Ethernet's design is attested to by the fact that it continues to be adapted to new applications, and is constantly being upgraded to provide new capabilities. **DSProfinet IRT** is offered in three platforms of **1)** PCI-based DSP motion control ler **2)** Stand-alone DSP motion controller and **3)** Soft motion controller (meaning commands are generated inside a PC by the user program.)

DSProfinet IRT
Stand-alone

Siemens Sinamics (CU310)

DSProfinet

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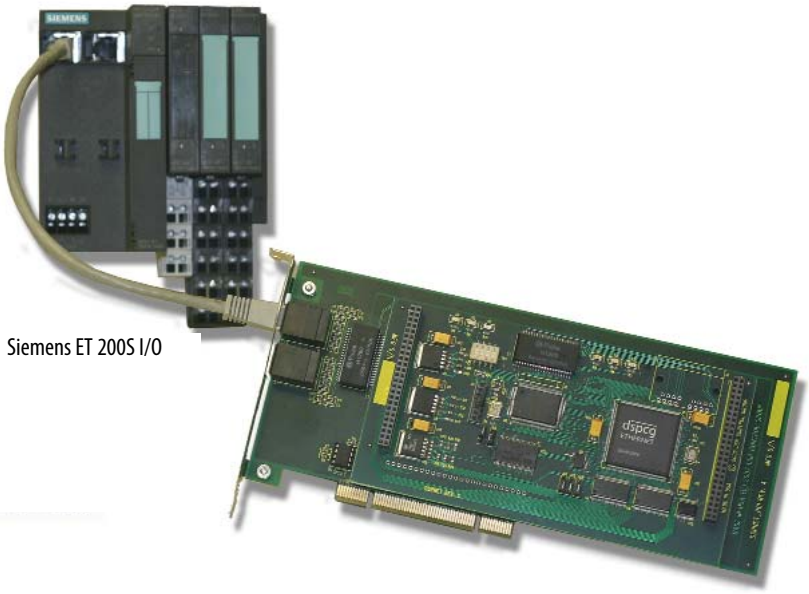
when programming with DSProfinet IRT Controller, a single Ethernet cable is sufficient to configure and program all your SINAMICS S120 drives on the Profinet IRT network.

Whether the Profinet network is inclusive of a single or multiple SINAMICS S120 drives, DSProfinet as the IRT Controller is capable of transmitting the isochronous real-time information through an Ethernet cable in a daisy chained fashion. The PROFIdrive commands on DSProfinet links your PC program to multiple SINAMICS S120 units in a coordinated system.



Siemens ET 200S I/O

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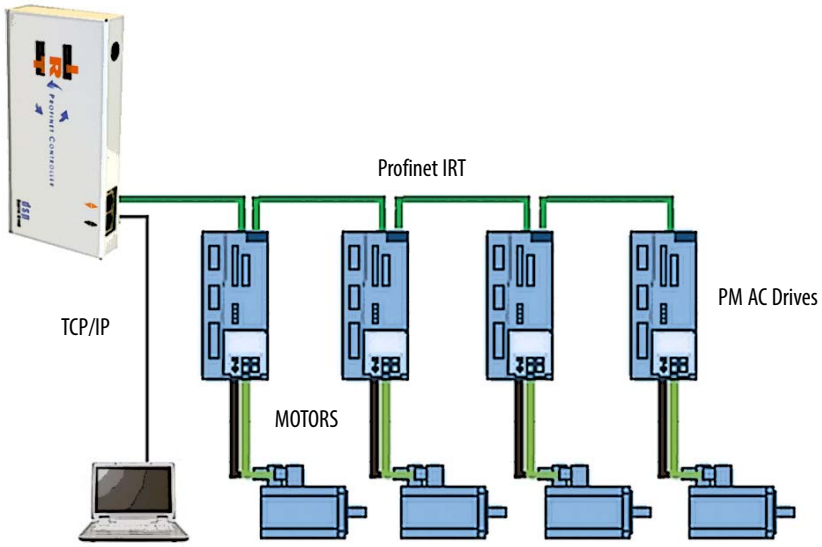
Determinism of the IRT Profinet Controller

For high performance motion control applications such as precise coordination of hundreds of axes with microsecond precision, Profinet includes an isochronous real-time channel. As indicated by the word "isochronous" in its acronym, Profinet IRT (Profinet Isochronous Real-Time) is used for closed-loop control of a system, where the control (both the set-point and feedback) for multiple devices occurs during the same sample period. This sample period can be as strict as 250 microseconds, meaning that the controller in a Profinet IRT network issues its command to all devices every 250 microseconds. Similarly, each device in the Profinet IRT will respond with its data (for example, the actual position and/or speed in a motion system) during the same period.



Operational Principle of DSProfinet IRT Motion Master

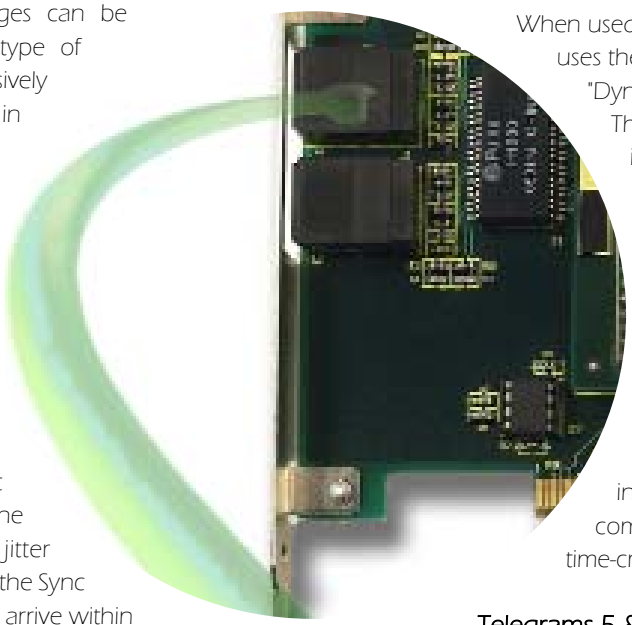
After an initial communication period between the controller and the device(s), Profinet IRT begins to start taking place. (Note that this initial communication period is just used to establish the parameters of the ensuing Profinet IRT communication, such as how much and what type of data will be exchanged during each interval, etc. It only needs to take place once and will last less than 30 seconds.)

There are two important classes of messages that get exchanged during each interval. (Occasionally there will be additional network management-type messages appearing in the network, but these are not related to control nor are they periodic. Also, they would certainly occur after the IRT messages for the current interval have been sent and received.) One of these classes of messages is synchronization messages, commonly referred to as "Sync" messages. These messages can be thought of as the "keep-alive" type of message. They are sent exclusively from the controller to the devices in the network and no response from the devices is necessary. Also, they do not contain any control data, but instead serve to ensure that the controller is keeping up with the strict timing constraints of Profinet IRT. Namely, that it is starting the interval precisely one millisecond (or two milliseconds, as the case may be) from the last interval. This is the message that the devices will use to base the jitter calculations off of. In other words, the Sync message is the message that must arrive within one microsecond of when it is supposed to, for every interval.

Also during the interval, messages carrying data from the device to the controller and the controller to the device will be exchanged. These messages are named Real-Time Class 3 (RTC) messages. (Don't let the lack of the word "isochronous" from this name mislead you - Real-Time Class 1 messages are for Profinet RT (non-IRT) communications.)

For each interval, the controller will send out one RTC message for each device that it is controlling. This RTC message will contain the data, such as speed set points or position information that the device needs to have. In return, at the same time each device in the network is sending an RTC message to the controller. This RTC message will correspond with the RTC message it received. For example, if speed control is being performed, the controller's RTC to the device will have a desired speed (speed set point) and the device's RTC to the controller will have the actual speed. Finally, one may wonder what exactly connects the Profinet IRT controller to its devices. The answer is standard Ethernet cable. Profinet IRT will function with a CAT 5 Ethernet cable, with an Ethernet interface operating at 100 MB/s.

Information exchange between DSProfinet and SINAMICS



When used with SINAMICS S120, DSProfinet uses the PROFIdrive profile that contains "Dynamics Servo Control" (DSC) concept. This can be used to significantly increase the dynamic stability of the position control loop in what Siemens refers to as application class 4 with simple means. The telegrams used by DSProfinet are 5 & 6 (for DSC 1 position encoder and DSC 2 position encoder respectively), 390, 391 and 392 (telegrams for control unit Drive Object 1, DO1, digital inputs/outputs). Cyclic communication is used to exchange time-critical process data.

Telegrams 5 & 6 (motion parameters)

From the DSProfinet IRT Controller to the SINAMICS S120 Telegram 5 (application class 4 DSC) delivers:

CTW1	control word 1
NSOLL_B....	32-bit speed set point
CTW2	control word 2
G1_CTW.....	encoder 1 control word
XERR	position deviation
KPC	position control gain factor

Using the same telegram, S120 returns (to DSProfinet) the following data:

STW1 ..... control word 1
NIST_B ..... 32 bit actual speed
STW2 ..... status word 2
G1_STW ..... encoder 1 status word
G1_XIST1 ..... encoder 1 actual position value 1
G1_XIST2 ..... encoder 1 actual position value 2

Telegram 390 (I/O parameters)

From the DSProfinet IRT Profinet Controller to the SINAMICS S120 Telegram 390 delivers:

CU_CTW .....control unit control word
O_DIGITAL .....16 bit digital output control word

Using the same telegrams S120 returns the following data to the DSProfinet:

CU_STW .....control unit status word
I_DIGITAL .....16 bit digital input control word

In addition, telegrams 391 and 392 also send and return (to DSProfinet) probe status:

PR_CTW .....from DSProfinet to SINAMICS and
PR_STW .....from SINAMICS to DSProfinet

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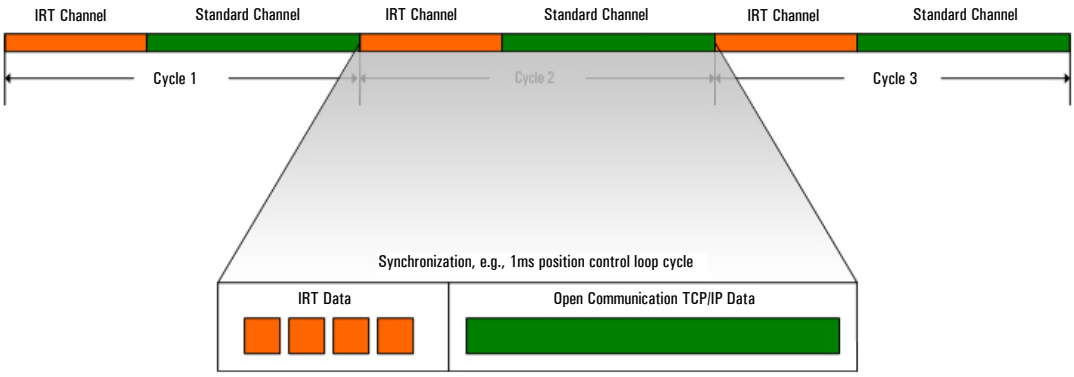
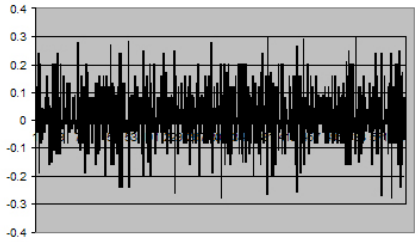


Critical data for motion applications are transmitted on Profinet via the IRT Channel ensuring a precise and deterministic response.

What is unique about the Profinet IRT Controller?

Certainly other Ethernet protocols in motion control today operate on a regularly occurring interval basis. So one may ask, what is special about Profinet IRT Controller? The guiding factor that sets Profinet IRT apart from other real-time, cyclic protocols is the concept of "jitter". The jitter is defined as a time fluctuation in the start of the interval. For example, in a one-millisecond interval, if the controller started the next interval 100 nanoseconds after the termination of previous interval, the system could be described as having a jitter of 100 nanoseconds at this point in time.



DSProfinet Jitter (in fraction of a microsecond) vs. sample time

Other cyclic protocols may (EtherCat) or may not (Profinet RT, Ethernet PowerLink) be concerned with whether there is jitter at the start of each interval.

In the case of Profinet IRT, both devices and controller are very concerned with jitter. The threshold for jitter allowed by the Profinet IRT protocol is defined to be one microsecond. Hence, an entity that wishes to serve as a controller in a Profinet IRT network must be able to start each cycle very precisely on the aforementioned millisecond boundary. The devices in a Profinet IRT network are designed to be made aware of when a controller is not adhering to the jitter requirement. Upon recognition of this situation, the devices will stop operating with the controller. It would then be up to the controller to essentially "start over" and show the devices that it is capable of operating within the jitter specification. (For example, maybe the controller wasn't able to start a series of cycles due to a bad cable. Once the cable is replaced, the controller will be able to attempt Profinet IRT with the devices from the beginning.)

The operation of cyclic control at these extremely precise intervals (such as one or two-millisecond interval times occurring within one microsecond of jitter) is what allows for extremely precise coordinated motion control applications to occur across multiple axes.