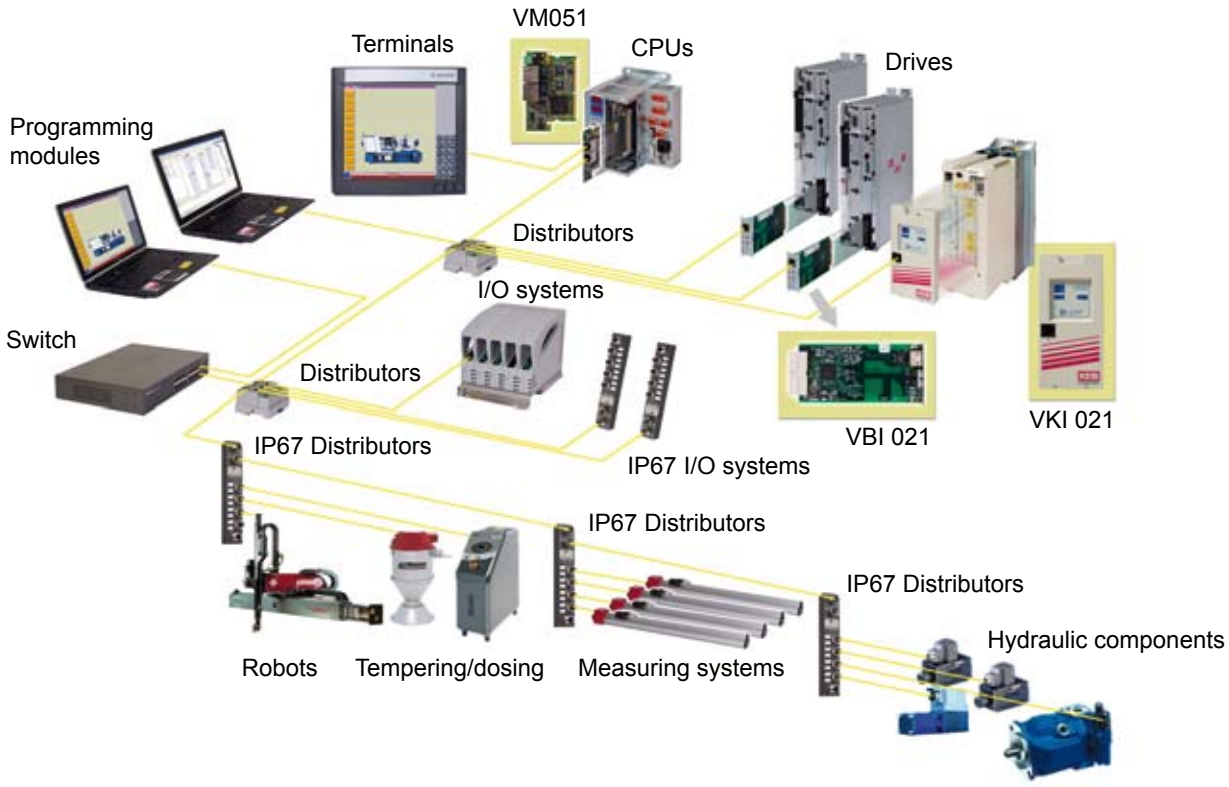
Realtime Ethernet VARAN Bus

VARAN - Versatile Automation Random Access Network

The VARAN bus system meets all requirements of a modern industry network optimized for machine automation. It is based on IEEE 802.3 100TX standard Ethernet technology. The protocol is implemented completely in the hardware. All messages are acknowledged and repeated immediately in the event of an error. The VARAN bus makes a strong impression with its speed, openness, simple implementation and low costs, as well as its optimized real time performance and high reliability.

The entire bus is seen as a 4GB memory area, in which each client is assigned a defined memory space. Therefore, the control CPU can access each station with simple memory read and write instructions.



VARAN bus topology example

The Basics

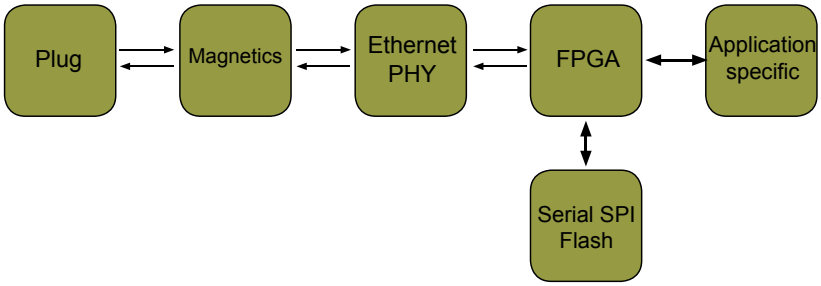
With the VARAN bus, the requirements for hard real time control are combined with those of automation and implemented using Ethernet technology. In order to take full advantage of the available networking, TCP/IP cross traffic is integrated. The technology is open and can be used by everyone. Collisions are avoided through the use of the Manager-Client principle. The VARAN bus can reach highest speeds, shortest cycle times and minimum synchronicity jitter. In addition, the VARAN bus offers the unique possibility of asynchronous direct access.

Data packets are repeated within the cycle until a valid acknowledgment is received. Therefore, the validity of all data is guaranteed at the end of each cycle. This constant testing of data validity, even with bus cycle times less than 100 µs, is only possible through the use of the VARAN data frame (1 - 128 bytes).

The VARAN bus can also, if required, transport Ethernet frames that are used by clients for start-up and evaluation.

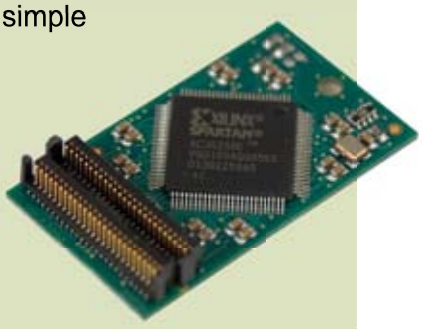
The basic design of a VARAN application is the same for both the manager and the client. Connectors, transmitters and the Ethernet PHY component form the physical layer of the Ethernet. The PHY component provides auto-crossover detection so that standard CAT 5 cables (crossover or straight through) can be used.

For the supply of device power, a 24V DC supply voltage can be added. Actuators and sensors are connected using a single connector providing both communication data and power. For the VARAN protocol application, an FPGA and a serial SPI Flash are required. Application-specific tasks can also be integrated in the FPGA.



Facts that Convince

- **Guaranteed hard real time data transfer**
  Each instruction is immediately acknowledged by the receiver within the bus cycle.
- **Speed**
  High transfer rates, higher sample rate, higher regulating properties and increased data quality.
- **Automatic addressing**
  Minimum network planning and administration costs.
- **Hot plug in**
  Participants can be added or removed during operation.
- **High reliability**
  In the event of an error, instructions are repeated immediately within a bus cycle.
- **Open standard**
  VARAN technology is open and can be used by anyone.
- **Direct access**
  In addition to standard, isochronous and asynchronous data transfer, immediate direct access to a station for tasks with high priority is also possible.
- **Simple implementation**
  Even in small sensors and actuators.
- **Simple programming**
  For the bus manager, the bus system represents a large RAM.
  Each participant is assigned an area within this memory space so that simple read/write instructions can be used.
- **Low implementation costs**
  Through the use of low cost standard components.
- **System consistency**
  Standard TCP/IP cross traffic is possible.
- **Simple maintenance and servicing**
  With comfortable service and diagnostic tools.



Performance Data

Bus cycle time	< 100 µs	
Isochronous access time	2.18 µs	8 I/Os = 1 Byte
	5.05 µs	1 Drive 16 Bytes r/w
Asynchronous direct access	< 25 µs	128 Bytes
Synchronic inaccuracy	< 100 ns	Jitter
Portable to Gigabit Ethernet without protocol changes.		

(Access time is only valid if the clients are connected directly to the manager)

The VARAN Bus in Detail:

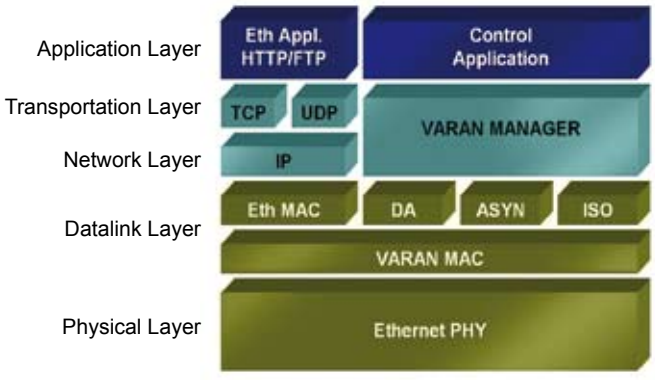
One controls all: the VARAN manager manages the entire bus memory area, which can support up to 65,536 participants. Each participant is assigned a defined linear address space of 65,536 bytes during the start-up phase.

The exchange of information is based on two operations: “write the following data to address x” and “bring me the following number of bytes starting from address x”.

The VARAN Manager

Each data transfer is initiated and centrally managed by the VARAN manager exclusively. All protocol-specific tasks of the VARAN manager are processed in the FPGA, which relieves the burden from the control CPU.

The manager consists of several areas with various priority levels: Direct Access (DA), Asynchronous (ASYN), Isochronous (ISO). The VARAN manager according to the layer concept of the OSI model:



Each data object in the application (control application) consists of a description field and a data field.

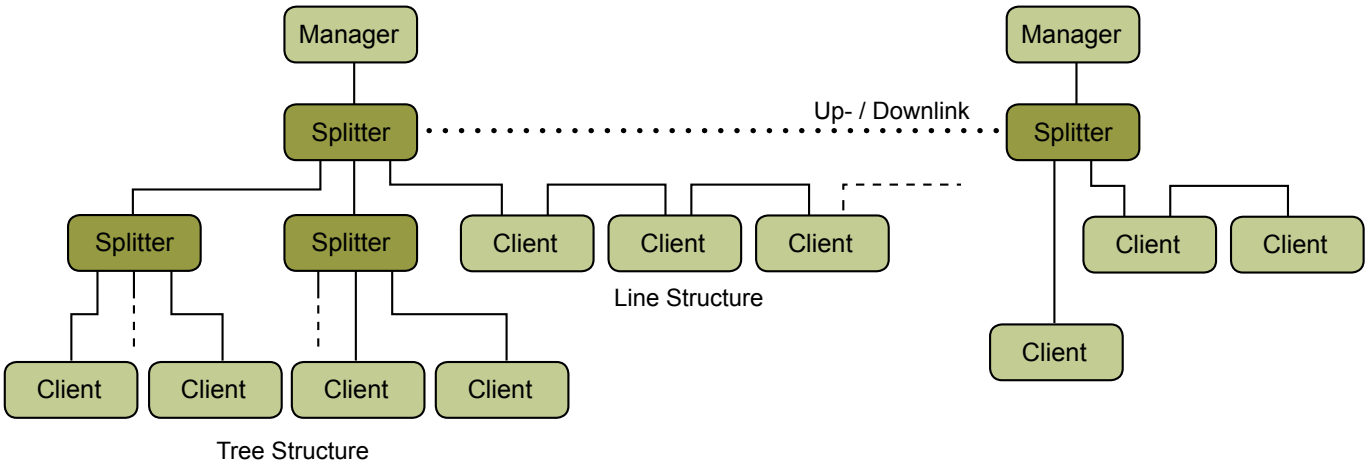
The description field contains the addresses to be accessed, the number of bytes to be transferred, the identification for read and write as well as the number of retries allowed. Additionally, what action to take in the event of an error is also defined (exception or offline flag only).

The data field contains the data objects.

VARAN Bus Structure

Principally, any combination of tree, star and linear structure is possible. A distributor, the so-called VARAN splitter, is used for building tree and star topologies.

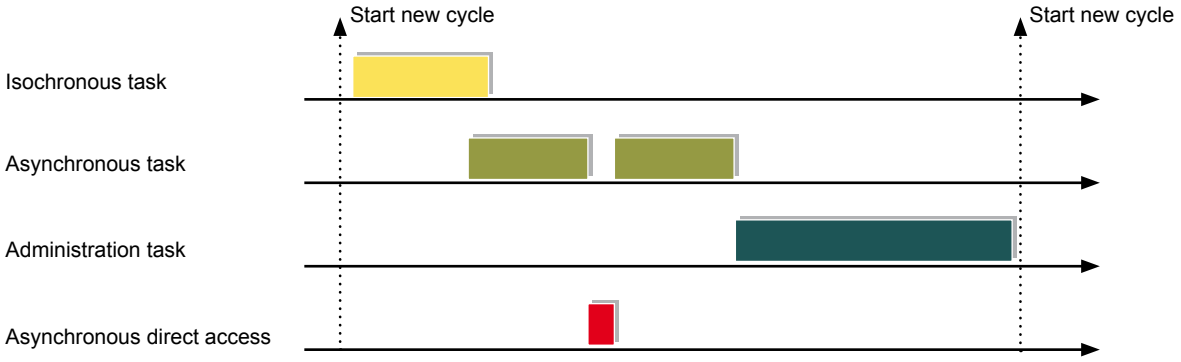
The VARAN splitter distributes the data packets to all output ports and shields the network from undesired access. The splitter function can be integrated in all clients. Using a VARAN master splitter, several VARAN systems can be cascaded into a complete synchronous network: A multi manager structure is thus generated. This enables several machines to be connected in synchronous real time without problems.



Possible Configurations

Bus Cycle Distributions

At the start of each bus cycle, the manager sends a global SYNC instruction. The isochronous real-time objects are sent next followed by the asynchronous objects and finally the data objects of the administration task. In the administration task, processes such as scanning for new stations or the transmission of Ethernet IP cross traffic are executed. The asynchronous direct access interrupts the running tasks for less than 25 µs of the bus cycle for an immediate client update.

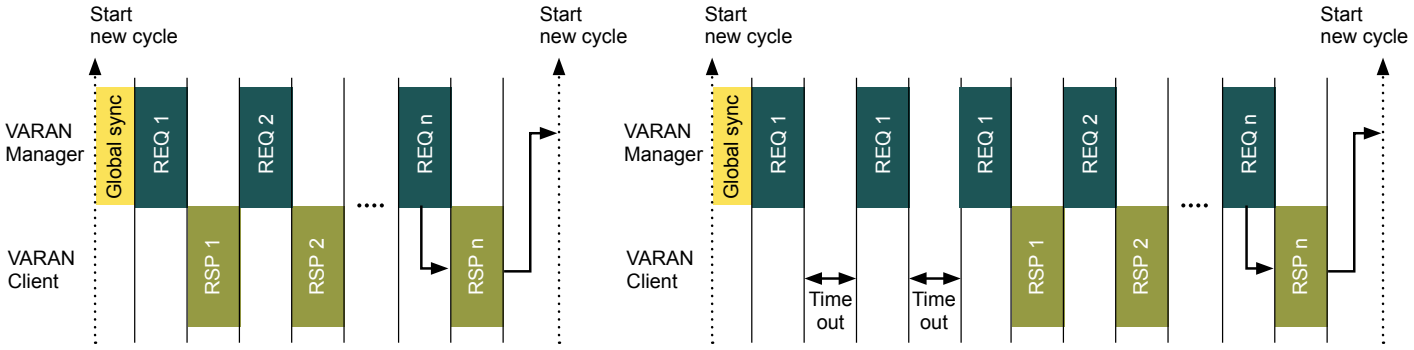


Communication timing: VARAN enables asynchronous direct access to bus stations at any time.

All Data is Valid at the End of a Cycle

When developing VARAN, special attention was given to the validity of data at the end of every cycle. The client acknowledges every instruction received from the manager immediately. If the client does not answer within the specified timeout period or the answer is erroneous, the manager immediately repeats the instruction without incrementing the message counter until a valid response is received. The client thus recognizes the instruction as a repetition. This process guarantees that all data is valid at the end of the cycle.

The constant testing of data validity, even with cycle times smaller than 100 µs, is only possible using the VARAN data frame (1-128 Bytes).



Standard communication **Error retry**

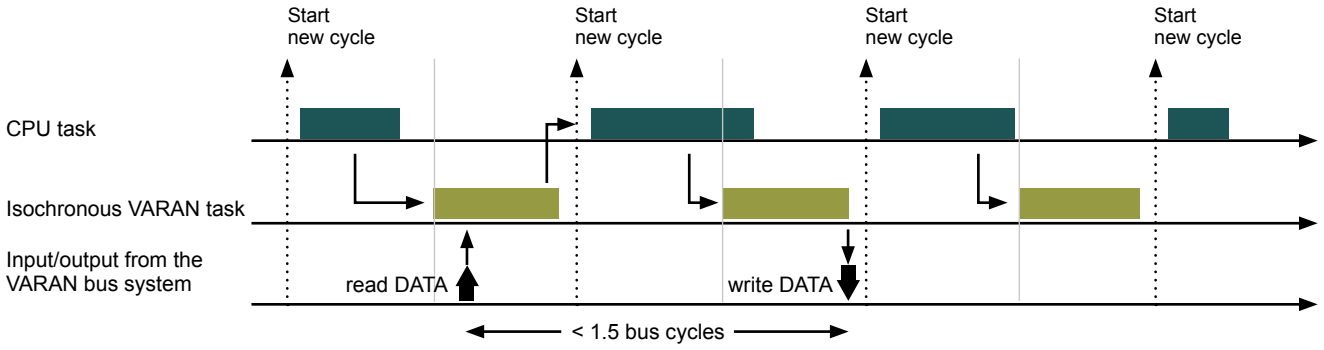
The IEEE 1588 defined clock synchronization of the bus stations is not required for the VARAN bus.

Access Times in the µs Range

The update times are an essential aspect of real time Ethernet networks. When writing to 16 I/Os (instruction length of 2 Bytes), the VARAN bus has an update time of only 2 µs. Drives with 16-byte actual and set values each can be processed with a single read/write instruction in 5 µs. These times increase by 1 µs per distributor node. To obtain short update and bus cycle times, a tree structure is therefore recommended.

Latency Time

For read and subsequent write access to a bus station, the latency period is approximately 1.5 bus cycles (including the processing of I/O data by the CPU).



Ethernet Frames

The Ethernet cross traffic is controlled by the VARAN manager. Each client with a standard IP Ethernet port is detected and queried during the administration task for Ethernet frames that are to be transmitted. Existing IP data is then transmitted to all IP nodes (IP tunneling).

Identification Plate

All modules with a VARAN connection are given an electronic label containing the device specific data:

- Vendor-ID
- Device-ID
- License number

Modules with an invalid identification plate or license are deactivated. The bus system is therefore protected against undesired participants. It is also possible to add customer-specific files in the VARAN client. The module description, for example, can be saved in the client as a PDF and accessed via the VARAN service tool.

Safety

Safety protocols can also be transferred over the VARAN bus. The protection level is defined by the user through the applied safety protocol and the safety class of the participant. In this case, the VARAN bus serves as the transmission medium only.

VARAN Instruction Overview

- **Memory Read:**
  Reads data from the memory of a client. This instruction contains the start address and the number of bytes to be read. The client answers with the required data.

- **Memory Write:**
  Writes data to a client memory space. The write command contains the start address and the data to be written. The client sends an acknowledgement.

  These two instructions can be combined in a single **read/write** instruction.

- **Global Write:** All bus participants are addressed simultaneously. This instruction is used, for example, for a global reset of all bus stations or to transmit the SYNC command.

- **Foreign Package Request/Response:**
  Initiates the transportation of foreign data packets (TCP/IP, safety or other protocols) through the VARAN bus system.

Connection Technology

Principally, it is important to distinguish between IP20 in the control cabinet and IP67 requirements in an industrial environment. Several name brand manufacturers of connectors are actively working on ideal solutions for IP67 connection technology. For IP20 connections, caution should be taken to ensure that all RJ45 type connectors meet the requirements for the application because of vibration and contact problems.

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